August 2021

Major transport program strategic assessment report

Key findings to inform Victoria's infrastructure strategy 2021-2051

INFRASTRUCTURE VICTORIA

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Glossary

Term	Description
ABS	Australian Bureau of Statistics
AV	Automated vehicles
AZEVIA	Infrastructure Victoria's Automated and Zero Emissions Vehicle Infrastructure Advice
BCR	Benefit cost ratio
CCM	Cross city motorway project
CLR	City Loop reconfiguration project
DDW	Infrastructure Victoria's Density Done Well Research
EAV	Electric and autonomous vehicles
FER	Functional Economic Region
FUA	Functional Urban Area
ICE	Internal combustion engine
LGA	Local Government Area
MM2G	Melbourne Metro Two and direct Geelong rail services project
NDS	Network development scenario
NPV	Net present value
OMR	Outer Metropolitan Ring Road project
PT	Public transport
PV	Private vehicle
RMS	Road management systems
SA2	Statistical Area 2 (ABS standard geographic classification)
TBC	Transport base case
TNP	Transport network pricing
VC	Volume capacity ratio
VHT	Vehicle hours travelled
VKT	Vehicle kilometres travelled
VLUTI	Victorian Land Use and Transport Integration
WFH	Working from home
WRU	Western rail upgrade project
ZEV	Zero emission vehicles

Executive Summary

Addressing future economic, transport and land use challenges

This report provides Infrastructure Victoria's strategic assessment of six major transport projects to support recommendations in *Victoria's infrastructure strategy 2021 – 2051*. These projects have been selected as they have significant benefits, costs, and the potential to address several of the state's key challenges. These projects accommodate future population growth in areas expected to come under the greatest pressure. They improve access to jobs and services between the city, key precincts, and outer suburban and growth areas, and support Plan Melbourne's direction 1.1 to create a city structure that strengthens Melbourne's competitiveness for jobs and investment.[1] These projects also encourage better use of existing assets through improved road network operation systems and an ability to realise the potential benefits of other major transport projects currently under construction and those fully committed in the future.

By 2051, there are projected to be over 5.5 million jobs and 10.8 million people in Victoria. The distribution of this population and employment growth presents several challenges in the size and complexity of future growth patterns and will impact how the state, Greater Melbourne and Victoria's regions function. Most of the growth will be in Greater Melbourne, as well as major regional centres including Geelong, Ballarat and Bendigo.

The magnitude and locations of the expected future growth in population and employment presents many challenges for Victoria's infrastructure, economy and urban development planning and patterns. Where this growth occurs has a major impact on the need to travel, and thus demand for transport infrastructure.

In many parts of Melbourne, population and jobs growth is expected to occur in similar locations, such as in Inner Melbourne and its eastern suburbs. In contrast, parts of Melbourne, including the northern and western growth areas, are forecast to experience strong population growth, but little employment growth to support their populations. The distance between these growth areas and employment centres with higher order employment opportunities is growing, creating issues not only for economic growth, but also for accessibility and equity.

Victoria has a significant pipeline of infrastructure projects that are under construction or planned to be delivered in the next decade. This includes the Metro Tunnel project, removal of 75 level crossings across Melbourne, the West Gate Tunnel, North East Link, major road upgrades, Melbourne Airport Rail and upgrades to every regional passenger line in Victoria.[2] The six major transport projects assessed in this report build upon this historical level of delivery and commitment to major road and rail projects by the state government. Along with Suburban Rail Loop, these six projects provide the momentum and next steps for the evolution of the network that is already taking place to meet this growth.

An evolving approach to strategic project assessment

Approaches to assessing infrastructure programs have evolved over time. Our innovative assessment framework considers a range of elements, reflecting a maturity in how we assess major transport projects. We have considered alignment with the objectives of Victoria's infrastructure strategy through a multi-criteria analysis, an economic evaluation that has been expanded to consider land use changes, a broader social, environmental and economic assessment, and consideration of distributional impacts.

Infrastructure projects are an investment for the long term, but the long term outlook can vary markedly. Structural changes can result in a significant shift in preferences, including those that shape travel choices and influence behaviour. This study develops and draws upon a range of scenarios to provide insight on the impact of these structural changes on the projects being considered. These scenarios include higher and lower population forecasts, a more permanent shift to working from home, and greater take up of autonomous and electric vehicles.

We have undertaken strategic modelling to inform our assessment of each of the six transport projects. As a first in Australia, Infrastructure Victoria has developed an integrated transport and land use model that functions with a spatial computable general equilibrium (SCGE) model. This model aims to determine the extent that different projects influence behaviour and preferences that impact the city's growth and facilitate underlying growth in demand. Traditionally, most projects are considered using a fixed distribution of residential and job locations. The Victorian Land Use and Transport Integration (VLUTI) model considers how infrastructure investment could change the distribution of population and employment across Victoria. This innovative VLUTI model allows for population, employment and transport infrastructure to directly influence each other, causing changes in where people live and where jobs are located.

Using this assessment framework, modelling, scenario and sensitivity testing, we have identified the conditions within which a transport project is required, as well as measures that are required to support the benefits and mitigate against any potential unwanted outcomes. Our modelling and scenarios show the potential for many projects to grow the city

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[1] *Plan Melbourne, p12*

[2] *Victoria's Big Build https://bigbuild.vic.gov.au/about*

outwards, which can have environmental, economic and social impacts. Our modelling also shows the impacts of induced demand, and the risk of eroding future benefits from new infrastructure projects. Integrated transport and land use planning can help to identify and mitigate these risks and unlock greater benefits for Victorians.

Getting the most out of infrastructure investments

Infrastructure Victoria's approach to tackling challenges is to consider opportunities to manage demand and make better use of existing assets before building new infrastructure. Supporting more homes in priority established places for residential intensification will support better use of the existing transport network. Previous modelling undertaken by Infrastructure Victoria found that allowing more people to live closer to jobs and services can grow Victoria's economy and increase the efficiency of the transport network.[3]

Transport network pricing is a system designed to influence how, when and where people use the transport system. A comprehensive network pricing system assists in getting the most benefits from the significant government investment in the transport network through reducing crowding and congestion and enabling transport projects to perform at their best.[4] Transport network pricing should be implemented in advance of major new-build transport projects to manage demand and congestion to allow for greater benefits from the existing network. If not already in place, at a minimum transport network pricing should be established alongside major new-build projects.

Summary assessment of the six major transport projects

Road management systems (RMS) make road operations more agile and responsive and help transport infrastructure perform better. More efficient road management improves safety, travel times and reliability. There is clear merit in making better use of our existing infrastructure assets, particularly in the short term. Consistent with international examples, our strategic assessment indicates that improving road operations management can have significant benefits with relatively low cost of implementation. This is even the case where localised infrastructure investment may be needed to alter the road layout to improve efficiency. This project produced a benefit cost ratio between 8 to 14 (using a discount rate of 7% and 4% and upper and lower cost ranges).

While our modelling found that significant benefits flow from RMS, there can also be adverse impacts in the longer term. Short term congestion relief encourages more car use which contributes to worsening congestion in the longer term in some areas, particularly in areas that are denser, such as Inner Melbourne. Improved travel times, coupled with a transition to zero emission vehicles with their lower operating costs, may result in more people travelling further and living beyond Melbourne's Urban Growth Boundary (UGB).

These potential adverse impacts should be managed through a comprehensive set of transport policy interventions that focus on the movement of people and goods across all road-based modes, including trams, buses, cyclists and pedestrians. This includes making full use of the RMS technology's demand management capabilities, introducing transport network pricing, ensuring public transport remains a priority where it shares road space and strong enforcement of the urban growth boundary. The RMS technology should be equipped with the ability to operationalise network operating plans and manage incident responses in real time. The modelling results show a clear need to complement this technology with further public transport priority on roads and commitments to provide more space for cycling.

The ***City Loop Reconfiguration and Northern Rail Corridor Upgrade*** (CLR) project will provide more cross-city suburban metro rail services for growing areas in the north, east and south-east of Melbourne. Population growth in the north will increase demand for public transport, and Shepparton and Seymour regional train lines will not be able to meet this future demand. The current metropolitan train network is nearing capacity and will not support many more trains to enter the City Loop. Redesigning two of the four tunnels in the City Loop will allow more trains to travel through the city and continue to the other side, rather than travelling around the City Loop and returning on the same line. This will result in more services being able to operate on key train lines, increasing capacity and reliability across the network. Into the future, it will allow a subsequent project to introduce separation of express and stopping metro services on the eastern line towards Camberwell. Introducing metro style services on these lines will also make interchanging onto Suburban Rail Loop services easier and more reliable.

This project also enables the extension of suburban metro services beyond Craigieburn towards Beveridge and Wallan with the addition of new stations. It also provides options to improve services and reliability on the V/Line network to Seymour and Shepparton. Our modelling shows that this project attracts more jobs and housing along these rail lines in the north, including Coburg and Broadmeadows, while also attracting growth in Melbourne's south, including suburbs such as Cheltenham and Moorabbin. This results in more jobs proportionally closer to growing residential areas and improves access to regionally important services and tertiary education opportunities. Land use plans, such as Activity

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[3] *Arup 2020. Problem Definition Report prepared for Infrastructure Victoria*

[4] *See Infrastructure Victoria's reports on Transport Network Pricing modelling: Good Move: Fixing Transport Congestion and Fair Move: Better Public Transport Fares for Melbourne*

Centre Structure Plans, should be updated to realise these urban infill opportunities, and residential development should be encouraged close to train stations.

Our strategic assessment indicated a strong case for this project, as it addresses significant capacity constraints on the train network at a relatively low cost. With only three kilometres of new tunnels required to be built, the City Loop Reconfiguration project achieves significant capacity uplift at comparably low cost. This project produces a benefit cost ratio between 1.1 to 1.9 (using a discount rate of 7% and 4% and upper and lower cost ranges).

There is a significant opportunity to commence construction of the City Loop Reconfiguration immediately following completion of the Melbourne Metro Tunnel project, to take advantage of the additional capacity and reduce construction disruption. As this project supports the transition to a metro style network, it will alter how some people move around the city. Accompanying accessibility improvements to other interchanges between train lines, other public transport modes and active transport in the city would support greater movement between modes and around the city.

The ***cross city motorway*** (CCM) project would facilitate travel for people and freight across the inner north of Melbourne by providing a connection between the West Gate Tunnel, CityLink and the Eastern Freeway. Our strategic assessment found that while there is no immediate need for a connection between the Eastern Freeway and CityLink as it has modest impact on congestion outcomes, one may be necessary in the longer term, in 20 to 30 years. This project produces a benefit cost ratio between 0.3 and 0.7 (using a discount rate of 7% and 4% and upper and lower cost ranges). Additionally, if the project is delivered, active and public transport improvements and transport network pricing for Inner Melbourne should be implemented ahead of or in conjunction with it so that more benefits can be realised.

Our strategic assessment indicates that the cross city motorway generally redistributes traffic by drawing small amounts of vehicles from North East Link and the West Gate Freeway. Whilst our modelling indicates there are travel time gains for those using a cross city motorway, these benefits are countered by an increase in congestion along the Eastern Freeway, including towards the EastLink tunnel in Ringwood. This results in the project having modest usage and benefits across the network. Introducing transport network pricing (TNP) has a better impact on congestion than CCM. However, longer term growth and autonomous and electric vehicles could increase the number of trips undertaken by smaller vehicles and increase the case for CCM, particularly if measures to manage demand such as TNP or realise efficiency gains from automated vehicles on existing motorways are not introduced. The number of freight vehicles using CCM over the forecasting period is lower than OMR and other comparable sections of the freight network that exist or are in delivery. However the project significantly improves the number of connections across the freight network. Therefore, an option to construct the project in the long-term future should be retained.

However, alternative alignments should be investigated to determine the preferred option to be retained. Planning for an updated alignment compared to the former East West Link proposal should consider the implications of the construction of the West Gate Tunnel project. It should also assess the likely impact of options such as TNP and autonomous vehicles, both as potential alternatives for the project and as complementary options. Urban renewal in Arden-Macaulay and the Fitzroy Gasworks site (including an $84 million secondary school and community facilities[5]), the importance of additional open space and the Moonee Ponds Creek's Aboriginal cultural heritage, biodiversity and water quality must also be considered in determining the alignment. Consideration must also be given to impacts on access to services and residential amenity, where housing estates are adjacent or close to the alignment.

Melbourne Metro Two and Direct Geelong Rail Services (MM2G) is a city shaping project that will provide a significant uplift in rail services, relieve future pressure on the public transport network, improve access to jobs and services and provide urban infill opportunities in key precincts. As conceived in this assessment, the project includes two new rail tracks that are firstly staged to be delivered from Newport through Fishermans Bend to Southern Cross, with a subsequent stage that involves the tunnels continuing through central Melbourne to the inner north. The project will increase capacity and frequency on several train lines, particularly those passing through Newport and Clifton Hill and the Regional Rail Link. The project also provides the opportunity for new electrified Geelong services to operate and provide a more direct route to Southern Cross, which could be the next step following delivery of Geelong Fast Rail.

Our strategic assessment identified that the project is likely to have significant benefits, although with significant costs. This project produces a benefit cost ratio between 0.3 and 0.6 (using a discount rate of 7% and 4% and upper and lower cost ranges). Alternate options should be considered to reduce the cost of this project, while still delivering on key outcomes. These could include alternative route alignments, value engineering the design, and staging the project.

Our modelling shows that trams to Fishermans Bend would be over capacity by the mid-2030s. A heavy rail connection is required for Australia's largest urban renewal site to achieve the precinct's vision for "unprecedented levels of walking, cycling and public transport connectivity" and its jobs and population targets.[6] This project has the potential to generate significant economic benefits for the state by providing improved access to jobs from outer areas to an expanded central city with knowledge-intensive jobs. Our modelling also shows that this project generates significant land use change

[5] *https://vpa.vic.gov.au/project/arden/#supporting-documentation; https://participate.melbourne.vic.gov.au/macaulay-refresh; https://www.development.vic.gov.au/projects/fitzroy-gasworks*

[6] *DJPR, Fishermans Bend Framework Plan*

benefits related to reduced transport costs. There are also expected to be further land use change benefits that have not been quantified, arising from the improved amenity and wellbeing of residents who benefit from this project.

Our modelling also shows that this project supports population and employment growth in Geelong, contributing to future growth of this regional city. Consideration should be given to coordinating and sequencing this growth in Geelong, to ensure that development occurs close to train stations and within identified growth areas. There will be a need to plan for infrastructure supporting population and employment growth to be delivered in a timely way, accounting for existing and planned infrastructure in the adjacent City of Wyndham.

In addition to protecting the corridor, land use settings should be reviewed to ensure that they encourage more housing and jobs close to the new infrastructure. If it is yet to be established, transport network pricing should be implemented in conjunction with the project.

The ***Outer Metropolitan Ring Road (and Rail Corridor)*** (OMR) supports economic development and projected population growth in Melbourne's outer-western and northern suburbs. These parts of Melbourne have underdeveloped road networks, without equivalent road options compared to the well-developed road network in the city's established areas. The focus of this assessment has been on the road component of this corridor as the assessment of the rail line is integrated with the interstate rail network and Inland Rail Project, and therefore needs to be considered from a national perspective with the Australian Government.

Following construction of North East Link (NEL) there is a compelling case to construct the first stage of the OMR, which is the section from Thomastown towards the Hume Freeway known as the "E6", to continue the link between the east and north of Melbourne. This project provides strong traffic flow, allowing better travel times and reliable movement of people and freight, helping keep supply chains efficient. Ultimately, the OMR supports economic and jobs growth in the outer north and west by linking current and future industrial and logistics precincts with intermodal transport terminals. The project also benefits regional Victoria by allowing more direct access to major international and interstate transport gateways by bypassing Melbourne's growing suburbs and established areas.

Our strategic assessment indicated a compelling case for the road component of the project, assuming that it would be progressively developed from the eastern to western end. This project produced a benefit cost ratio between 1.1 to 3.4 (using a discount rate of 7% and 4% and upper and lower cost ranges). Sections of this project, including in the north-west growth areas surrounding Melbourne Airport, and in the south-west surrounding Werribee, address critical constraints on the current road network.

The road supports truck access to intermodal terminals, such as those proposed to the west and Beveridge, to facilitate interstate freight movements by rail. Opportunities to provide better public transport connections from the growing outer north to the La Trobe National Employment and Innovation Cluster (NEIC) to improve access to health and education jobs and services, as well as to Melbourne Airport, should be considered, along with more active transport links. Consideration should also be given to how the project can contribute to appropriate treatment of Aboriginal cultural heritage areas such as rivers and major creek valleys, enable open space connectivity, improve tree canopy, and positively impact on native vegetation offsets, including accelerating the acquisition and preservation of the Western Grasslands Reserve.

While tolls were applied to the project in our assessment, a broader motorway network approach to road pricing beyond the OMR itself will ensure that the desired benefits are achieved, and manage the likelihood that new constraints do not emerge elsewhere on the motorway network. It was found that a pricing approach for users of the road that considers the broader network was needed to ensure management of the flow-on effects of the project across the established parts of the network.

The ***Western Rail Upgrade*** (WRU) project increases rail capacity for growing communities, including in Melton, Mitchell, Casey and Cardinia. This project would be the next step following the committed project of introducing higher capacity V/Line trains on the Melton corridor to the west, and further high capacity metro trains to the south-east. Growth areas to the west, including Wyndham and Melton, in the north around Wallan, and Cranbourne and Pakenham in the south-east are projected to continue to grow rapidly and collectively accommodate hundreds of thousands of new residents by the mid-2030s. These areas, particularly in the west and north, have underdeveloped transport networks. Regional V/Line services currently stop at stations in most of these growth areas to the west and north, adding suburban passengers to these services. This results in increasing overcrowding and unreliability for those travelling to and from regional centres including Geelong and Ballarat.

Our strategic assessment provided a strong case for this project, which addresses the population and network challenges of the western growth areas. Additional train services as well as larger trains will provide a significant capacity uplift for passengers along the Melton corridor. This project produced a benefit cost ratio between 1.5 to 3 (using a discount rate of 7% and 4% and upper and lower cost ranges), with benefits outweighing the costs.

Our modelling of a working from home scenario and an electric and automated vehicles scenario indicated that more people may want to live in growth areas due to the changes in behaviour and technology. The fast tracking of Precinct Structure Plans may also result in growth occurring faster in these areas than otherwise expected, and potentially across more growth fronts. Expanding rail to these outer suburbs and growth areas will be even more important under this

scenario to support the growing population and enable greater public transport use. Providing bus and active transport connections to the train stations along the western rail corridor will be important to improve access to residential areas, particularly to help support young people who do not drive but need to access education, services and jobs. Independent and active transport can contribute to improved health outcomes and reduced congestion. Opportunities for increased residential density surrounding the train stations should be considered in established and growth areas.

Conclusion

No single intervention can solve Melbourne's transport and land use challenges. The transport network is interconnected, and a suite of solutions is required to address future transport challenges and improve connections between where people live and jobs, education, services and recreation. For example, growth area rail extensions combined with bus service reforms, rail line capacity upgrades and new road connections will improve access to suburban jobs from Outer Melbourne. These transport projects will also provide more job opportunities and access to services for Victorians.

Our assessment highlights that there is a strategic sequencing of these six major transport projects, given their impacts, benefits, and the challenges that each address. This major transport program builds upon the pipeline of projects being delivered in Victoria and complements the direction and vision to provide even greater benefits for the state.

1. Introduction

Strong population growth that has been occurring across Victoria and in Melbourne is increasing the demand for travel and transport services. Fast-growing areas such as Melbourne's outer suburban growth and urban renewal areas are generating substantial increases in trips to access locations across the city. Victoria's major regional centres are also growing, creating a need to improve capacity on regional trains that connect regional centres to metropolitan Melbourne. The impact of the COVID-19 pandemic is expected to initially pause population growth and then growth will progressively increase over the coming decade.

Six of the recommendations in *Victoria's infrastructure strategy 2021 – 2051* are related to major transport projects that respond to the challenges produced by underlying growth in these areas and across the city more broadly. The changes in accessibility and capacity driven by these transport projects can influence changes in housing, employment, social infrastructure and the location of services. Transport infrastructure can facilitate underlying growth, while influencing land use due to changes in accessibility. The scale and extent that different projects achieve these two outcomes can vary markedly.

This study uses an integrated transport and land use model that aims to determine the extent that different projects can help to shape the city while supporting underlying growth in demand. Traditionally, most projects are modelled using a fixed distribution of residential and job locations.[7] The Victorian Land Use and Transport Integration (VLUTI) model considers how infrastructure investment could change the distribution of population and employment across Victoria. This innovative VLUTI model allows for the location of people, jobs and transport infrastructure to directly influence each other, causing changes in where people and jobs are located.[8] Infrastructure projects are an investment for the long term, but the long-term outlook can vary markedly. Structural changes can result in a shift in preferences, including those that shape travel choices and influence behaviour such as the industries in which people work and where these jobs are located. This study develops and draws upon a range of scenarios to provide insight on the impact of these structural changes on the projects being considered. These scenarios include changes in population forecasts, a greater shift to working from home and greater take up of autonomous and electric vehicles.

Infrastructure Victoria's approach to tackling challenges is to consider opportunities to manage demand and make better use of existing assets before building new infrastructure. Insights from our previously released research and modelling on transport network pricing (TNP) to better manage demand and changing planning settings to encourage density are applied in this study. Consideration of ways to better use the existing network by improving road operations management are also assessed.

In addition to improving road management systems (RMS) to make better use of existing assets, five build projects are considered. These include the City Loop Reconfiguration and Northern Rail Corridor Upgrade (CLR), Cross City Motorway (CCM), Melbourne Metro Two and Direct Geelong Rail Services (MM2G), Outer Metropolitan Ring Road (OMR), and the Western Rail Corridor Upgrade (WRU).

An assessment framework has been applied to the six projects. Elements of the framework include consideration of the extent to which the project achieves the strategy objectives through a multi-criteria analysis, an economic evaluation, a broader social, environmental and economic assessment, and consideration of distributional impacts.

This assessment informs six of the major transport recommendations in *Victoria's infrastructure strategy*. In addition, this report presents notable findings for other recommendations. This report highlights additional opportunities to achieve the objectives of *Victoria's infrastructure strategy* by considering recommendations together as well as individually.

[7] Hensher, D., & Button, K. (2007). Handbook of transport modelling (2nd ed.). Emerald.

[8] Infrastructure Victoria (2021) *Victorian Land Use and Transport Integrated (VLUTI) Model Architecture.*

1.1 Report Structure

This report comprises the following chapters and is accompanied by five technical reports.

Chapter 2 presents an overview of the state's growing and changing population, as well as *Victoria's infrastructure strategy*. It also discusses key transport challenges and future scenarios that may impact major transport projects.

Chapter 3 outlines the approach used to assess the major transport projects.

Chapter 4 presents and assesses how infrastructure projects can address these key network challenges, including the potential impact of initiatives to better manage demand and improve the network that these transport projects would form a part of.

Chapter 5 summarises the key findings of this report, outlining the key impacts to the transport recommendations and any relevant adjacent recommendations.

The Appendices to this report include additional detail on the future scenarios, our assessment approach, and other additional information.

This report is accompanied by the following technical reports that have been prepared by or with the assistance of Victoria University, Arup and AECOM:

a. Major Transport Program Capital Cost Report by Infrastructure Victoria
b. Strategic Modelling Outcomes Report by Arup
c. Transport Cost Estimate Report by AECOM
d. Transport Modelling Scenarios – Economics Report by AECOM
e. VLUTI modelling architecture technical report prepared by Infrastructure Victoria, with contributions from Victoria University, Arup and AECOM

2. Victoria's Future Outlook and Challenges

2.1 Future Outlook

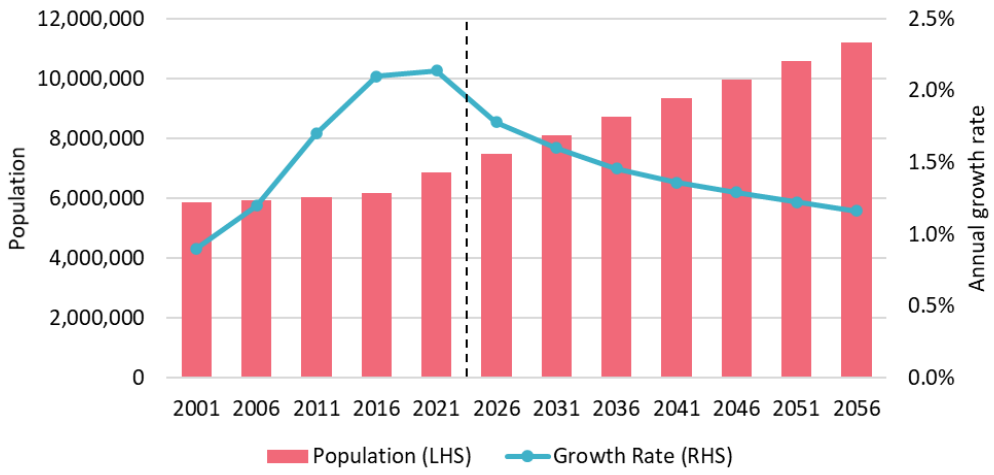
Population growth

Before the COVID-19 pandemic, Victoria's population had been growing strongly for over a decade. Never had the state added so many new residents so quickly. In 2019, Victoria added 122,200 extra people to its population – a 1.9% increase on the previous year, and the largest increase of all Australian states and territories.[9]

By 2051 there are projected to be over 5.5 million jobs and 10.8 million people in Victoria.[10] The distribution of this population and employment growth will impact how the state, Greater Melbourne and Victoria's regions function and presents several challenges in both the size and complexity of future growth patterns. Most of the growth will be concentrated in Greater Melbourne, as well as regional centres including Geelong, Ballarat and Bendigo.

Our primary forecast, prepared prior to the COVID-19 pandemic, has Victoria increasing by 4.4 million people by 2051, at an average annual growth rate of 1.6% per year from 2018. This reflects a similar number of people being added to Victoria in each decade, resulting in the annual growth rate in percentage terms decreasing in the longer term.

Figure 1: Victoria Population Forecast – Baseline



Source: DELWP. Victoria in Future Population Forecasts, 2019

The forecast population growth for Victoria is mainly due to projected migration, which has been the largest driver of population growth in recent years. Greater Melbourne absorbed most of this increase – of the 148,000 extra residents in 2016-17, only 13% settled in the regions (with most settling in Ballarat, Bendigo, Geelong and peri-urban towns in close

[9] *ABS Estimated Resident Population 2019*

[10] *DELWP 2019 Victoria in Future Population Forecasts*

proximity to Melbourne). The number of migrants coming to Australia is forecast to be held constant in average terms, meaning that growth in percentage terms will fall in coming decades, as indicated in Figure 1.[11]

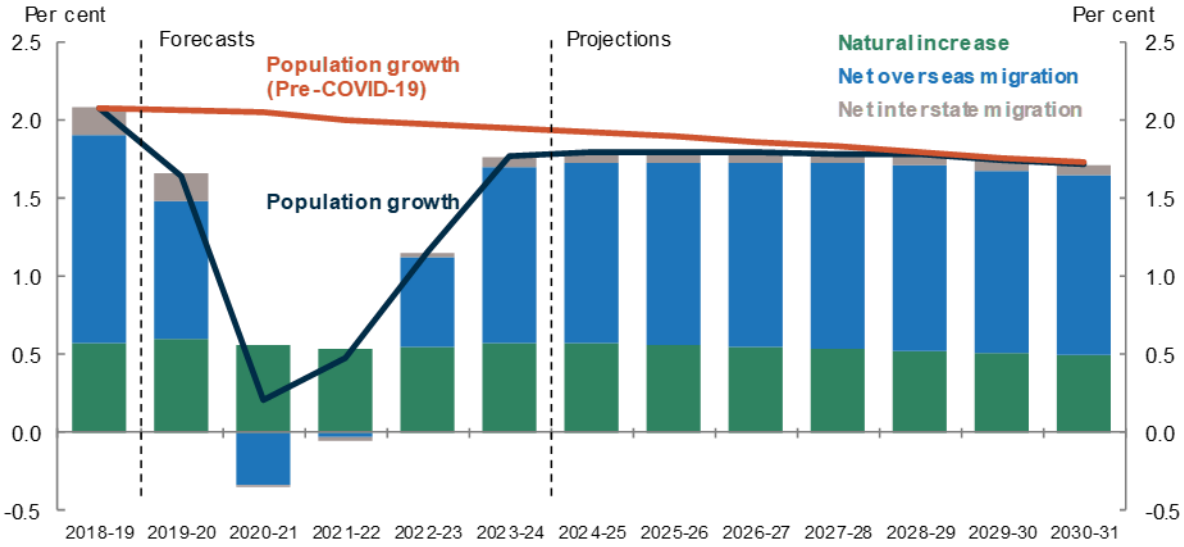
Growth scenarios

The impact of the COVID-19 pandemic is expected to initially pause population growth, after which it will progressively increase over the coming decade. Australia's population is expected to be slightly less than projected prior to the onset of the pandemic and will be older overall. Analysis undertaken by the Australian Government Centre for Population estimates that by 30 June 2031, Australia's population will be around 4% smaller (1.1 million fewer people) than it would have been in the absence of the COVID-19 pandemic.[12] Australia's population will still grow and is expected to reach 28.8 million people by June 2031, three years later than forecast in the absence of the COVID-19 pandemic.[13]

In light of the COVID-19 pandemic, and subsequent significant drop in international migration to Australia in 2020-21, this study considers a range of scenarios with varying population growth rates. Prior to 2020, migration accounted for up to 60% of population growth in Victoria.[14] Increases or decreases in average net overseas migration could have a significant effect on Victoria's future population. Data on population growth to September 2020 has shown a decline in net migration, resulting in the population of Victoria only growing by 0.7% in the preceding 12 months. Prior to 2019, average population growth rates in Victoria were around 2.2% per year.[15]

The Australian Government Centre for Population has prepared forecasts of population growth for Victoria, accounting for the impact of the COVID-19 pandemic. Figure 2 highlights the impacts on short-term population growth rates between 2020-21 and 2022-23. Population growth in Victoria is projected to recover to close to what was forecast prior to the COVID-19 pandemic by 2023-24, faster than other states and territories.[16] The Victorian State Budget 2021-22 forecasts population growth in line with these estimates, with growth slowly picking up from 2022-23 onwards.[17]

Figure 2: Future Population Growth Rates and Components for Victoria



Source: Australian Bureau of Statistics, National, state and territory population, March 2020, 2020), Centre for Population projections

Uncertainty about future population increases with longer term forecasts make it especially pertinent to plan for a range of future scenarios. We have considered long-term high and low population growth scenarios based on the official forecasts for Victoria published by the Australian Bureau of Statistics (ABS) for series A (high) and C (low).[18] The high population scenario assumes Victoria has an extra 6 million people by 2051, compared to the base scenario of an

[11] *DELWP 2019 Victoria in Future Population Forecasts*

[12] *Australian Government Centre for Population December 2020, Population Statement https://population.gov.au/publications/publications-population-statement.html*

[13] *Australian Government Centre for Population December 2020, Population Statement https://population.gov.au/publications/publications-population-statement.html*

[14] *ABS Estimated Resident Population 2020*

[15] *ABS Estimated Resident Population 2020*

[16] *Australian Government Centre for Population December 2020, Population Statement https://population.gov.au/publications/publications-population-statement.html*

[17] *Victorian State Budget 2021-22, Budget Paper 2: Strategy and Outlook*

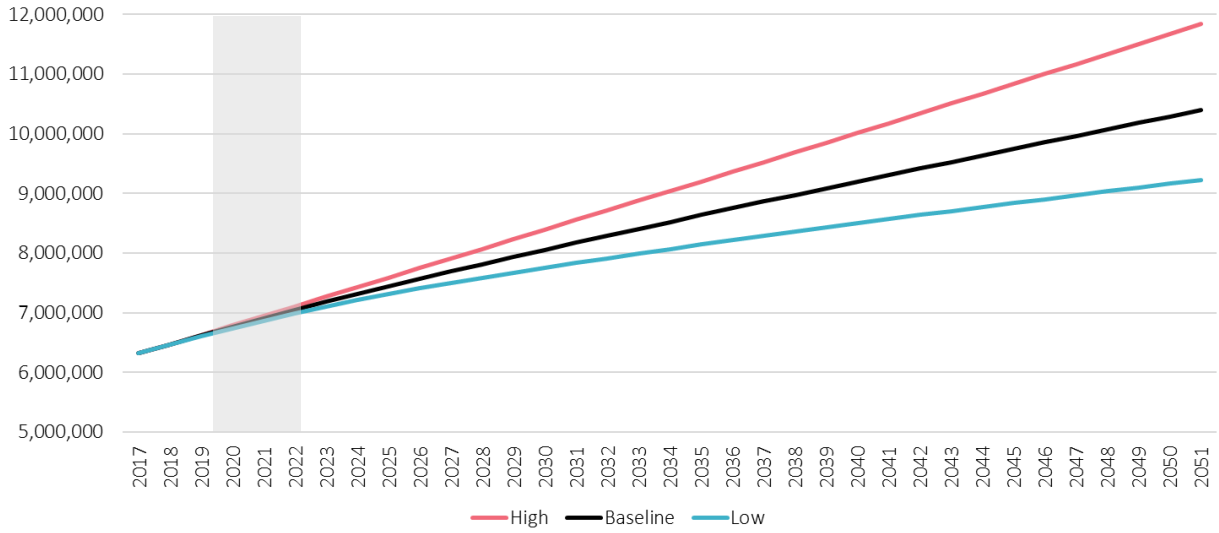
[18] *ABS Population Projections, Australia https://www.abs.gov.au/statistics/people/population/population-projections-australia/2017-base-2066*

additional 4.4 million people. This is equivalent to an average annual population growth rate of 2.0%, compared to a baseline forecast growth rate of 1.6% per year to 2051.

The low population growth scenario assumes fewer overseas migrants and a lower birth rate. Under this lower growth scenario, population is forecast to grow at 1.2% per year to 2051, resulting in Victoria still accommodating 3 million extra people.

Whilst Victoria's population forecasts will be reset in the near term to account for the impacts of the COVID-19 pandemic, this short-term reduction in growth rate will fall within the long-term annual average low to high population forecasting range used for this study towards the end of this decade.

Figure 3: High and Low Population Forecasts



Source: Baseline – DELWP Victoria in Future 2019; High and Low – ABS Population Projections
Note: Impacts of the COVID-19 pandemic to population growth to 2022/23 are not shown on this chart.

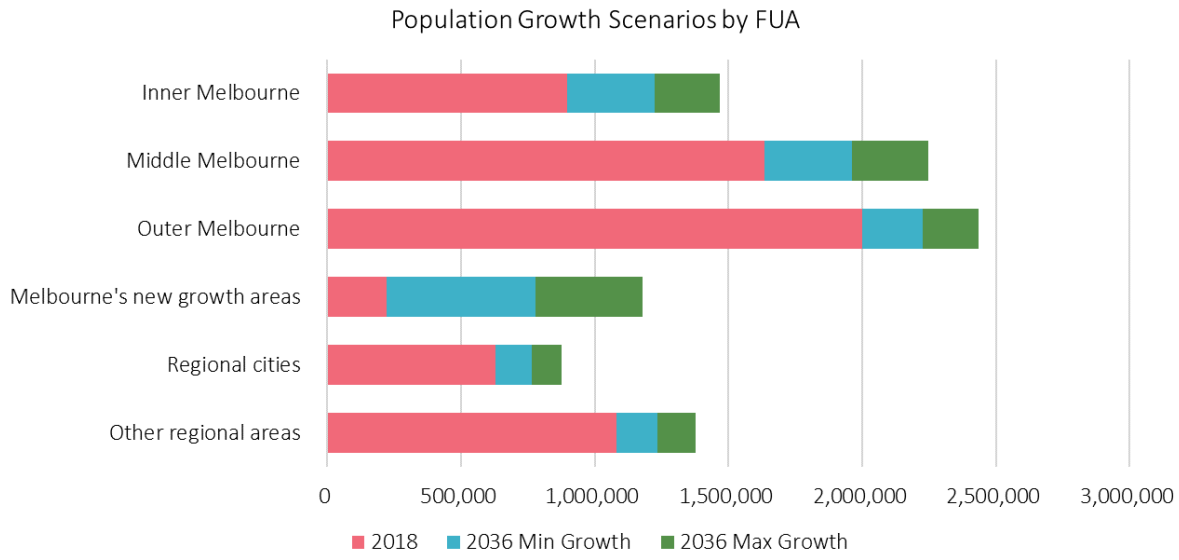
Population growth across the state is far from uniform, and some places will grow faster than others. Over the next 15 years, over 30% of Melbourne's population growth will occur in new growth areas in the north, west and south-east.[19] Population growth is also forecast within existing urban areas, albeit at a lower growth rate. Almost a third of Melbourne's 2036 population will be young people aged under 20 years and people over 75 years, with over 260,000 more young people living in growth areas and almost 220,000 more older people living in established areas.[20]

Our modelling shows a range of possibilities across the high and low population growth scenarios. Most striking is the variability in Melbourne's growth areas. Under the low population growth scenario, the new growth areas are still expected to have a large proportion of Victoria's population growth (see Figure 4).

[19] *DELWP 2019 Victoria in Future Population Forecasts*

[20] *DELWP 2019 Victoria in Future Population Forecasts*

Figure 4: Population change in Melbourne's new growth areas is highly variable across scenarios



Source: DELWP Victoria in Future Population Forecasts and ABS Population Projections
Note: FUA are functional urban areas, a region system defined by the distance from the CBD. A map is provided in Appendix D.

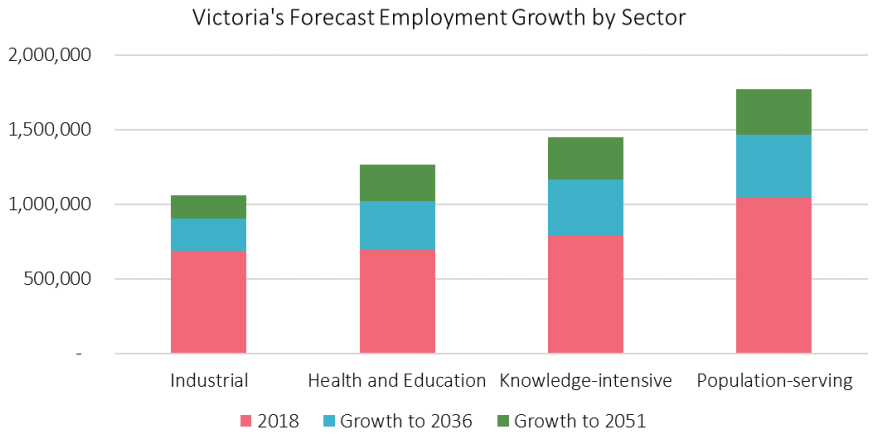
Employment growth

By 2051, the state is expected to have an additional 2.3 million jobs compared to today, with over 5.5 million jobs in Victoria in 2051.[21] The economy is expected to continue its trajectory away from traditional sectors such as manufacturing towards service sectors including health, education, and professional services.

All industry sectors are expected to grow, with health and education forecast to have the highest growth, increasing by 2.2% per year to 2036. This strong growth is driven both by the ageing population and by ongoing increased demand for health services across a range of other cohorts.

Likewise, knowledge intensive jobs are also forecast to grow strongly, at an annual average growth rate of 2.2% per year to 2051. Population serving jobs, which include industries such as construction and retail, will remain the largest employing sector, but will grow at a lower rate (1.9% per year) than knowledge intensive, and health and education sectors. Low growth is forecast for industrial jobs, which are forecast to increase by 1.5% per year to 2051.

Figure 5: Victoria Employment Forecasts



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

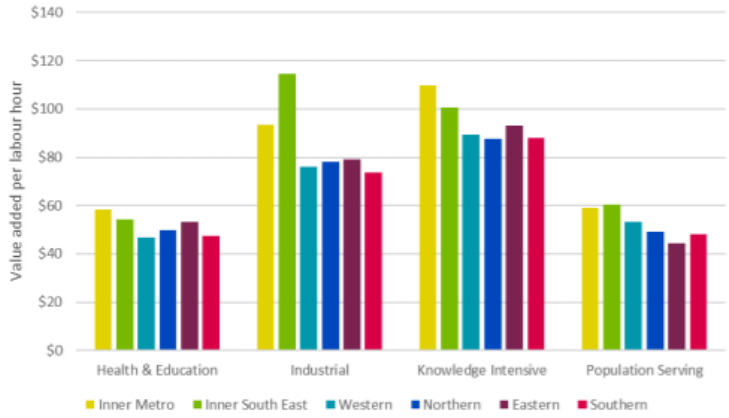
[21] *Melbourne Functional Economic Region Report, Small Area Land Use Projections (SALUP) 2019 prepared by SGS Economics and Planning*

Different types of jobs produce different levels of economic value added and therefore the contribution to the economy varies by sector. In 2018, knowledge intensive firms generated 39% of gross value added in metropolitan Melbourne, followed by industrial activities (25%), population serving (22%), and health and education (14%).[22] The location of jobs also affects economic value added. Across each jobs sector, the Inner Melbourne and Inner South-East regions have higher value added per labour hour than other regions across Melbourne (see Figure 6 below).

Higher value jobs tend to cluster at specific locations and generate high levels of economic output as a result.[23] Private sector decisions largely influence the economic performance of these locations. It is challenging for governments to try to replicate these clusters in other locations which do not have the necessary qualities of economic clusters or precincts.[24] Transport networks enable access to these existing and new places so they can be competitive, attractive, and contribute to the state's economy.[25]

This relates to the objective of *Victoria's infrastructure strategy* of supporting infrastructure that helps drive Victoria's changing and globally integrated economy so that it continues to be prosperous. Encouraging jobs growth in sectors and locations that produce high levels of value added will support economic growth and encourage further productivity improvements through business-to-business and freight activity.[26]

Figure 6: Labour productivity, by industry and FER 2018



Notes: Figures are in 2015-16 dollar values
Source: SGS Economics and Planning, derived from NIEIR (2018)

Employment and higher education are concentrated in inner and middle suburbs

In 2019, Melbourne's Central Business District (CBD) and inner suburbs had the city's highest concentration of jobs. Melbourne's inner and middle ring suburbs are also home to employment precincts and the job, research and education hubs identified as National Employment and Innovation Clusters (NEICs) by the Victorian Government.[27]

In recent years, the proportion of jobs in Inner Melbourne has been increasing relative to other parts of the state, which was primarily due to the structural transition of jobs.[28] Employment forecasts indicate the proportion of jobs in each functional urban area (FUA) will remain broadly steady when taking the number of jobs in Outer Melbourne and Melbourne's New Growth Areas as one combined area.[29]

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[22] *SGS Economics & Planning 2018 derived from NEIR*

[23] *Puga, D. (2010). The Magnitude and Causes of Agglomeration Economies. Journal of Regional Science, 50(1), 203–219*

[24] *Day, J., Han, W., Wu, A. B., & Zheng, J. (2018). Has Sub-centre Policy Produced Subcentres? An Evaluation of Melbourne's Urban Spatial Planning since 1996. Agenda: A Journal of Policy Analysis and Reform, 25(1), 5-23*

[25] *Giuliano, G., Redfearn, C., Agarwal, A., & He, S. (2012). Network accessibility and employment centres. Urban Studies, 49(1), 77-95*

[26] *Weisbrod, G., Goldberg, J., & Frank, P. (2021). Measuring the Regional Economic Impact of Transportation Access Improvements in the Context of a Large Metropolitan Region. Transportation Research Record; Cui, J., Dodson, J., & Hall, P. V. (2015). Planning for urban freight transport: An overview. Transport Reviews, 35(5), 583-598*

[27] Department of Environment, Land, Water and Planning (DELWP) (2017), Plan Melbourne 2017-2050

[28] Dingle, T., & O'Hanlon, S. (2009). From manufacturing zone to lifestyle precinct: Economic restructuring and social change in inner Melbourne, 1971–2001. Australian Economic History Review, 49(1), 52-69; SGS Economics & Planning, Economic Social & Environmental Profile: Metropolitan Inter-Regional Report,
Melbourne, report for Infrastructure Victoria, 2019,

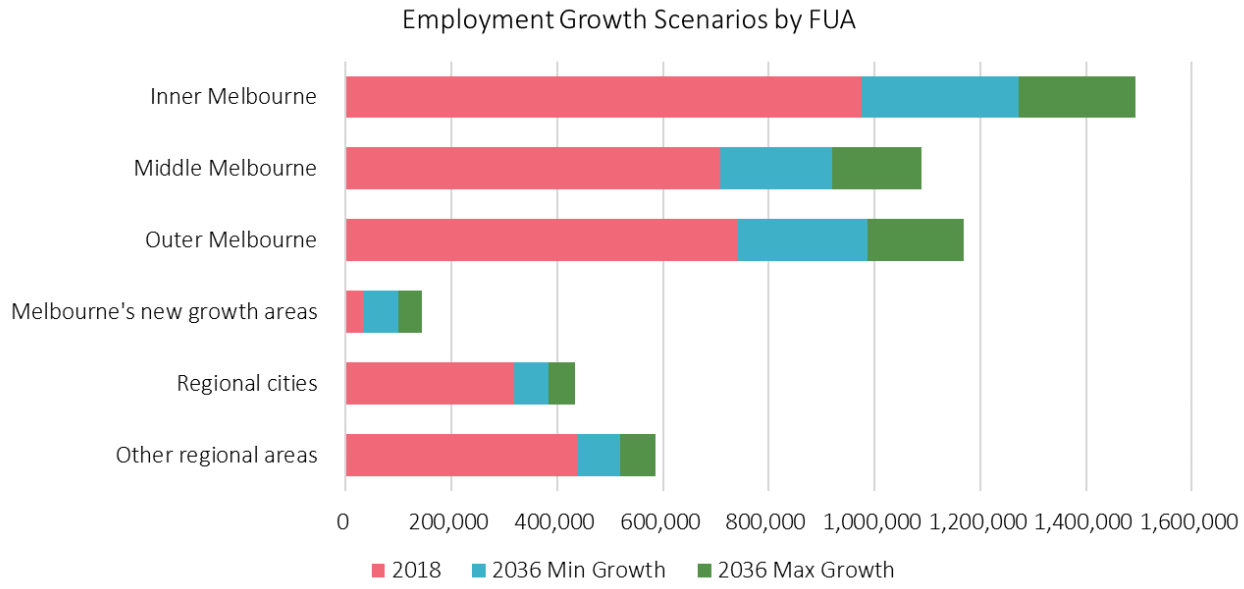
[29] SGS Economics & Planning (2019) Functional Economic Region Report, Melbourne, report for Infrastructure Victoria, p.14

Our forecasts consider scenarios in which Melbourne could have between 4 and 5 million jobs in 2036, growing to between 5 and 6 million by 2051. In all scenarios, most of Victoria's extra jobs were created in the established areas of Melbourne.

Compared with the variability across the scenarios for population, the location of jobs appears much less variable in different scenarios, regardless of population growth or distribution. This reflects the fact that jobs in knowledge intensive, industrial and health, and education sectors tend to cluster at specific precincts. Population serving jobs and some health jobs also tend to follow residential locations.[30]

These precincts are shown in Figure 8. Given their specialised nature and agglomeration benefits from being located in highly accessible locations, these precincts take many decades to replicate in new locations, if at all. Transport should serve these state or metropolitan significant precincts to further improve their economic outcomes and provide more equitable access to a range of jobs for people living in areas without easy access to Inner Melbourne, while also potentially shaping outcomes for other locations.[31]

Figure 7: Employment locations are similar in different scenarios



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Plan Melbourne

Plan Melbourne is the Victorian government's long-term planning strategy, guiding the city's growth and change to 2050.[32] The strategy outlines key measures that support housing closer to jobs and transport and identifies key areas for future growth.

Plan Melbourne identifies seven key outcomes:

- Melbourne is a productive city that attracts investment, supports innovation and creates jobs
- Melbourne provides housing choice in locations close to jobs and services
- Melbourne has an integrated transport system that connects people to jobs and services and goods to market
- Melbourne is a distinctive and liveable city with quality design and amenity
- Melbourne is a city of inclusive, vibrant and healthy neighbourhoods
- Melbourne is a sustainable and resilient city
- Regional Victoria is productive, sustainable and supports jobs and economic growth

Plan Melbourne identifies places of state significance that will be the focus for investment and growth. This includes the central city, national employment and innovation clusters (NEICs), metropolitan activity centres, state-significant

[30] SGS Economics & Planning (2019) Functional Economic Region Report, Melbourne, report for Infrastructure Victoria, p.9

[31] Department of Environment, Land, Water and Planning, Plan Melbourne 2017-2050, 2017, https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy_.pdf

[32] Department of Environment, Land, Water and Planning, *Plan Melbourne 2017-2050*, 2017, https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy_.pdf

industrial precincts (SSIPs), transport gateways, health and education precincts and major urban renewal precincts (see Figure 8). These places serve different purposes to support a growing population and encourage economic growth.

Plan Melbourne also identifies the need to facilitate investment in Melbourne's outer suburbs and growth areas to increase local access to employment. This includes improving connections to NEICs to increase access to high-value knowledge jobs from outer areas.

For regional Victoria, *Plan Melbourne* has a policy to stimulate employment and growth in the state's 10 largest regional cities. Geelong, Ballarat and Bendigo are projected to accommodate over 50% of all population growth outside of Melbourne. Growth in peri-urban areas beyond metropolitan Melbourne will attract about 32% of regional Victoria's population in the same period. There are also directions in *Plan Melbourne* to improve connections between cities and regions. This includes links both within regions to major hub destinations as well as back to Melbourne.

Figure 8: *Plan Melbourne* Activity Centres

Source: Plan Melbourne

Figure 9: *Plan Melbourne* Regional Cities

Map 23

Victoria's connected cities and regions

- Capital city
- Regional city
- Regional centre
- 100-km radius from central Melbourne
- Transport gateway – airport
- Transport gateway – seaport
- Primary road
- Secondary road
- Rail network

Source: Plan Melbourne

2.2 Victoria's infrastructure strategy 2021–2051

The significant growth forecast for Victoria presents many challenges, not only for the transport network, but also enabling economic and productivity growth and supporting social and environmental outcomes. *Victoria's infrastructure strategy 2021–2051*[33] identifies recommendations aimed at confronting these long-term challenges, managing urban change, harnessing infrastructure for productivity and growth, and developing regional Victoria.

In developing strategy recommendations, Infrastructure Victoria's approach is to first consider how demand can be managed, followed by better using existing assets, before proposing new-build projects. Proposals reflecting this approach have been assessed as part of this study. Previous research undertaken by Infrastructure Victoria has informed consideration of the impacts of alternative scenarios, including TNP[34] and automated and electric vehicles (AEV).[35]

2.2.1 Objectives

Victoria's infrastructure strategy has 10 objectives for Victoria, several of which are particularly relevant to the role that the transport network has in supporting Victoria's community, economic and environmental outcomes, while also developing a more resilient community. This section provides an overview of these roles and how these will be considered in this report. All 10 objectives are presented in Appendix B.

Community

The development of Victoria's transport network and the way it shapes land use should support the objectives of preparing for population change, enable workforce participation and reduce disadvantage.

Victoria's infrastructure needs to **prepare for population change** by meeting new and shifting demands from a growing and changing population. Change will vary and occur in different ways including changing demographics, family structures, and cultural diversity. To cater for a growing number of Victorians, land use and transport needs to accommodate an increasing number of movements, particularly for those in faster growing parts of the state. This study will consider scenarios with different levels of population growth.

Victoria's infrastructure also needs to enable **workforce participation** by enabling Victorians to develop capabilities and have access to opportunities by ensuring travel times and the capacity of the network are not a barrier to engaging in secure and meaningful work. As well as access to local jobs where they live, Victorians should be able to access a more diverse range of jobs, including a greater range of specialised jobs that tend to be in key employment areas and clusters. This will also improve opportunities for better skill matching.

Infrastructure should also help to **reduce disadvantage** and ensure Victorians can access the resources and capabilities needed for a good quality of life. The development of the transport network and well-located housing opportunities should help to reduce disadvantage so that people have equal access to opportunities regardless of their backgrounds, attributes or locations. A qualitative assessment will be undertaken to determine the distributional benefits of each initiative, to measure reductions in disadvantage.

Economy

The development of Victoria's transport network and its impacts on land use should support the objectives of driving Victoria's changing and globally integrated economy and lift productivity.

Infrastructure should help **drive Victoria's changing and globally integrated economy** so that it continues to be prosperous. The state needs to stay attractive for trade and investment nationally and internationally, adapting to change and capitalising on economic opportunities. Transport can assist by improving access and capacity to locations and can unlock land that is attractive for investment and improve connections to trading gateways.

In doing so, transport and associated land use changes can **lift productivity** in business-to-business activity, including the movement of goods. Importantly, providing access to a large pool of potential employees can help job matching to strengthen a firm's competitiveness, along with potential customers. This can occur through a combination of improving travel time, improving capacity and creating land use opportunities for more people to live closer to jobs. A number of these impacts are captured as wider economic benefits and land use benefits for those who change residence in the economic evaluation.

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[33] Infrastructure Victoria 2021. *Victoria's infrastructure strategy 2021-2051*

[34] *See Infrastructure Victoria's reports on Transport Network Pricing modelling:* Good Move: Fixing Transport Congestion *https://www.infrastructurevictoria.com.au/report/executive-summary/ and* Fair Move: Better Public Transport Fares ***for Melbourne*** *https://www.infrastructurevictoria.com.au/report/fair-move-executive-summary/*

[35] *See Infrastructure Victoria's Advice on Automated and Zero Emissions Vehicles Infrastructure (AZEVIA): https://www.infrastructurevictoria.com.au/project/automated-and-zero-emission-vehicle-infrastructure/*

Environment

The transport sector is the second largest contributor to greenhouse gas emissions in Victoria.[36] The sector needs to contribute to the objective of **advancing climate change mitigation and adaptation,** to achieve the legislated target in Victoria of net zero greenhouse gas emissions by 2050.[37] Lower and zero emission vehicles (ZEVs) will contribute to achieving this, and such a scenario is considered in this study. In addition, a project may also help shape land use that encourages the use of low or zero emission transport options, including more walking and cycling. Transitioning to low or ZEVs, including zero emissions freight and buses, will also contribute to achieving this target. Renewable electricity generation would also support better environmental outcomes from trains and trams. Environmental impacts of major infrastructure projects are considered in the multi-criteria assessment of projects.

Resilience

The COVID-19 pandemic has emphasised the need to **build resilience to shocks**. Infrastructure, including its operational systems, can help to better prevent, respond to, and recover from shocks. This can support Victoria to be less vulnerable to economic, technological, biological, ecological, and geopolitical disruptions and emergencies.

The COVID-19 pandemic has hastened the pace of some key structural trends such as working from home**,** and this is considered as a scenario. However, structural changes do happen periodically and test and alter travel preferences and land use. Along with a range of population scenarios highlighted earlier, the uptake of autonomous vehicles in the future will also be considered, along with changes regarding transport network pricing and increased density.

2.3 The Mobility Challenge

The magnitude and location of the expected future growth in population and employment presents many challenges for Victoria's infrastructure, economy and urban development patterns. Where this growth occurs will have a major impact on the need for, and demand on, transport infrastructure.

In many parts of Melbourne, population and jobs growth is expected to occur in similar locations, such as in Inner Melbourne and in the eastern suburbs of Melbourne. In other parts of Melbourne, such as the outer northern and western growth areas, there is strong population growth but little employment growth forecast. The distance between these growth areas and employment centres with higher order employment opportunities (including non-population-based jobs) is increasing, creating issues for accessibility and equity.[38]

As the figure below shows, Melbourne's new growth areas are forecast to receive almost 30% of the state's population growth by 2051, but only 6% of employment growth. This is in stark contrast to Inner Melbourne, which is forecast to have 18% of the state's population growth and 30% of employment growth.

The growth areas to the north and west of Melbourne are on the same corridors as the growing major regional centres of Geelong and Ballarat. Additional forecast growth within these growth areas compromises access to metropolitan Melbourne from these regional centres, particularly access to Inner Melbourne from Geelong and Ballarat, as well as between outer suburbs and regional centres.

The forecast distribution of population and employment growth creates additional demands on the transport network and challenges in the context of the objectives of *Victoria's infrastructure strategy*.

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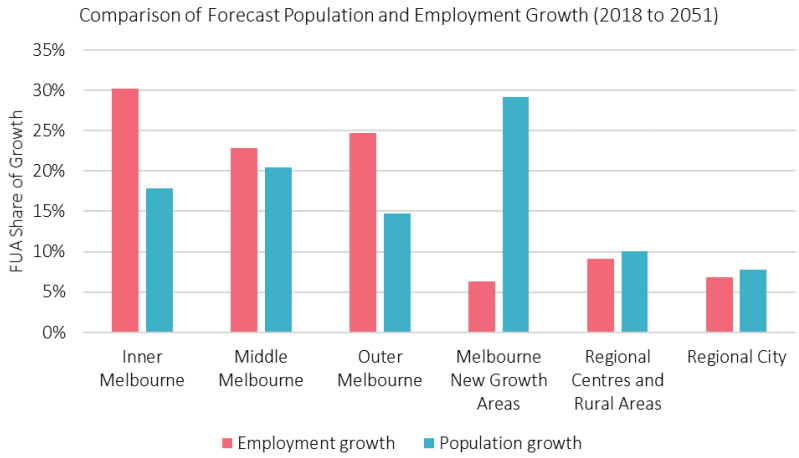
[36] *DELWP, Victoria's Climate Change Strategy https://www.climatechange.vic.gov.au/greenhouse-gas-emissions-in-victoria*

[37] *https://www.climatechange.vic.gov.au/media-releases/victorias-net-zero-by-2050-emissions-reduction-target*

[38] *Li, T., & Dodson, J. (2020). Job growth, accessibility, and changing commuting burden of employment centres in Melbourne. Journal of Transport Geography, 88*

Figure 10: Population and Employment Growth Forecasts by Functional Urban Area



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

We have identified five transport challenges that summarise these key mobility challenges for Victoria. These were identified based on our assessment of the main challenges and their level of impact on the transport network and broader Victorian economy. The table below outlines how the transport challenges align with the objectives of *Victoria's infrastructure strategy,* and is followed by further exploration of these challenges.

Table 1: Alignment of Strategy Objectives and Transport Challenges

Strategy Objective	Transport Challenge
01 – Prepare for population change	Challenge 1 – Access to jobs from place of residence
03 – Reduce disadvantage	
04 – Enable workforce participation	
05 – Lift productivity	Challenge 2 – Access to potential workforce
06 – Drive Victoria's changing, globally integrated economy	Challenge 3 – Business-to-business travel (including freight)
07 – Promote sustainable production and consumption	Challenge 4 – Transport's contribution to achieving net zero emissions
09 – Advance climate change mitigation and adaptation	
10 – Build resilience to shocks	Challenge 5 – A more resilient network to a wide range of different scenarios

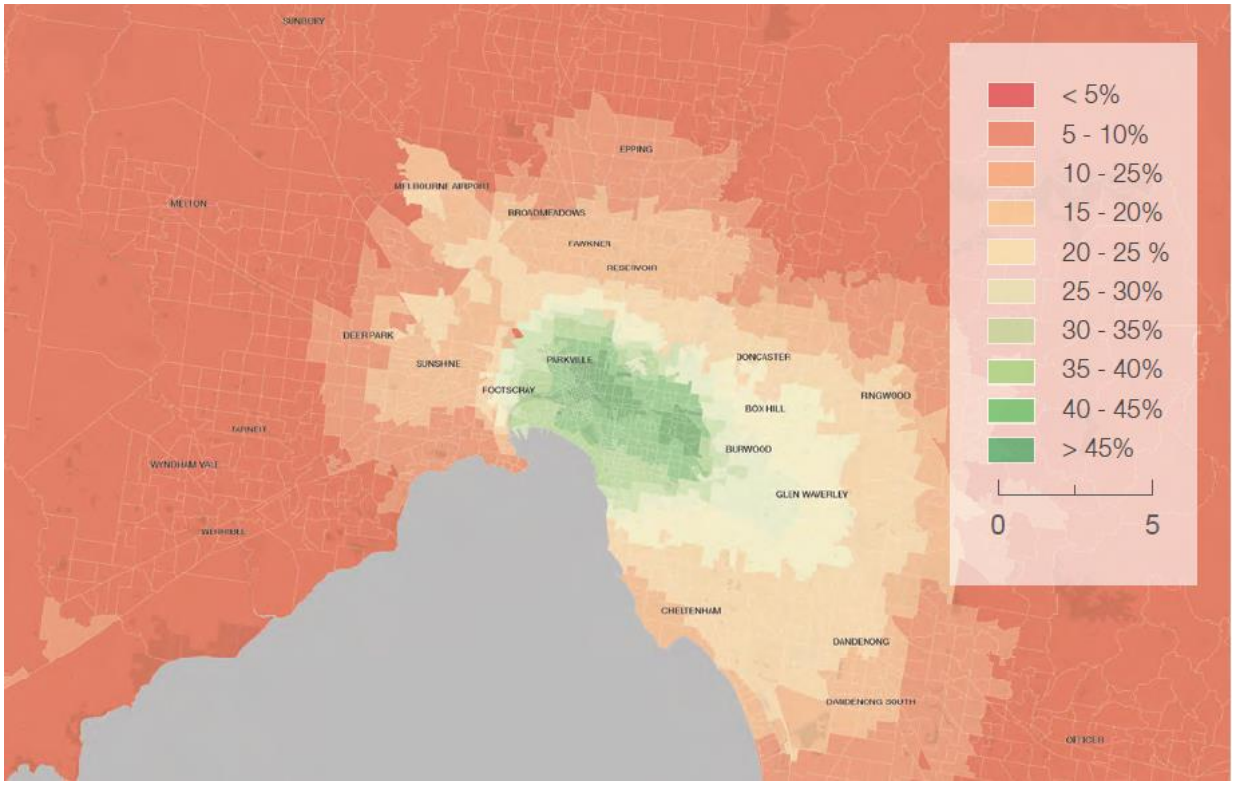
Challenge 1 – Access to jobs from place of residence

It is increasingly difficult for a growing number of Victorians to get to destinations with specialised opportunities, including for jobs and study.

The vast majority of a growing number of new trips will need to be accommodated on the network that we have today, including those that connect onto new projects. Projects already underway will make a substantial contribution to movement across the state and metropolitan Melbourne, including to specialised destinations and growth areas.

Melburnians in the northern, western and south-eastern growth areas are forecast to be impacted the most. The lower number of job opportunities within a 60-minute travel time means that people living in growth areas travel further than those in established areas, particularly for specialised employment opportunities (as shown in Figure 11). This is compounded by the strong population growth rate resulting in the number of job opportunities per working resident being comparatively lower in outer areas.

Figure 11: Access to jobs within 60 minutes is lower in Melbourne's West and North

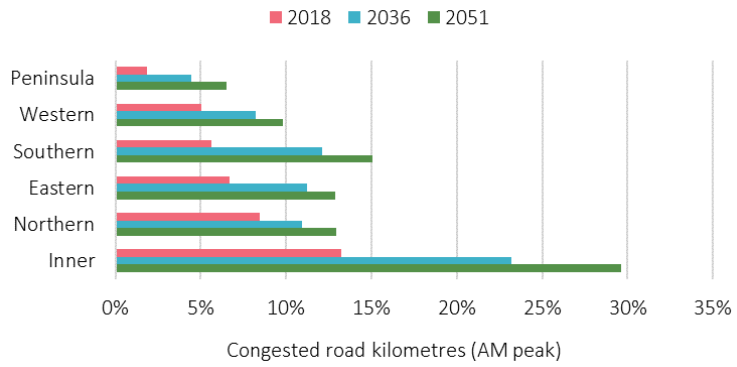


Source: Arup, Strategy Update: Problem Definition Modelling Outcomes, Report for Infrastructure Victoria, November 2020

With more people travelling further, more of the road network is congested and rail services are more frequently becoming overcrowded. In particular, the proportion of congested roads during the AM peak across Inner Melbourne is expected to double to around 30% by the mid 2030s, with road congestion also expected to increase in the growth areas to the north, west and south-east. This road congestion will also reduce access to dispersed and industrial employment areas which are predominantly accessed by private vehicle. This expected future road congestion is based on the network development scenario (NDS) that includes various future road and public transport investments for committed projects that are planned or under construction. Without these, road congestion would be even worse in the future.

These increases will have flow on effects on travel to regional areas, particularly to Geelong, Ballarat and to Northern Victoria. Movements to the west and north are particularly impacted, including access from those places into Inner Melbourne.

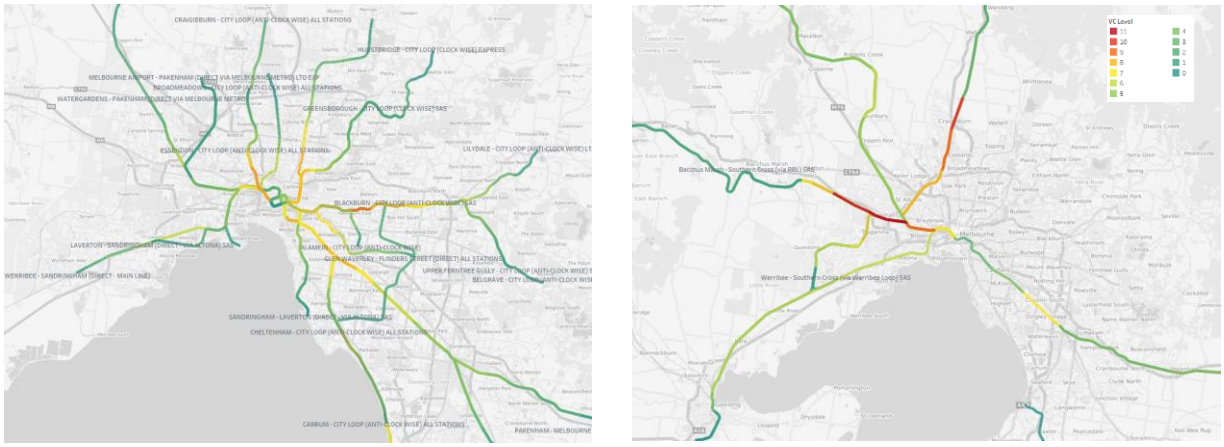
Figure 12: Change in AM peak road congestion levels (2018 to 2036 to 2051)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report
Note: Network development scenario outcomes are shown for 2036 and 2051. This represents a future scenario that includes all funded and committed projects, representing reasonable assumptions about the development of a future transport network that aligns with existing transport planning approaches. This is described in Section 3.2 and Appendix D of this report in more detail.

With increasing private vehicle travel times, public transport is forecast to become a more attractive option to get to the CBD, Inner Melbourne and knowledge-based parts of NEICs that are increasing in job density with growing public transport mode shares. However, overcrowding is more prevalent on the north and west regional and metropolitan rail lines. Overcrowding leads to operational unreliability, and at worst, rail passengers being unable to board the next arriving train. In addition, travel times for those living in newer suburbs to the north and west are expected to be higher than they are today.

Figure 13: Rail travel time spent in crowded conditions in 2036



Note: VC = vehicle to capacity ratio. This is a ratio of demand to capacity. It is a commonly used measure of congestion where a value above 10 indicates the train line is very congested and over capacity, and values closer to 1 represent little to no congestion on that line.
Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Challenge 2 – Access to potential workforce

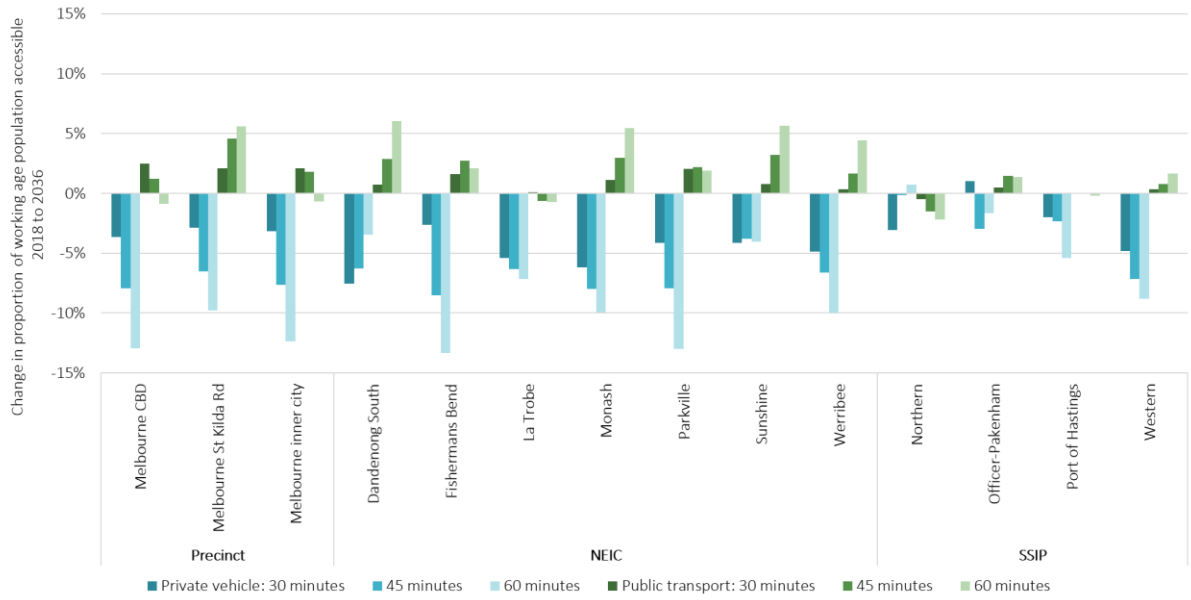
The development and competitiveness of knowledge and industrial employment areas is being increasingly compromised by deteriorating access to the potential workforce.

It is becoming harder to access knowledge and industrial precincts across Melbourne, as the transport network becomes more congested and less reliable. This is particularly the case for access by private vehicles, where there are falls in the proportion of working age residents who can access NEICs and SSIPs by car in 30, 45 or 60 minutes (see Figure 14). Access by public transport is either little changed or slightly improved in 2036. There is therefore a challenge for firms and employers in these areas in accessing the labour market. These employment precincts are important contributors to Victoria's economy, through both knowledge-based and service jobs and through freight and logistics.[39]

Whilst the catchment area by private vehicle is greater than by public transport, the catchment area and population-serving knowledge and industrial areas within 60 minutes is declining by private vehicle (see Figure 15 and Figure 16). The capacity of roads to serve areas of increasing density is declining. Good private vehicle access is contributed to by public transport mode share taking cars off the road. However, public transport capacity is not keeping up with the growth of industrial precincts.

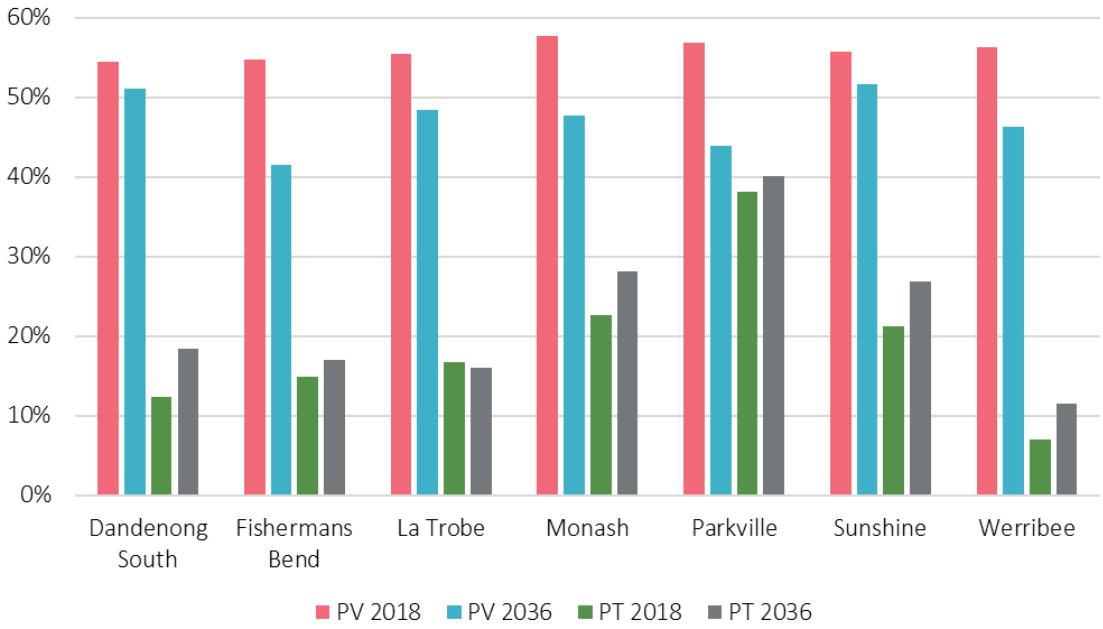
[39] *SGS Economics & Planning (2019) Functional Economic Region Report, Melbourne, report for Infrastructure Victoria, p.9*

Figure 14: Change in Access to Working Age Population from Selected Destinations, 2018 to 2036



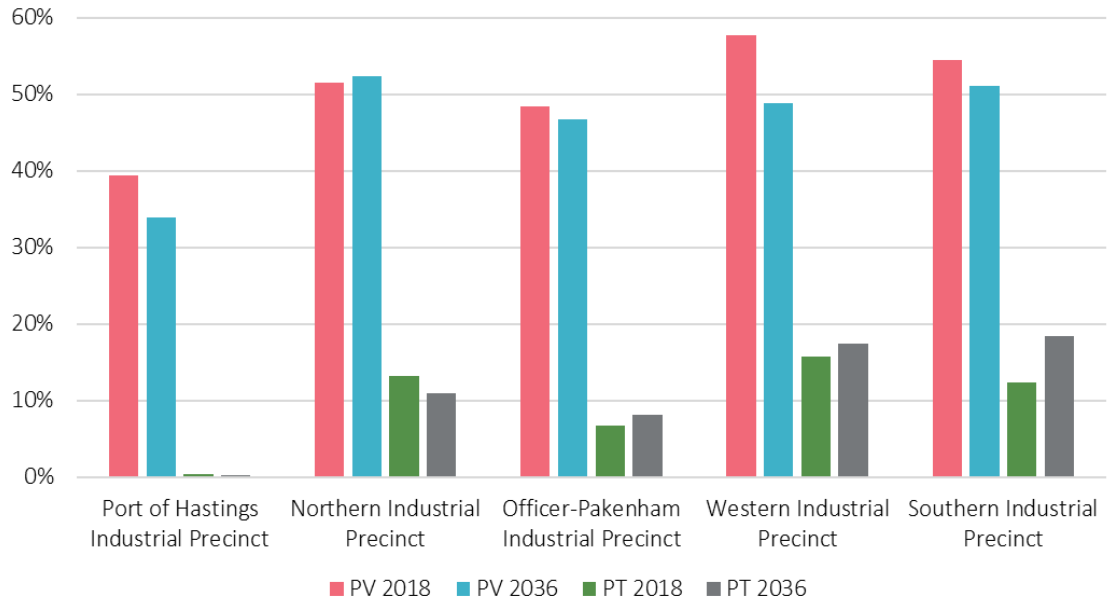
Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report, showing Transport Base Case outcomes

Figure 15: Percentage of metropolitan Melbourne's Working Residents able to access NEICs within 60 minutes in AM Peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report showing Transport Base Case outcomes
Note: The Transport Base Case is a future scenario that aligns with the network development scenario and excludes the major transport programs being assessed in this report (i.e. CLR, MM2, WRU, CCM, OMR and RMS). It includes all funded and committed projects, including North East Link and Suburban Rail Loop. It also includes some initiatives that are not currently Victorian Government policy commitments but represent reasonable assumptions about the development of a future transport network that aligns with existing transport planning approaches. This is described in Section 3.2 and Appendix D of this report in more detail.

Figure 16: Percentage of metropolitan Melbourne's Working Residents able to access SSIPs within 60 minutes in AM Peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report showing Transport Base Case outcomes

Challenge 3 – Business-to-business travel for freight

The competitiveness of knowledge and industrial employment areas is being increasingly compromised by deteriorating business-to-business connections, including freight.

There will be increasing growth in freight demand in Victoria, with freight volumes predicted to increase from around 360 million tonnes in 2014 to nearly 900 million tonnes in 2051.[40] Metropolitan Melbourne freight volumes are forecast to grow at an average annual rate of 2.6% over the same period, and 1.5% in regional Victoria.[41] Within metropolitan Melbourne, there is expected to be growth in freight demand between key transport gateways, particularly between the north and west. This is driven by continued growth in industries such as logistics and manufacturing, along with key movements to and from Melbourne Airport, and key interstate and intrastate corridors, including the future transport gateways of the Western and Beveridge Intermodal Freight Terminals and the Bay West Port.

Without further improvements to the network, this increasing demand will result in greater congestion, reduced productivity and increased costs, particularly for business and freight travel.[42] Whilst localised congestion reflects activity in local areas, it can also be a challenge for accessing knowledge precincts and labour market catchments.[43]

Travel times between the Northern SSIP and the Port of Melbourne are expected to increase by 27% between 2018 and 2036 and 50% by 2051 under the network development scenario.[44] This trend is also seen across other transport gateways and freight precincts.

Average freight speeds (peak and interpeak) are also expected to decline under the network development scenario across Greater Melbourne. Average AM peak freight speed is expected to decline by 14% in 2036 and average interpeak freight speed is expected to decline by 9% in 2036. These are expected to further decline by 2051.[45]

[40] *Department of Transport 2018, Delivering the Goods – Victorian Freight Plan*

[41] *Department of Transport 2018, Delivering the Goods – Victorian Freight Plan*

[42] *Weisbrod, G., Vary, D., & Treyz, G. (2003). Measuring economic costs of urban traffic congestion to business. Transportation research record, 1839(1), 98-106*

[43] *Osman, T., Thomas, T., Mondschein, A., & Taylor, B. D. (2019). Does traffic congestion influence the location of new business establishments? An analysis of the San Francisco Bay Area. Urban Studies, 56(5), 1026-1041*

[44] *Arup 2021 Strategic Modelling Outcomes Report*

[45] *Arup 2021 Strategic Modelling Outcomes Report*

Challenge 4 – Transport's contribution to achieving net zero emissions

Continued growth in transport sector emissions will result in the state not meeting its target of net zero emissions.

Increased population in the future will place greater pressure on the transport network. If current travel mode shares continue in the future, not only will congestion become worse, but transport sector emissions will also increase dramatically. From 1990 to 2018, this sector's contribution to Victoria's emissions increased from 15.9 to 23.5%. Road transport currently accounts for 88% of the transport sector's emissions.[46]

CO_2 emissions from transport are expected to increase from 144,000 metric tonnes in 2018, to 224,000 in 2036, and 288,000 in 2051 per weekday under a base case scenario.[47] This represents a doubling of transport emissions between 2018 and 2051. This estimate only includes emissions from private vehicles based on the current profile of car and truck usage and technology (petrol and diesel) and does not include emissions from public transport.

In comparison, expected road transport emissions levels by 2051 are expected to be equivalent to the CO_2 emissions released from burning almost 1,600 railcars worth of coal every weekday.[48] The state will not meet its target of net zero emissions by 2050 without interventions that encourage a switch to lower energy intensive modes of transport and shifts in land use that result in better environmental outcomes, such as well-located and dense housing.

Furthermore, Victoria will need to transition to ZEVs for trips which cannot be avoided or shifted to active or public transport. Victoria has recently commenced heading in the right direction in this regard. With the release of *Victoria's zero emissions vehicle roadmap*, the Victorian Government has outlined its approach to boosting ZEV uptake in Victoria. This includes a target for 50% of new light vehicle sales to be ZEVs by 2030.[49] Recommendations 1 and 2 of *Victoria's infrastructure strategy* on ZEVs aim to complement and further strengthen the actions the Victorian Government is taking to reduce emissions in the transport sector.

Challenge 5 – A more resilient network to a wide range of different scenarios

The transport network needs to become more resilient to a wide range of different outcomes.

Uncertainty around the future means that the transport network should be able to adapt to change and respond to a range of outcomes.[50] The COVID-19 pandemic is an example of a major shock that has impacted the transport network. This has been felt in the short term by the impact of lockdowns and subsequent reduced travel. This is likely to have lasting impacts in the medium and longer term with the potential for a more permanent shift to working from home.[51] Future infrastructure, particularly transport, should be designed with consideration of outcomes of these future scenarios to ensure it is resilient to change.[52]

Future outcomes include both shocks and structural changes that will impact the transport network. Examples of shocks include the COVID-19 pandemic and other unexpected natural disasters. Structural changes already underway include the shift towards the service industry and knowledge-based jobs, and a decline in manufacturing, which has implications for the economic structure of cities and labour markets. Other long-term structural challenges include increasing risks from climate change, and the rise of automated and electric vehicles.[53]

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[46] *https://www.climatechange.vic.gov.au/__data/assets/excel_doc/0011/504002/Victorian-Greenhouse-Gas-Emissions-Report-2018a-Chart-data.xlsx*

[47] *Arup 2021 Strategic Modelling Outcomes Report. This base case refers to the Transport Program Base Case*

[48] *Using United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator*

[49] *Victorian Government (2021) Victoria's zero emissions vehicle roadmap* https://www.energy.vic.gov.au/__data/assets/pdf_file/0014/521312/Zero-Emission-Vehicle-ZEV-Roadmap-FINAL.pdf

[50] *Marchau, V. A., Walker, W. E., & Van Wee, G. P. (2010). Dynamic adaptive transport policies for handling deep uncertainty. Technological forecasting and social change, 77(6), 940-950*

[51] *Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? Journal of Public Economics, 189, 104235*

[52] *Banister, D., & Hickman, R. (2013). Transport futures: Thinking the unthinkable. Transport Policy, 29, 283-293*

[53] *Helmrich, A. M., & Chester, M. V. (2020). Reconciling complexity and deep uncertainty in infrastructure design for climate adaptation. Sustainable and Resilient Infrastructure, 1-17; Infrastructure Victoria, Advice on automated and zero emissions vehicles infrastructure, October 2018, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf*

2.4 Future Scenarios

In this report we have examined several potential future scenarios to determine the likely impact on major transport projects and their resilience, in terms of both travel patterns, land use and economic outcomes. The modelling undertaken for this report makes assumptions about future growth and trends, based on historical trends and other known factors. However, there is uncertainty about the future, particularly in the longer term, and the level of impact that external shocks can have. [54] The following five scenarios (Table 2) have been selected to test the resilience and impacts on the major transport projects, including three external trend scenarios and two policy change scenarios.

An overview of each scenario is provided below, with the impacts to each major transport project described in chapter 4. Our approach to modelling each scenario is outlined in chapter 3, and Appendix A provides further detail.

Table 2: Future Scenarios

External Trend Scenarios	Policy Change Scenarios
High and low population growth	Policies that support more homes in established places
A permanent shift to working from home for part of the week	Implementation of transport network pricing
Increased use of automated and electric vehicles	

2.4.1 Alternative population growth

Population is a key driver of demand for infrastructure.[55] Baseline population growth forecasts have been used in the modelling undertaken for this report, which assume a continuation of recent trends in births, life expectancy, migration and living arrangements across all of Victoria. These forecasts are sourced from the Department of Environment, Land, Water and Planning (DELWP), released in their *Victoria in Future 2019* publication.[56] These comprehensive forecasts are developed using mathematical models and expert knowledge, relying on trend analysis and assumptions about future change.

As noted in *Victoria in Future 2019*, uncertainty about the future increases over longer projection horizons and with smaller geographic areas. Different policy settings and changes in the economy could result in changes to the expected size, distribution and composition of the population. In particular, migration levels are more sensitive to changes in policy or economic conditions than births or deaths and are expected to have a bigger impact on future population growth. [57] The COVID-19 pandemic has shown a significant drop in international migration resulting from closed international borders, which has caused population growth to slow in Victoria in 2020.[58] These impacts were discussed in Section 2.1.

Higher or lower levels of population growth impact not only economic growth, but also demand for transport infrastructure, including congestion levels and average travel times, and patterns of where people live and work.[59] Two population growth scenarios (high and low growth) have been assessed to provide insight on the impacts and opportunities of alternative population growth on future infrastructure demand and use, and on the need and timing for each major transport project.

Overall, lower population growth may lead to less demand on the network and impact the timeframes for delivery of projects, as they may not be required as early as planned. Higher population growth may lead to more demand on the network and increased congestion and crowding which means a project delivering congestion relief and capacity upgrades might be required sooner. Higher population growth in the outer and growth areas would mean projects addressing growth area networks and improving access to jobs might be required sooner.

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[54] *Marchau, V. A., Walker, W. E., & Van Wee, G. P. (2010). Dynamic adaptive transport policies for handling deep uncertainty. Technological forecasting and social change, 77(6), 940-950*

[55] *Metz, D. (2012). Demographic determinants of daily travel demand. Transport Policy, 21, 20-25*

[56] *Department of Environment, Land, Water and Planning, Victoria in Future 2019, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/*

[57] Department of Environment, Land, Water and Planning, *Victoria in Future 2019*, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/

[58] *https://www.abs.gov.au/articles/population-and-covid-19, accessed 3 June 2021*

[59] *Metz, D. (2012). Demographic determinants of daily travel demand. Transport Policy, 21, 20-25*

2.4.2 Working from home

Across the world, the COVID-19 pandemic has disrupted how and when people travel, and how goods and services are supplied by businesses to consumers, accelerating changes that were underway. Some industries have rapidly adapted to this changing economic climate, for example, by making greater use of working from home arrangements for some occupations. This adaption could lead to further, permanent changes in how and where economic activity takes place and the infrastructure required to support it. In Victoria, there was a partial shift to working from home from mid-March 2020 that was followed by a more comprehensive shift in early August 2020 which started to be relaxed from late September 2020. Many businesses are still operating under a hybrid model, with some employees continuing to work from home on certain days of the week or during periods when this is required for public health reasons.

An ABS survey of businesses found that before the COVID-19 pandemic, 71% of businesses had no staff teleworking (working from home).[60] More than 90% of businesses with at least 20 employees had less than 25% employees teleworking. Only 6% of businesses had 75 to 100% of employees teleworking. The industries with the largest shares of teleworking before the COVID-19 pandemic were Professional, Scientific and Technical Services (59%), Information Media and Telecommunications (52%), Administrative and Support Services (46%) and Financial and Insurance Services (43%).[61]

During the pandemic, the share of businesses with no workers teleworking fell from 71% to 56%. The share of businesses with at least 75% of employees working from home increased from 7% to 17%.[62] While the situation in Victoria is evolving, there is recognition that the incidence and frequency of working from home will be higher in the future due to the accelerated adoption of working from home practices during the pandemic.[63]

The largest shifts to working from home tended to occur in industries that already had the greatest share of employees working from home pre-pandemic.[64] It is expected that maintaining working from home arrangements after the COVID-19 pandemic will lead to an ongoing hybrid approach to flexible work.[65] This will reduce the number of people commuting to work, causing decreases in peak hour congestion.

A working from home (WFH) scenario was modelled in VLUTI to assess the impacts on transport and land use outcomes, and the impacts to major transport projects. The WFH scenario increases the number of people in specific industries and locations that are working from home. The primary impact of this is a redistribution of population away from centralised areas such as the CBD and regional cities, as the need to access defined employment hubs is reduced. Inner Melbourne is modelled as experiencing the largest impact with smaller populations by 3.6% and 3.5% in 2036 and 2051 respectively, compared to the network development scenario (base case). The shift to working from home also results in around 2% less population living in regional cities in 2036 and 2051 compared to the network development scenario. Further, this scenario forecasts increased population living in outer and growth areas as people commute less frequently to work. This scenario forecasts a decline of 3.7% in private vehicle trips in the AM peak in 2036, and a decline of 2.6% in trips by public transport in 2036.[66] However, this population shift may create additional demand for roads and public transport in these outer and growth areas across the day and outside of peak hours.

The shift to working from home leads to a moderate increase in crowding across the public transport network in Inner Melbourne and Melbourne's New Growth Areas during the morning peak in 2036 compared to the network development scenario. This is likely because whilst there are less people travelling overall due to the shift to working from home, the increase in Inner Melbourne employment, more households living in outer areas and longer trip distances result in people shifting to public transport to take advantage of the better travel time and convenience it offers for long distance Inner Melbourne trips. While public transport trips are reduced, people are travelling from further away, increasing total passenger kilometres travelled. This increases congested kilometres travelled, especially because crowding now occurs earlier on the network with more people travelling from the extremities of the network.

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[60] *Australian Bureau of Statistics, 2020*

[61] *Australian Bureau of Statistics, 2020*

[62] *Australian Bureau of Statistics, 2020*

[63] *Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? Journal of Public Economics, 189, 104235; Lennox, J. (2020). More working from home will change the shape and size of cities. Centre of Policy Studies/IMPACT Centre Working Papers g-306, Victoria University, Centre of Policy Studies/IMPACT Centre*

[64] *Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? Journal of Public Economics, 189, 104235*

[65] *University of Sydney, Business School, Institute of Transport and Logistics Studies (2020) Transport Opinion Survey (TOPS), September, https://www.sydney.edu.au/content/dam/corporate/documents/business-school/research/itls/tops-2020-sep.pdf*

[66] *Arup 2021 Strategic Modelling Outcomes Report*

2.4.3 Automated and electric vehicles

Automated vehicles (AVs) and electric vehicles (or zero emissions vehicles, ZEVs), together and individually, have profound implications for the way people travel around locally and across the state. These technology changes represent a potential opportunity for all Victorians to enjoy a better quality of life through greater accessibility, improved road safety, cleaner air, lower greenhouse gas emissions, better health, and a stronger economy.[67]

A future with AVs and ZEVs could have significant infrastructure and land use implications. We have modelled an electric and automated vehicles (EAV) scenario in the VLUTI model that tests the implications of a transport network-wide technology change. The key input changes for the EAV scenario include lower vehicle operating costs for ZEVs and for AVs, lower value of in-vehicle time and improved network efficiency. The lower value of in-vehicle time reflects the flexibility of how a passenger can spend time in an AV if they are not preoccupied with driving, while the improved network efficiency represents the gains from a more connected and cooperative vehicle fleet.

The modelled trajectory of take up of AVs is such that at 2036, 11.5% of vehicles are AVs, rising to 46.5% at 2051. ZEV take up is modelled with 38.5% of vehicles being ZEVs at 2036, rising to 89.6% at 2051. While this scenario tests the combined impact of ZEVs and AVs, the different speed in take up of ZEVs and AVs means that the outcomes at 2036 are largely a result of the ZEV impacts, while at 2051 outcomes largely stem from AVs.

The specific technologies and market models that will accompany the rise of ZEVs and AVs are still uncertain. Therefore, there is significant uncertainty around the overall timing and extent of impacts of the EAV scenario. The implications of AVs are particularly unclear as the associated technology and required infrastructure are still in early development. Infrastructure Victoria's 2018 *Advice on automated and zero emissions vehicles infrastructure* (AZEVIA) explored a wide range of possible future outcomes, while this EAV scenario only tests one particular outcome.[68]

The modelled outcomes of the EAV scenario find that road use in the future is higher with AVs and ZEVs, while public transport has a lower mode share. However, we again note the substantial uncertainty around the EAV scenario. For example, AZEVIA modelled a scenario 'Fleet Street' under which public transport mode share increases, compared to a base case, due to the prevalence of fleet AVs.[69]

The EAV scenario sees worse road congestion in 2036 as the lower operating costs of ZEVs make driving more attractive. However, the network efficiency benefits of AVs, as modelled in 2051, mean that road congestion generally reduces, even with additional demand for car trips. The exception to this is in Inner Melbourne which experiences worse congestion at 2051 in the EAV scenario. The land use impacts of the EAV scenario show a greater degree of dispersion of employment and population throughout Melbourne.

The EAV scenario has multiple and conflicting implications for the performance of individual transport projects. With more people using the road, this could imply that there is a greater need for road projects which add road capacity. Conversely, instead of a new road project, a substantial level of decongestion benefits could be achieved through the technology of AVs. Infrastructure Victoria's AZEVIA work noted that the network efficiency gains of AVs could mean that government can delay or avoid some major road capital investments.[70]

This scenario shows a lower share of public transport users as car travel becomes more attractive. A new public transport project may therefore benefit a smaller number of people with correspondingly lower levels of consumer benefits. However, as highlighted earlier, there is substantial uncertainty around the implications of AVs on public transport use.

The EAV scenario demonstrates that while there are benefits to be harnessed from the technology change of ZEVs and AVs, there are also possible adverse outcomes (lower public transport use and less dense cities) which need to be planned for and mitigated against. These adverse outcomes further strengthen the need for recommendations in *Victoria's infrastructure strategy* on transport network pricing (TNP), encouraging active and public transport, integration of land use and transport planning, and supporting more homes in established places.

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[67] *Infrastructure Victoria 2018. Automated and Zero Emissions Vehicles Infrastructure Advice*

[68] *Infrastructure Victoria's Automated and Zero Emissions Vehicle Infrastructure Advice (AZEVIA) 2018 https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf*

[69] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

[70] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

2.4.4 Supporting more homes in established places

A key recommendation in *Victoria's infrastructure strategy* is to support more homes in priority established suburbs for residential intensification to better use existing infrastructure. Infrastructure Victoria's community research on *Density done well* found that Melburnians living in established areas are willing to embrace density under the right conditions, including extra infrastructure to accommodate more residents.[71] Residential development close to the existing transport network supports better use of the network.

Prioritising home building in established suburbs ultimately costs less in infrastructure spending than expanding in new growth areas. Infrastructure costs in established suburbs with the capacity to support growth can be two to four times lower than in new growth areas, excluding transport and open space.[72] *Plan Melbourne* supports housing choices in locations close to jobs and services, with integrated transport systems to provide connections for people, goods and services.[73]

Previous research undertaken by Infrastructure Victoria modelled different scenarios of development patterns across Melbourne to determine the impacts on the transport network.[74] This research has been used to inform this scenario and the potential impacts to each major transport project.

Overall, this scenario forecasts fewer private vehicle trips and more public and active transport trips due to more people living in established areas, such as Inner Melbourne. Average travel times were minimally impacted, and congestion only increasing in line with population growth. Public transport trips were shorter and more likely to be on trams. Policy that encourages increased density of residents in established areas is expected to have minimal impacts to broader network performance, and significant improvements on accessibility.

2.4.5 Transport network pricing

Transport network pricing (TNP) was one of the top three recommendations in Infrastructure Victoria's first *30-year infrastructure strategy* released in 2016 and continues to be one of our core research areas. Our research shows comprehensive network-wide changes to the pricing of roads, public transport and parking are required to get the most out of our existing and future transport system, managing demand and changing the way Victorians use the transport system.

TNP is a system designed to influence how, when and where people use the transport system by including the impact that people's travel has on others into a price signal. Under transport network pricing, prices can be set to incentivise commuters to travel at quieter times, such as in the off peak, and shift modes from private vehicles to public transport. TNP will help to ease congestion and improve environmental and health outcomes. TNP will also enhance large government infrastructure investments in our transport network, helping these projects to perform at their best once delivered, and sustaining these benefits over the longer term.

Previous research by Infrastructure Victoria[75] utilising the Melbourne Activity and Agent Based Model (MABM) to measure pricing policy responses provides a strong evidence base to help infer the expected benefits and impacts of implementing TNP alongside the major transport projects.

There are a range of potential TNP opportunities that should be implemented alongside the delivery of major transport infrastructure projects. Our research shows that an inner city cordon charge would help manage demand, which particularly affects the need for road projects in Inner Melbourne. Road pricing would also help to manage the flow-on effects from new road projects across the network, and encourage people to switch to public transport modes, potentially creating additional demand for public transport. Variation in public transport fares would allow users to make better use of new public transport.

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[71] RPS, *Infrastructure Victoria 30-Year Infrastructure Strategy Engagement Report (Stage One and Two)*, Melbourne, Infrastructure Victoria, 2020, https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/05/Density-done-well-engagement-report-FINAL.pdf

[72] *Infrastructure Victoria 2019, Infrastructure Provision in Different Development Settings* https://www.infrastructurevictoria.com.au/project/research-infrastructure-provision-in-different-development-settings/

[73] *Plan Melbourne Metropolitan Strategic Plan*

[74] *Arup 2020 Problem Definition Outcomes Report*

[75] *Infrastructure Victoria, Good Move: Fixing transport congestion, released March 2020 and Infrastructure Victoria, Fair Move: Better public transport fares for Melbourne, released September 2020*

3. Assessment Approach

3.1 Overview

Approaches to assessing infrastructure projects have evolved over time. Our assessment framework considers a range of innovative elements, reflecting a maturity in how we assess major transport projects. We have considered the following in our assessment of major transport projects:

- alignment with objectives of *Victoria's infrastructure strategy* through a multi-criteria analysis
- strategic modelling using the VLUTI model
- an economic evaluation expanded to consider land use changes, including sensitivity analysis
- a broader qualitative social, environmental and economic assessment and consideration of distributional impacts
- consideration of the impacts of future scenarios.

This chapter outlines our assessment approach and each of these core components. Further detail on the approach and assumptions is provided in the supporting technical reports.

3.2 Demand Forecasts

The VLUTI model was used to model a future base case (network development scenario), a transport base case and six project cases, with each of the six major transport projects being considered for this report. Two future scenarios were also modelled in VLUTI, a working from home scenario and an automated and electric vehicles scenario. All scenarios were modelled for 2036 and 2051.

The VLUTI model is an integrated land use and transport model combining a spatial economic model developed by Victoria University's Centre of Policy Studies (CoPS) and the Department of Transport's (DOT) Victorian Integrated Transport Model (VITM). These two models operate together to incorporate land use outcomes in a feedback loop with the traffic distribution and assignment process. This allows for land use and network performance to directly influence each other during testing, rather than land use remaining as a static input. Whilst these interactions can be complex to interpret, generally interventions that increase accessibility will attract more residents or jobs towards those locations in varying ways. A full description of the VLUTI model is provided in the supporting technical report: *VLUTI Model Architecture Report*.

VLUTI forecasts were compared with the conventional modelling approach of using the conventional VITM model for two selected projects. An economic assessment has been undertaken using these VITM results, to compare to the economic assessment using the VLUTI model. This was undertaken to test the economic outcomes to understand the key differences in the two approaches and to better understand the value of the VLUTI model in estimating land use changes relating to transport.

The two projects selected for this comparison were cross city motorway (CCM) and the City Loop reconfiguration and northern rail corridor upgrade (CLR). Refer to sections 4.3 (CLR) and 4.4 (CCM) for the comparison. We consider the VLUTI model approach to capture a greater range of project impacts as it considers changes to the location of households and jobs, compared to VITM which does not account for these. This means the benefits estimated using VITM will vary from VLUTI as demonstrated for these two projects. However, the economic assessment of each project using the VLUTI model does not incorporate the non-transport benefits to households and places changing locations into the cost benefit analysis that the VLUTI model projects.

Network Development Scenario (Base Case)

A network development scenario (NDS) was modelled in VLUTI, representing a future base case. This includes all funded and committed projects at the time of testing, and any non-committed projects that have not been fully planned or assessed but are expected to play an important role in meeting future demand. These represent reasonable assumptions about the development of a future transport network that aligns with existing transport planning approaches. The Arup *Strategic Modelling Outcomes* report outlines the major future road and public transport assumptions underpinning the NDS.

Statewide totals of population, employment, households and enrolments were taken from the Small Area Land Use Projections (SALUP) demographic projections.[76] This is a standard dataset used to inform strategic transport modelling assessments in Victoria. The VLUTI model generates its own distribution of population, employment and households that align to these statewide totals. This distribution aligns with SALUP forecasts at a broad level. Further detail on the modelling assumptions, inputs and results are provided in Arup's report.

Transport Base Case

A transport base case was also modelled in VLUTI, which represents the future network development scenario without the six major transport projects that are being assessed in this report. This allows for the major transport program project cases to be compared to a future base case that does not include the specified project.

Project Case

Each major transport project was modelled separately and compared against the transport base case, to assess the impacts of each individual project. Specifications of the six major transport projects are outlined in Chapter 4 of this report, with further detail provided in Arup's *Strategic Modelling Outcomes* report.

The six major transport projects as shown in Figure 17 are:

- **City Loop Reconfiguration and Northern Rail Corridor Upgrade (CLR)** – a broad group of interrelated changes to the rail network facilitating increased service provision along the Craigieburn, Frankston and Glen Waverley corridors. Also includes new stations and electrification of the metro line towards Wallan.
- **Cross City Motorway (CCM**) – the widening of the Eastern Freeway from Chandler Highway inbound and a new road tunnel that forms an east-west connection connecting the Eastern Freeway and CityLink to the West Gate Tunnel.
- **Melbourne Metro Two and Direct Geelong Rail Services (MM2G)** – the construction of a new rail tunnel connecting Newport to Clifton Hill, to support additional train services on Hurstbridge, Mernda, and Werribee / Williamstown services and support direct electrified train services to Geelong.
- **Outer Metropolitan Ring Road (OMR)** – a new tolled ring road across Melbourne's outer western and northern suburbs, facilitating motorway travel for private vehicles and freight. While the corridor will ultimately be used for rail freight also, no rail freight has been considered as part of this scope. The rail component of this project is not part of this project assessment as the rail proposal has significant and complex interactions with the interstate freight network and terminals in other Australian states.
- **Road Management Systems (RMS)** – a combination of network-wide operational improvements, such as improved traffic signal timings. This is to be implemented on arterial roads in metropolitan Melbourne as well as lane configuration changes on select corridors to assist with traffic flows and public transport reliability and punctuality, assumed to drive an increase in efficiency across the network.
- **Western Rail Corridor Upgrade (WRU)** – upgrades to the Melton rail corridor to support extension of the metropolitan rail services from Sunshine to a new station at Mount Atkinson. This would also enable increased capacity to the Pakenham/Cranbourne corridors in Melbourne's south-east.

[76] *Generated by SGS Economics & Planning, Melbourne Functional Economic Region Report 2019*

Figure 17: Overview of Major Transport Projects

Source: Arup 2021

COVID impacts

The COVID-19 pandemic has seen a decline in public transport patronage, with public transport use in Melbourne ranging between 60% to 80% of pre-pandemic levels between March and May 2021.[77] Previous research by Infrastructure Victoria on the short-term impacts of the COVID-19 pandemic on transport use assumed a decrease in public transport mode share between 37% to 55% based on observed short-term changed user preferences.[78] The modelling undertaken for this report assumes that in the long-term, public transport usage will revert to pre-pandemic levels (by 2036 and 2051).

We have also undertaken two scenarios to address the longer-term impacts of the COVID-19 pandemic, including a low population growth scenario and an increased working from home scenario. These scenarios demonstrate some of the changes from more permanent COVID-related behavioural effects.

Model limitations

Model outputs are always an approximation of what can be expected in the real/built environment. They are subject to technical limitations and the general uncertainty associated with projections. As such, it is important that results from the VLUTI model are interpreted with an understanding of the strengths and weaknesses of these modelling tools, as well as the basis of inputs adopted.

The supporting technical report on the VLUTI model (*VLUTI Model Architecture* report) and Arup Demand Modelling Report present these limitations in more detail. Some of the limitations of the model include:

- The model is dependent on land use forecasts which have a degree of uncertainty given the long-term horizon and level of detail required.
- Future road and public transport assumptions around timing and scope may shift over time as government expectations of future investment evolve.
- Intersections are not explicitly modelled, but rather a simplification of reality. This mainly presents limitations in assessing projects that involve intersection improvements.
- Commercial vehicle movements in the future are modelled within the freight component of VITM and may be affected by the assumptions contained in this component.

[77] *Apple mobility trends data for Greater Melbourne region https://covid19.apple.com/mobility*

[78] *Infrastructure Victoria 2021. Transporting Melbourne's Recovery – Immediate policy actions to get Melbourne moving* https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/05/Transporting-Melbournes-Recovery-January-2021-FINAL.pdf

3.3 Costs

Overview

Order of magnitude cost estimates were developed to support the cost benefit analysis in strategically assessing the major transport projects. Cost estimates were prepared for the six projects outlined, covering the same scope as was modelled in VLUTI. Total cost estimates are inclusive of infrastructure works, on-costs, government costs, land acquisition costs, contingencies, rolling stock, 50-year renewal costs and operations and maintenance costs. These costs are considered within an order of magnitude of -40% and +60%.

The cost estimates have been compiled, where possible, by measuring approximate high-level quantities and pricing at current day rates, plus adding allowances where insufficient information exists for basic elements that are necessary to deliver each project. Cash flow is based on analysis of similar scale infrastructure projects that have been constructed or are under construction.

An initial cost estimate was prepared by AECOM. Following the modelling and reviewing of initial economic evaluation results, we then considered opportunities to refine the projects, such as considering the timing of the project or specific scope elements, and considered advice about initial cost estimates. Consequently, a range of cost estimates are presented. These are the initial costs and the refined costs, which fall within the order of magnitude bounds of -40% and +60%. These costs are used in this report as upper and lower project cost ranges.

Analysis of these costs along with more detail on the assumptions and limitations is provided in the supporting technical report: *Major Transport Program Capital Cost Report*.

Limitations

As this is a strategic assessment, the order of magnitude costs reflect a limited project scope definition. The cost has been based on information derived from desktop studies only, without site visits or site investigations being carried out. Additionally, costs associated with land acquisition have been sought and adopted from publicly available information.

3.4 Assessment

3.4.1 Multi-criteria analysis

A multi-criteria analysis (MCA) has been conducted for the six major transport projects to consider how well they meet the objectives of *Victoria's infrastructure strategy* under a range of quantitative metrics.[79] Broader economic, social and environmental impacts are considered separately in a qualitative assessment. An MCA approach can highlight contradictory or conflicting issues that may not be evident in an economic evaluation. It can also present a straightforward yet methodologically sophisticated summary of a large range of technical data. Scores and weights are applied consistently across projects to highlight their differences and similarities.[80] The following section describes our approach to this assessment, including alignment with key strategy objectives. Outcomes of this assessment are provided in Chapter 4 for each transport project and summarised in Chapter 5 to show the comparison across all projects.

Assessment Structure

Infrastructure Victoria's several transport related objectives, as referenced in the strategy, can be categorised into a series of transport challenges (see Table 1). These challenges include:

- **Challenge 1** – Access to jobs from place of residence
  - Objective 1: Prepare for population change
  - Objective 3: Reduce disadvantage
  - Objective 4: Enable workforce participation
- **Challenge 2** – Access to potential workforce
  - Objective 5: Lift productivity
- **Challenge 3** – Business-to-business travel (including freight)
  - Objective 6: Drive Victoria's changing, globally integrated economy
- **Challenge 4** – Transport's contribution to achieving net zero emissions
  - Objective 7: Promote sustainable production and consumption
  - Objective 9: Advance climate change mitigation and adaption
- **Challenge 5** – A more resilient network to a wide range of different scenarios

[79] *Dean, M. (2020). Multi-criteria analysis.* Standard Transport Appraisal Methods. Advances in Transport Policy and Planning, 6, *165-22*

[80] *Dean, M. (2020). Multi-criteria analysis.* Standard Transport Appraisal Methods. Advances in Transport Policy and Planning, 6, *165-22*

- Objective 10: Build resilience to shocks

The first four challenges have been assessed in the MCA, informed by various transport, accessibility and environmental metrics from the VLUTI model. Details of each challenge are provided below. The fifth challenge has been addressed in our analysis of the transport projects' resilience to future scenarios as described in section 3.4.4.

Assessment Metrics

Challenge 1 – Access to jobs from place of residence

This challenge was measured against the performance of the road and public transport networks and their ability to handle projected changes in Victoria's population and jobs distribution. The approach to rate this involved:

- For road performance, projects were assessed against the *ratio of congested to total vehicle kilometres during the AM peak.* Reduced congestion means a more efficient road network, and a higher project score.
- Rail was assessed based on the *ratio of crowded to total passenger kilometres during the AM peak.* Projects were ranked at how well they reduced the proportion of crowding on either metropolitan or V/Line services.
- The impact of these two road and rail metrics, in addition to jobs and population distribution, is captured in the final job accessibility metric. This captures the change in *percentage of jobs across the state that can be accessed from a given origin within a travel time catchment of 45 minutes via private vehicle and public transport (AM peak).* Final scores were weighted based on the total population of each region, and therefore, influenced by projects that make the greatest net impact to jobs accessibility.
- The more job opportunities provided as a result of better travel times or jobs redistribution, the higher the project scores.

Challenge 2 – Access to potential workforce

From a business perspective, access to labour force is a key measure to assess the catchment potential benefits of a transport project. The approach to rate this involved:

- The metric used to measure labour force accessibility is the *percentage of working population across the state that can access a given job destination within a travel time catchment of 45 minutes via private vehicle and public transport (AM peak).*
- Final scores were weighted based on the total job opportunities in each region, and therefore, influenced by projects that provide the greatest net benefit to labour force catchment.

Challenge 3 – Business-to-business travel (including freight)

While business-to-business travel can be measured by the overall efficiency of the road and public transport networks, this is already captured in Challenge 1. Therefore, the focus metrics of Challenge 3 are primarily on freight (heavy vehicle) congestion and connectivity of key transport gateways and SSIPs. The approach to rate this involved:

- For freight performance, projects were assessed against the *ratio of congested to total freight kilometres during the AM peak.* Reduced freight congestion means a more efficient freight network, and a higher project score.
- Freight connectivity was measured for new road infrastructure projects by analysing the structure of the freight network in connecting major freight destinations like State Significant Industrial Precincts (SSIPs), intermodal freight terminals, airports, seaports and National Employment and Innovation Clusters (NEICs). This metric was quantified by looking at new freights routes established by new road project links between these major freight destinations, Melbourne's Functional Economic Regions (FERs) and regional Victoria. More road freight routes supported by a new project means more alternatives and a higher project score.
- Freight utilisation was also assessed to identify the number of trucks using the new road infrastructure projects to undertake trips on the network. The foundation of this metric is to consider the forecast number of trucks that will use the new road infrastructure and therefore how essential the new road is to support forecast freight movements in Victoria. The future projections for truck volumes roads were also benchmarked against other existing and committed roads. Their final score was assigned by only comparing with new projects, explained in more detail in the following MCA ranking section.

Challenge 4 – Transport's Contribution to Achieving Net Zero Emissions

The approach to rate this involved:

- The metric used to rank project performance is the *daily CO_2 emissions from road-based transport*, including both private and commercial (including freight) vehicles. This is impacted by levels of congestion and more vehicles on the roads, both leading to a higher level of CO_2 emissions.
- Emissions from public transport service improvements or uplift are not captured within the analysis, although these could be avoided with the future introduction of renewables to power trains and trams, along with an alternative-fuel bus fleet. Increased take up of zero emissions vehicles will also contribute to avoided emissions

from transport, however take up of private ZEVs is likely to take some time compared to zero emission public transport. The Victorian Government expects that the full transition of private vehicles to ZEVs will take several decades.[81] It is important to highlight that emissions results within the MCA are calculated with a private vehicle fleet remaining as internal combustion vehicles. In reality, we expect a lower emissions result than measured in these scenarios as ZEV uptake increases in the future.

MCA rankings

Each of the six major transport projects were then quantitatively compared in terms of how well they performed under each assessment metric. Rankings used are as follows:

- Negative (N, reduced performance)
- Negligible (~, no change)
- Low (L)
- Low-Medium (L/M)
- Medium-High (M/H)
- High (H)
- Exceptional (E)

These rankings are comparative, defined to draw a distinction between the different transport projects. The MCA captures the performance of projects in the 2051 project case, compared to the 2051 transport base case. If a project's performance in 2036 is significantly different to its performance in 2051, this is also mentioned in the accompanying text.

Projects that significantly improve conditions for a given metric are rated as Exceptional (E). The remaining projects are rated on a scale from Negative (N) to High (H). A ranking of 'N' suggests that a project has had a negative impact such as an increase in road congestion or decrease in jobs accessibility. It is important to note that projects are ranked based on their performance *in comparison to each other within each metric.* For example, a 'H' allocated in the road network congestion metric is not necessarily comparable to a 'L/M' in the vehicle emissions metric. As discussed earlier, results from this assessment are provided in Chapter 4 for each transport project and summarised in Chapter 5 to show the comparison across all projects.[82]

3.4.2 Economic evaluation

Overview

A cost benefit analysis (CBA) was conducted for each major transport project. The economic framework developed for this CBA is in line with Department of Treasury and Finance (DTF) guidelines for economic assessments of transport projects.[83] Our innovative modelling approach has expanded the economic framework to include transport-related benefits from changes in the spatial distribution of population and jobs, based on changes estimated in the VLUTI model. This is an evolution of our approach to economic assessment since the 2016 infrastructure strategy was developed. This section provides an overview of the economic assessment methodology and further detail is provided in the supporting technical report – AECOM's *Economics Report*.

The economic assessment was conducted for three outcomes: static land use, dynamic land use, and dynamic land use plus wider economic benefits (WEBs) (see Figure 18). The VLUTI model simulates land use changes resulting from transport changes, which produces dynamic land use outcomes. That is, population and employment shift location due to changes in accessibility driven by transport network changes.

Static land use outcomes represent a conventional approach to CBA, where there are no changes to land use from the project. Dynamic land use outcomes represent a new approach to CBA, whereby benefits are estimated using an adjusted land use forecast from the VLUTI model based on a new distribution of population and jobs. Dynamic land use outcomes include conventional benefits, as well as land use change benefits related to transport. Dynamic land use outcomes plus WEBs include the same dynamic benefits as well as wider economic benefits estimated on dynamic land use outcomes.

This CBA includes conventional transport benefits, as well as transport benefits of changes in households and jobs and wider economic benefits. It does not quantify any non-transport related benefits of these changes and can therefore be seen as a conservative approach. Further research is required to develop a methodology to quantify these non-transport-

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[81] *Department of Environment, Land, Water and Planning, 2021, Victoria's Zero Emissions Vehicle Roadmap, https://www.energy.vic.gov.au/__data/assets/pdf_file/0014/521312/Zero-Emission-Vehicle-ZEV-Roadmap-FINAL.pdf*

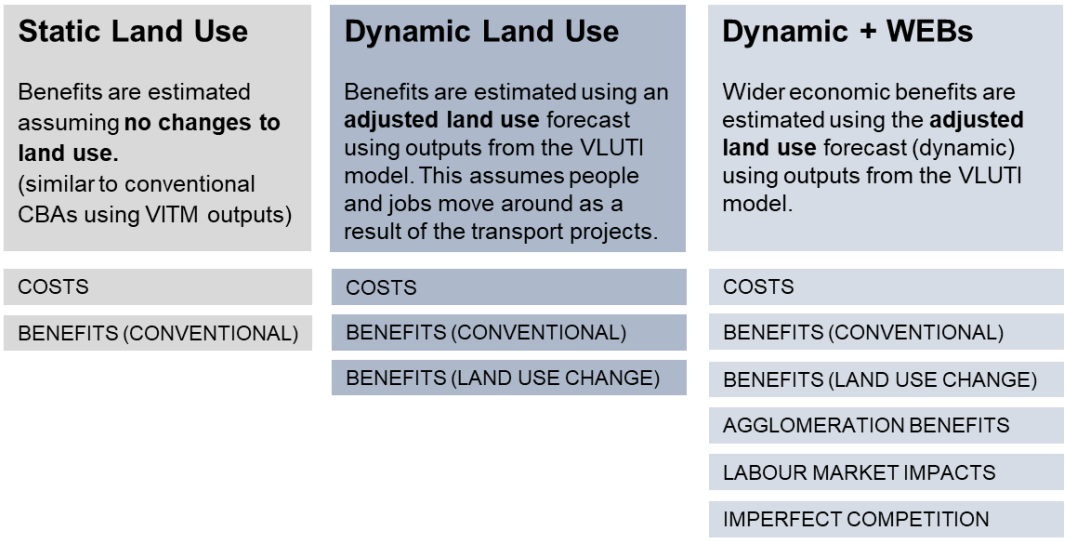
[82] *The MCA was applied to the projects using a combination of weighted sum and outranking methodologies. See Yannis, George, Kopsacheili, Angeliki, Dragomanovits, Anastasios, & Petraki, Virginia. (2020). State-of-the-art review on multi-criteria decision-making in the transport sector. Journal of Traffic and Transportation Engineering (English Edition), 7(4), 413-431.*

[83] *Department of Treasury and Finance, Victoria, 2013, Economic Evaluation for Business Cases Technical guidelines*

related benefits to improved wellbeing, such as place-based benefits including access to more affordable housing or better residential amenity.

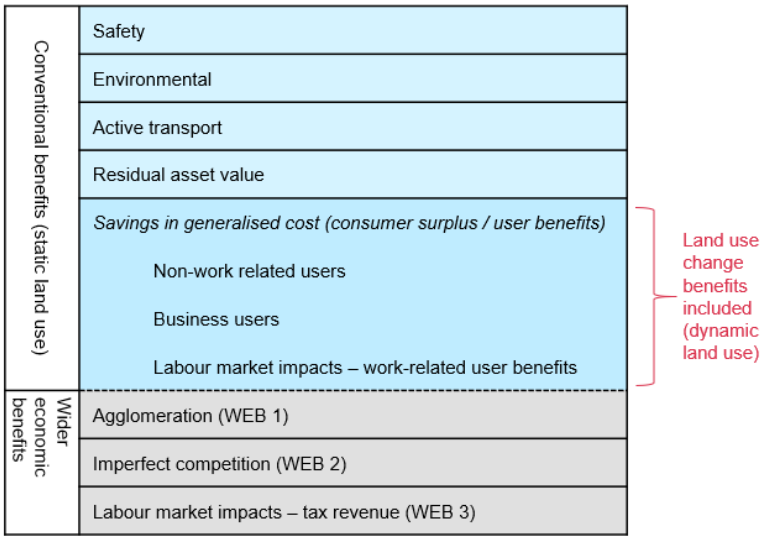
The VLUTI model uses expected utility as a measure of welfare for working and non-working households. This reflects the contributions of wages, residential amenity, commuting costs and housing rental prices.[84] Gross state product (GSP) provides an indication of the economic contributions to welfare, however it does not account for all components of welfare. GSP has been used in this report to provide an indication of the direction of these welfare benefits, noting the limitations with this approach. Further development is required to determine an approach to quantifying these broader welfare benefits and incorporating them into an economic assessment.

Figure 18: Approach to economic assessment



This diagram in Figure 19 outlines how the conventional benefits, WEBs, and land use change benefits all fit together given the static and dynamic land use outcomes. Conventional benefits include safety, environmental, active transport, savings in generalised cost (consumer surplus / user benefits) and residual asset value. Land use change benefits are estimated as the consumer surplus benefits (user benefits) under the dynamic land use scenario (where people and jobs move). WEBs include agglomeration benefits, imperfect competition, and tax revenues from the labour market impacts. Labour market impacts include benefits to workers arising from reduced travel costs, included as a conventional benefit, as well as the tax revenue generated by the labour market, which is included as a wider economic benefit.

Figure 19: Benefits included in the economic assessment



[84] *Infrastructure Victoria 2021 VLUTI Model Architecture Report*

Conventional transport benefits

Conventional benefits that have been quantified in this economic assessment include:

- *Savings in generalised cost* (consumer surplus) – reduced travel time, overcrowding relief and resource corrections for vehicle operating costs and public transport fares.
- *Safety* – savings in crash costs arising from a reduction in vehicle kms travelled and improved network safety which reduces the number of road accidents that are likely to occur.
- *Environmental* – savings in environmental externalities (air pollution, greenhouse, noise, water, nature and landscape, urban separation). Note this assessment assumes no changes due to the uptake of electric vehicles in the future, but we have modelled a scenario which examines this from a transport perspective.
- *Residual asset value* – asset value at the end of appraisal period (50 years).
- *Active transport* – health benefits from increased walking and cycling as part of public transport trips.

These benefits could also create disbenefits when there is a negative impact arising from the project. For example, a road project could increase the vehicle kilometres travelled by cars and therefore create additional environmental externalities or increase vehicle accidents, rather than reducing them.

There will also be other social and environmental benefits that cannot be quantified due to their intangibility or other measurement difficulties. A qualitative analysis of the broader economic, social and environmental outcomes of each project has been undertaken to identify these benefits.

Land use change benefits from transport

The VLUTI model estimates land use changes as a result of transport improvements, resulting in an alternative distribution of population and jobs. For example, an individual or business may choose to relocate to take advantage of lower travel or freight costs resulting from a new transport project and move to an area that has better access to jobs and services.

To estimate the land use change benefits under the dynamic land use scenario, users are split into three user groups:

- New and lost users who shift from one mode of transport to the other or change their destination due to job relocation or trip redistribution. That is, users who change their mode or destination as a result of the project.[85]
- Existing users who stay at the same location (existing-staying users)
- Existing users who relocate to a new location (**existing-relocated users**)

The land use change benefit is estimated as the consumer surplus for this third group of **existing-relocated users**. This is estimated in a similar way to staying users but considers their new location and the altered travel time and cost, given their new location.

Further detail of how the land use change benefits were estimated is provided in AECOM's economics report.

Wider economic benefits

Wider economic benefits (WEBs) are improvements in economic welfare, that have not been typically captured in traditional CBA. They arise from productivity gains and also from market imperfections: that is, prices of goods and services differing from the costs to society as a whole.[86]

This economic assessment includes three categories of WEBs, as per the Australian Transport Assessment and Planning (ATAP) guidelines[87], including:

1. Agglomeration economies
2. Output change in imperfectly competitive markets
3. Tax revenues from labour markets

Further detail of how the WEBs were estimated is provided in AECOM's economics report. WEB 1 (agglomeration economics) and 3 (tax revenues from labour markets) are calculated within the VLUTI model, and cross checked against calculations using the method recommended by the ATAP guidelines.[88] The two approaches produced similar results.

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[85] *New and lost users are identified by calculating the difference of demand for an origin destination pair between the project and the base case. If the difference is positive, the increase of demand is new users. Similarly, if the difference is negative, the reduction of demand is defined as lost users. Further detail of these calculations is provided in AECOMs Economics Report Technical Appendices.*

[86] *Abelson P. (2019). The wider economic benefits of transport infrastructure: A review (Working Paper ITLSWP-19-11). Institute of Transport and Logistics Studies.*

[87] *https://www.atap.gov.au/tools-techniques/wider-economic-benefits*

[88] *https://www.atap.gov.au/tools-techniques/wider-economic-benefits*

WEB 2 (output change in imperfectly competitive markets) is calculated using the approach recommended by ATAP, using outputs from VITM and an assumed upscale factor.

Costs

Costs were sourced from the costing report, and for each project include:

- capital costs
- operating and maintenance costs
- asset renewal costs.

These are described in more detail in the supporting technical report on costs.

3.4.3 Broader economic, social and environmental assessment

This section outlines the broader impacts identified in the economic, social and environmental assessment and considers how they align with the objectives of *Victoria's infrastructure strategy*. We have identified key areas to focus on for each transport project based on a high-level assessment of the level of impact, confidence and data availability, and resources required. These impacts are discussed in the report with qualitative commentary and modelling outputs where available. Chapter 4 details the expected broader economic, social and environmental impacts for each transport project.

Economic

Broader economic benefits

Transport projects that significantly improve accessibility can influence the locational choices of businesses and households.[89] This improved accessibility is provided by reduced travel times, reduced congestion and improved capacity on the transport network. These types of projects can influence urban development and strengthen Victoria's economy through broader economic benefits.[90]

Over time, firms will tend to locate closer to areas that improve their land use efficiency. Being located in areas with high accessibility reduces transaction costs through ease of contact with suppliers and customers. This also increases access to a skilled labour force. Firms will have differing levels of demand for land, as well as ability to pay for areas with high accessibility. This will vary by industry and occupation, with manufacturing and logistics industries requiring larger land plots and knowledge-intensive firms requiring offices with smaller land use requirements. These differences drive the locational choices of firms across the metropolitan area and will influence the level of benefits likely to arise from major transport projects.[91]

Benefits to Victoria's gross state product (GSP) arise through three impacts brought about by major transport projects including:

- new jobs and households created in Victoria as a result of the project
- labour productivity improvements generated through improved accessibility and job location
- improved value chains through greater freight reliability and speed.

Some of these elements are captured by the VLUTI model, which estimates GSP and productivity improvements resulting from the modelled transport projects.[92] These outputs have been used to inform the broader economic assessment for each project (outlined in Chapter 4).

These benefits align with several objectives of *Victoria's infrastructure strategy*, and will contribute positively to the following:

- Objective 1: Prepare for population change
- Objective 3: Reduce disadvantage
- Objective 4: Enable workforce participation
- Objective 5: Lift productivity
- Objective 6: Drive Victoria's changing, globally integrated economy

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[89] *Holl, A. (2006). A review of the firm-level role of transport infrastructure with implications for transport project evaluation. Journal of Planning Literature, 21(1), 3-14; Mackie, P., Graham, D., & Laird, J. (2011). The direct and wider impacts of transport projects: a review. In de Palma, A., Lindsey, R., Quinet, E., & Vickerman, R., eds. A handbook of transport economics, pp.501-526*

[90] *Abelson P. (2019). The wider economic benefits of transport infrastructure: A review (Working Paper ITLSWP-19-11). Institute of Transport and Logistics Studies.*

[91] *Balbontin, C., & Hensher, D. A. (2019). Firm-specific and location-specific drivers of business location and relocation decisions. Transport Reviews, 39(5), 569-588*

[92] *The VLUTI model assumes that total population, households, and jobs in Victoria remain fixed in future under all scenarios, and therefore GSP and productivity improvements do not incorporate any additional jobs and households above this level.*

- Objective 7: Promote sustainable production and consumption
- Objective 10: Build resilience to shocks

Infrastructure cost changes

Previous research by Infrastructure Victoria found that infrastructure capital costs in greenfield areas can be two to four times higher than in established areas, when existing infrastructure in established areas has the capacity to support growth (excluding transport costs). Infrastructure costs can be influenced by several factors in addition to the development setting, and therefore, can vary significantly for different developments within the same setting.[93]

Transport projects that enable a shift in residential development towards incremental growth in established areas that have the capacity to accommodate growth, and away from additional new development in growth areas, will produce a benefit arising from lower infrastructure costs (excluding cost of dwelling and transport). The reverse is also true, in that transport projects that encourage additional residential development in new growth areas, instead of in established areas, will generate additional costs through new infrastructure provision.[94]

Impacts to the cost of providing new infrastructure are only felt when the level of residential development reaches a certain level. Smaller shifts in households are unlikely to have a large impact, given the comparatively smaller demands for local infrastructure.[95]

Consideration of this impact aligns with the objectives of *Victoria's infrastructure strategy* of preparing for population change and promoting sustainable production and consumption.

Place benefits

Place benefits can arise from improved urban amenity in residential and commercial areas arising from a change in population and jobs influenced by the transport project. [96] The change in land use to residential development is likely to result in higher value use, better amenity and quality of development. The location of the change is also important to consider, as residential and mixed-use development in areas which have good access to transport and services will generate greater benefits than in locations with poor access.[97]

Property prices have been used as a proxy to assess this benefit in other jurisdictions. In this report, the VLUTI model produces estimates of property price uplifts at a local area level (Statistical Area 2 (SA2)), which have been used to inform the assessment of each project. However, it should be noted that property prices can be highly volatile and are affected by a wide range of variables, in addition to the type of development.[98] Property prices can be used as a proxy for place benefits but we acknowledge that there are difficulties in isolating the particular impact that could be attributed to each transport project.

This benefit aligns with the objectives of *Victoria's infrastructure strategy* of preparing for population change and promoting sustainable production and consumption.

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[93] Infrastructure Victoria, *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne Technical Paper Volume 1*, Melbourne, Infrastructure Victoria, 2019, p.2, www.infrastructurevictoria.com.au/wp-content/uploads/2019/08/IPIDDS-Metro-Melbourne-Vol-1-Technical-Paper-Aug2019.pdf.pdf

[94] Infrastructure Victoria, *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne Technical Paper Volume 1*, Melbourne, Infrastructure Victoria, 2019, p.2, www.infrastructurevictoria.com.au/wp-content/uploads/2019/08/IPIDDS-Metro-Melbourne-Vol-1-Technical-Paper-Aug2019.pdf.pdf

[95] Infrastructure Victoria, *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne Technical Paper Volume 1*, Melbourne, Infrastructure Victoria, 2019, p.2, www.infrastructurevictoria.com.au/wp-content/uploads/2019/08/IPIDDS-Metro-Melbourne-Vol-1-Technical-Paper-Aug2019.pdf.pdf

[96] *Handy, S. (2003), "Amenity and Severance", Hensher, D.A. and Button, K.J. (Ed.) Handbook of Transport and the Environment, Emerald Group Publishing Limited, Bingley, pp. 117-140 d*

[97] *Merlin, L. A., Levine, J., & Grengs, J. (2018). Accessibility analysis for transportation projects and plans. Transport Policy, 69(C), 35-48*

[98] *Vogiazas, S., & Alexiou, C. (2017). Determinants of housing prices and bubble detection: evidence from seven advanced economies. Atlantic Economic Journal, 45(1), 119-131*

Case Study – Land use changes of historical road projects

Research conducted in 2012 assessed the land use and economic impacts of major transport projects that were already constructed. This report found that the City Loop transformed the northern section of the CBD, while the north west of Melbourne was opened up for both industrial and residential development by the Western Ring Road. CityLink has provided heightened connectivity between the CBD and north and south-eastern parts of Melbourne. The data, statistical analysis and anecdotal evidence all support this.

CityLink was constructed through an established part of Melbourne, meaning it could address existing demand. The Western Ring Road on the other hand generated new demand through its greenfield location, facilitating growth of industrial and residential areas in Melbourne's west. The figures below illustrate the impacts to employment from these two projects.

Figure A: CityLink Employment Impacts (2011)

Figure B: Western Ring Road Employment Impacts (2011)

Source: Long run impacts of major transport projects, SGS Economics & Planning

Case Study – Valuing land use change benefits for the Canberra Light Rail project

The Canberra Light Rail business case released in 2016 included quantified benefits of realising higher density within the cost benefit analysis. The land use benefits that were captured relate to the value of change in land use, that is, where the project unlocks additional development, employment and population along the corridor.

Efforts to activate development along the light rail corridor will generate economic benefits by replacing existing land use with higher value use by improving quality and/or increasing density of developments. The table below outlines the approach used to value the change in land use through property prices and developer costs, which valued only new land use and did not include the value of existing property stock.

The land use benefits of this project were estimated to be $381 million, out of a total project benefit of $984 million (present values).

Table 25 Approach for value of change in land use

Benefit	Element	Method
Value of change in land use	Market value of new land use	Estimate of sales value of the properties, or present value of the stream of future rental values.
	less market value of existing land use	Estimate of sales value of existing properties, or present value of the stream of future rental values.
	less enabling and development costs	Developer's costing.
	less marketing and financing costs	Developer's costing.
	Taxes	All the above costs should be net of taxes and duties

Source: Canberra Light Rail Business Case, ACT Government

Social

Transport projects can improve access to community and services providing social benefits, particularly in areas that currently have poor or limited access to these services.[99] Suitable and accessible transport options can also reduce the risk of exclusion from economic, social and political participation in society for at-risk groups.[100] Research in south-eastern Melbourne communities found that, among other factors, a lack of transport services and the distances involved in accessing services and communities is a key barrier for socially isolated groups. This is particularly the case for disadvantaged cohorts including those under 20 years, over 75 years, and people with a disability[101] Transport projects that provide better services for diverse and disadvantaged groups will generate social benefits that are not quantified in this economic evaluation.

NEICs and health and education precincts identified in *Plan Melbourne* have an important role to play in providing access to health care, education and other community services in locations outside the CBD and closer to residential

[99] *Thomas, R. (2020). Social equity and disadvantage. In Curtis, Carey. ed., Handbook of Sustainable Transport. Edward Elgar Publishing, pp. 37-47*

[100] *Martens, Karel, Jeroen Bastiaanssen and Karen Lucas (2019), 'Measuring transport equity: key components, framings and metrics', in Karen Lucas, Karel Martens, Floridea Di Ciommo and Ariane Dupont-Kieffer (eds.) (2019), Measuring Transport Equity, Amsterdam: Elsevier, pp. 13–36*

[101] *SGS Economics & Planning, Social Isolation in the Southern Melbourne Region - Issues Paper 2019* https://www.parliament.vic.gov.au/images/stories/committees/lsic-LA/Early_childhood_engagement_in_CALD_communities/Submissions/018_attach4_2019.10.11_-_City_of_Greater_Dandenong.pdf

areas including growth areas.[102] Transport projects that improve access to these precincts from residential areas will contribute to improving social and health outcomes for residents.[103]

Health and safety

Transport projects can improve health outcomes if they encourage more active transport trips, such as walking or cycling.[104] Residents living in neighbourhoods with better active and public transport options are likely to undertake more physical activity when travelling.[105] Public transport projects that encourage more walking and less car-based transport will contribute to improved health outcomes.[106] Active transport can also reduce barriers to accessing health, education and other services.[107] Consideration should also be given to ensuring active and public transport options improve access for a diverse range of people, including both existing and new users.

Transport projects can also have a negative impact on health outcomes. Car and truck exhaust carries fine particles (PM2.5) which are small enough to lodge in people's lungs and potentially the bloodstream. Long-term exposure can lead to heart disease and respiratory infections and contribute to slight increases in mortality effect.[108]

Transport projects also contribute to accidents and deaths, either from increased risks on local and arterial roads, or from reduced risks on freeways.[109] These impacts are quantified in the conventional economic assessment, where the safety benefit calculates fatalities and injuries on the road network. There could be additional unquantified impacts from accidents and deaths caused by transport projects.

Disadvantage

Transport projects improve access to employment opportunities, education, health care, and community and social services.[110] This can lessen levels of disadvantage for residents in areas that have improved access as a result of the transport intervention.[111] However, a transport project can also negatively impact levels of disadvantage for residents who may have levels of access reduced due to poor affordability or other changes.[112]

For example, a transport project improves access to a location that previously had poor access to jobs and services, making the area more attractive to residents and likely resulting in higher property prices.[113] This brings about benefits for residents who can afford to remain in the area and who may benefit from higher property prices and improved access to jobs and services. However, it may also cause residents who cannot afford to remain to move to a cheaper location with poorer access to jobs and services, thereby impacting levels of disadvantage.[114] Planning for transport projects that are integrated with land use planning can potentially enable a greater diversity of housing, for example, in proximity to railway stations, which can help housing affordability and choice.[115]

Housing affordability

Transport projects that influence land use change can improve access to affordable housing in areas that are well connected and provide more housing options in established areas.[116] Transport projects can also make housing less

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[102] Department of Environment, Land, Water and Planning, *Plan Melbourne 2017-2050*, 2017, p.10, https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy_.pdf

[103] *Geurs, K., Boon, W., & Van Wee, B. (2009). Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom. Transport Reviews, 29(1), 69–90*

[104] *Gössling, S., Nicolosi, J., & Litman, T. (2021). The health cost of transport in cities. Current environmental health reports, 1-6*

[105] *Stappers, N. E. H., Van Kann, D. H. H., Ettema, D., De Vries, N. K., & Kremers, S. P. (2018). The effect of infrastructural changes in the built environment on physical activity, active transportation and sedentary behavior–a systematic review. Health & place, 53, 135-149*

[106] *Patterson, R., Webb, E., Millett, C., & Laverty, A. A. (2019). Physical activity accrued as part of public transport use in England. Journal of Public Health, 41(2), 222-230*

[107] *Infrastructure Victoria 2019, The Role of Infrastructure in Addressing Regional Disadvantage https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/11/Background-paper_The-role-of-infrastructure-in-addressing-regional-disadvantage.pdf*

[108] Broome, R. A., Powell, J., Cope, M. E., & Morgan, G. G. (2020). The mortality effect of PM2. 5 sources in the Greater Metropolitan Region of Sydney, Australia. *Environment international*, 137, 105429.

[109] *Muir, C., Johnston, I. R., & Howard, E. (2018). Evolution of a holistic systems approach to planning and managing road safety: the Victorian case study, 1970–2015. Injury prevention, 24(Suppl 1), i19-i24 ; Noland, R., & Quddus, M. (2004). A spatially disaggregate analysis of road casualties in England. Accident Analysis and Prevention, 36(6), 973–984*

[110] *Geurs, K., Boon, W., & Van Wee, B. (2009). Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom. Transport Reviews, 29(1), 69–90*

[111] *Lucas, K. (2012). Transport and social exclusion: Where are we now? Transport policy, 20, 105–113*

[112] *Currie, G. and Delbosc, A. (2011), "Transport Disadvantage: A Review", Currie, G. (Ed.) New Perspectives and Methods in Transport and Social Exclusion Research, Emerald Group Publishing Limited, Bingley, pp. 15-25*

[113] *Chen, Y., Yazdani, M., Mojtahedi, M., & Newton, S. (2019). The impact on neighbourhood residential property valuations of a newly proposed public transport project: The Sydney Northwest Metro case study. Transportation Research Interdisciplinary Perspectives, 3, 100070*

[114] *Delmelle, E. C., Nilsson, I., & Bryant, A. (2020). Investigating Transit-Induced Displacement Using Eviction Data. Housing Policy Debate, 1-16*

[115] Scheurer, J., & Curtis, C. (2019). Reducing social spatial inequity with public transport in Melbourne, Australia. In A Companion to Transport, Space and Equity. Edward Elgar Publishing.

[116] *Saberi, M., Wu, H., Amoh-Gyimah, R., Smith, J., & Arunachalam, D. (2017). Measuring housing and transportation affordability: A case study of Melbourne, Australia. Journal of Transport Geography, 65, 134–146*

affordable by making places more attractive, which increases demand for housing from people moving to the area.[117] A range of factors influence the housing market, including demand for housing, supply, interest rates, availability of finance, incomes, and government policy.[118] Housing affordability is affected by many factors, including the supply of new dwellings. First home buyers and low income households may find it more difficult to afford housing in locations with limited supplies of new dwellings.[119]

Transport accessibility

Transport projects result in improved access to job opportunities, education and services across various precincts and regions. This gives working-age residents greater access to jobs and employment opportunities, particularly in areas that currently have poor or limited access. For those who are studying, transport projects can improve access to education including secondary schools serving large catchments, TAFEs and universities. All Victorians need access to key social infrastructure, services, shops and recreation, and transport projects provide important connections to the places in which these are located.[120] Transport connections can create opportunities for people to develop their social capital and economic resources, along with better land use planning.[121] Public transport is particularly important for groups who do not or cannot drive, including young and older people, those with disabilities and people with low incomes for whom car ownership is prohibitively expensive.[122]

The degree to which a transport project improves accessibility can also vary by gender, given the differences in occupations, work hours and opportunities that are available to men and women.[123] Travel patterns of men and women can differ, depending on a range of factors including trip purpose, time of day and location. Evidence of differing travel patterns shows that typically the primary caregiver is more likely to trip chain (for example, combining a work trip with an unpaid care trip such as a school drop off) and can therefore have greater issues with transport accessibility.[124]

In Australia, women are more likely to be caregivers and thus more likely to trip chain. Men are more likely to take a typical work trip. These roles are slowly changing, with greater sharing of parenting and caregiving responsibilities and more part-time work for both men and women.[125]

Transport network improvements and improved land use planning that better meets the needs of parents and caregivers have the potential to further improve access to jobs and provide greater independence, more job opportunities and increase labour force participation for those with caregiving responsibilities.[126] Greater participation in the workforce supports economic growth.[127]

Better understanding the distribution of the impacts, including for different cohorts such as gender, caregiver roles and age would provide greater understanding of the impacts, benefits and opportunities of transport and other projects.[128] It would also ensure that project design considers the varying needs of all users and provides improved transport and land use outcomes. Recent advances in modelling, such as the MABM model which uses agent-based modelling, is a step forward in better understanding how changes to the transport network can affect different cohorts.[129]

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[117] Essential Economics, *Viability of High Density Residential Development in Activity Centres Refresh, 2018*, https://www.planning.vic.gov.au/__data/assets/pdf_file/0028/392752/FINAL-REPORT-Viability-of-High-Density-Residential-Development-in-Activity-Centres-Refresh-EE-Report.pdf

[118] *Yates, J. (2011) Housing in Australia in the 2000s: On the Agenda too Late? Sydney: Reserve Bank of Australia, https://www.rba.gov.au/publications/confs/2011/yates.html*

[119] *Been, V., Ellen, I. G., & O'Regan, K. (2019). Supply skepticism: Housing supply and affordability. Housing Policy Debate, 29(1), 25-40*

[120] *Geurs, K., Boon, W., & Van Wee, B. (2009). Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom. Transport Reviews, 29(1), 69–90; Bastiaanssen, J., Johnson, D., & Lucas, K. (2020). Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence. Transport reviews, 40(5), 607-628*

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[123] *Craig, L., & van Tienoven, T. P. (2019). Gender, mobility and parental shares of daily travel with and for children: a cross-national time use comparison. Journal of transport geography, 76, 93-102*

[124] *Francis, S and Pearce, K 2020. Reimagining movement and the transport appraisal process through a gender lens: a case study in the United Kingdom utilising a lifecycle approach*

[125] *Craig, L., & van Tienoven, T. P. (2019). Gender, mobility and parental shares of daily travel with and for children: a cross-national time use comparison. Journal of transport geography, 76, 93-102*

[126] *McQuaid, R. W., & Chen, T. (2012). Commuting times–The role of gender, children and part-time work. Research in transportation economics, 34(1), 66-73*

[127] *https://treasury.gov.au/publication/corporate-plan-2016-17/increasing-productivity-and-workforce-participation*

[128] *Lowe, C., Stanley, J., & Stanley, J. (2018). A broader perspective on social outcomes in transport. Research in transportation economics, 69, 482-488*

[129] *Ahanchian, M., Gregg, J. S., Tattini, J., & Karlsson, K. B. (2019). Analyzing effects of transport policies on travelers' rational behaviour for modal shift in Denmark. Case studies on transport policy, 7(4), 849-861; Gillian Harrison, Enzo Bivona & Rosaldo Rossetti (2020) Editorial: Special issue on Simulation in Transportation, Journal of Simulation, 14:4, 239-241*

The projects assessed in this report have the potential to improve access to jobs, services, education and recreation in different ways. They can also create challenges for accessing important social and recreational infrastructure by creating physical barriers in existing neighbourhoods or catchments. Analysis of these potential impacts is a developing area that requires further research and development.[130] Consideration of how these impacts could be included in transport assessments are further explored in section 4 within each project's broader economic assessment.

Environmental

Like any large-scale infrastructure, general building, and development for population growth, major transport projects can cause negative environmental impact and result in the generation of additional CO_2 emissions both during and after construction.[131] Some impacts, such as decisions about route alignment, can be avoided through spatial planning and design but unavoidable impacts may require actions for mitigation, including offsets and restoration.[132]

The conversion of natural landscapes to impervious surfaces for roads or other paved surfaces presents challenges for the environment. This includes stormwater management challenges with more extensive impervious surfaces, waterway pollution from road runoff, impacts to biodiversity including fragmentation of habitat and movement corridors, and loss of tree canopy.[133] Established trees may be removed where they are in the path of the alignment, or to establish construction zones, contributing to the loss of tree canopy.[134]

Transport projects that reduce the amount of natural environment and tree canopy, and increase the area of hard, constructed surfaces, can contribute to worsening urban heat island effects, particularly in built up areas such as cities.[135] Consideration should be given to the extent that a project contributes to urban heat island effects and is designed to minimise the impacts as far as possible.[136]

Road transport projects also contribute to increased CO_2 emissions if there is induced demand for additional travel and freight movements in internal combustion engine (ICE) vehicles.[137] Air pollution from transport-related fine particles carried by wind can negatively impact on human health, ecosystems, biodiversity, waterways and soils.[138]

These impacts should be mitigated through encouraging use of ZEVs and provision of additional low emission public transport options. This could include electric buses and exploring options for lower emission trains and trams.[139] Encouraging people to use active transport modes such as walking and cycling will also contribute to positive environmental outcomes.[140]

These impacts align with the objective of *Victoria's infrastructure strategy* of protecting and enhancing natural environments and advancing climate change mitigation and adaptation.

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[132] *Department of Environment, Land, Water and Planning (2017) Guidelines for the removal, destruction or lopping of native vegetation, Victorian Government, East Melbourne, https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/91146/Guidelines-for-the-removal,-destruction-or-lopping-of-native-vegetation,-2017.pdf*

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[138] *Colvile, R. N., Hutchinson, E. J., Mindell, J. S., & Warren, R. F. (2001). The transport sector as a source of air pollution. Atmospheric environment, 35(9), 1537-1565; Barker, Jerry R, and David T Tingey. (2012) Air Pollution Effects on Biodiversity. Boston: Springer*

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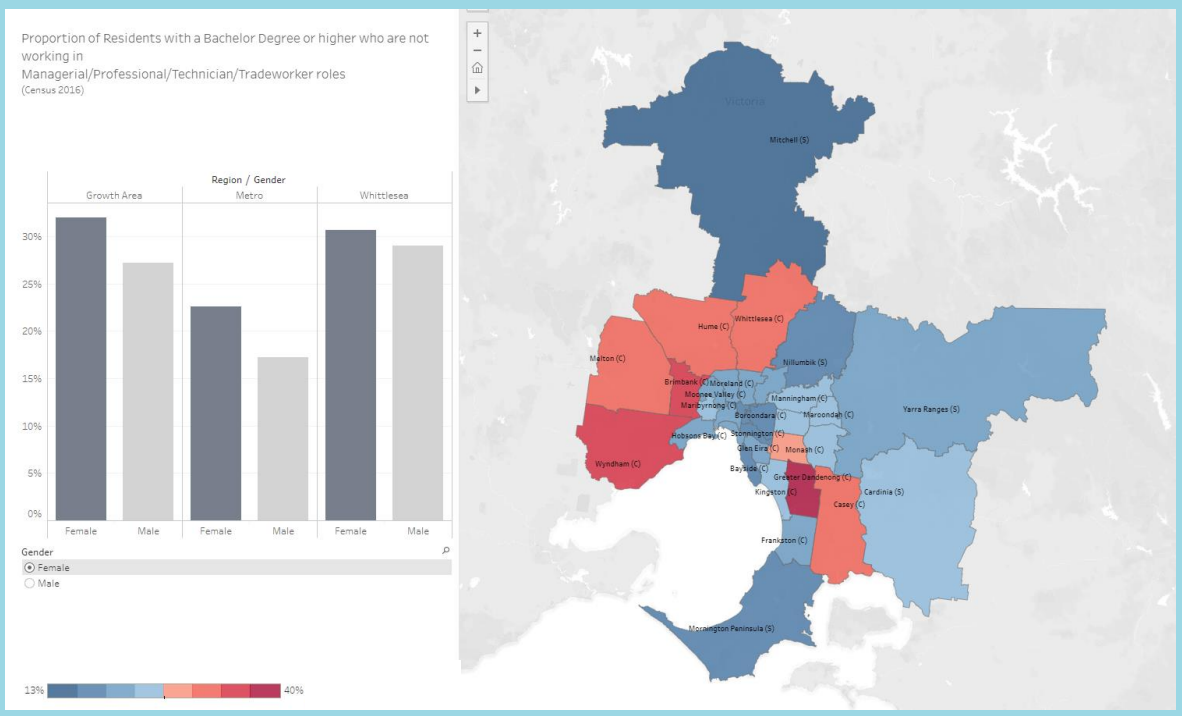
[140] *Brand, C., Dons, E., Anaya-Boig, E., Avila-Palencia, I., Clark, A., de Nazelle, A., Gascon, M., Gaupp-Berghausen, M., Gerike, R., Götschi, T. and Iacorossi, F. (2021). The climate change mitigation effects of daily active travel in cities. Transportation Research Part D: Transport and Environment, 93, 102764*

Case Study – Analysis of gender equity in employment in Melbourne's growth areas
Analysis of occupations, skills, income and education levels by gender across local government areas (LGA) in metropolitan Melbourne found that growth area LGAs have a high proportion of both men and women with a Bachelor degree or higher who are not working in managerial/professional/technician roles.

While there was gender inequality in employment across all locations in Melbourne, it was most pronounced for women in growth areas. Tertiary educated women living in growth areas are less likely to be in a job that reflects their level of qualification compared to men, and compared to women living in inner and middle areas. The analysis found that women travel shorter distances to full-time employment than men across metropolitan Melbourne, and more women do more unpaid childcare than men, especially in growth areas.

This suggests that highly educated residents in these areas are not working in jobs that match their skill level, which is more pronounced for women. This could be due to a range of factors, such as lack of suitable work opportunities that are within a suitable commuting distance, or family and caring responsibilities.

Transport projects that improve access to jobs that better match the skills of residents in growth areas will have even greater benefits. This includes benefits not only for the individual but also for the broader economy, through improved labour force participation.



Source: SGS Economics & Planning, Gender Equity in Employment – Report prepared for City of Whittlesea

3.4.4 Future scenarios

We have assessed the impacts of six future scenarios on each major transport project. This future scenario assessment has been informed by several inputs, including VLUTI model outputs for two scenarios (working from home and electric and autonomous vehicles), population growth projections from the ABS, and previous research undertaken by Infrastructure Victoria on supporting homes in priority areas and TNP. This section outlines our approach for each future scenario. Further details are provided in Appendix A.

High and low population growth

Two alternative population growth scenarios have been developed:

- High growth scenario – assumes Victoria's population grows **faster** than baseline growth rates.
- Low growth scenario – assumes Victoria's population grows **slower** than baseline growth rates.

The low and high growth scenarios are based on the official forecasts published by the ABS for Victoria, using the low and high series forecasts.[141]

Under the baseline scenario, Victoria's population is forecast to reach 8.7 million by 2036. Under the high growth scenario, the population reaches 8.7 million four years earlier, by 2032. Conversely, under the low growth scenario, the population is not expected to reach 8.7 million until 2043, almost seven years later than the baseline. The baseline scenario assumes an annual average growth rate of 1.8% per year to 2036, whilst the high scenario assumes a 2.2% annual growth rate, and the low scenario assumes a 1.3% annual growth rate.

These differences become more pronounced in the longer term. By 2051, Victoria's population is forecast to reach 10.5 million people. Under the high growth scenario the population is expected to reach 10.5 million by 2043, seven years earlier. Under the low growth scenario the population is not expected to reach 10.5 million until 2066, 15 years later than the baseline scenario.

We have assumed that the transport and land use model outcomes from the baseline scenario occur in line with the high and low population growth scenarios. That is, expected 2036 model outcomes are now assumed to occur in 2032 in the high growth scenario, and in 2043 in the low growth scenario. This simplifying assumption has been used to demonstrate the variation in demand, rather than provide a specific result under alternative growth scenarios.

Working from home

A working from home (WFH) scenario has been developed to assess the impacts of working from home arrangements on the economy, transport and land use outcomes, and on major infrastructure projects. We have used the VLUTI model to investigate the potential medium to long-term infrastructure and land use implications of increased working from home for some industries/professions in Victoria. Detail on how the VLUTI model works and the changes made for this scenario can be found in Appendix E and the *VLUTI Model Architecture Report*.

The following adjustments were made to the VLUTI model to create the WFH scenario, to model the impacts on transport and land use outcomes.

1. The share of workers within each occupation that are able to work from home was identified. These occupations were selected and estimated based on international evidence and ABS data. All further adjustments were only made to these selected occupations.
2. We adjusted the commuting cost coefficient in the model to account for the reduced costs of commuting when working from home for approximately two additional days per week. The reduced commuting costs impact the choices that working households make around where to live and work, as well as in what occupation.
3. We adjusted other indirect cost shares associated with working from home in the model. These include household transport costs, household internet costs and firm internet costs.
4. We adjusted the number of trips made in the transport model (VITM) by two days per week (on average) for those in working from home occupations.

Electric and autonomous vehicles

The VLUTI model has been used to model an alternative future scenario with electric and automated vehicles (EAV). This modelling and our assessment of this scenario is also informed by previous Infrastructure Victoria advice on this topic.[142]

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[141] *ABS Population Projections, Australia 2017 – 2066, released Nov 2018* https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release#victoria

[142] *Infrastructure Victoria 2018, Automated and Zero Emissions Vehicles Infrastructure Advice*

There is significant uncertainty around the overall timing and extent of impacts of this sensitivity test, particularly around AVs. A wide range of possible future outcomes are possible with the rise of ZEVs and AVs and this sensitivity only tests one particular outcome. For more detail on the effects of other possible scenarios involving AVs, see Infrastructure Victoria's *Advice on automated and zero emission vehicles infrastructure 2018*.

The AV component of this scenario considers both privately owned vehicles and hire vehicles which are analogous to existing taxi services ('fleet AVs').

The key input changes, compared to the network development scenario, which the EAV scenario tests are:

- **Changes to value of time (VOT)**: Given the broader flexibility of how one spends their time when riding within an AV, the perceived in-vehicle cost of travel will be lowered compared to a conventionally driven vehicle (CDV).
- **Changes to Vehicle Operating Cost (VOC**): Past research by Infrastructure Victoria has indicated that the VOC of electric vehicles is lower than that of a CDV due to several factors. Modifications to the VOC vary based on assumed fleet mix and region.
- **Network Operating Efficiency**: The lane capacity assumptions across the statewide network have been altered to reflect operating efficiency gains that could potentially accompany the introduction of AVs. AVs will adopt 50% of the capacity of ordinary vehicles on freeways. For arterials, this will increase to 67%, representing diminishing returns in a more complex environment. For local and secondary roads, it will be assumed that AVs will not perform any better than conventional vehicles.
- **Dead Running**: A portion of private AV use will involve empty vehicles returning to their origin after their owners reach their destination. This will be represented within the VITM by taking a proportion of trips within a time period, flipping their direction and applying that back to the highway assignment process in order to represent this extra demand. The VOC component of the dead running will be added to overall costs for the trip.
- **Increased Trip-Making due to Lower Perceived Travel Costs**: Related to the impacts of AVs set out above is an expected general reduction in the perceived cost of car travel, potentially leading to not only a shift in modal choices, but also an increase in overall trip making activity.

The trajectory of take up of electric and autonomous vehicles is shown in the following table. By 2036, 11.5% of vehicles are modelled as being autonomous, which rises to 46.5% by 2051. Fleet AVs were assumed to have a higher take up in inner and middle areas of Melbourne, where there is more intensive trip making that could support this commercial service. Private vehicle trips are assumed to continue to dominate journeys in outer and regional areas, with the take up rate of electric or autonomous vehicles being stronger in Inner Melbourne and lowest in regional Victoria. This assumed future fleet mix is based on Infrastructure Victoria and Arup's research, including our *Advice on automated and zero emission vehicles infrastructure 2018,* and professional judgement regarding a plausible future uptake and share of different vehicle types in Victoria.

Table 3: Assumed Future Fleet Mix

Note: Total share proportions are indicative based on the number of trips originating from each FUA based on reference case results from the problem definition modelling report. As mode share shifts, these proportions are likely to shift in turn.

Year	Region	PV Trip Share	CDVs	Electric CDVs	Private AVs	Fleet AVs
2036	Inner	*69%*	48%	32%	10%	10%
	Middle	*91%*	55%	30%	7.5%	7.5%
	Outer	*96%*	65%	25%	5%	5%
	Regional	*99%*	68%	25%	4%	3%
	Total Share	-	*61.5%*	*27.0%*	*5.9%*	*5.6%*
2051	Inner	*68%*	0%	20%	30%	50%
	Middle	*90%*	5%	35%	35%	25%
	Outer	*95%*	10%	50%	25%	15%
	Regional	*98%*	20%	50%	20%	10%
	Total Share	-	*10.4%*	*43.2%*	*26.5%*	*20%*

Source: Arup 2021 Strategic Modelling Outcomes Report

Transport network pricing

Previous research undertaken by Infrastructure Victoria provided a strong evidence base to inform our assessment of this scenario and how it impacts the major transport projects. This previous research includes:

- *The Road Ahead: How an efficient, fair and sustainable pricing regime can help tackle congestion,* released November 2016
- *Five Year Focus: Immediate actions to tackle congestion,* released in April 2018
- *Good Move: Fixing transport congestion,* released March 2020
- *Fair Move: Better public transport fares for Melbourne,* released September 2020

The research covered in these reports includes direct access to community opinion, transport modelling, international case studies and the advice of policy decision-makers to help inform not only the fundamentals of a TNP scheme, but also the implementation pathway.

The transport and equity impacts of a reformed TNP scheme were modelled previously using the Melbourne Activity and Agent Based Model (MABM). One of the greatest strengths of the MABM is that it is an agent-based model, capable of tracing the movements of individual 'agents' or travellers as they move around Greater Melbourne throughout the day. By using the MABM to model future scenarios we can identify not only the overall impact on the transport network from pricing reform, but also identify who is better off, and by how much.

Key findings from the model outputs produced by MABM were used to assess the impacts of introducing transport network pricing on the major transport projects.

Supporting more homes in established places

Previous research undertaken by Infrastructure Victoria for the draft strategy has been used to inform our assessment of the impacts of this future scenario on the major transport projects. In this work, a scenario that simulated land use zoning changes which permitted more homes near the principal public transport network in 2036 was modelled in the VLUTI model.[143] Key findings from this modelling on the impacts to the transport network and land use have been used to assess the impacts of supporting more homes in established places alongside the major transport projects.

[143] *See Arup Problem Definition Modelling Outcomes report (Nov 2020) for full detail and analysis of modelling conducted for Infrastructure Victoria's draft strategy. This VLUTI model was a previous iteration of the current version used in assessing the major transport programs in this report. https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/12/ARUP-Problem-Definition-Modelling-26-October-2020.pdf*

4. Major Transport Projects

4.1 Overview

This chapter presents the results of our assessment of major transport projects that support future growth and have the potential to shape transport and land use outcomes.

Consistent with Infrastructure Victoria's guiding principles to make better use of existing infrastructure before embarking on building new infrastructure, this chapter first presents our assessment of the Road Management Systems (RMS) project.

The remainder of this chapter is concerned with building major capital-intensive transport infrastructure projects, which range from new motorway infrastructure to new rail tunnel projects, to provide critical future network capacity and support expansion of the electrified rail network into significant population growth centres (including City of Greater Geelong, Melton LGA, Mitchell LGA, and Wyndham LGA). These include (shown below in Figure 20):

- City Loop reconfiguration and northern rail corridor upgrade (CLR)
- Cross city motorway (CCM)
- Melbourne Metro Two and direct Geelong rail service (MM2G)
- Outer Metropolitan Ring Road (OMR)
- Western rail corridor upgrade (WRU).

The assessment of the OMR is on the road component of this corridor as the assessment of the rail line is integrated with the interstate rail network and Inland Rail Project, and therefore needs to be considered from a national perspective with the Australian Government.

Figure 20: Overview of Major Transport Projects

Source: Arup 2021

Note: RMS applies to parts of the network within the dotted grey boundary in Metropolitan Melbourne.

4.2 Improving Road Network Management Systems

Objectives

The Road Management Systems (RMS) project aims to transform the operational performance to improve the use of the road network for all modes. The existing road network will need to accommodate most of the future growth in trips. This project involves improving the management of the road network using a combination of up-to-date technology, modifications to the layout of roads and the development and application of innovative and improved operational practices.

Examples of this include upgrading traffic signals and detection information to make real-time decisions about what changes should be made to a traffic signal cycle, and using technology to change the function of a lane. This could be applying a clearway, bus lane, or switching the operational direction of a lane so that the road can change to better meet travel demand. These initiatives get better use out of our existing road network by taking a dynamic approach to network operations.

The RMS project is expected to support the following four objectives of *Victoria's infrastructure strategy*:

- **Objective 1:** Prepare for population change - through increasing capacity and functionality of the road network to support more efficient operations, while supporting a more dynamic approach to transport mode prioritisation.
- **Objective 4:** Enable workforce participation - through better connecting people and jobs by reducing travel times and improving the reliability of journey times across the network, according to network priorities.
- **Objective 5:** Lift productivity - by boosting market access and improving connectivity to enhanced labour skills with more reliable and efficient key transport links.
- **Objective 6:** Drive Victoria's changing, globally integrated economy - through efficient transport network performance, which improves commercial vehicle travel across the network.

Need

A 2014 Victorian Auditor General's report into *Using Information Communications and Technology (ICT) to Improve Traffic Management* found that the effectiveness of existing traffic systems is limited when road capacity is increasingly saturated.[144] At the time of the audit it was also identified that VicRoads was only reviewing, on average, 200 traffic signal sites per year (there are 4,000 traffic signals sites across Victoria), or a quarter of its internal five-year target. Although a budget commitment was recently made (mid-2020) to both update existing ICT systems and increase the number of yearly traffic signal reviews from 200 to 500, the premise for this particular project was to model and estimate potential improvements to RMS that could improve on-road transport system performance.

In June 2020, the Victorian Government announced $340 million in funding for the Smarter Roads project which includes installing 700 CCTV cameras to identify bottlenecks, 200 wireless travel time sensors and 40 new visual message boards across parts of Melbourne. Additional measures included reinstatement of temporarily suspended road occupation charges, which charges private parties daily for occupying road space on the arterial network,[145] as well as six extra incident response crews and new extended towaway zone status for clearways within 15km of the CBD.[146]

As the existing funding commitment is expected to involve rolling out the Smarter Roads to select parts of the road network, our assessment has been carried out on the basis that the rollout be expanded network-wide and hence expected benefits will flow to all arterial roads across Greater Melbourne.

Our assessment of the RMS project will be undertaken compared to conditions without the Smarter Roads project. It should be noted that some of the benefits of this assessment are expected to be achieved by the state government's Smarter Roads project in improved road operations management.

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[144] *Victorian Auditor General Office 2014. Using Information Communications and Technology (ICT) to Improve Traffic Management*

[145] *VicRoads https://www.vicroads.vic.gov.au/traffic-and-road-use/road-occupation-charging#:~:text=The%20road%20occupation%20charge%20is,worksite%20on%20an%20arterial%20road*

[146] *VicGov Media Release June 2021, https://www.premier.vic.gov.au/keeping-victorians-moving-during-coronavirus/*

How can road management systems improve journeys?

Examples of when road management systems could potentially improve traffic flows are:

- Traffic waiting at a red light for long periods or having to wait for multiple red and green light cycles before passing through, whilst no or little vehicles move through the intersection. Intersections which are pre-programed will continue to run traffic cycles which do not reflect the current needs of the intersection. This delay is unnecessary and leads to frustration for all road network users.
- Roads which experience significant imbalances of moving people or vehicles, particularly in managing peak hour traffic, with some lanes or pedestrian crossing having queues and others are less full. For instance, being able to modify how different lanes are used dynamically across the day such as switching their direction, allowing or restricting parking and allocating them for particular types of vehicles, such as public transport, can better help manage the number of people travelling in the peak direction.
- Receiving better advice and altered traffic conditions in response to unexpected incidents, such as accidents, or planned disruptions, including due to construction, by changing traffic signals and advisory signage in real time.

Project Description

The assessment of the RMS project involved estimating and capturing the potential impacts of improving existing road operations technology and traffic management – primarily on arterial roads at a network level. Three separate interventions were implemented and combined to model the effect of all three interventions on the road network simultaneously. The three interventions, which represent an approximation of the impact of Road Management Systems project, are listed below:

1. **Improvements to arterial road operations management systems**, with different treatments across the network to support more efficient movements across Melbourne, whilst particularly aiming to improve roads with trams.[147]
    - For Inner Melbourne, operational efficiencies were applied for all roads with tram services[148] to reflect better travel for trams along the road under the same conditions. Private vehicle and freight traffic using these roads also benefitted from these efficiency improvements. However, users of other roads did not receive these efficiency benefits. The purpose of focussing the efficiency improvements on roads with trams was to support public transport use in Inner Melbourne where it has been forecast that road congestion will significantly increase in coming decades.
    - For Middle and Outer Melbourne, all primary and secondary arterial roads were assumed to achieve operational efficiencies to reflect the upgrade of all intersections on these roads. This improvement was also experienced by public transport which operate along these corridors
2. **New clearways** to provide additional capacity and to help facilitate the movement of traffic. The north-south corridor from Grange Road Fairfield to Denmark Street Hawthorn along with Church Street Hawthorn was among those chosen to be illustrated as a case study following a network-wide assessment.[149]
3. **On-road public transport improvements** to help facilitate the efficient and reliable movement of public transport through congested parts of the road network using clearways, dedicated lanes, and lane management systems. An example of this was extending the Johnston Street (Fitzroy) lane management system which was extended further west from Wellington Road to Nicholson Street. Overhead lane use management gantries allocated one lane to be a continuous bus lane, two traffic lanes in the peak direction and one lane for counter peak traffic. To realise this, it was assumed that some sections had parking restrictions on both sides of the road during peak periods. A bus lane was also allocated on Elgin Street to provide a continuous lane through to Carlton (Lygon Street).

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[147] *Arup undertook sensitivity testing to the VLUTI model to determine a suitable network efficiency improvement, which determined that a 6.25% increase in freeflow and lane capacity would result in a 5% reduction in Vehicle Hours travelled, indicating faster travel times on the network. Further information is available in the Arup Demand Modelling Report*

[148] *In inner Melbourne, roads with the 'Tram and Shopping and Parking' designation received the network efficiency improvement*

[149] *Other examples were also included but modelled outcomes indicated that these were too localised to have a meaningful impact and therefore were not explicitly considered in this assessment*

A general provision for complementary road layout works was assumed to be needed given the strategic nature of VLUTI. This was assumed to comprise the **Arterial Road Network Employment Centre Enhancements (ARN)** that was developed for the 2016 strategy. This project involved "Targeted upgrades to the road network surrounding major employment centres to support their development by improving access and avoiding bottlenecks, with design prioritisation given to public transport".[150] The capital implementation cost was estimated to range between $1 to $3 billion in 2016 dollars.

The strategic nature of VLUTI is not able to capture active transport interventions, and as such no active transport initiatives have been modelled in this project. Therefore, this project scope only explores the impacts of road management systems with regards to the interventions described above. However, the system can be applied for the benefit of cyclists.[151] [152]

Case Study – Better road management technology can support cyclists

Advanced traffic signal control has been used to reduce delays for cyclists along Canning Street, by detecting the cyclist approaching the intersection and altering the phase of the signals. For cyclists travelling at 22-26 kmph, the new technology is coordinated to provide non-stop passage from Brunswick to Melbourne's CBD. A similar approach has been taken on Albert Street in East Melbourne, which measured improvements in average travel times for cyclists of about 20% in the morning peak, with minimal delays for private vehicle speeds.

Project Costs and Timing

A cost range was established with the project's lower cost being focussed on the three interventions that were modelled and the Arterial Road Network Enhancement Program.

The total estimated cost of RMS, inclusive of planning, construction / implementation, contingencies, and maintenance costs are shown in the table below. Details of these are presented in *Infrastructure Victoria's Major Transport Program Capital Cost* and *AECOM Cost Report*.

The capital expenditure costs of the roads are shown in the following table. Contingencies for design, construction and prolongation have also been included in the total cost.

The road operations management system and clearway has been assumed to be progressively implemented from 2022 to 2025, and the road layout improvements to be progressively implemented by 2036.

Table 4: RMS capital expenditure cost profile (2020 dollars)

Project	Lower Cost ($ millions)	Upper Cost ($ millions)
Road operations management systems improvement	745	745
Clearway implementation	10	10
Road layout improvements (including public transport)	3,800	4,500
Total RMS	**4,555**	**5,255**

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

[150] *AECOM PWC 2016 options Assessment 3 p. 73*

[151] *https://www.vicroads.vic.gov.au/newsmedia/2021/canning-street-green-wave-for-bike-riders*

[152] *https://www.bicyclenetwork.com.au/newsroom/2019/09/16/green-wave-a-go-on-albert-street/*

Multi-criteria Analysis

The RMS project demonstrates strong results for three of the four major transport challenges, as described in section 3.4.1. Road-based access to destinations with specialised opportunities, including for jobs and study, is enhanced in 2036 with less road network congestion. This also broadly equates to increased labour force accessibility as well as lower freight congestion and better freight connectivity. This is particularly the case for Outer Melbourne and New Growth Areas that rely heavily on road-based access over longer distances to transport people and goods.

The RMS project performs strongest for Challenge 2 (assisting business-to-business travel) and well for reducing freight congestion, as part of Challenge 3. In 2036, congested freight kilometres for journeys originating in Inner Melbourne decrease by 5.5% when compared to the transport base case. As the RMS project is not a new link in the network, its performance is not assessed against freight connectivity or freight utilisation.

The modelling shows that this benefit is harder to sustain into the long term, however, as more attractive private vehicle travel times encourage more use of private vehicles onto roads. By 2051, the congested freight kilometres benefit in Inner Melbourne has effectively been lost. The longer-term congested freight kilometres benefit shifts to Growth Areas (-3.4%) and Outer Melbourne (-2.4%). It is for this reason that freight congestion receive the Medium-High ranking in the MCA.

The modelling indicates the RMS project achieves similar strong results for access to jobs with private vehicles. This is significant given the expected employment growth in Middle and Outer Melbourne FUAs (refer to Table 5). Due to the metropolitan network-wide scale of the project and the project's expected ability to generate additional capacity within the road network, households and businesses with access to private vehicles can make use of travel time savings in 2036 to get to jobs in Middle and Outer Melbourne. The modelling results indicate that private vehicle travel time benefits are relatively consistent across Melbourne in 2036. The decrease in average private vehicle trip times in 2036 ranges between -1.7% (Inner Melbourne) to -1.9% in both Outer Melbourne and New Growth Areas.

Similar to freight, as more people are attracted to private vehicle travel made possible by lower travel times, these benefits become harder to sustain into 2051. Compared to the 2051 transport base case, it is estimated that average private vehicle travel times will be between -0.6% lower in Middle Melbourne and -1.3% lower in New Growth Areas.

Job accessibility within 45 minutes by private vehicle also increases sharply in 2036 and is still overwhelmingly positive in 2051.[153] New Growth Areas experience a 10.3% increase in jobs accessible via private vehicles, whereas the increase in Inner Melbourne is more modest at 3.0% in 2036. These increases remain very positive in 2051 and are estimated to still be 9.0% and 2.6% respectively.

Whilst RMS is expected to improve road performance to address Challenges 1-3, this comes at significant cost to Challenge 4, vehicle emissions. The RMS project triggers some of the greatest increases in emissions in 2036 and 2051 of all projects assessed. Even with ZEV uptake, the environmental outcomes are far from certain and have consequently been assessed as negative in terms of vehicle emissions.

Table 5: RMS MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
Road Management Systems (RMS)	M/H	L/M	H	H	M/H	~	~	N

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

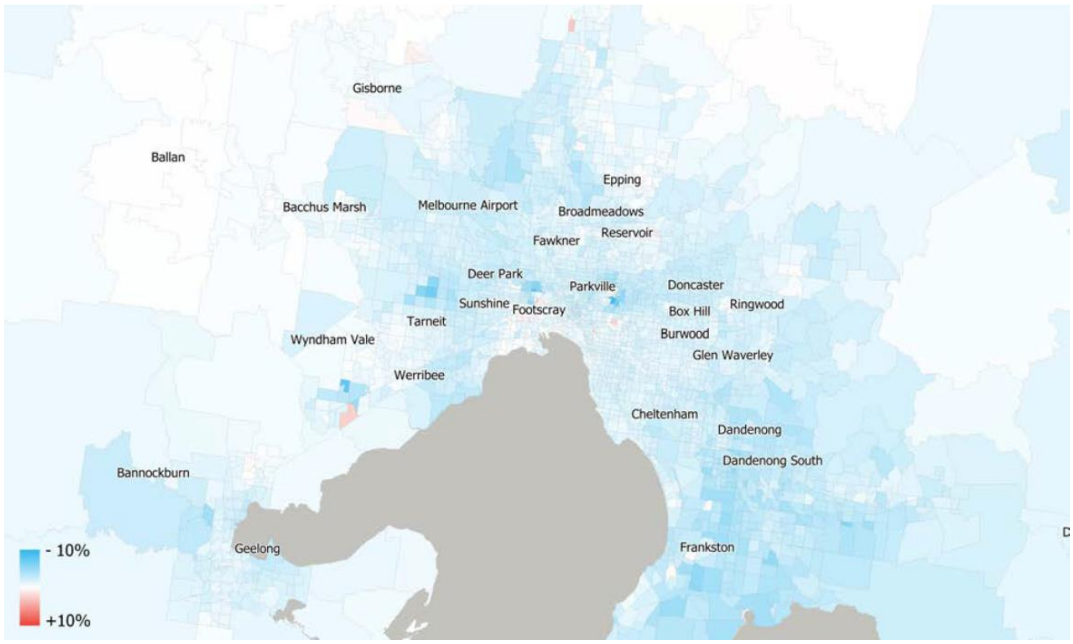
Transport Outcomes

The benefits of the RMS project vary from one functional urban area (FUA)[154] to another, although there is a fairly consistent pattern of less delay and better road conditions across the network. The RMS technology provides outer and growth areas with the opportunity to travel further with less delay. The more favourable road conditions accrue overwhelmingly to private vehicle users in the form of travel time savings during peak hours. This project also increases private vehicle kilometres travelled (VKT) by between 1.8% and 2.6%, with between -1.0% and 2.3% fewer vehicle hours travelled (VHT), when compared to the transport base case in 2036. Travel times savings for different areas are presented in Figure 21.

[153] *Job accessibility is measured as the proportion of jobs accessible within 45 minutes travel time from a place of residence*

[154] *See map of functional urban areas (FUA) in Appendix D*

Figure 21: Changes in Private Vehicle Travel Times with RMS (AM Peak 2036)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

If the estimated network performance is looked at strictly in terms of RMS's ability to deal with existing travel demand and patterns more efficiently, then the results clearly show that this scenario produces some of the best results of any of the projects assessed. However, as more of the future estimated travel demand is added to the transport system, the benefits become harder to sustain in the longer term. Our modelling forecasts that private vehicle hours travelled across the Inner and Middle Melbourne FUA networks in 2051 will be similar or slightly more with RMS compared to the transport base case in the AM peak. The attractiveness of private vehicles results in a shift away from public transport use.

To improve the outcomes of RMS, the project should be designed in a way that benefits the greatest number of people over a sustained period rather than optimising traffic demand to reduce delays in the short term.

The modelling results indicate that, without policy interventions, the RMS project sees a pronounced decrease in public transport usage in the New Growth Areas and Outer Melbourne. These new travel patterns are forecast to manifest themselves by 2036 and remain relatively stable into the 2051 horizon. This suggests RMS, when deployed as a standalone solution, has the potential to permanently decrease public transport usage in many parts of Melbourne. These increased private trips and lower public transport mode share effects can be thought of as a substantial shift in aggregate travel demand, with a stronger preference for individualised private travel over greater distances, particularly in outer areas. The RMS project gives rise to a commensurate land use response where people seek to take advantage of the ability to travel greater distances more often and at higher average speeds.

The modelling results also indicate that bus patronage and performance would benefit greatly from targeted road space management policy interventions designed to drive better on-road public transport performance across the network. For example, against the backdrop of decreasing patronage across all bus routes in metropolitan Melbourne, there are a number of bus routes that experience better travel times that increase in patronage. Crowded bus kilometres in the 2051 AM peak are estimated to increase in Inner Melbourne by 4.4% and Outer Melbourne by 30%. Meanwhile, Inner Melbourne bus boardings in the 2051 AM peak are forecast to increase by 3.6% when compared to the transport base case. A consistent and targeted approach to road space management will be needed to ensure more efficient use of road space and drive efficiencies in the transport network.

Such an approach would counterbalance forecast increases in private vehicle travel and mitigate significant long-term risks to network performance. For example, these results could be used to inform future road network management priorities for sub-regions of the metropolitan on-road transport network, including individual corridors by time of day and by mode. Combining RMS with road space allocation (see Case Study on Johnston Street) and supporting transport network pricing can be ways to better achieve overall objectives.

Place and corridor-based performance goals could be adopted in concert with travel demand management to achieve more predictable and stable transport outcomes across the network. Ensuring a corridor is physically configured in a way to ensure it can move a predetermined number of persons within a given time period in accordance with modal priorities

should be possible. Upgraded RMS technology has the potential to provide more predictable and stable network outcomes, but this must be matched with a clear network management operations plan to achieve broader objectives.

The wide scope of RMS changes, when combined with on-road lane management technology and enforcement in Melbourne, has significant potential to improve the use of the road network. The benefits of road space management, with RMS technology, is likely to be more effective and accepted by the community if successfully implemented with public information and education campaigns. Recent VicRoads campaigns on hook turns and responsible driving around trams are examples of successful campaigns.

Case Study – Dynamic lane management systems in Johnston Street, Fitzroy

Victoria is currently undergoing a large program of major transport infrastructure projects. The Government estimates there are $80 billion of projects currently underway. This volume of transport infrastructure investment raises the question of how to make better use of existing infrastructure as well as integrate these investments with existing infrastructure using technology.

Johnston St, Fitzroy is currently a five lane, east west throughfare with overhead dynamic lane management signals that provides part time bus lanes with peak period clearways between the Yarra River and Wellington Street. The 2.5km commercial and retail corridor intersects with Hurstbridge and Mernda train lines at Victoria Park Station, trams along Brunswick Street (route 11), Smith Street (route 86), Nicholson Street (96) as well as Hoddle Street buses. To help keep traffic moving in other periods, the middle lane becomes a lane for right turning traffic.

At present, frequent bus routes 200 and 207 that operate along the street use the existing lane management to help reduce delay for buses. This represent a bus every 6 minutes in peak periods. Infrastructure Victoria is proposing that bus services be improved between Victoria Park and Parkville (Melbourne University) as part of preparing for Melbourne Metro Two (Recommendation 61).

The RMS project modelling extended the dynamic lane management system further west from Wellington Street to Nicholson Street. The modelling has been predicated on extending the dedicated bus lane in peak periods and providing two lanes of peak direction general traffic whilst keeping one lane for counterflow general traffic. The parallel parking offering was removed between Smith Street to Nicholson Street in peak periods to estimate changes to corridor performance. The modelling results indicate that this road layout change provides peak direction buses with better travel times and has the potential to attract 65% more public transport passengers in the AM peak in 2036, whilst reducing existing private vehicle traffic volumes by 2%. The net result is an estimated increase in demand along the corridor of 13%, or 550 persons in the AM peak.

Increased public transport demand arising from this project is most pronounced in 2036. Traffic signal upgrades and road space reallocation are expected to produce significant positive knock on patronage effects for bus routes servicing Lonsdale Street and Hoddle Street as well as other on-road public transport including trams. More reliable and faster access by public transport to Johnston Street also increases local employment.

In the longer term however, as more people take advantage of better private vehicle travel times offered by RMS traffic improvements, the modelling shows that road system efficiencies erode through to 2051. These results emphasise the need to ensure that major transport infrastructure investments are designed to harness the potential benefits of RMS and ensure benefits are maximised into the long term. The modelling results indicate that lane management initiatives can help to lock in benefits for buses in the short as well as longer term, particularly when delivered in concert with RMS upgrades.

Demographic Outcomes and Land Use Implications

Population

As a result of improving traffic flows on suburban arterial roads, some people opt to take advantage of these travel time savings and improved accessibility by shifting to Outer Melbourne, the growth corridors, the Mornington Peninsula and even beyond the urban growth boundary (UGB) to the city's peri-urban areas (see Figure 22). As an example, population increases in the Shire of Yarra Ranges, in suburbs such as Mooroolbark, Lilydale and Mt Evelyn, are similar to the shifts that the WRU and CLR projects have on the western and northern growth areas respectively. Healesville and the series of towns in the Yarra Valley all have larger populations in 2051 than in the transport base case. In some places outside the UGB projected population declines seen between 2018 and 2051 in the transport base case are reversed. These areas have high bushfire risk and environmental sensitivities and any additional residential development to meet population demand should be concentrated in areas of lower risk, such as within existing towns and urban settlements. There is also a shift in population growth in suburbs concentrating along Port Phillip Bay, extending from the City of Kingston to the Mornington Peninsula, which would require more consideration of impacts on fragile coastal environments.

There were some established suburbs that became more attractive, with improved flows on arterial roads providing better connections to the motorway network. Suburbs such as Essendon and Doncaster could experience even more growth than projected, where additional residential development can take advantage of existing social and utilities infrastructure within those established areas.

Fewer people are drawn to live in Inner Melbourne because it is more accessible to get to because of reduced congestion and travel times initially, although these benefits are eroded over the longer term. By 2051, there is more congestion overall, however an even greater levels of road use too – such that the proportion of congested travel to total travel on the roads actually decreases, illustrating improved road efficiency.

Jobs

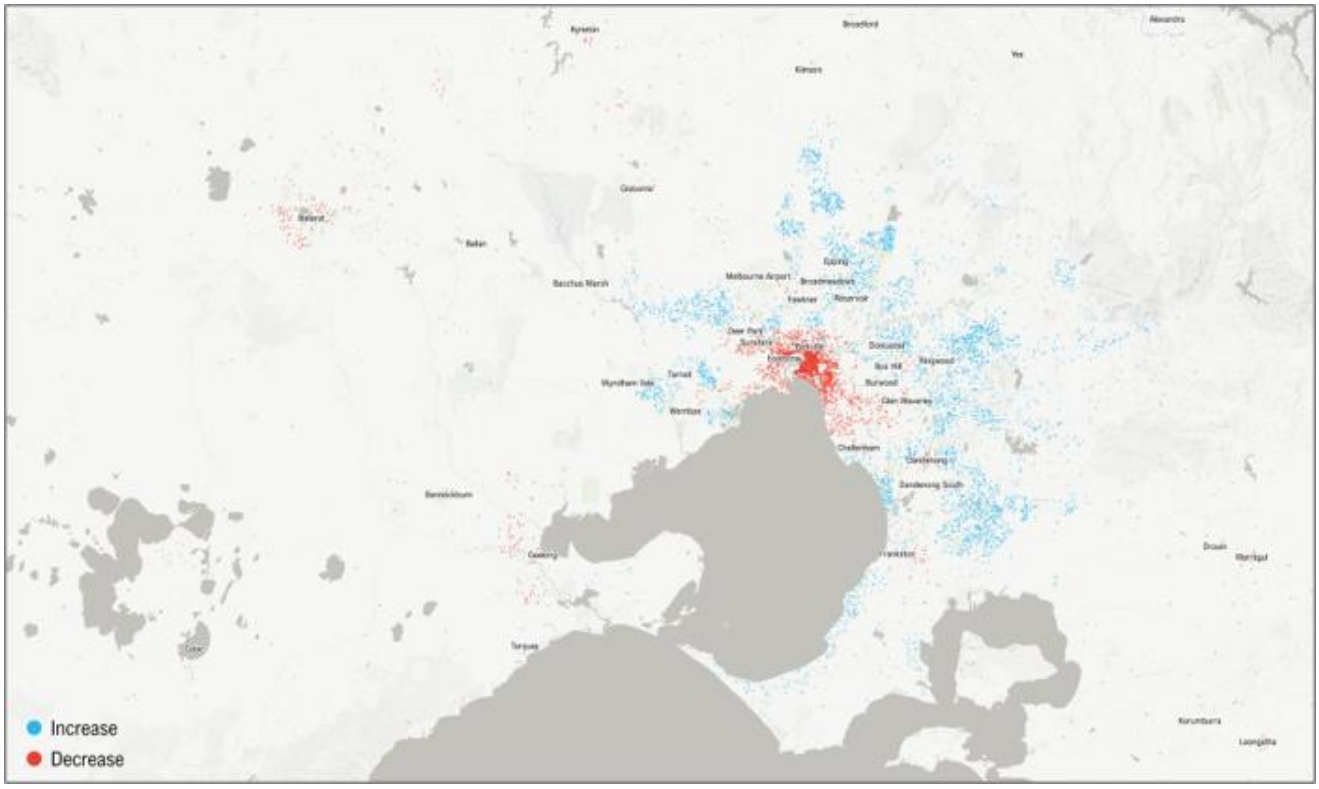
The project only has a small impact on changes in employment locations but does show some positive job relocation impacts where populations fall, particularly in Inner and Middle Melbourne. Increases in jobs occur in places which also have higher forecast growth in the transport base case, particularly in Melbourne's east, south-east and in proximity to the airport. As Inner Melbourne becomes more congested compared to the transport base case in the longer term, some jobs relocate to middle and outer areas.

Healesville in the Yarra Valley has one of the largest increases, of which a proportion is due to population relocating there. The Hawthorn area also experiences increases, which could be due to the modelled Power to Denmark Street clearway. While those base numbers are some of the highest outside central Melbourne, the introduction of the clearway and its cumulative impact with the extended corridor to the north along Grange Road may make this area more attractive as a business location.

In central Melbourne, Docklands gains additional jobs with slightly lower growth in the CBD, which could be attributable to the relatively better road access into Docklands.

The modelling of this project was confined to metropolitan Melbourne. Regional centres such as Warragul, Mildura, Shepparton, Wodonga and Wangaratta also have slightly fewer jobs than in the base case, with RMS being the only project that affects this many places in regional Victoria. The rollout of RMS to regional Victoria, particularly major centres, should be considered as part of delivery of this project.

Figure 22: Population changes due to RMS compared to transport base case, 2051



Source: Arup 2021 Strategic Modelling Outcomes Report

Figure 23: Employment changes due to RMS compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes Report

Economic Assessment

Cost benefits analysis

The economic evaluation for this project assessed the costs and benefits, using conventional transport guidelines for cost benefit analysis. The assessment has been expanded to include land use change benefits, wider economic benefits (WEBs) and broader impacts. Further detail on the approach to the economic assessment can be found in section 3.4.2.

The table below presents a summary of the estimated benefits from the RMS project, using a discount rate range of 4% and 7%. The largest benefit category is consumer surplus benefits, which includes reduced travel times and vehicle operating costs for road users.

Table 6: Road Management Systems Benefits (Present Value $ million)

Benefit	Static Land Use	Dynamic Land Use	WEBs only	Total
Consumer surplus benefits	$41,223 - $78,587	-$5,285 – -$10,354		$35,938 - $68,233
Active transport benefits	-$571 – -$1,120	-$38 – -$83		-$609 – -$1,203
Safety benefits	-$1,429 – -$2,793	-$63 – -$59		-$1,492 – -$2,852
Environmental benefits	-$720 – -$1,423	$18 - $41		-$702 – -$1,382
Residual values	$0 - $0	$0 - $0		$0 - $0
WEBs			$470 - $831	$470 - $831
Total benefits	**$38,503 - $73,251**	**-$5,368 – -$10,455**	**$470 - $831**	**$33,605 - $63,627**

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: The "Headline" ranges are provided using 4% and 7% discount rates

Summary results from the cost benefit analysis (CBA) are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes all of the quantified benefits outlined in the table above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 8.1 and 12.6 using upper project costs, and 9.3 and 14.4 using lower project costs, for the total outcome (dynamic land use including WEBs, ranges using 7% and 4% discount rates). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and WEBs arising from productivity improvements. When only static land use outcomes are included, the BCR is still positive, ranging between 9.3 to 14.5 using upper project costs and 10.6 to 16.6 using lower project costs. Figure 26 shows the distribution of consumer surplus benefits generated by this project across Melbourne. This highlights the widespread nature of the benefits.

Unlike the other major transport projects assessed in this report, the RMS project is intended primarily as a better use project. Minor physical road layout infrastructure improvements are required on the network beyond IT system upgrades and lane reconfigurations spread across the network. Reviews of RMS that focus heavily on signal optimisation projects are known to consistently produce high cost benefit ratios when standard cost benefit analysis is carried out.[155]

The RMS project is estimated to have a positive impact on GSP, increasing by 0.6% in 2036 and 0.8% in 2051. This GSP uplift captures some of the benefits that flow to individuals who change housing location due to the transport project, in addition to the transport benefits already quantified in the cost benefit analysis.

Given the inputs used for this evaluation, this analysis indicates that the RMS project is very compelling. This finding is consistent with conventional cost benefit analysis for road management proposals that increase traffic flow with technology. A better-use approach to roadways would be expected to generate benefits that are far greater than the expected cost of such a project in the long term. These benefits manifest themselves predominately in the form of travel time savings to private vehicles (refer Figure 25), including freight vehicles. The benefits to public transport and active transport users are estimated to be far more modest (also refer Figure 25).

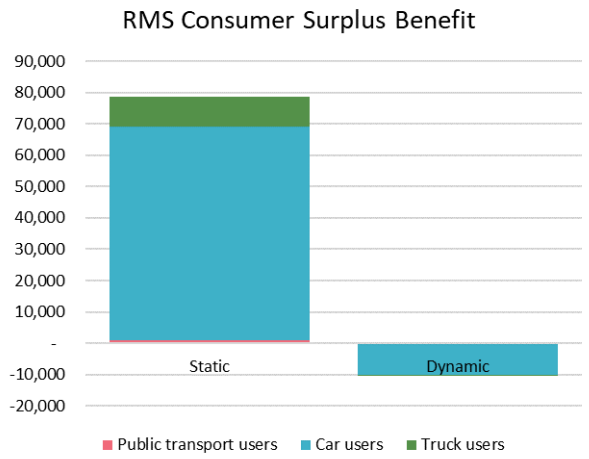
[155] *NZ Transport Agency research report 594, 2016. Demonstrating the benefit of network operations activities https://www.nzta.govt.nz/assets/resources/research/reports/594/594-Demonstrating-the-benefit-of-network-operation-activities.pdf]*

Table 7: RMS Benefit Cost Ratio (BCR) and Net Present Value (NPV) ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	9.3 – 14.5	$34,356 - $68,188	8.0 – 12.4	$28,988 - $57,734	8.1 – 12.6	$29,458 - $58,565
Lower project costs	10.6 – 16.6	$34,880 - $68,825	9.1 – 14.2	$29,512 - $58,370	9.3 – 14.4	$29,982 - $59,201

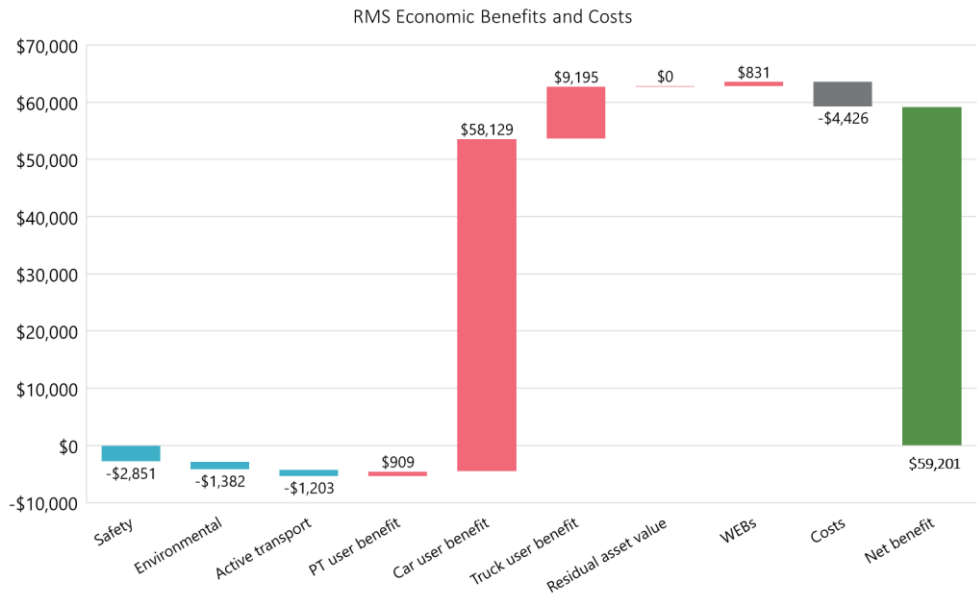
Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Figure 24: RMS Consumer Surplus Benefits – Static and Dynamic Land Use



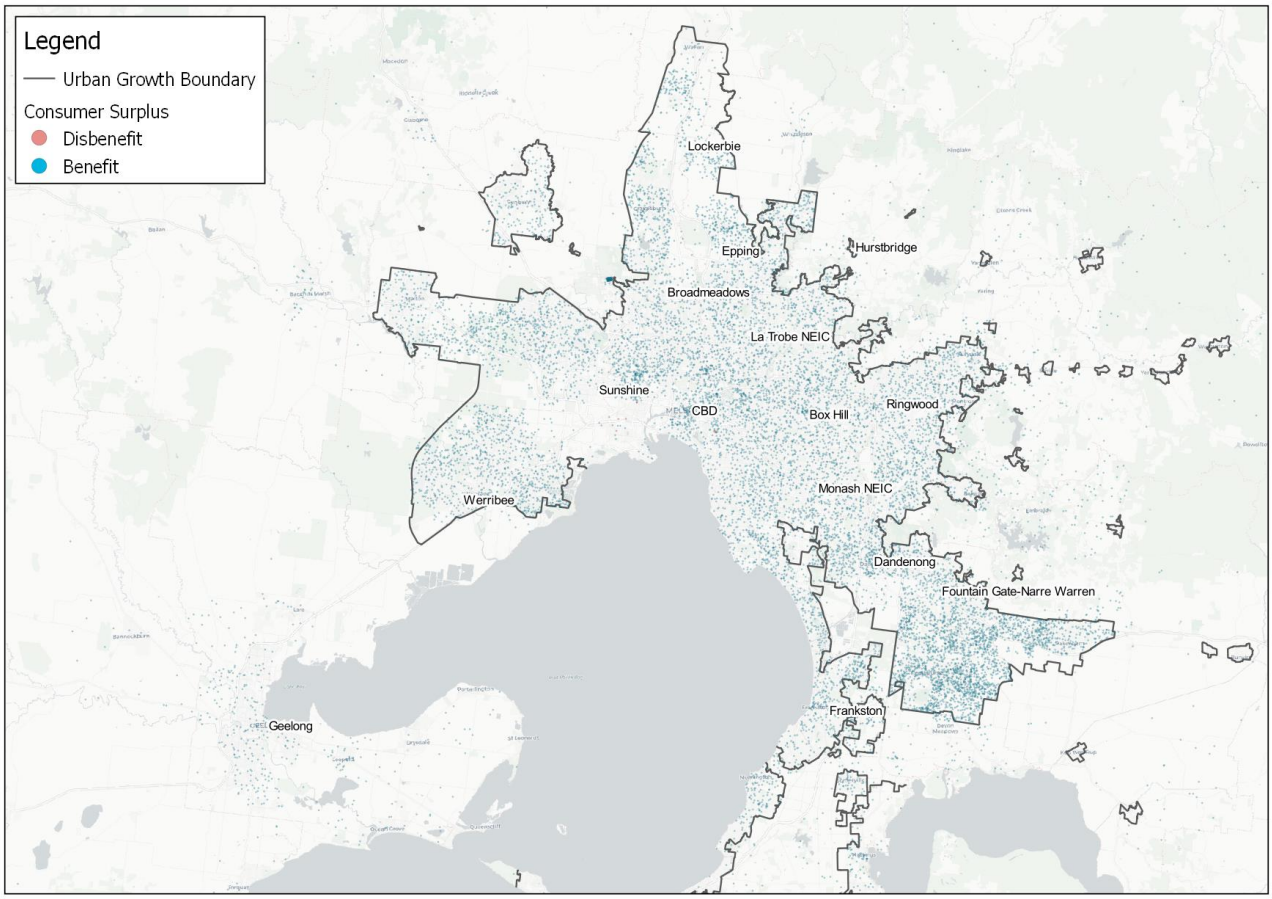
Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

Figure 25: RMS Benefits and Costs (Present value $ millions)



Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Total dynamic land use plus WEBs results presented using lower project costs and 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Figure 26: RMS Consumer Surplus Benefits for Private Vehicles (2051)



Note: This map shows change in total consumer surplus by travel zone, not change per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits.
Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

Social Assessment

Improving traffic flow on arterial roads can benefit all road users. Most Victorians across all socio-economic segments move around using private vehicles.

The RMS project will also have some benefits for public transport users, particularly outside of peak commuting times. For people who do not drive and are able to access services, amenities and social infrastructure in important centres such as the Metropolitan Activity Centres outside of the morning weekday peak hours, their average travel times on public transport are slightly faster for most centres compared to the transport base case.

Work trips in the AM peak by public transport to those centres are not consistently shorter, with New Growth Area centres having slightly longer average travel times.

Access to jobs and tertiary education institutions in NEICs during the morning public transport commute are slightly faster than in the transport base case. Other public transport trips for education are more mixed depending on the time of day and location, with travel during the interpeak typically slightly faster than the transport base case rather than during the evening peak. This may better suit people who are dependent on public transport and are only studying, rather than studying and working.

The RMS project is forecast to result in additional car use on arterial roads and less public transport use because of this mode shift. There is a need to ensure that the adverse impacts of this are managed for other road users and the broader community. In addition, consideration needs to be given to how on-road improvements to other modes including public transport can be part of the overall road demand management task to maintain or improve the journey experience. These effects will have a greater impact on disadvantaged transport user groups who are less likely to drive. For example, *Victoria in Future 2019* projects almost 270,000 additional young people under 20 years old will live in

Melbourne's growth areas by 2036, but they are unlikely to directly benefit from improved flow on suburban arterial roads.[156]

In addition, with more trips being made by private vehicles, there are also likely to be more accidents on the road. RMS results in more cars moving onto arterial roads, away from highways. Increased vehicle volumes will occur across the metropolitan arterial road network. These roads have a higher rate of fatality and injury per 100 million kilometres travelled, making the burden of injury and death for this project higher than the transport base case.

Implementation of RMS must be managed with clear modal priorities, with different priorities applying for different parts of the network. Should the flow for private vehicles be increased without consideration of pedestrians, neighbourhoods may become disconnected, particularly for pedestrians. For example, accessing Local Activity Centres and open spaces may be harder with this project, particularly on foot or by bicycle. The Department of Transport's Movement and Place Framework indicates these modal priorities in different parts of the network.

Environmental Assessment

The emissions footprint of RMS is produced by a substantial increase in car travel. Our assessment shows that while the project results in a net reduction of truck travel, these environmental benefits are offset by the increase in private vehicle travel across the network and mode shift away from public transport. The take up of ZEVs may help to offset this, but the full transition of private vehicles to ZEVs is not expected for several decades.

If upgrades to RMS are paired with capital upgrades to the road network, such as intersection widening and flaring, there may be a negative impact on vegetation and further contributions to urban heat island effects, particularly in growth areas where temperatures are already higher than in established suburbs.[157] Together with increased small particle air pollution associated with more vehicle movements, biodiversity and ecosystem quality are likely to be negatively impacted with a decline in vegetation cover.

[157] *Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. Journal of environmental management, 197, 522-538*

And C. Sun et al. (2019). Urban Vegetation, Urban Heat Islands and Heat Vulnerability Assessment in Melbourne, Melbourne, Clean Air and Urban Landscapes Hub, www.planning.vic.gov.au/__data/assets/pdf_ file/0018/440181/UHI-and-HVI2018_Report_v1.pdf

Case Study – Repurposing road space to support place-based initiatives

Whilst the RMS project results highlight potential for increased capacity on many arterial roads, there remains considerable potential to reallocate road space in support of place-based initiatives, particularly on non-arterial roads. In many parts of the world, the COVID-19 pandemic has shifted the way governments around the world think about managing and allocating road space to better meet the needs of people. Between March and August 2020 over 500 cities, states, and countries adjusted the allocation of street space and other transport resources in response to changing mobility demands brought on by the pandemic.

In September 2020, the Victorian government announced a $100 million support package for the Melbourne CBD. $30 million was allocated to small and medium-sized businesses to purchase outdoor dining equipment, with a maximum of $5,000 per business. Another $30 million was allocated towards supporting COVID-safe cultural events to attract Melburnians back to the CBD, and $40 million was allocated to physical upgrades such as widening footpaths. Other local government areas transformed suburban shopping strips with parklets to allow alfresco seating. It is estimated that over 300 such sites have been created in the past year across the state.

In 2018 Transport for London commissioned research into the value of street improvements by testing small scale improvements in several public spaces. The research found that improvements to the quality of the publicly owned and managed areas of London's mixed streets, including high streets and town centres, return substantial benefits to the everyday users of streets, as well as to the occupiers of space and investors in surrounding property. These included a one third uplift in the physical quality of the street resulting from interventions, a 17% difference in vacancy rates between improved and unimproved street environments, a 96% boost in static activities (standing, waiting and sitting) and 93% boost in active street behaviours (principally walking).

The widespread success of the pop up parklets and dining in Melbourne over the past year suggests that further efforts need to be made to ensure the positive aspects of this reallocation of road space can be harnessed into the future. This includes reform of the prevailing processes for undertaking road space reallocation and a fair allocation of long-term costs (Recommendation 41).

Sources:
Taking To The Footpaths: Getting Ready For Outdoor Dining, 14 September 2020 https://www.premier.vic.gov.au/taking-footpaths-getting-ready-outdoor-dining

Combs, Tabitha S., and Carlos F. Pardo. "Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy." Transportation Research Interdisciplinary Perspectives 9 (2021): 100322.

Melbourne Parklets Map https://melbourneparklets.ushahidi.io/views/map

Street Appeal – The value of street improvements Summary Report, UCL report commissioned by Transport for London, http://content.tfl.gov.uk/street-appeal.pdf

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity to a range of potential outcomes. This informs the conditions in which a project should or shouldn't go ahead, and how sensitive a project's viability is to changes. The BCR results based on the modelling of improved traffic flows can be seen as the maximum scenario, generating the highest benefits.

These sensitivity tests include varying the inputs into the CBA, including the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the project's opening year and construction start year, and increasing the value of travel time in the future.

The BCR ranges under each test for each of the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below. This project has a BCR above one under all sensitivity tests. This highlights that even with significant changes to the capital costs, benefits, timing and key inputs this project will generate benefits that outweigh the costs. The sensitivity tests that delay opening by 5 and 10 years produce a lower BCR than the core scenario, highlighting the benefit of implementing this project in the short term.

Table 8: RMS Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static Land Use	Dynamic Land Use	Total (Dynamic Land Use with WEBs)
4% discount rate	16.6	14.2	14.4
7% discount rate	10.6	9.1	9.3
3% discount rate	19.7	16.8	17.0
10% discount rate	7.5	6.5	6.6
20% decrease in capital costs	13.2 - 20.4	11.4 - 17.5	11.5 - 17.8
20% increase in capital costs	8.9 - 13.9	7.7 - 11.9	7.8 - 12.1
40% increase in capital costs	7.6 - 12.0	6.6 - 10.3	6.7 - 10.4
Exclusion of construction cost escalation	12.5 - 19.5	10.7 - 16.7	10.9 - 16.9
40% decrease in total benefits	6.4 - 10.0	5.5 - 8.5	5.6 - 8.6
20% decrease in total benefits	8.5 - 13.2	7.3 - 11.4	7.4 - 11.5
20% increase in total benefits	12.8 - 19.9	11.0 - 17.0	11.1 - 17.3
Delay opening by 5 years	6.3 - 13.1	5.3 - 10.8	5.3 - 10.9
Delay opening by 10 years	6.7 - 13.9	5.5 - 11.3	5.6 - 11.4
Value of travel time	7.1 - 16.2	6.0 - 13.8	6.1 - 14.0

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: These sensitivity tests are provided for the lower cost and use a 7% and 4% discount rate range.

Future Scenarios

RMS is highly resilient to future scenarios assessed in this report and will contribute to the agility of the road network to rapidly respond to changes. The project provides significant benefits for road network users and will do so in both high and low population growth scenarios. The road network is expected to experience growing congestion over time, and the project will result in significant network efficiency benefits, regardless of increased public transport use, changes to where people live and work, and other scenarios considered. With RMS, the network will be able to better respond to changing demand and travel patterns more rapidly.

This project is unique in its alignment with one of the more unpredictable scenarios, Electric and Automated Vehicles (EAV). The RMS project results in an increased efficiency of the road network, and similarly the AV component of EAV results in improved road efficiency. Furthermore, the RMS project includes technology upgrades to road management systems which could also help enable the new technologies of EAV.

A summary of the implications of each future scenario and the expected impact on the RMS project is documented below in Table 9.

Table 9: Resilience of RMS to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	Sensitivity tests undertaken indicate that the RMS project appraisal is not sensitive to movement in timeframe, largely due to the significant benefits generated relative to the small cost of investment. As such, high population growth is not likely to make this project significantly more attractive.	~
Low population growth	Sensitivity tests undertaken indicate that the RMS project appraisal is not sensitive to movement in timeframe, largely due to the significant benefits generated relative to the small cost of investment. As such, low population growth is not likely to make this project significantly less attractive.	~
Working from home	VLUTI model runs undertaken on a WFH scenario indicate that population is likely to increase in middle and outer suburbs, increasing demand for road and public transport travel in these areas. As such, the problems on the transport network are likely to worsen in this scenario compared to the transport base case. RMS will provide benefits by improving travel times and road network capacity in the middle and outer suburbs, therefore a minimal impact is expected.	~
Automated and electric vehicles	The EAV scenario sees greater private vehicle trips across the road network, with 20% higher daily VKT at 2051 compared to the NDS. This could imply greater consumer surplus benefits and subsequently a higher BCR for RMS, if EAV is considered. RMS is expected to be operational from 2025, while the full impacts of EAV scenario are not apparent until 2051 and after. This means that an EAV scenario is not likely to have a substantial impact on the economic outcomes of RMS in the short term.	~
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, reducing the number of new car trips on the network. However, the road network is already experiencing congestion, and RMS will still result in significant benefits to existing users. As such, targeted density outcomes would either be unlikely to materially reduce benefits or make the project less attractive, or could significantly improve outcomes as the road network operator will be able to adjust the operations of the network in that area to respond to changing travel patterns and mode choices. For example, it will provide flexibility and responsiveness for the road manager to provide more priority for trams and buses, and walking or cycling, using technology in areas that are rapidly changing.	+
Transport network pricing	This scenario, with the inclusion of an inner city cordon, is likely to focus on travel demand management to the inner city. This is consistent with the proposed approach for RMS which will improve middle and outer suburbs while prioritising public transport corridors in Inner Melbourne. The implementation of network-wide distance-based road pricing would also complement middle and outer suburb capacity improvements from RMS.	+

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

Implications

The implications of implementing RMS technologies can be summarised as follows:

There is a compelling case for the project

- The economic assessment reveals that this project generates significant benefits across the network with a relatively low cost compared to other build interventions.
- Sensitivity tests indicate that the project still performs well with conventional cost benefit analysis even with increased costs and fewer benefits. This suggests that the project is worthwhile, with consideration given to the risks that could arise from improved RMS.
- The project enables the network to become more agile and able to respond to a range of scenarios more readily.

There is a need to implement a clear network operating plan alongside RMS, that is linked to strategic transport network management objectives and outcomes, with the potential support of TNP

- There are strong benefits for the project, but it may also result in unintended consequences, such as encouraging induced private vehicle traffic in areas with higher concentrations of movements, such as Inner Melbourne and parts of Middle Melbourne.
- A strategic road network operations plan is needed to help manage the impacts of these unintended consequences that outlines how demand will be accommodated and managed across the different modes. The Department of Transport's *Movement and Place* framework provides a part of the basis for this and TNP can also assist.
- It is important to ensure that public transport remains a priority where it shares road space, to ensure better reliability and attractiveness. This could take the form of dedicated clearway lanes for buses or other road space allocation measures. Technology also has a greater role to play in better tracking of public transport throughout the network, to minimise disruptions and delays.

The strategic network operating plan needs to consider the potential impacts of technology uncertainties, and be supported by TNP

The results show that there is significant scope for RMS technology to address this gap, however this technology must be implemented in a way that addresses the above issues and resolves land use risks and uncertainties.

- One of the key challenges is to successfully manage the increased demand on the road network that arises from the flow improvements and TNP can assist with this.
- The interplay of RMS with AVs is also an important consideration. RMS may be important in enabling and managing growth of AVs, but with AVs increasing the attractiveness of car travel, there are risks of even greater outward expansion and therefore induced traffic from both RMS and AVs.

There needs to be consideration of potential land use impacts of this project, including steps to manage and mitigate these impacts

- Melbourne's New Growth Areas attract more new residents than in the transport base case as a result of the RMS project. This may result in additional population growth greater than what is already planned for in existing Precinct Structure Plans (PSPs).[158] These plans and their associated developer contribution schemes may therefore underestimate future demand for homes and community infrastructure, with demand for both potentially occurring earlier than anticipated. In the future, this may result in PSPs requiring further review to accommodate additional population growth in good locations, close to activity centres and the Principal Public Transport Network (PPTN). People living closer to stations are more likely to use trains which could address the impact of declining public transport use.[159]
- New suburbs are also an opportunity to systematically provide alternative movement corridors for pedestrians and cyclists, away from major arterial roads where vehicle flow improvements occur. A connected open space network should provide options for active transport connections between homes, town centres and activity centres. These movement corridors should also be prioritised for tree planting to provide shaded travel and recreational routes.
- With improved private vehicle access to the Yarra Ranges, Yarra Valley and Mornington Peninsula, more people are expected to live in these areas. Existing settlement boundaries in these areas need to be maintained to ensure that additional land subdivision does not fragment these important landscapes and that residential development occurs

[158] https://vpa.vic.gov.au/greenfield/

[159] Reid Ewing, Shima Hamidi, James B Grace, 2016, Compact development and VMT—Environmental determinism, self-selection, or some of both? *Environment and Planning B: Planning and Design*, Volume: 43 issue: 4, page(s): 737-755

within established townships.[160] Many of these areas are also subject to a Bushfire Management Overlay which designates areas at extreme risk from bushfire hazard (as distinct from bushfire prone areas). Particular attention should be given to ensuring that these risks are adequately managed.

- This additional population growth may also place more pressure on Melbourne's agricultural land, particularly within and close to the UGB. Adequate protections need to be in place to protect this valuable resource, such as through the implementation of recommendations that may come through DELWP's review of Melbourne's green wedges and agricultural land.[161]

Relevant Recommendations in Victoria's Infrastructure Strategy

Recommendation 24: Introduce new on-road demand management technology

Victoria's infrastructure strategy recommends that in the next five years, introduce new on-road demand management technologies, including to integrate management systems for different road-based transport modes. In the same time period, combine them with a road infrastructure upgrade program to optimise the technologies' benefits, such as by providing extra clearways and introducing dedicated lanes for bus routes.

Recommendation 33: Publish Victoria's transport plan

Victoria's infrastructure strategy recommends immediately developing and publishing Victoria's integrated transport plan. This will provide critical guidance on the network operations plan that will provide appropriate prioritisation of active transport, public transport, commercial vehicles, and private vehicles which will guide the implementation of road management systems across Metropolitan Melbourne.

Recommendation 41: Reallocate road space to priority transport modes

Victoria's infrastructure strategy recommends immediately beginning delivering road space reallocation initiatives to better support and enforce priority movement through streets and places. Adopt a five-year target for delivery of more ambitious road space reallocation initiatives. Legislate for faster, simpler, and more consultative road space reallocation in government decision-making.

Recommendation 51: Incorporate congestion pricing for all new metropolitan freeways

Victoria's infrastructure strategy recommends that congestion-based peak and off-peak tolling be applied to all new metropolitan freeways, including the North East Link, to better manage traffic flow and impacts on nearby local roads.

Recommendation 52: Trial full-scale congestion pricing in Inner Melbourne

Victoria's infrastructure strategy recommends that in the next five years, full-scale congestion pricing be trialled in Inner Melbourne to reduce congestion on inner city roads.

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[160] https://www.planning.vic.gov.au/__data/assets/pdf_file/0022/124753/Yarra-Ranges-Localised-Planning-Statement.pdf and https://www.planning.vic.gov.au/__data/assets/pdf_file/0026/103958/Mornington-Peninsula-Localised-Planning-Statement.pdf

[161] https://www.planning.vic.gov.au/policy-and-strategy/green-wedges-and-agricultural-land

4.3 City Loop Reconfiguration and Northern Rail Corridor Upgrade

Objectives

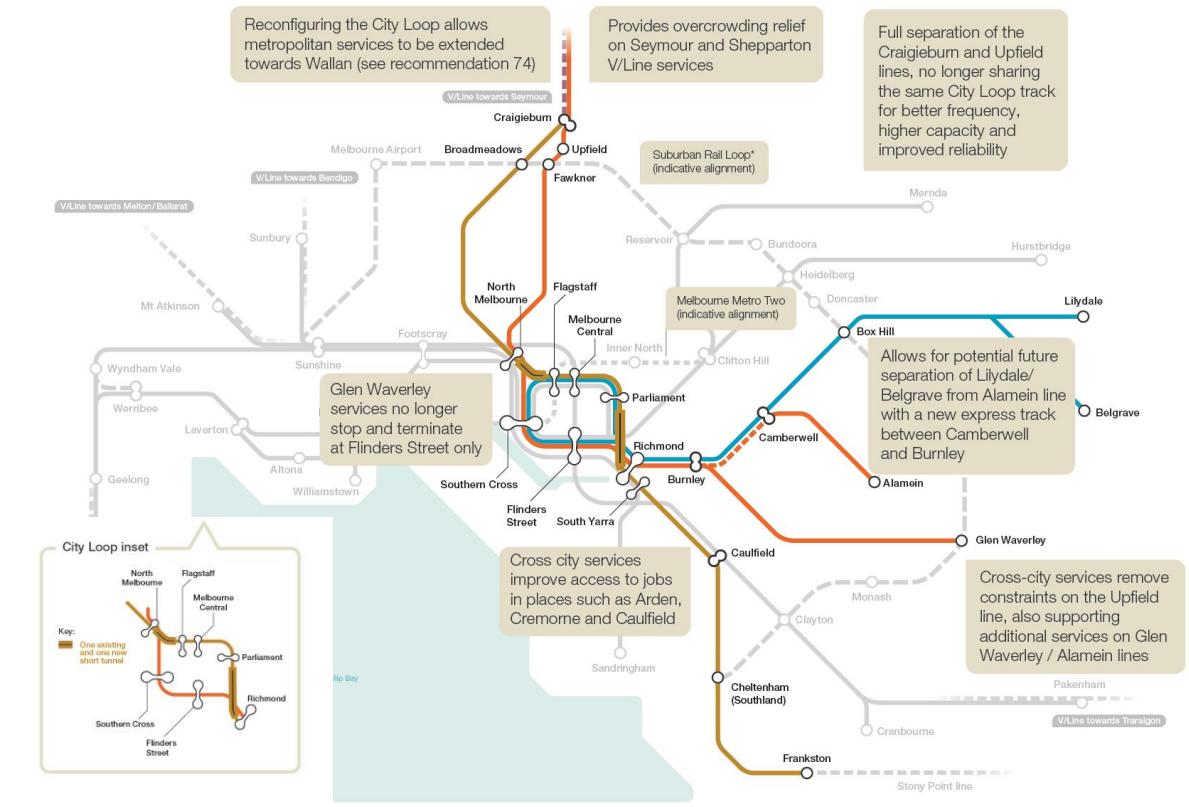
This project will provide two new metro style services, one of which can be extended to serve the emerging growth areas of the northern suburbs and provide overcrowding relief for the Seymour / Shepparton V/Line services.

The City Loop reconfiguration and northern rail corridor upgrade (CLR) project involves transforming more rail lines into metro style services by altering the City Loop. It will also extend services from the Upfield line into the northern growth corridor including the Mitchell Shire. This will provide more reliable services and additional capacity for new services on the Craigieburn, Frankston, and Upfield lines (including future electrification towards Wallan), as well as on services that travel to the eastern suburbs through Burnley.

In addition, the introduction of new metro style services will mitigate network disruption impacts, improving reliability of the metropolitan rail network for all users. It will also provide crowding relief for northern regional V/Line services to Seymour and Shepparton. The project will also provide those on the Glen Waverley line with more central city stations to stop at in peak periods.

Undertaking this project will set up the rail network to create an express metro service for the Belgrave and Lilydale lines. This would enable all services on these lines to operate as an express service from Camberwell into the city, potentially stopping only at Glenferrie and Richmond, as well as more services from Alamein stopping all stations to serve intermediate stations including Auburn, Hawthorn, Burnley and East Richmond.

Figure 27: Benefits of CLR



**SRL West is still under investigation by the Victorian Government and we have therefore assumed it involves the extension of Wyndham Vale RRL services to Werribee.*

Note: Suburban Rail Loop Stage 1 corridor (Cheltenham/Southland to Box Hill) has been determined, with subsequent stages and corridors to the north and west to be determined (https://suburbanrailloop.vic.gov.au/). For the purposes of modelling for this study, it has been assumed that Wyndham Vale services will be extended to Werribee Station as per Western Growth Corridor Plans and PSPs and will be referred to in this report as 'Wyndham Vale RRL' services.
Source: Infrastructure Victoria Visualisation of Project Specification (2021)

This project is expected to support the following objectives of *Victoria's infrastructure strategy:*

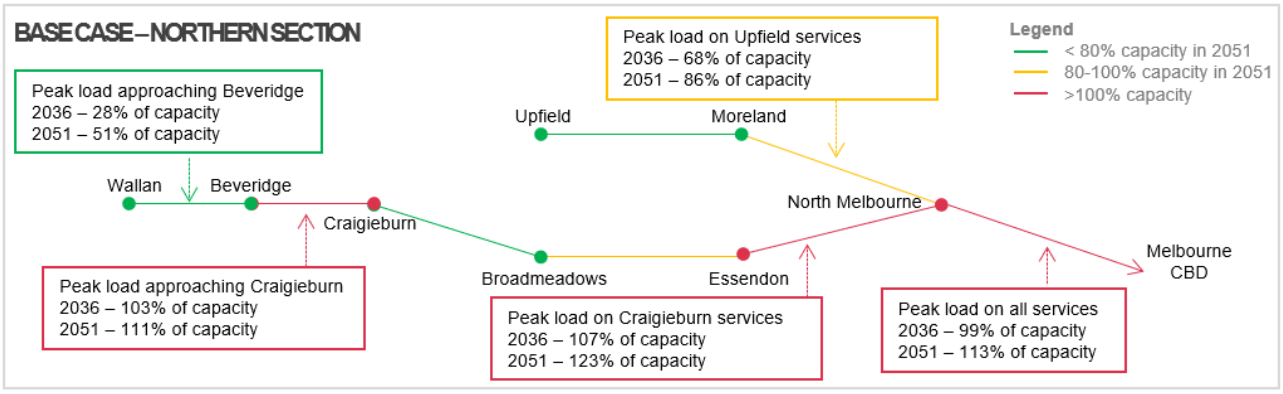
- **Objective 1:** Prepare for population change – by providing improved transport connections and additional capacity to support growing travel demand in the northern growth area and unlock future network capacity for other lines to accommodate infill and densification over time.
- **Objective 4:** Enable workforce participation – by providing transport connections to employment clusters in the north, and to the CBD, providing access to training and a range of secure work opportunities.
- **Objective 5:** Lift productivity – by increasing access to jobs and supporting Victorians in maintaining a good standard of living from an economy boosted by enhanced skills, innovation, market access, and efficient investment.
- **Objective 6:** Drive Victoria's changing, globally integrated economy – by enhancing connectivity and ensuring Victoria remains an attractive place for business and trade, competitive with other cities across Australia and the world.

Need

The northern growth corridor will experience significant population growth, with Mitchell Shire projected to grow from 50,000 residents[162] in 2021 to almost 160,000 by 2051.[163] This population growth will lead to significant growth in travel demand from new residents, as jobs growth is not expected to match population growth and residents will be required to commute to employment clusters, NEICs and Inner Melbourne, including the CBD, to access study and work opportunities.

In the mid-2030s, there will be insufficient capacity on Seymour V/Line services to meet the significant peak passenger demand at Donnybrook Station, which is the existing train station servicing much of this growth corridor. Peak services originating from Craigieburn are expected to experience overcrowding (over 100% capacity) by the mid-2030s, with overcrowding on the line expected to exceed 120% of capacity by 2051.

Figure 28: Metropolitan train service line load projections for Craigieburn, Upfield, and Seymour services (transport base case)



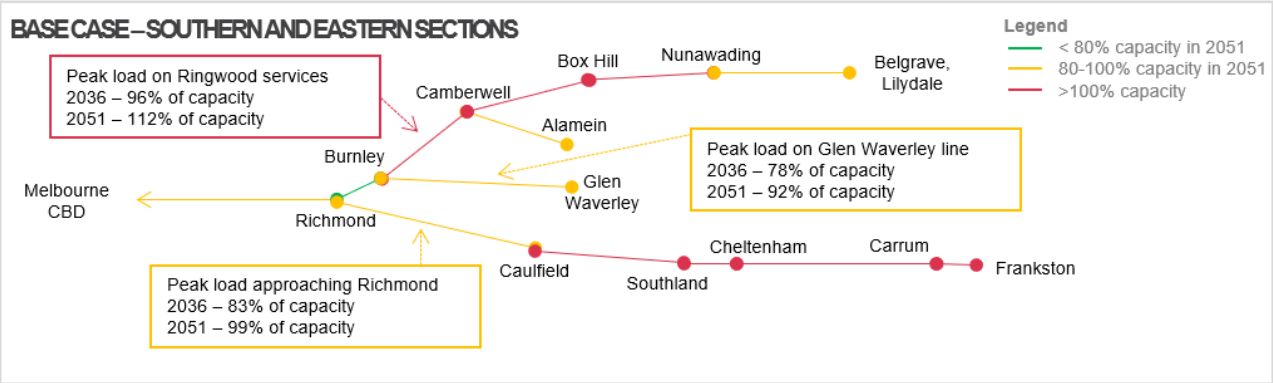
Source: Visualisation of ARUP / AECOM modelling results (2021) by Infrastructure Victoria

Services originating from Belgrave, Lilydale, and Upper Ferntree Gully are all expected to experience overcrowding (over 100% capacity) in the early 2040s. Frankston line services are projected to experience overcrowding by 2036, due to the lack of services connecting outer suburbs to Southland Station.

[162] *DELWP 2019 Victoria in Future Population Projections*

[163] *2019 Small Area Land Use Projections, SGS Economics and Planning*

Figure 29: Metropolitan train service line load projections for Burnley and Frankston services (transport base case)



Source: Visualisation of ARUP / AECOM modelling results (2021) by Infrastructure Victoria

The current integrated network results in network-wide disruptions and limits growth of train services

The train network currently operates as an integrated network with train services in proximity sharing access to the City Loop. This means that a disruption that occurs in one part of the network can result in delays and cancellations across the train network. An example of this is that a delay on the Craigieburn train service impacts the Upfield, Seymour, Shepparton, Sunbury and Bendigo train lines, with possible implications for Regional Rail Link services from Geelong, Bendigo, and Ballarat. This is a significant operational risk, making it difficult to develop timetables which offer reliable services when the impact of one incident can cascade across the network.

The Victorian Government has an opportunity to separate services and routes into independent lines, which will significantly reduce the cascade effects of disruption to services across the network. The Metro Tunnel Project will separate train services from the Sunbury, Pakenham, and Cranbourne lines into one independent train line, running across the city as a metro style service.[164] The Metro Tunnel Project creates the first of seven independent train lines, which would limit disruptions to the affected line only, removing almost all shared sections of the train network which can cause reliability issues.

In addition, the integrated networks limit the number of services which can originate on a corridor. The Northern Group, which will have Upfield and Craigieburn services operating within a single City Loop tunnel (post Metro Tunnel opening), is limited to a total of 22 train services per hour. As the Craigieburn line is projected to need 16 services during the busiest hour of the morning peak, this constrains the Upfield line to only six services during the same period. With Craigieburn services sharing the same track with Seymour and Shepparton services from North Melbourne, any disruption to any one of these lines affects services on all four lines.

Project Description

The CLR project will enable the extension of metropolitan train services to the northern growth corridor, including Mitchell LGA, by reconfiguring parts of the existing City Loop to provide critical additional train capacity on the Upfield, Craigieburn, Frankston, and Glen Waverley train lines. This project will enable a subsequent project to deliver a fourth track between Burnley and Camberwell, which will support further network improvements such as allowing additional services along the Belgrave / Lilydale and Alamein lines. This subsequent project is not part of this assessment.

This project consists of both capital works and service improvements, as described in the following section.

Capital works required to reconfigure the City Loop and upgrade the Northern Rail Corridor

The City Loop is made up of four single tunnels, which include the Northern Group Loop (Upfield, Craigieburn, and Sunbury lines), Burnley Group Loop (Belgrave, Lilydale, Alamein, and Glen Waverley lines), Clifton Hill Group Loop (Mernda and Hurstbridge lines) and the Caulfield Group Loop (Frankston, Pakenham, and Cranbourne). Each single tunnel receives trains from its respective lines, carrying them through the City Loop and then back out to return to a station or stabling on the same group of lines (Burnley, Caulfield, Clifton Hill or Northern).

This project involves creating two independent metro lines by reconfiguring the two existing City Loop tunnels through constructing new single tunnel links between Flagstaff (Caufield Group Loop) and North Melbourne platform two (one kilometre in length), and Parliament (Northern Group Loop) to Richmond platform three (1.3 kilometres in length). The rail tunnels include the construction and formation of the tunnel and associated works such as cross-tunnels, access

[164] https://metrotunnel.vic.gov.au/

shafts, portal works and construction of the concrete lining, and allowance for the commissioning and de-commissioning of tunnel boring machines.

The assessment includes connections into the existing network, and assumes the asset condition of these tracks and systems being connected into are of reasonable condition, or if they needed to be improved would be funded as part of a separate maintenance program.

Moving towards a metro style system results in changes to interchange activity, as more frequent services across the day make interchanging easier with different services stopping at either above ground or underground stations. For this assessment, it has been assumed that North Melbourne station, with two large pedestrian bridges at either end of the station, will have sufficient capacity particularly following Sunbury services being directed into the Metro Tunnel. The pedestrian bridge at Richmond station, however, may face constraints given its physical layout, and it is therefore possible that the engineering challenge may be too significant.

For this assessment, it has been assumed that improvements will be undertaken at Richmond Station until it becomes more cost effective to facilitate more interchanges at either South Yarra or Burnley Stations. To reflect this upper cost limit, new pedestrian bridges for South Yarra and Burnley have been included in the cost estimate, noting the specific sites are yet to be finalised.

The project also involves rebuilding the rail connection between Upfield and Roxburgh Park along with new tracks to Craigieburn, corridor upgrades and electrification to Wallan and new stations at Lockerbie and Beveridge.

Additional services during peak periods from Craigieburn, Upfield and Glen Waverley Lines and the northern growth area

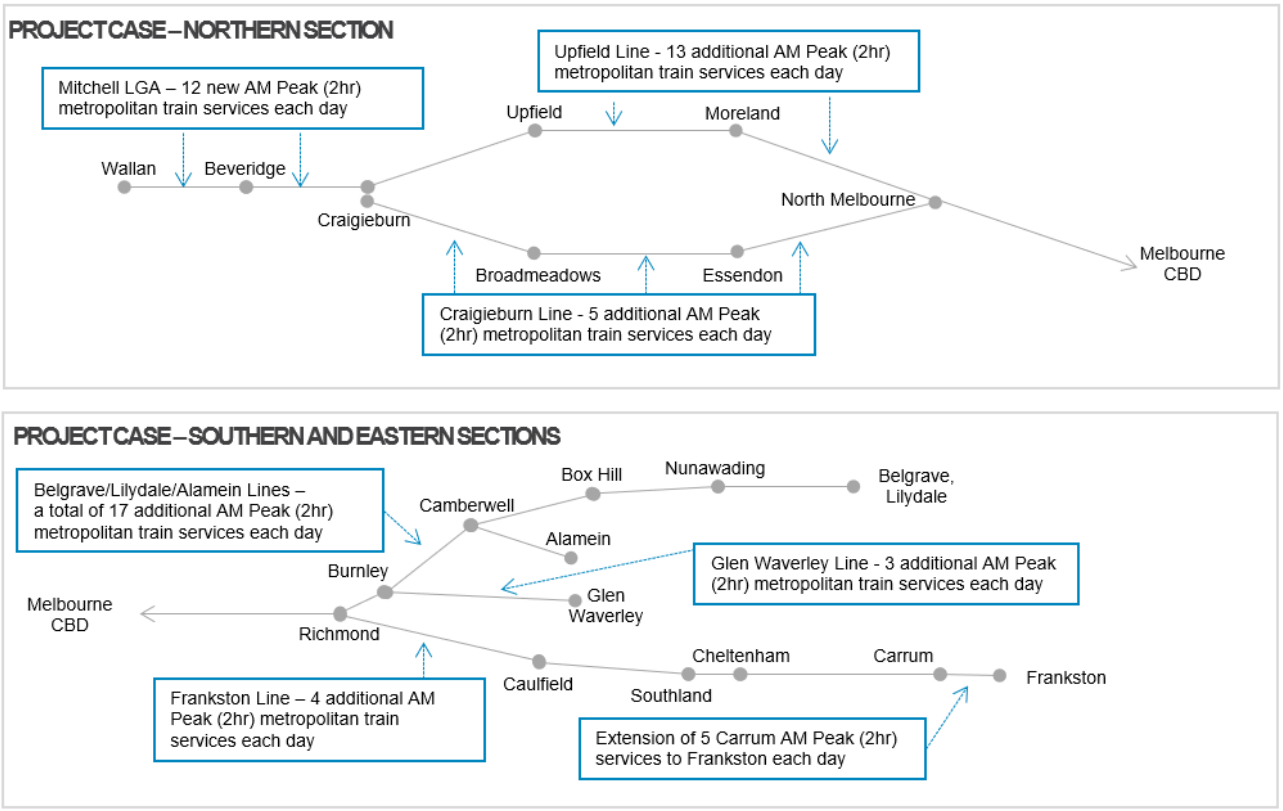
The CLR project is an opportunity to make changes to existing tunnels and infrastructure to allow corridors to form independent train lines across the network. CLR would facilitate the creation of two independent lines:

- **Frankston – Craigieburn**: All train services originating on the Frankston or Craigieburn train lines would now run across the city in a closed system. This will allow the Craigieburn line, which will be limited to 18 train services per hour during the peak period, to increase services to up to 22 trains per hour over time as well as some additional Frankston services. Corridor upgrades on the Craigieburn line are assumed to be part of this project, however upgrades on the Frankston line have been assumed to have been completed as part of other projects prior to this project commencing.
- **Glen Waverley – Upfield**: All train services originating from the Glen Waverley or Upfield lines would now travel across the city in a closed system, which will allow the Upfield line, which is currently limited to six train services per hour, to be able to run up to 22 trains per hour. This is a significant corridor capacity increase of over 250%. This change will also support additional services on the Glen Waverley lines (as shown below in Figure 30). Corridor upgrades for both the Upfield and Glen Waverley lines are included in this project, with any further level crossing removals assumed to occur as part of a level crossing removal program.

CLR will provide sufficient additional train capacity to the Upfield line to support an extension of the metropolitan train network into the Mitchell LGA (to either Beveridge or Wallan). A summary of the additional train services during the morning peak (2 hours) is shown below in Figure 30.

The service uplift for additional Ringwood services, which are dependent on additional capital works to deliver the fourth track between Burnley and Camberwell, are also shown in Figure 30, but were excluded from the project appraisal.

Figure 30: City Loop Reconfiguration and Northern Rail Corridor Upgrade passenger capacity uplift (2036 and 2051) – inbound AM peak (2 hours)

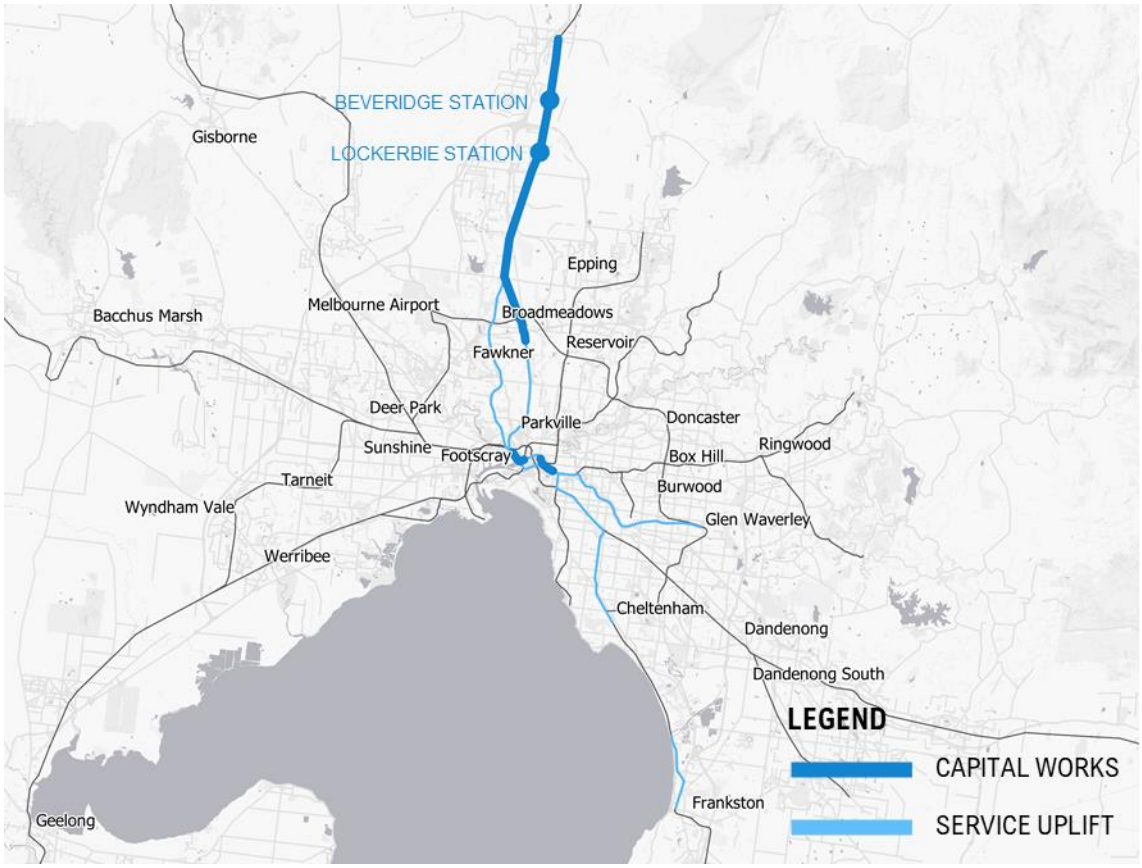


Source: Visualisation by Infrastructure Victoria (2021), Network Development Scenario service plans

Two new stations to serve the northern growth area

Beyond Craigieburn, there are only two stations in the northern growth area, at Donnybrook and Wallan, which are 15 kilometres apart. With considerable development planned between these two stations, a further two new stations are planned, one at the proposed Metropolitan Activity Centre at Lockerbie (Cloverton) and the second at Beveridge (Figure 31).

Figure 31: City Loop Reconfiguration and Northern Rail Corridor Project Alignment



Source: Arup 2021

Project Costs and Timing

The total estimated cost of CLR, inclusive of contingencies, 50-years renewal costs and operations and maintenance costs (O&M) are shown in the table below. This includes the capital cost for all of the enabling works required for this project, including upgrades on the Upfield and Glen Waverley rail lines. The cost of level crossing removals that are required for this project is not included, as it is assumed this would be covered under a separate program.

Total capital expenditure cost is estimated to be between $6.1 billion and $6.9 billion (in 2020 values, including electrification from Beveridge to Wallan). Along with the reconfiguration of City Loop tunnels and electrification towards Wallan, other significant components of this cost include reopening the rail connection between Upfield and Somerton with an additional two tracks to Craigieburn and corridor upgrades along the Upfield, Craigieburn and Glen Waverley lines. It has been assumed that the train fleet will comprise 21 additional six-car sets of X'Trapolis trains or similar. Contingencies for design, construction and prolongation have also been included in the total cost.

Construction in this assessment has been assumed to start in the late-2020s, and is expected to be completed in the mid-2030s, with the project operational from 2036. There is an opportunity to do this earlier to help minimise disruption.

The Metro Tunnel Project (currently under construction) will enable some new services on the Craigieburn and Upfield lines, but these would reach capacity by the mid-2030s. If they were operational without first reconfiguring the City Loop, the services would be heavily disrupted for long periods during construction of the CLR project, affecting many more passengers. Reconfiguring the City Loop immediately after completing the Metro Tunnel Project in 2025 minimises disruptions to passengers, particularly as the realignment of the Cranbourne and Pakenham services through the Metro Tunnel can leave one of the two City Loop tunnels affected by this project unused.

The window of opportunity to deliver the project with these efficiencies will close as demand continues to increase, and the network may only temporarily have enough spare capacity to change train service patterns during construction to minimise passenger impacts. The Victorian Government must decide within two years whether to take advantage of this opportunity.

Table 10: CLR capital expenditure cost profile (2020 dollars)

Project	Lower Capex ($m)	Upper Capex ($m)
CLR Project (including electrification from Beveridge to Wallan)	6,138	6,935
CLR Project (excluding electrification from Beveridge to Wallan)	5,621	6,418

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

Multi-criteria Analysis

The CLR project provides strong and consistent public transport crowding benefits on most metropolitan and V/Line services in both 2036 and 2051. Through boosted metropolitan services travelling towards growing corridors like Frankston and Glen Waverley, along with new electrified services towards Wallan, the proportion of congested passenger kilometres to total passenger kilometres in 2051 is reduced from 40.6% of the rail network in the transport base case down to 38.6% in the project case. In addition, this project has set up the network into metro style lines so that subsequent projects can readily improve capacity.

The overcrowding relief is even stronger in 2036, as less of the network is congested to begin with, allowing large capacity uplift projects like CLR to perform even better. Mode shift and a reduction in driving also contributes to strong road decongestion benefits.

Increased services contribute to greater accessibility to jobs, most notably for residents in the Middle Melbourne FUA, while Inner Melbourne experiences the strongest increase in access to labour force.

As a result of fewer vehicle trips attributable to drivers shifting onto a more attractive public transport network, the level of freight congestion and average travel times to key freight destinations also reduces. Of all assessed rail projects, CLR performs well in its contribution to relieving freight congestion, especially in 2051. As the CLR project is not a new road link in the freight network, its performance is not assessed against freight connectivity or freight utilisation.

Through mode shift and improved road conditions, vehicle emissions from the CLR project also fall by the most of any project in both 2036 and 2051.

Overall, the CLR project provides favourable assessments in terms of road congestion, public transport crowding, and freight congestion and connectivity, and presents an overall compelling case as a major transport project.

Table 11: CLR MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
City Loop Reconfiguration (CLR)	H	H	L/M	L/M	H	~	~	E

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

Transport Outcomes

The CLR project is expected to improve transport network reliability, provide additional train services to meet growing demand in the north, east, and south-east (Craigieburn, Frankston, Glen Waverley, and Upfield), and provide a new metropolitan electrified service to new and existing train stations in the northern growth corridor. This project will support the growing demand, created by population increases in the northern growth corridor, providing access to jobs, study opportunities, and reducing social disadvantage.

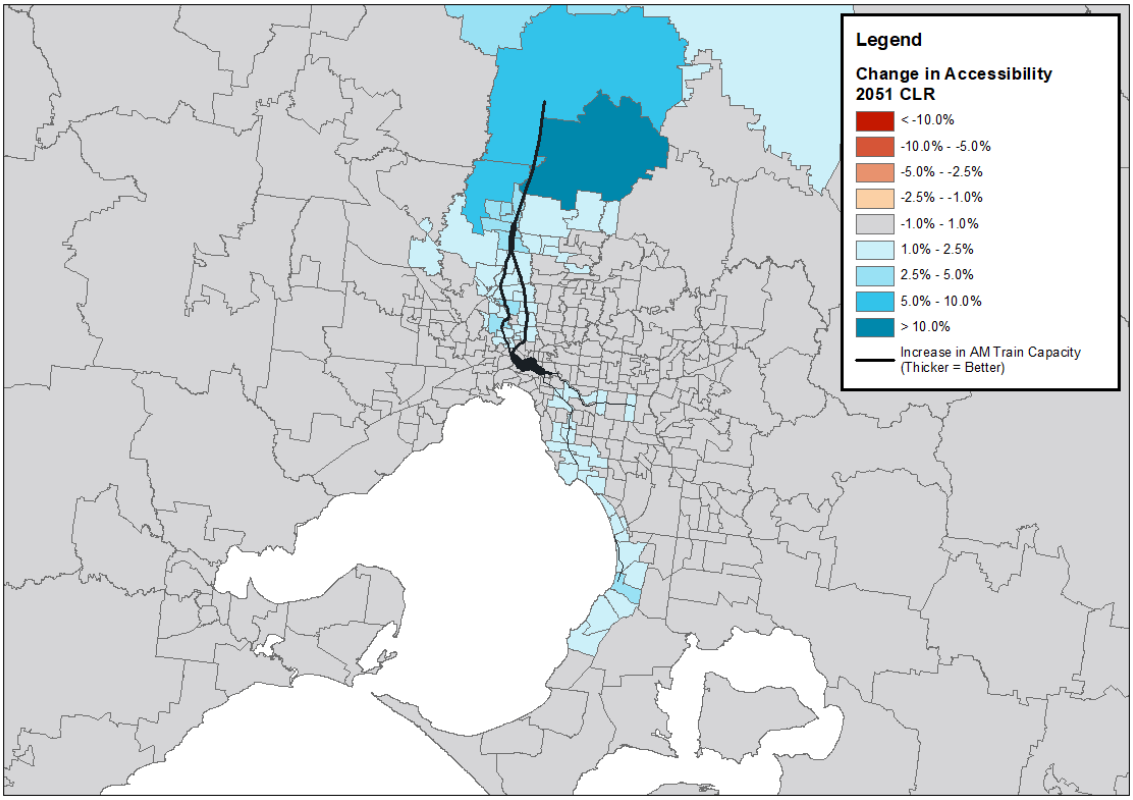
It will also ensure that Shepparton and Seymour regional V/Line services can continue to meet regional demand without being overcrowded for long parts of the journey, as most passengers will use the extended metropolitan electrified services.

The following sections explore the transport outcomes for both public transport and private vehicle travel from this project.

Public transport

CLR is expected to attract new patronage growth in middle suburbs and growth areas, with an additional 1.4 million annual morning peak (2 hour) public transport trips predicted by 2051. This project delivers significant improvements in access to jobs for residents in the northern growth corridor, with improvements of over 10% as shown below in Figure 32.

Figure 32: CLR impact on access to jobs from place of residence in 2051 (AM Peak)

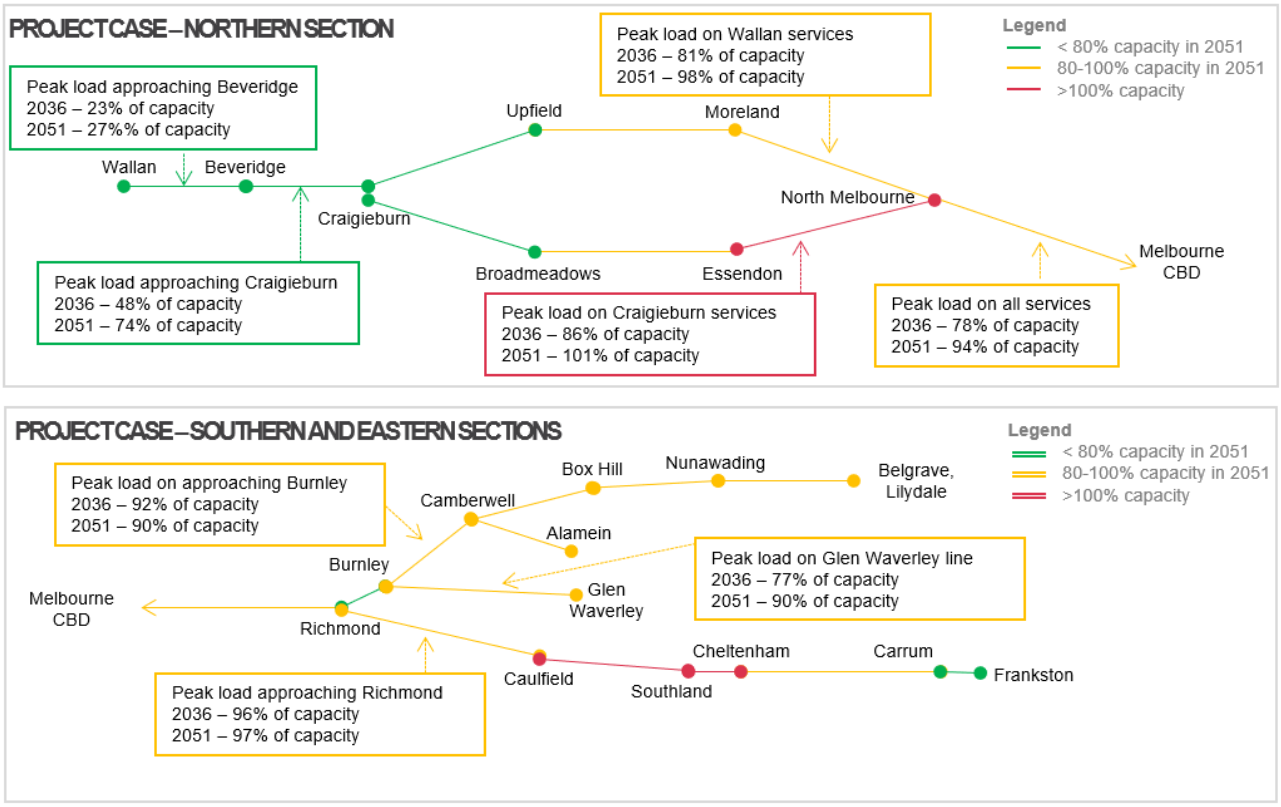


Source: ARUP 2021 Strategic Modelling Outcomes Report

The CLR project results in a significant drop in crowding on metropolitan train services in the north, east and south-east of Melbourne, with reductions in crowded passenger kilometres travelled by over 5% in 2036. Overall benefits are largely driven by the capacity relief on the new metropolitan services from the northern growth area, which reduces overcrowding (103% of capacity) on the Seymour and Shepparton V/Line trains departing Beveridge in 2036 to trains at 48% capacity. By 2051, the new northern growth area metropolitan train service is expected to attract over 1.5 million new annual morning peak (2 hour) passengers at Beveridge, Lockerbie (Cloverton), and Donnybrook stations, and arrive at Craigieburn with only 74% capacity utilised, accommodating future growth in Mitchell and Whittlesea LGAs (shown below in Figure 33).

Other significant network performance improvements include reduced crowding on the Ringwood corridor, with crowding levels dropping from overcrowded base case levels (96% in the year 2036, 112% in the year 2051) to a utilisation of 90% in 2051. Services originating from Frankston will continue to experience overcrowding in 2051, but passengers boarding at Mentone Station will experience additional boarding opportunities, while services approaching Cheltenham Station are expected to be full (100% capacity).

Figure 33: Metropolitan train service line load projections for Burnley and Frankston services (CLR project case)



Source: Visualisation of ARUP modelling results (2021) by Infrastructure Victoria

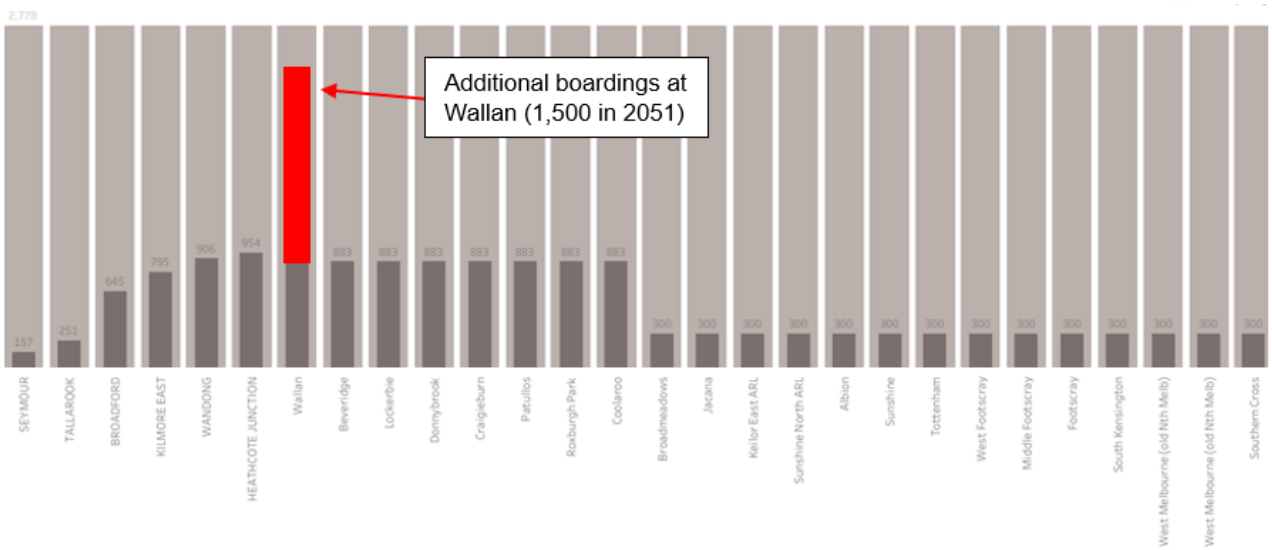
Staging of Northern Rail Corridor Upgrade works towards Wallan

In 2051, services originating at Seymour are only operating at 35% capacity, with space to accommodate 1,800 additional passengers in the two-hour morning peak. Passenger demand for train services from Wallan station to Melbourne in the two-hour morning peak are expected to reach 1,500 passengers by 2051, which would increase the utilisation of Seymour train services from 35% to 88%. As such, this analysis suggests that Northern Rail Corridor Upgrade works from Beveridge towards Wallan could be deferred until a later stage, post-2051, when additional capacity is required to support growing travel demand. However, if a significant proportion of the two-hour passenger demand occurred in the busiest hour (60%), some passengers may experience difficulties boarding at Wallan.

In the event that upgrade works did not occur to Wallan and the new metropolitan services originated from Beveridge, some of the passenger demand at Wallan may be attracted to travel to the new Beveridge Station to access the less crowded, electrified service. This would further delay the need to extend the electrification to Wallan beyond 2051.

It is therefore recommended that Northern Rail Corridor Upgrade works to Beveridge occur initially, and that further upgrade works to Wallan be considered in the longer term. Further detailed analysis in the business case should be undertaken to refine the staging of the upgrade works to go to Beveridge, Lockerbie (Cloverton) or Donnybrook.

Figure 34: Seymour Regional Rail Services (2051) with Wallan Station boardings (CLR project case, AM peak 2hr)



Note: V/Line regional services that have a passenger capacity of 2,700 will be able to accommodate the 1,500 boardings at Wallan Station in the morning peak should the metropolitan service only be extended to Beveridge.
Source: Visualisation of ARUP / AECOM modelling results (2021) by Infrastructure Victoria

City Loop Reconfiguration: Enabling the creation of a Belgrave / Lilydale Express Metro service

The Burnley group is made up of the Belgrave, Lilydale, Alamein, and Glen Waverley metropolitan train services, and has exclusive use of one of the four City Loop tunnels. The Burnley group has an effective capacity of 21 trains per hour during the busiest period, which can support:

- 12 express services from Belgrave and Lilydale (originating beyond Ringwood)
- six stopping all station services (originating at between Ringwood and Box Hill)
- three Alamein services, stopping all stations.

The Burnley group is a key beneficiary of the City Loop Reconfiguration project, as it provides additional capacity for patronage growth into the second half of the 21st century, by separating the Glen Waverley services from the rest of the Burnley group.

As shown in Figure 33, services on the Burnley group are expected to experience overcrowding in the early 2040s, and further works will be critical to providing additional capacity to accommodate future growth.

By constructing a fourth express track between Burnley and Camberwell and undertaking junction upgrade works at Burnley Station, Alamein services can also be separated from the Belgrave and Lilydale lines, allowing the delivery of the following services:

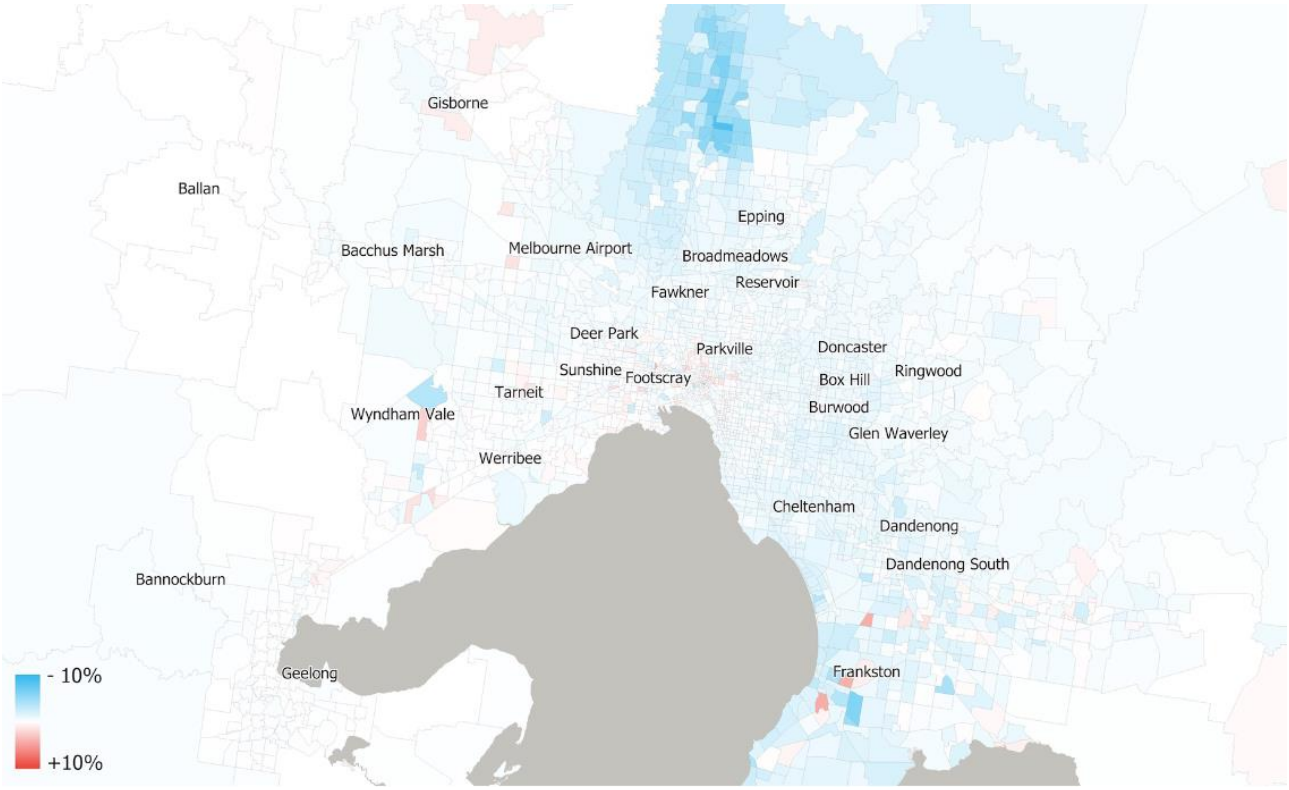
- Additional capacity for up to 11 additional express metro services from Belgrave and Lilydale in the AM Peak (2 hour) **and** simplifying services. This will lead to better reliability and improved access to seating for passengers.
- Consistently provide express services all times of the week for passengers on the Belgrave and Lilydale services.
- Increase the number of Alamein services stopping all stations from a train every 20 minutes to a train every 10 minutes during peak periods, increasing the frequency and capacity at stations such as Auburn, Hawthorn, Burnley, and East Richmond.

Private Vehicles

The CLR project is expected to impact car trips during the morning peak, with a reduction of 0.5 million annual morning peak (2 hour) trips across Melbourne by 2036, and a reduction of 1.2 million private car trips annually in the morning peak by 2051. This change in demand will lead to reductions in vehicle congestion of 3.2% in 2036, and 4.4% in 2051.

While traffic is expected to increase in growth areas, the CLR project is predicted to reduce private vehicle travel time in the northern growth area by as much as 10% for some locations, as shown below in Figure 35.

Figure 35: CLR change in private vehicle travel time, 2051 compared to transport base case (AM period)



Source: ARUP / AECOM Modelling Report (2021)

Demographic Outcomes and Land Use Implications

Population

The CLR project results in population uplift around the Craigieburn and Upfield train line in the north, and the Frankston line in the south-east, where the project results in improved public transport accessibility.

In the north, population uplift is highest in the Northern Growth Corridor where PSPs in Hume, Mitchell and Whittlesea LGAs have been completed or are proposed.[165] These are places experiencing high growth under the transport base case. Much of this additional population growth is projected to occur around the future Cloverton activity centre, a Metropolitan Activity Centre (MAC) identified in *Plan Melbourne* (as Lockerbie).[166] This additional growth occurs over a large area, with population uplift occurring in PSPs which are not immediately serviced by a train station. This includes Beveridge North-West and Woodstock, both located more than 2km from the nearest train station (Lockerbie / Cloverton). While the Wallan area has more population than the transport base case, the increases are less pronounced than to the south in Beveridge and Lockerbie (Cloverton).

Additional households are also attracted to Wollert which currently has limited access to public transport. In addition, parts of Hume LGA's more established outer areas, such as Craigieburn, experience more population growth with the rail service improvements.

Along the Frankston line, additional population growth occurs in a consistent pattern around train stations along the length of the corridor from Caulfield to Frankston Station. Population uplift continues towards the Mornington Peninsula, south of Frankston station, towards Mornington. Some additional growth occurs beyond Frankston along the Stony Point line in Somerville, although the Stony Point line does not directly benefit from increased accessibility as part of the CLR project (Figure 36). Responding to improvements in accessibility with increased train services, population is also attracted to stations along the Glen Waverley line in the corridor from Kooyong to Glen Waverley. Both the Frankston and Glen Waverley lines service established suburbs, with neither providing connections to any new growth areas but may provide opportunities for additional residential development.

In the north, significant positive changes in accessibility across a large area result in population growth occurring outside the UGB north of Wallan. Small but significant pockets of population uplift occur in Whittlesea and around Kilmore. These are places with a low-density, rural character, which are at risk of increased development because of their proximity to Melbourne and increasing transport accessibility. They are also subject to a Bushfire Management Overlay which designates areas at extreme risk from bushfire hazard (as distinct from bushfire prone areas).[167] A similar pattern is also observed in peri-urban areas east of the Frankston line, although at a much smaller magnitude. Unplanned residential development outside Melbourne's UGB will place pressure on green wedge areas, agricultural land and distinctive landscapes, the strengthened protection of which are currently subject to review by DELWP.[168]

The project unlocks the potential for future population growth within proximity of train stations in established suburbs, particularly in Melbourne's inner north. An opportunity for better use of existing infrastructure occurs in train station precincts which are already supported by activity centres. Along the Craigieburn line, Broadmeadows and Glenroy stations are both within existing activity centres, while the Essendon activity centre is accessible within an 800-metre walk of both Essendon and Glenbervie Stations. Along the Upfield line, Coburg, Moreland, and Batman stations are within proximity to the Sydney Road Coburg Activity Centre. Along the Frankston line, activity centres are more likely to contain train stations, resulting in a number of opportunities for urban consolidation supported by existing infrastructure and services. In two cases (Cheltenham Station and Glen Waverley Station), service upgrades are occurring in activity centres which will also benefit from the addition of new Suburban Rail Loop (SRL) stations.

Central Melbourne's population growth is marginally slower than in the transport base case with this project. The Inner Melbourne FUA shows a fall of 0.2% in 2036 and 0.7% in 2051 population growth compared to the transport base case. This is driven by improved accessibility occurring in the north attracting some of this growth towards the northern corridor. This is not expected to have a large impact on central Melbourne given the significant population growth forecast for this region even without the project.

Jobs

The CLR project results in a similar distribution of job uplift along the train corridors which benefit from capacity and service improvements. This results in population serving jobs increasing in places where additional population growth occurs in the Northern FER, while there is very little change in the Southern FER. This may be related to the different scale of population change between the two regions, with the Northern FER experiencing much more growth overall

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[165] https://vpa-web.s3.amazonaws.com/wp-content/uploads/2019/02/PSP-status-map-February-2019.pdf

[166] Department of Environment, Land, Water and Planning, *Plan Melbourne 2017-2050*, 2017, p.14, https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy_.pdf

[167] http://planning-schemes.delwp.vic.gov.au/schemes/vpps/44_06.pdf?_ga=2.172901923.1482342793.1566774710-899408773.1556675708; https://www.planning.vic.gov.au/policy-and-strategy/bushfire/bushfire-content-drawers/difference-between-the-bmo-and-the-bpa

[168] *https://www.planning.vic.gov.au/policy-and-strategy/green-wedges-and-agricultural-land and https://www.planning.vic.gov.au/policy-and-strategy/distinctive-areas-and-landscapes*

(+1.7%) compared to the Southern FER (+0.03%). Very limited jobs change occurs in existing jobs clusters, including the central city, as a result of the project. The only exception is the Northern SSIP, which grows by more than 1% over the transport base case by 2051. Some activity centres with train stations have modest increases, including Broadmeadows, Cheltenham, Frankston and Southland.

Job changes are much smaller than the population changes produced by the CLR project. For example, Cloverton has notable additional population growth but almost no increase in jobs. Calibration of the model provides a partial explanation for this, with existing patterns of agglomeration being a powerful influencing factor for where future jobs are located. In this case, although additional benefits are generated by increasing accessibility, these time savings are not able to influence a larger number of jobs to relocate from existing job clusters to Cloverton. This highlights the complexity of business location decisions and the limits of transport projects alone to drive change.[169]

Figure 36: Population changes due to CLR compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes report

[169] *Balbontin, C., & Hensher, D. A. (2019). Firm-specific and location-specific drivers of business location and relocation decisions. Transport Reviews, 39(5), 569-588*

Figure 37: Jobs changes due to CLR compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes report

Economic Assessment

The economic evaluation for this project assessed the costs and benefits, using conventional transport guidelines for cost benefit analysis. The assessment has been expanded to include land use change benefits, WEBs and broader impacts. Further detail on the approach to the economic assessment can be found in section 3.4.2.

The table below presents a summary of the estimated benefits from the CLR project, using a discount rate range of 7% and 4%. The largest benefit category is consumer surplus benefits, which includes the travel time savings for public transport users, including private vehicle users who switch to public transport.

Table 12: CLR Benefits (Present Value $ million)

Benefit	Static Land Use	Dynamic Land Use	WEBs only	Total
Consumer surplus benefits	$3,748 - $9,408	$1,084 - $3,135		$4,832 - $12,543
Active transport benefits	$240 - $596	-$34 – -$100		$206 - $496
Safety benefits	$68 - $151	$41 - $127		$109 - $278
Environmental benefits	$45 - $111	$102 - $291		$147 - $402
Residual values	$23 - $139	$0 - $0		$23 - $139
WEBs			-$226 – -$892	-$226 – -$892
Total benefits	**$4,124 - $10,404**	**$1,193 - $3,453**	**-$226 - -$892**	**$5,091 - $12,965**

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: The 'Headline' ranges are provided using 4% and 7% discount rates

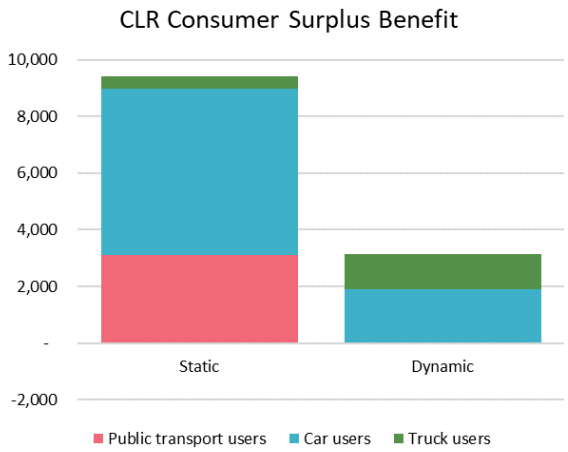
Quantified benefits

Total benefits of this project are made up of static land use, dynamic land use and WEBs. The static land use benefits represent the estimated conventional transport benefits arising from this project, without any changes to the location of population and jobs. The dynamic land use benefits arise from changes in the location of population and jobs caused by the project.

Dynamic land use benefits are positive for this project. This is due to more people moving to areas that have greater accessibility in the north and south-east of Melbourne because of the CLR project. This results in an increase in both public transport and private vehicle trips from the population living in these areas. As these areas become slightly less congested with the project there are small land use benefits to car and truck users.

Figure 38 shows the consumer surplus benefits under static and dynamic land use outcomes for public transport users, car users and truck (freight) users. This highlights that congestion relief benefits to car users contribute almost two thirds of the static land use benefits, followed by public transport users. It also shows the additional benefits arising under the dynamic land use outcome for car users.

Figure 38: CLR Consumer Surplus Benefits for Static and Dynamic Land Use Outcomes



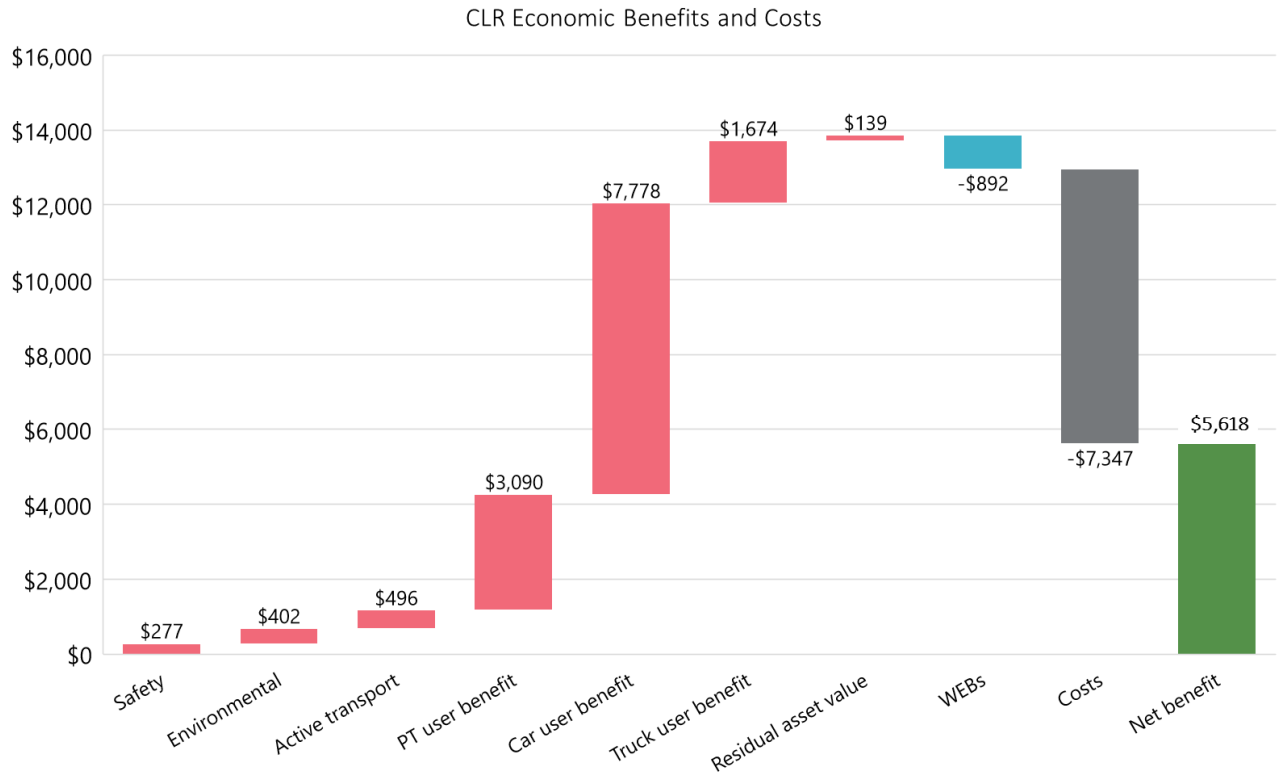
Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

WEBs have been estimated as negative for this project using the VLUTI model. This is due to a small decrease in employment growth in the central city, resulting from the CBD becoming relatively less accessible with changes to the City Loop. Due to the reconfiguration of the City Loop providing increased reliability and less disruption across the network, fewer trains stop at all the City Loop stations, including Flinders Street and Southern Cross. This leads to a higher incidence of interchange and a corresponding increase in average public transport travel times for trips made within the CBD. As the model has a fixed number of jobs for Victoria, new jobs are shifted towards areas with improved travel times and accessibility in the north and south, and away from the CBD.

WEBs have also been estimated using the conventional VITM approach which showed a positive benefit. This is further explained in the following section which outlines the conventional VITM results.

Figure 39 shows the economic benefits of this project compared to the total estimated cost in present value terms. This shows the large contributions from car users, followed by public transport users to the total benefit. It also highlights that the benefits are expected to be greater than the cost of this project in present value terms, with a positive net present value (net benefit).

Figure 39: CLR Economic Benefits and Costs (Present Value $ millions)



Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Total dynamic land use plus WEBs results presented using upper project costs and a 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Summary cost benefit analysis results

Summary results from the cost benefit analysis are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes all quantified benefits outlined in the table above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 1.1 and 1.8 for upper project costs and 1.2 to 1.9 for lower project costs, for the total outcome (dynamic land use including WEBs, ranges are provided using 7% and 4% discount rates). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and wider economic benefits arising from productivity improvements.

Given the inputs used for this evaluation, the CLR project produces a BCR above 1. That is, the project is expected to generate benefits that are greater than the expected cost of this project in the long term.

Table 13: CLR Benefit Cost Ratio and Net Present Value ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	0.9 – 1.4	-$529 - $3,004	1.1 – 1.9	$664 - $4,743	1.1 – 1.8	$438 - $5,564
Lower project costs	1.0 – 1.6	-$89 - $3,694	1.3 – 2.1	$1,104 - $7,147	1.2 – 1.9	$878 - $6,255

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report and Infrastructure Victoria Analysis 2021
Note: Ranges provided show results using a 7% and 4% discount rate

Figure 40 shows the distribution of the public transport consumer surplus benefits across metropolitan Melbourne resulting from the CLR project in 2051. This highlights that the majority of the economic benefits from this project are concentrated in the north of Melbourne in areas surrounding the rail corridor (blue areas on the map), along with the south-east rail corridors.

Conventional VITM CBA results

This project was also modelled in VITM, using the conventional approach without any land use changes. An economic assessment has been undertaken using these results, to compare to the economic assessment using the VLUTI model. This was done to compare the conventional modelling and economic assessment approach with our new approach using the VLUTI model. The table below shows the benefit cost ratios for this project using VITM.

The VITM results are slightly higher than the VLUTI results, driven by stronger population and demand in the northern corridor in the SALUP forecasts that are used in VITM (compared to the forecasts used in VLUTI). The conventional VITM results also show higher WEBs for CLR (compared to negative WEBs in VLUTI) as the VITM model does not account for any loss of jobs or population in the CBD from the increase in population in the northern corridor. This comparison highlights the benefits of the VLUTI model in accounting for these land use changes effects. However, it does highlight the need to be able to quantify the full set of benefits to households and broader place-based benefits.

Table 14: CLR Cost Ratio and Net Present Value – VITM Comparison ($ million)

	Conventional BCR	Conventional BCR including WEBs
Upper project costs	1.2 – 2.0	1.4 – 2.2
Lower project costs	1.3 – 2.2	1.4 – 2.4

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report and Infrastructure Victoria Analysis 2021
Note: Ranges provided show results using a 7% and 4% discount rate

Broader impacts

There are also expected to be broader impacts arising from this project which cannot be quantified in a cost benefit analysis. We have assessed metrics from the VLUTI model where available and provide commentary on the expected direction of these impacts. These broader impacts include:

- broader economic benefits
- infrastructure cost changes
- place benefits
- social and health impacts
- environmental impacts.

This project encourages increased residential development in New Growth Areas and Outer Melbourne. These areas have infrastructure capital costs that tend to be higher than in established areas on average (excluding transport costs).[170] This project could have additional costs in providing this infrastructure for New Growth Areas, depending on the amount of household growth that occurs. This impact has not been quantified due to lack of suitable data.

Place benefits can arise from improved urban amenity in residential areas arising from a change in land use driven by the transport project. The change in land use to residential development is likely to result in higher value use, better amenity and quality of development. Residential development that occurs in areas which have good access to transport and services will generate greater benefits than in locations with poor access.

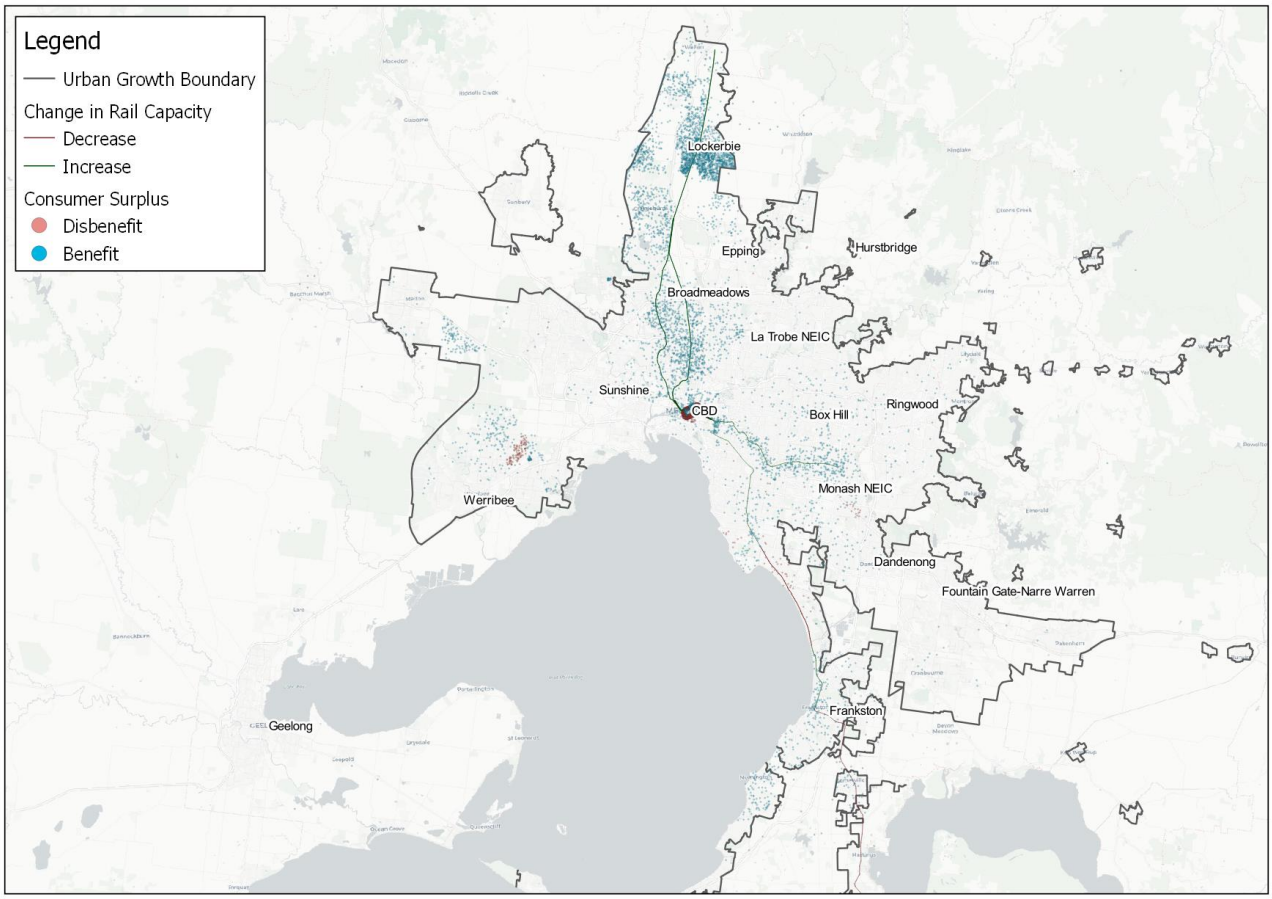
Land values have been used as an indicator of the distribution and magnitude of place benefits, acknowledging the limitations of this approach. The largest impact is expected in Wallan and Beveridge, in line with the increase in population also expected for this area. Increases are generally focused along the rail corridor and are largest in the northern and southern corridors.

Distribution impacts

Figure 40 shows the distribution of the public transport consumer surplus benefits across metropolitan Melbourne resulting from the project in 2051. This highlights that most of the economic benefits from this project are concentrated in the north and south-east of Melbourne in areas surrounding the rail corridor (blue dots on the map). People in these areas are expected to have the greatest improvements to public transport travel times and therefore have the largest proportion of benefits from this project. Some areas outside of the project alignment, such as in the CBD and south-west, see reduced public transport consumer surplus. This is caused by some people moving away from these areas and towards the rail corridor that is now more attractive due to the transport project.

[170] *Infrastructure Victoria 2019, Infrastructure Provision in Different Development Settings*

Figure 40: CLR Public Transport Consumer Surplus Benefits (2051)



Note: This map shows change in total consumer surplus by travel zone, not per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits
Source: AECOM 2021 Transport Modelling Scenarios – Economics Report

Social Assessment

Transport projects can improve access to employment opportunities, education, health care, and community and social services.[171] This can help to address some drivers of disadvantage for residents in more disadvantaged areas that have improved access.[172] The CLR project will have particular benefits for public transport user groups such as children, the elderly and people with a disability, from an increase in rail service frequencies, which also relieves crowding. The 126,000 young people in the Northern Growth Corridor in 2036[173] will have a better rail service, but they will also need frequent connecting buses to access trains since many new homes are not within walking distance of train stations.

The Northern Growth Corridor contains some of the most disadvantaged parts of Melbourne.[174] This project improves access from these areas to a greater range of jobs, education and services, including higher skilled jobs. The CLR project improves access to jobs in the northern growth corridors and to the south-east, with average travel times to employment centres including to the Monash and La Trobe NEICs by public transport during the morning peak improving, as well as in established suburbs in the north and south-east.

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[171] *Pope, Jeanette. "The role of infrastructure in addressing regional disadvantage in Victoria." (2019). [website] HYPERLINK "https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/11/Background-paper_The-role-of-infrastructure-in-addressing-regional-disadvantage.pdf"https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/11/Background-paper_The-role-of-infrastructure-in-addressing-regional-disadvantage.pdf*

[172] *Ibid*

[173] *Department of Environment, Land, Water and Planning, Victoria in Future 2019, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/*

[174] *Australian Bureau of Statistics Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA). cat. no. 2033.0.55.001. 2016.*

Because this project makes growth areas more accessible, increased demand for housing in these locations may increase land values and property prices.[175] This could make housing in these areas less affordable.[176] Recent data shows that homeowners in Melbourne's New Growth Areas are already more likely to experience mortgage stress, increasing the likelihood that prospective homeowners may be priced out of the market.[177] It is likely they would have to relocate further away from the metropolitan area for a given type of dwelling, as house prices increase with proximity to the CBD.[178] The level of impact should be considered and, where necessary, offset through mechanisms to increase the supply of affordable housing in areas in locations close to public transport, services and jobs.[179]

People living in Melbourne's established inner north and to the south along the Frankston train line will have improved rail services from this project, resulting in more residents being attracted to live in those locations. The capacity of existing infrastructure to accommodate growth, as well as the adequacy of current housing supply should be considered.

These types of locations should be prioritised for a wider range of housing types and at higher than current densities. This should include the corridor to Upfield, as it has the highest increase in passenger capacity in this project in the morning peak period. It may particularly benefit the projected higher proportions of elderly Melburnians in places such as Essendon, Cheltenham and Frankston, making these locations even better suited to those who do not drive.[180] Ensuring high quality walking and on-road public transport access to stations will be particularly important to this group.[181] Better active transport infrastructure and limits on station car parking may also encourage people to change how they travel to stations which receive service improvements, and this can contribute to improved health outcomes from incidental exercise.[182]

Research has found that tertiary educated women living in growth areas are less likely to be in a job that reflects their level of qualification compared both to men, and to women living in inner and middle areas.[183] This project has the potential to provide greater access to jobs that better suit the skills of women in growth areas, through providing increased capacity on the rail corridors connecting to the city. While access options might improve, average public transport work trip travel times to central city locations during the morning peak are slightly longer than in the transport base case.

Environmental Assessment

Carbon emissions are reduced overall because of fewer private vehicle trips associated with this project. However, localised increases may occur, given more private vehicle movements in growth areas. This may result in increased negative health impacts due to air pollutants such as PM2.5.[184] In 2016, the Northern Growth Corridor experienced mean urban temperatures 8 to 13 degrees hotter than a non-urban baseline. With more people living in the area as a result of this project, adequate planting of vegetation is required. Canopy trees in particular can mitigate these existing high temperatures, as well as encourage more people to walk and cycle to train stations.[185]

Existing suburbs with improved rail services and additional population in the inner north and south have relatively unconnected public open spaces. They do have some large parcels of public land with restricted access which should be priorities for opening for communities to access, especially in communities with higher than projected populations. The inner north is currently undergoing significant development and population growth, and provision of better open space connections by councils and agencies will help these areas to take advantage of more people seeking to live in these areas as a result of this project.[186] Connected open spaces could also benefit rail users walking to stations.

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[175] *Grace, Renan, and Meead Saberi. "The value of accessibility in residential property." Australasian Transport Research Forum (ATRF), 40th, 2018, Darwin, Northern Territory, Australia. 2018.*

[176] *Whitzman, C., Legacy, C., Martino, E., Raynor, K., Palm, M., Wiesel, I., Davison, G. and Woodcock, I., 2018. Can Australian governments steer 'just intensification'? Evaluating Victorian affordable housing policy.*

[177] *Digital Finance Analytics (2021). "Mortgage heat stress maps" [website] https://digitalfinanceanalytics.com/blog/tag/mortgage-stress-heat-maps/*

[178] *Ibid*

[179] *Palm, Matthew, Katrina Raynor, and Carolyn Whitzman. Project 30,000: producing social and affordable housing on government land. University of Melbourne, 2018. P.25*

[180] *Department of Environment, Land, Water and Planning, Victoria in Future 2019, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/*

[181] *Engels, Benno, and Gang-Jun Liu. "Social exclusion, location and transport disadvantage amongst non-driving seniors in a Melbourne municipality, Australia." Journal of Transport Geography 19.4 (2011): 984-996.*

[182] *Guillen, Pablo, Miguel Loyola, and Ursa Komac. "What Australia can learn from bicycle-friendly cities overseas." The Conversation (2020).*

[183] *SGS Economics & Planning 2018. Gender Equity in Employment – Report prepared for City of Whittlesea*

[184] *Cepeda, Magda, et al. "Levels of ambient air pollution according to mode of transport: a systematic review." The Lancet Public Health 2.1 (2017)*

[185] *Hurley, J., Saunders, A., Both, A., Sun, C., Boruff, B., Duncan, J., Amati, M., Caccetta, P. and Chia, J. (2019) Urban Vegetation Cover Change in Melbourne 2014 - 2018, Centre for Urban Research, RMIT University, Melbourne, Australia, p.38; Sarkar, C., Webster, C., Pryor, M., Tang, D., Melbourne, S., Zhang, X., & Jianzheng, L. (2015). Exploring associations between urban green, street design and walking: Results from the Greater London boroughs. Landscape*

and Urban Planning, 143, 112-125; Levine, J., Zellner, M., Arquero de Alarcón, M., Shiftan, Y., & Massey, D. (2018). The impact of automated transit, pedestrian, and bicycling facilities on urban travel patterns. Transportation planning and technology, 41(5), 463-480

[186] https://vpa.vic.gov.au/strategy-guidelines/metropolitan-open-space-network/

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity of the project's BCR to a range of potential outcomes. This informs the conditions in which a project should or shouldn't go ahead, and how sensitive a project's economic viability is to changes.

These tests include varying the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the project's opening year and construction start, and increasing the value of travel time in the future. The BCR under each test for the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below.

This project has a BCR above one under most sensitivity tests, except when a discount rate of 10% is used. This highlights that whilst there is some variation in the BCRs, there is not expected to be a large impact from changes in costs and benefits. This suggests there are strong drivers for this project in addressing capacity constraints in the Northern Rail Corridor.

A sensitivity test to bring forward construction and opening of this project by five years is also shown in the table below. This is to highlight the likely economic outcome of taking advantage of starting construction of this project following completion of the Metro Tunnel Project in 2025. There is only a very small difference to the BCR between this earlier opening sensitivity test (opening in 2030) compared to the core project scenario of opening in 2035. Given this, and the avoided disruption from taking advantage of this construction window, a key question to be examined in future development of this project is whether to start construction of the City Loop reconfiguration earlier than 2030.

Table 15: CLR Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static land use	Dynamic land use	Total (Dynamic land use with WEBs)
4% discount rate	1.4	1.9	1.8
7% discount rate	0.9	1.1	1.1
3% discount rate	1.7	2.3	2.1
10% discount rate	0.6	0.8	0.7
20% decrease in capital costs	1.1 - 1.7	1.4 - 2.2	1.3 - 2.1
20% increase in capital costs	0.8 - 1.2	1.0 - 1.6	0.9 - 1.5
40% increase in capital costs	0.7 - 1.1	0.8 - 1.4	0.8 - 1.3
Exclusion of construction cost escalation	1.1 - 1.7	1.1 – 1.9	1.0 – 1.8
40% decrease in total benefits	0.5 - 0.9	0.7 - 1.1	0.7 - 1.1
20% decrease in total benefits	0.7 - 1.1	0.9 - 1.5	0.9 - 1.4
20% increase in total benefits	1.1 - 1.7	1.4 - 2.3	1.3 - 2.1
Delay opening by 5 years	1.0 - 1.5	1.3 - 2.1	1.2 – 2.0
Delay opening by 10 years	1.1 - 1.5	1.5 - 2.4	1.4 - 2.1
Bring forward opening by 5 years	0.9 - 1.4	1.0 - 1.7	1.0 - 1.7
Value of travel time	1.7 – 2.9	1.2 - 2.1	1.1 – 2.0

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: These sensitivity tests are provided for the upper cost and ranges are shown using 4% and 7% discount rates.

Future scenarios

CLR is considered to be generally resilient to all future scenarios that have been assessed. The project provides significant benefits for public transport users by alleviating overcrowding, but some scenarios are likely to reduce public transport demand for travel, which in turn may reduce the demand for the project and delay the need for investment.

The City Loop tunnel sections of the project scope are more resilient than the Northern Rail Corridor Upgrade, as the decision to undertake works immediately after the Metro Tunnel Project opens will significantly reduce the extent of disruption for existing users. The Northern Rail Corridor Upgrade, by contrast, is more prone to the risk of less demand from growth areas into the city using public transport, which may occur under the low population growth or in the EAV scenario. Under the WFH scenario, population growth in outer suburbs and growth areas will increase demand for public transport, strengthening the case for investment.

Policy scenarios are likely to support the need for the project, with targeted density outcomes driving higher public transport mode share in key locations and TNP increasing the cost of driving into Inner Melbourne.

A summary of the implications and expected impact of each future scenario on the CLR project is documented below in Table 16.

Table 16: Resilience of CLR to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	A high population growth scenario will bring forward issues with road network congestion and public transport crowding, driving greater public transport usage and higher economic benefits. It is expected this would also increase the BCR for the project. This would be largely driven by the impact on growth along the Seymour line. Undertaking the City Loop Reconfiguration immediately after the Metro Tunnel Project provides flexibility for Melbourne to respond to this scenario, particularly as the state government has accelerated the approval of PSPs in the Northern Growth Corridor.	~
Low population growth	Even under a low population growth scenario, Seymour V/Line trains are still likely to experience overcrowding in the 2030s. However the growth in demand for public transport over time is likely to result in diminished benefits reducing the BCR overall.	-
Working from home	The WFH scenario indicates that residents will need to commute to the office less, resulting in a shift in residential locations to reflect an alternative lifestyle. The modelling also indicates that population is likely to increase in middle and outer suburbs and jobs increase in Central Melbourne, thus increasing demand for road travel in these areas. Outer suburbs and growth areas experience an increase in public transport demand as increases in residents and Central Melbourne jobs offsets travel reductions due to WFH. This is expected to increase the benefits of this project and improve the BCR.	+
Automated and electric vehicles	The EAV scenario is unlikely to have an impact in the timing of CLR. However, AV and ZEV take up is expected to be more substantial by 2051, which is expected to make Mitchell LGA a more attractive place to live. However, under the EAV scenario, public transport mode share drops significantly from 12% to 9% across Melbourne, and such a significant drop is likely to have a negative impact on this project's benefits and the BCR. There is a high degree of uncertainty around this scenario, and its implications for transport projects, as AVs are still an emerging technology.	-
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, increasing demand for public transport and resulting in greater benefits, increasing the BCR.	+
Transport network pricing	Infrastructure Victoria's research on TNP indicates that private car trips into Inner Melbourne could be reduced by almost one half, and peak public transport boardings are expected to grow but at a slower rate with higher peak and lower off-peak fares. Reconfiguring the City Loop provides flexibility for the system to then respond to demand along the corridors. This scenario is likely to focus on travel demand management to the inner city, which will result in higher public transport mode share for trips to destinations subject to the new cordon charges, increasing demand for public transport (resulting in greater benefits), and increasing the BCR. The increase is expected to be modest due to high costs.	+

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

Implications

Seymour V/Line and Craigieburn suburban services will be overcrowded during the 2030s, and possibly sooner

The CLR project is critical to addressing capacity constraints, particularly on the Seymour V/Line and for Craigieburn suburban services catering for the Northern Growth Corridor over time. The Victorian Government's fast-tracking of PSPs in the Northern Growth Corridor in response to the COVID-19 pandemic could further increase the rate of growth and rail demand on this corridor.[187]

Electrification to Wallan could be staged, with the first stage to Lockerbie (Cloverton) or Beveridge potentially lasting for sufficient considerable time with integrated land use planning.

Our assessment indicates that even in 2051, demand for train services at Wallan Station will not exceed capacity of the proposed V/Line services. As such, while electrification into the Northern Growth Corridor is required, an interim stage could see electrification to a new Beveridge Station, with an extension to Wallan at a later stage. In addition, other scope elements including upgrades to the Glen Waverley line may not be required as part of the initial works.

There should be better integration of PSPs with public transport connections, to support higher density mixed use communities and greater use of active transport. There should also be support for higher density development near the new stations in the Northern Growth Corridor. Cloverton Metropolitan Activity Centre (Lockerbie) will benefit from this project, and consideration should be given to supporting development in this centre close to the train station. Where residential development occurs some distance from the train station, supporting bus services or park-and-ride facilities should be provided to encourage public transport use.

This project results in increased population growth in the growth areas, particularly in the north. To mitigate against the risk of population growth occurring outside of the UGB, existing settlement boundaries should be strictly adhered to. Further planning work should be done to identify peri-urban towns at risk of expansion to ensure that land supply is adequately constrained to encourage urban consolidation.

Improved customer experience on Seymour and Shepparton V/Line Services

Operational changes to the V/Line services from Seymour and Shepparton will significantly reduce overcrowding on these services, as residents in the Northern Growth Corridor will only be able to board metropolitan services. This change will separate V/Line passengers from the busy, new metropolitan stations and services, reducing their exposure to overcrowding conditions and improving their access to seats for return trips during the afternoon peak period.

An option that should be considered is to deliver the reconfiguration of the City Loop straight after the Metro Tunnel Project to reduce inconvenience for Victorian rail users.

There is an opportunity to bring forward construction of this project to be timed to occur prior to or immediately after construction is complete for the Metro Tunnel Project. This is to minimise disruptions to passengers before the new metro services are delivered. Parts of the train network will be disrupted by the CLR construction works, and undertaking key works prior to the implementation of the additional Metro Tunnel Project services, particularly on the northern lines, will result in a better outcome for customers while future-proofing the network to support additional capacity as demand grows.

Housing and job opportunities for middle suburbs

The project unlocks the potential for future population growth within proximity of train stations in established suburbs particularly in Melbourne's inner north. An opportunity for better use of existing infrastructure occurs in train station precincts which are already supported by activity centres, such as the Coburg Activity Centre, which includes Moreland, Coburg and Batman Stations on the Upfield train line.

Along the Craigieburn train line, Broadmeadows and Glenroy stations are both within existing activity centres, while the Essendon Activity Centre is accessible within an 800-metre walk of both Essendon and Glenbervie Stations. Along the Frankston line, activity centres are more likely to contain train stations, resulting in opportunities for urban consolidation supported by existing infrastructure and services. In two cases (Cheltenham and Glen Waverley stations), service upgrades are occurring in activity centres which will also benefit from the addition of new Suburban Rail Loop (SRL) stations.

[187] https://vpa.vic.gov.au/fast-track-projects/

A major step towards metro systems that characterise large cities will result in changes to movement patterns across metro services and onto trams and buses.

This project results in trains stopping at fewer stations within the City Loop, due to its reconfiguration. This means that there is a slight increase in travel time for passengers travelling within the city. While this will involve more interchanges between rail services, as is common with metro systems in large cities, there may need to be accompanying accessibility improvements to other public transport modes and active transport in the CBD. An example of this is improving bike lanes and footpaths needed to meet broader underlying growth in movements within the city.

Improved bus connections from residential areas to the train station should also be provided to allow greater access for those without a car and for primary caregivers who are more likely to take multi-modal trips with multiple destinations.[188] Consideration should also be given to designing the train stations for personal safety and security, including access to the station from residential areas.[189]

A supporting network to access the stations with transport network pricing

TNP should also be considered for this project. This could include implementing differing fares for the various types of public transport modes to encourage use of the train line and supporting buses. This could also include adopting permanent off-peak discounts for public transport fares, incentivising people to utilise the new train line and supporting buses during quieter times of the day. This would further reduce crowding, complementary to the new services brought about by the project. Pricing for parking at train stations should also be considered to manage demand.

The project provides the foundation for Belgrave / Lilydale express metro and more frequent Alamein all stopping services.

This project is a key interdependency to delivering future service uplift on the Burnley group, through changes to operations to support an express metro from Belgrave and Lilydale. This will improve the operational performance of these services by adopting a consistent express service pattern. In addition, the Alamein line will be incorporated into the Wallan – Glen Waverley metro line and provide higher frequency services to Inner Melbourne stations including Auburn, Hawthorn, Burnley and East Richmond.

These upgrades require investment in track reconfiguration and a fourth track between Burnley and Camberwell. This should be explored as part of further project development to identify appropriate timing for these works.

Relevant Recommendations in Victoria's Infrastructure Strategy

Recommendation 60: Reconfigure the City Loop

Victoria's infrastructure strategy recommends completing a business case to reconfigure the City Loop within the next two years, including determining its timing. Include planning for more frequent metropolitan services on the Craigieburn, Upfield, Frankston, and Glen Waverley services, while considering a future express railway line between Camberwell and Burnley to prepare for future rail patronage on the Lilydale, Belgrave, and Alamein lines. Explore options and staging to extend metropolitan services to the Northern Growth Corridor, including Mitchell LGA, and identify new station locations. This should be completed in time to inform a decision about whether works should commence on this project immediately upon the opening of the Metro Tunnel Project.

Recommendation 35: Support more homes in priority established places

Victoria's infrastructure strategy recommends identifying new priority locations in established suburbs for residential intensification to better use existing infrastructure in the next year. Following this, in partnership with local government, review planning settings to allow increased housing density and establish design review advisory panels.

Recommendation 37: Develop an interconnected open space network

Victoria's infrastructure strategy recommends helping create an interconnected open space network and extend the urban tree canopy in the next three years by providing direct funding and reviewing and reforming the developer open space contribution scheme.

Recommendation 74: Extend rail services in Melbourne's western and northern growth areas

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[188] McCarthy, L., Delbosc, A., Currie, G., & Molloy, A. (2017). Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature. Transport reviews, 37(6), 767-781.

[189] Whitzman CA, Marathe RE, Thompson JA. (2019). "Tertiary Students' Public Transport Safety in Melbourne, Australia." *Melbourne, VIC, Australia: Transport, Health and Urban Design Researching Hub, Faculty of Architecture, Building and Planning, The University of Melbourne*

Victoria's infrastructure strategy recommends developing business cases to extend electrified metropolitan train services from Craigieburn to Beveridge, Sunshine to Rockbank and on the Wyndham Vale corridor in the next two years, to be delivered by 2031.

Recommendation 75: Link outer suburbs to rail with 'next generation' buses

Victoria's infrastructure strategy recommends immediately introducing 'next generation' bus services towards Clyde, Mornington Peninsula, Wollert and Armstrong Creek. In the next five years, complete feasibility studies to plan the ultimate development of public transport services on these corridors and secure remaining land required.

4.4 Cross City Motorway

Objectives

The Cross City Motorway (CCM) would facilitate east-west travel for people and freight across Melbourne's CBD by providing a connection between the West Gate Tunnel/CityLink and Eastern Freeway.

For the purpose of modelling, this project is assumed to include the widening of the Eastern Freeway from Chandler Highway to Hoddle Street, after which the CCM transitions into a three-lane tunnel that emerges past Royal Park. Traffic at this point can then access CityLink or continue towards a two-lane connection to Footscray Road and the West Gate Tunnel. However, recent urban development means that this may not be the most attractive option.

Despite making up only 7% of the Victorian road network, Melbourne's motorways (tollways and freeways)[190] carry approximately 40% of arterial road traffic. This means that each day, Melbourne's motorways support between four and five million trips. Beyond commuter journeys, most of Victoria's freight is moved by road. This means a safe, reliable and efficient motorway network, offering good traffic operations and better, reliable travel times, helps support the Victorian economy.

This project could support the following objectives of *Victoria's infrastructure strategy*:

- **Objective 1:** Prepare for population change – by providing strong transport connections and additional capacity to support growing travel demand.
- **Objective 4**: Enable workforce participation – by providing additional east-west freeway connections across Melbourne to improve access to employment clusters and transport gateways, providing access to training and a range of secure work opportunities.
- **Objective 5:** Lift productivity – by supporting Victorians to maintain a good standard of living from an economy boosted by enhanced skills, innovation, market access, and efficient investment.
- **Objective 6:** Drive Victoria's changing**,** globally integrated economy – by ensuring Victoria remains an attractive place for business and trade, competitive with other cities across Australia and the world.

Need

The business case developed for East-West Link in 2013 identified several needs which could be addressed by this project. This section highlights themes which are still relevant today, while also identifying key areas where the landscape has changed.

Melbourne as a place to build a business and live

Melbourne is home to Australia's busiest container port, which deals in the trade of on average 7,000 containers each day. The Port of Melbourne annually supports about $84 billion of imports and exports, including cereal grains, dairy products, fruit, vegetables, meat and manufacturing products which are exported to foreign markets. For export markets, 40% come from the west, north or inner suburbs of Melbourne.[191] This places reliance on the Monash Freeway and CityLink to support freight and private vehicle demand, and even minor incidents on the Monash Freeway lead to significant disruption. Melbourne Airport and key freight precincts and corridors are also located to the north and north-west of Melbourne.

North East Link will improve connectivity between the south-east and north and complete Melbourne's ring road. There are limited cross-city arterial roads that are already at or near capacity, which affect all road network users, including on-road public transport services. This has impacts on the cost of freight and public transport, as trucks, buses and trams are able to perform less efficiently due to increasing congestion or unreliable travel times.

The performance of Melbourne's transport network has a significant impact on its status as a liveable city, a place where businesses are attracted to trade and create jobs. There is a need to manage the performance of our road network to create efficient and reliable freight movements, which will provide certainty to businesses and industry and support business investment in Melbourne.

Connecting residents with jobs

The new and emerging growth areas in the west, such as Melton LGA and the south-west, including Wyndham LGA, are not expected to attract sufficient jobs to support the proposed population growth in the western suburbs over the next 15 years. Strong public transport connections between the east and west of Melbourne are important to support access to knowledge economy jobs in the inner city. Additionally, a number of NEICs are located in the north and south-eastern

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[190] *Motorways, or "M Roads" as defined by VicRoads, are duplicated (dual carriageway) roadways with at least 2 lanes in each direction. This classification includes all freeways (Monash/CityLink/Tullamarine, Eastern/East Link, Western Ring Road, etc) and the Bass Highway, South Gippsland Highway, and the Western Port Highway.*

[191] *Port of Melbourne https://www.portofmelbourne.com/wp-content/uploads/pcp-fs-statistics.pdf*

suburbs of Melbourne. *Plan Melbourne* has identified the importance of improving access to jobs across Melbourne and supporting major transport gateways as important locations for employment and economic activity. Businesses need access to large labour pools to recruit talent, and connecting booming growth areas in the west and north with employment clusters in the east is critical to the long-term competitiveness of these precincts.[192]

Improvements which have been made since 2013

The business case for East-West Link was completed in 2013, prior to the planning and delivery of a number of other major infrastructure projects, which have changed its role in the broader transport network.[193] This includes the following:

- The West Gate Tunnel Project will be providing a new east-west connection between the western suburbs and Inner Melbourne.
- Upgrades to the Monash Freeway, the City-Tulla Widening project, and North East Link have been progressed to strengthen connections to important employment clusters including Parkville, the Port of Melbourne and Melbourne Airport, and improve the reliability of the road network.
- Upgrades to the Eastern Freeway: this includes additional capacity east of Chandler Highway that is being delivered as part of North East Link.

As such, the needs of our road network have changed, and it is necessary to re-examine the impact this project would have on the transport network to establish if and when it might have an impact. In addition, this impact needs to be tested against the objectives of *Victoria's infrastructure strategy* to confirm whether it is still an important part of planning for our future.

Project Description

The CCM project comprises the connection between CityLink / West Gate Tunnel and the Eastern Freeway through a new tolled motorway. For the purposes of this strategic assessment, the connection would be made via a road tunnel under Carlton and North Melbourne.

The project has been modelled and costed on the basis of two components, which are described below. These have been assumed to be constructed simultaneously.

Section A is 9.2km long and comprises:

- twin three-lane road tunnels from Hoddle Street to Royal Park, exiting just west of the Upfield train line, connecting to the Eastern Freeway in the east
- viaducts would connect to CityLink southbound, adjacent to the existing sound tunnel and northbound close to Ormond Road
- widening of the Eastern Freeway from Chandler Highway to Hoddle Street by one lane in each direction to accommodate additional traffic
- allowance for an interchange with Hoddle Street.

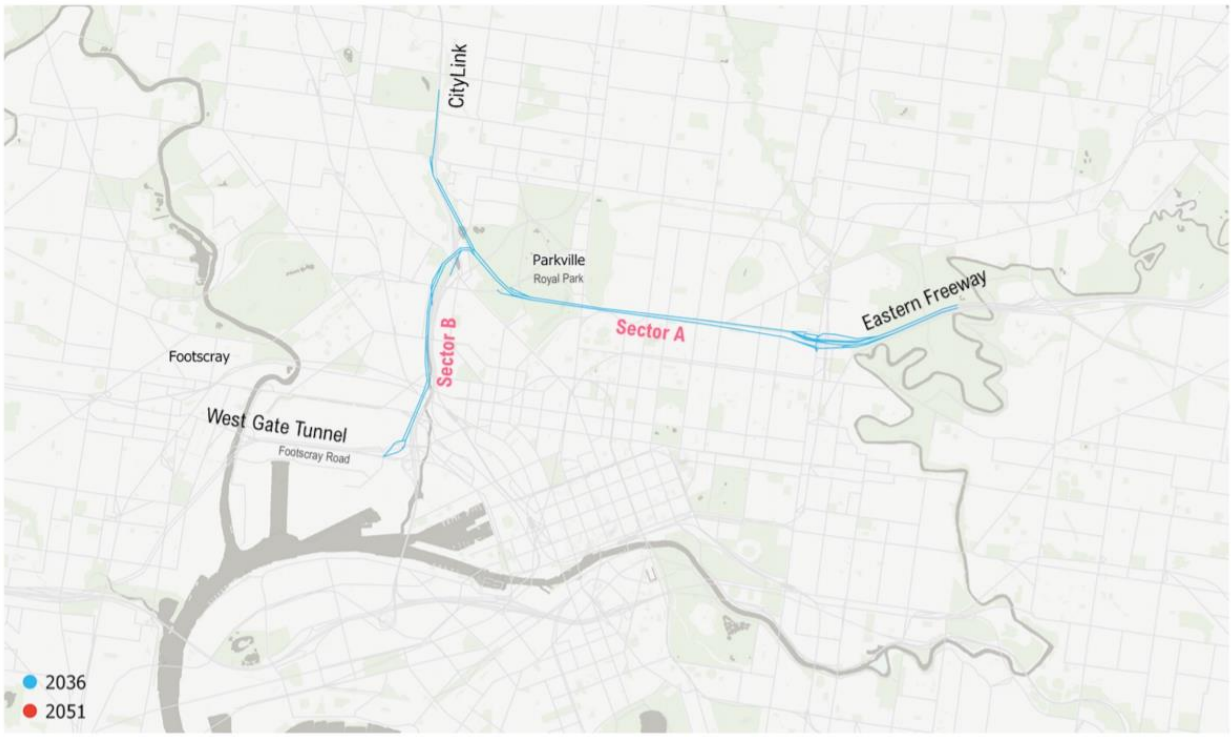
Section B consists of a 3.2km viaduct corridor running adjacent to CityLink with two traffic lanes plus one shoulder in each direction. It connects from the tunnel exit at Royal Park to Footscray Road and the West Gate Tunnel, via a viaduct over CityLink. A new northbound slip lane from the CCM viaduct would connect to CityLink before Racecourse Road. It has been assumed that two toll gantries will be implemented – one for each of Sector A and B.

Figure 41 illustrates the alignment assumed for this assessment.

[192] *Plan Melbourne 2017-2050 Summary, Outcome 1 https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0009/377127/Plan_Melbourne_2017-2050_Summary.pdf*

[193] https://www.premier.vic.gov.au/east-west-link-files

Figure 41: CCM Alignment Assumed for this Assessment



Source: Arup 2021 Strategic Modelling Outcomes report

An evolving land use environment

Since the East-West Link business case was completed in 2013, there have been a number of government commitments to urban renewal precincts, transport and other infrastructure projects along the corridor which increase the need for local area accessibility to support the broad range of employment, education, and community outcomes proposed (as shown below).

The CCM project may present short term, construction-related disruptions to the Fitzroy Gasworks site which is currently being redeveloped to create an urban village offering 1,100 new apartments, community amenity, retail offerings, and a new sports centre with open space. It also includes a new $84 million senior school campus for students from Collingwood College and Fitzroy High School, with construction to commence in 2021.[194]

In the longer term, the project may have implications for:

- The Arden urban renewal precinct which has been identified as a project on the VPA's Fast Track Program. This vision for this precinct is to provide approximately 34,000 jobs and 15,000 residents in a knowledge intensive employment and innovation precinct built around the new Arden Station.[195] This development emphasises building strong transport connections through the new Metro Tunnel Station at Arden, and improvements to the tram network.
- Moonee Ponds Creek, Royal Park, and other open space along the corridor will be impacted, affecting local ecosystems, native flora and fauna, and increasing flood risks and pollution.

These impacts will be further explored in the social and environmental assessments for the project, later in the chapter.

[194] *https://www.development.vic.gov.au/projects/fitzroy-gasworks?page=overview*

[195] *https://vpa.vic.gov.au/project/arden/*

Project Costs and Timing

The total estimated cost of CCM, inclusive of contingencies, 50-years renewal costs and operations and maintenance costs (O&M) are shown in the table below.

Total capital expenditure cost is estimated to range between $9.1 billion and $13.0 billion (in 2020 values). Large components of this cost include tunnels and bridges. This also includes land acquisition costs for the tunnelling and widening of the corridor. Contingencies for design, construction and prolongation have also been included in the total cost.

For the purposes of modelling and assessment, construction has been assumed to start in 2031 and is expected to be completed in 2035, with the project operational from 2036. Note, however, that *Victoria's 30-year infrastructure strategy 2021-51* does not recommend that CCM be constructed in this timeframe and instead an option be retained for its development should the project be needed in future decades.

Table 17: CCM capital expenditure cost profile (2020 dollars)

Project	Lower Capex ($m)	Upper Capex ($m)
CCM	9,100	13,027

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

Multi-criteria Analysis

By introducing a new direct cross city motorway, there are far better travel times for movements that utilise the tunnel. However, these tunnel travel time benefits only apply to a relatively small cohort of people. For travellers in Inner Melbourne, road congestion improves slightly. The project also creates localised cases of additional traffic on roads such as the Eastern Freeway which leads to an increase in congested kilometres travelled in the Middle Melbourne FUA. Despite this, as population redistribution with the project draws people closer to Inner Melbourne, there is a reduction in vehicle kilometres travelled across the wider network, and therefore a slight improvement to road network congestion.

At an aggregate level, travel time savings are small – and therefore the improvements in access to jobs and access to labour force are also small in the project case.

Despite slightly improved overall road conditions and some rerouting of freight onto the CCM alignment, there is a minor increase in the proportion of congested freight kilometres travelled across some localised areas. One example of this increase, in proportion of freight congestion, is the additional traffic on the Eastern Freeway driven by freight travelling east out of the CCM tunnel and into congested conditions on the Eastern Freeway. However, for the remainder of the freight network, the project has a minimal impact on freight congestion.

From a freight perspective, the CCM project performs better when considering freight connectivity. Due to the corridor's central location, close to existing and future freight links such as the Monash Freeway and West Gate Tunnel, the project supports a wide range of potential cross-city freight movements, including freight from Sunshine and Werribee National Employment and Innovation Clusters (NEICs), the Western State Significant Industrial Precinct (SSIP) and the Port of Melbourne. Across all major freight movements, the CCM project has the potential to provide an alternative route for approximately 65% of all freight trips, also boosting network resilience. Despite this strong connectivity result, the current corridor as modelled had lower freight utilisation numbers, expected to support around 8,000 trucks a day in both directions. As a benchmark when compared to sections of other major freight corridors such as the Burnley and Domain CityLink tunnels and the future West Gate Tunnel which are expected to carry up to 20,000 trucks a day (in both directions), freight volumes on the CCM project are well below the level of these other large motorways.

As the total number of private vehicle trips largely remain constant through 2036 and 2051, changing trip patterns and population distribution have a greater impact on vehicle emissions. In 2036, large increases in vehicle kilometres travelled increase emissions released compared to the transport base case, resulting in one of the highest outcomes of all projects assessed. By 2051, CO_2 emissions in Inner Melbourne continue to increase compared to the transport base case, however, emissions for the remainder of metropolitan Melbourne reduce. This is also due to fewer vehicle kilometres travelled across the network in 2051, leading to lower vehicle emissions, and therefore a high score in the MCA. It is important to highlight here that while a decrease in emissions for 2051 is a favourable outcome, we also expect much of the vehicle fleet to be ZEVs by this model year, leading to further reductions. The problem is far greater for 2036, given the project increases emissions during a period where a large proportion of the vehicle fleet could still be using internal combustion engines.

Table 18: CCM MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
Cross City Motorway (CCM)	M/H	L/M	L	L/M	~	H	L/M	H

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

Transport Outcomes

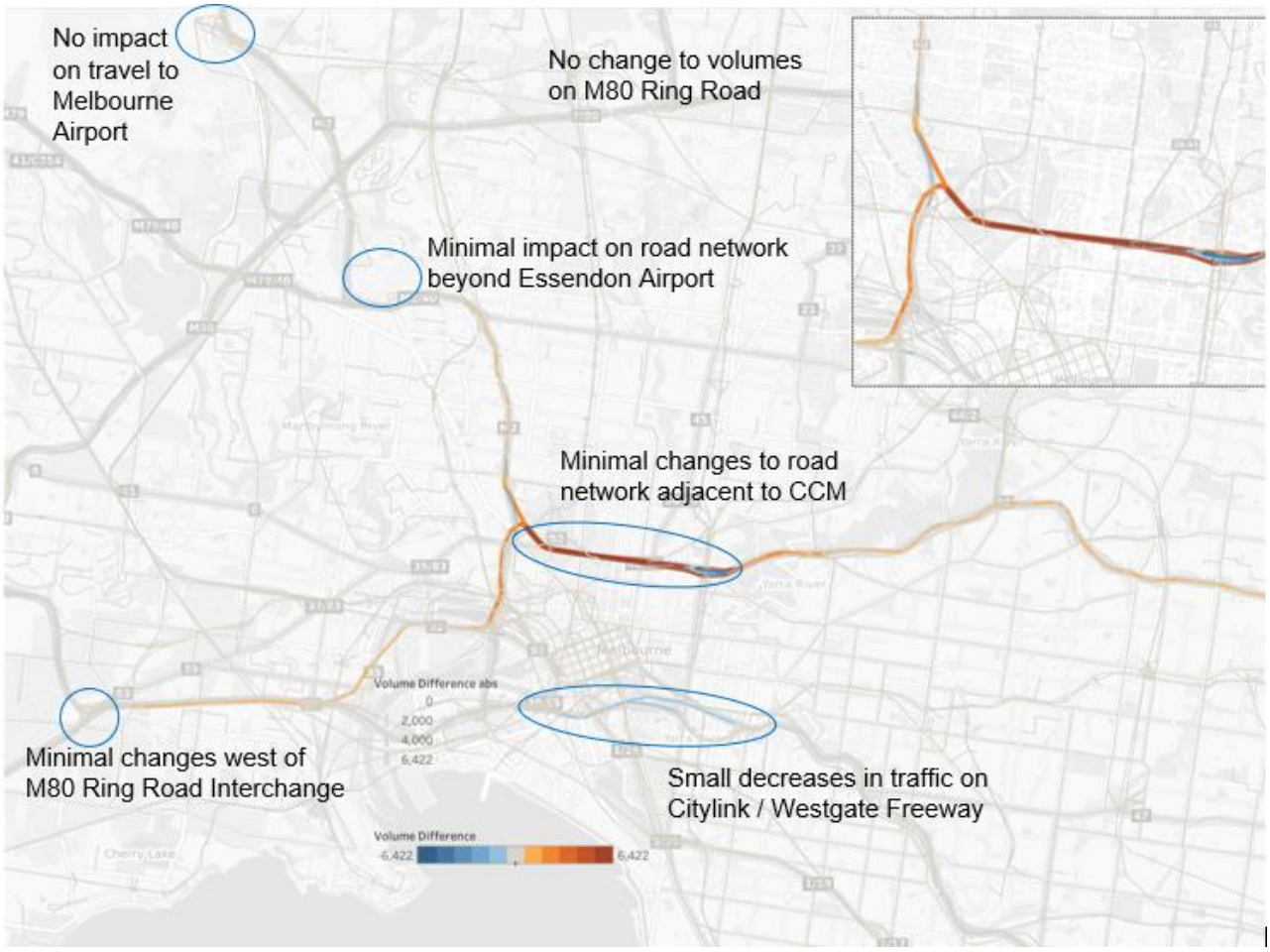
CCM is expected to improve transport network reliability, providing additional road network capacity to support cross-city movement for freight and private car users. The project has a negligible impact to mode share, and the impact is limited to a redistribution of existing trips across the road network. The following sections explore the transport outcomes of CCM for road network impacts and public transport travel.

Road network impacts

The VLUTI modelling shows that CCM is expected to have significant unused capacity in 2036 and 2051 during the AM peak, with traffic volumes below 60% of the road network capacity between Hoddle Street and CityLink in both directions. This stands in stark contrast to Alexandra Parade, which continues to experience congestion levels above 80% between Lygon Street and Hoddle Street. The change in traffic volumes shown in Figure 42 indicates the following:

- There is negligible change in traffic volumes on Hoddle Street, Nicholson Street, Lygon Street, and other north-south roads used to connect from Alexandra Parade into Inner Melbourne.
- Alexandra Parade has seen a very small reduction in traffic, with congestion levels above 100% in several sections, confirming that the existing road corridor is still preferred for road users.
- The increased traffic volumes only extend from the eastern suburbs west to the M80 interchange, and north along CityLink to Essendon Airport. This confirms that the new connection is only marginally improving connectivity between the eastern suburbs and Melbourne Airport.
- There is negligible change in traffic on the M80 Ring Road, as many north-east movements continue to be provided by North East Link.

Figure 42: Change in total traffic due to CCM, 2051 (AM peak)

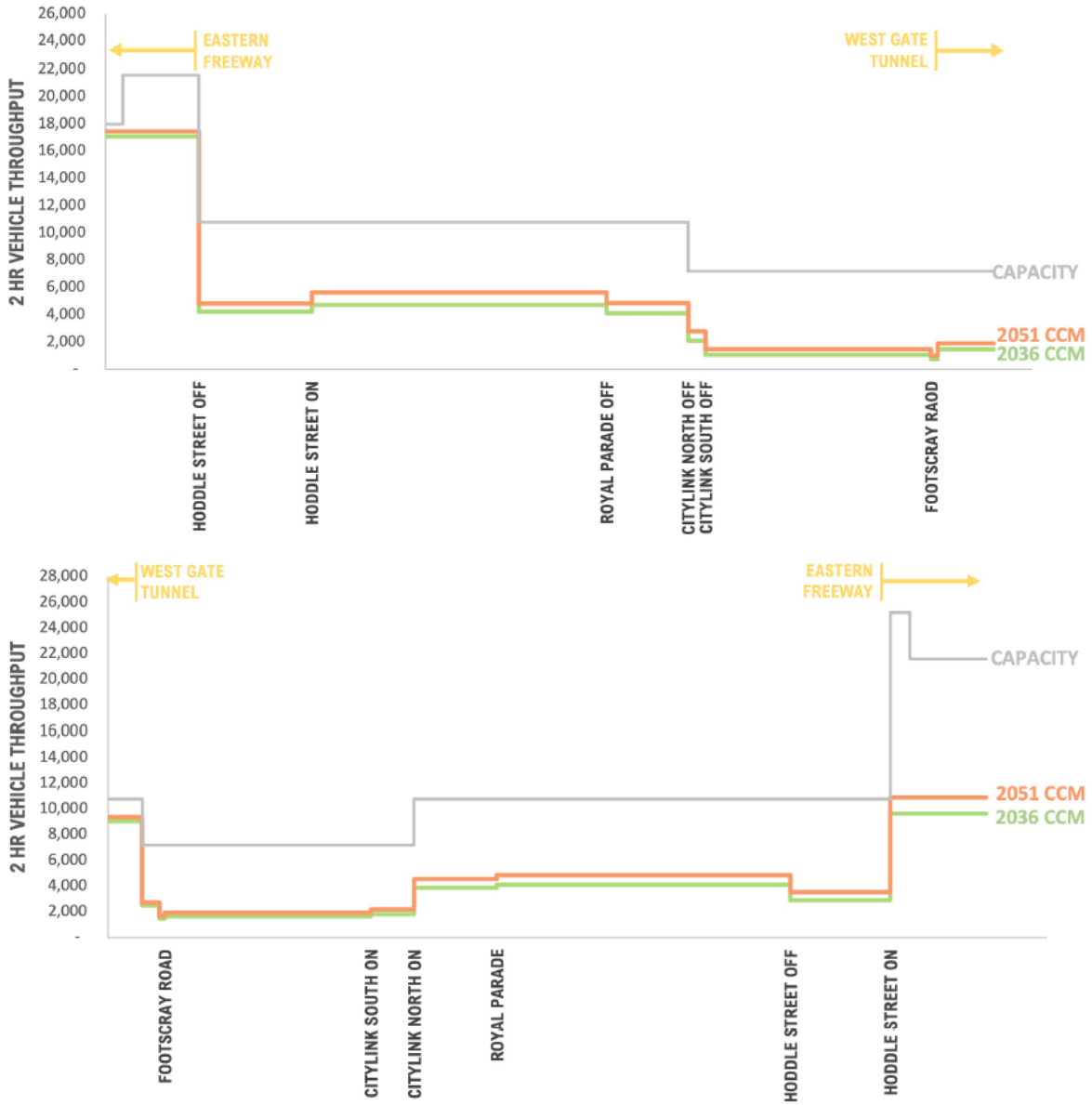


Source: Infrastructure Victoria Visualisation in Tableau (2021)

During the AM peak (2 hour), the highest traffic volume is observed in the westbound movement from the Eastern Freeway approaching the Hoddle Street off-ramp, which is projected to carry 17,000 vehicles in the 2 hour period in both 2036 and 2051. The movement from the Eastern Freeway onto Hoddle Street and Alexandra Parade will attract over 12,000 of those vehicles exiting the freeway at Hoddle Street, while less than 5,000 vehicles continue onto CCM despite the significant congestion on both Hoddle Street and Alexandra Parade.

CCM stands out as the only freeway standard road which does not have significant road network congestion. In comparison, traffic demand exceeds road network capacity on sections of the West Gate Freeway, Tullamarine Freeway, Eastern Freeway, and Monash Freeway in both 2036 and 2051. This suggests that the modelled future toll pricing approach is not appropriate to support the best use of the infrastructure, and that an integrated TNP approach, of which motorway tolling is part, may be required to encourage traffic to shift from Alexandra Parade to CCM, for example.

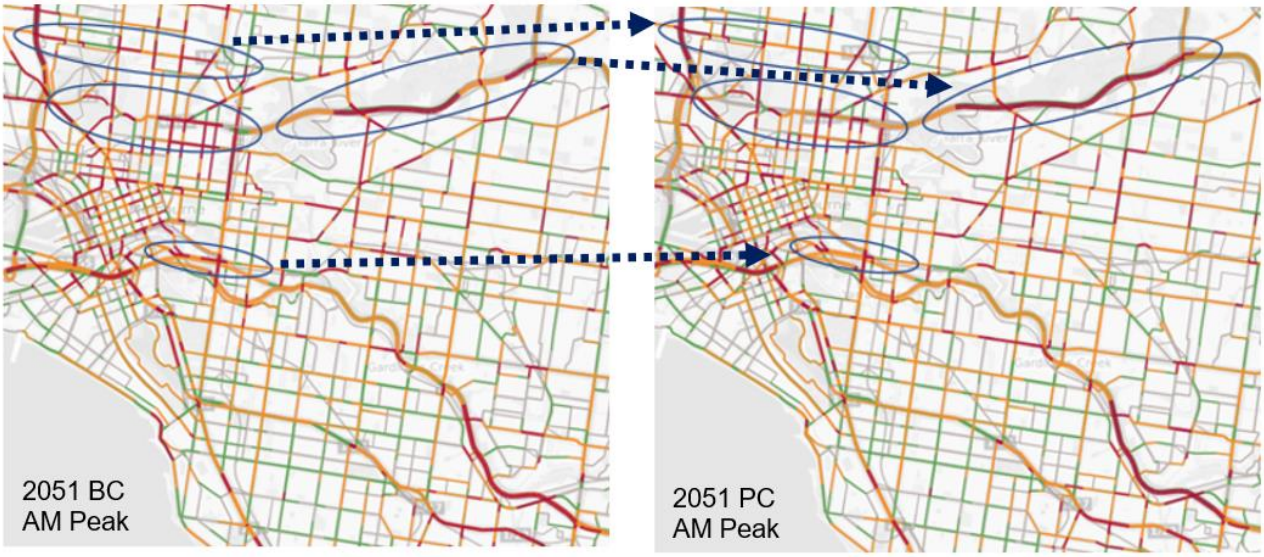
Figure 43: Volumes along the CCM corridor in the AM peak (2 hour)



Source: ARUP / AECOM modelling report (2021)

In 2051, CCM appears to reduce congestion on parallel roads such as Alexandra Parade, Elliott Avenue, Brunswick Road, and even Swan Street, which appears to align with the shift in traffic from the Monash Freeway / CityLink to CCM. At the same time, the modelling results indicate worsening road network congestion on the Eastern Freeway, while the Tullamarine Freeway continues to be very congested (as shown below in Figure 44). This suggests that the Eastern Freeway and the Tullamarine Freeway may be acting as bottlenecks, restricting the use of CCM for cross-city movements due to the lack of broader network capacity.

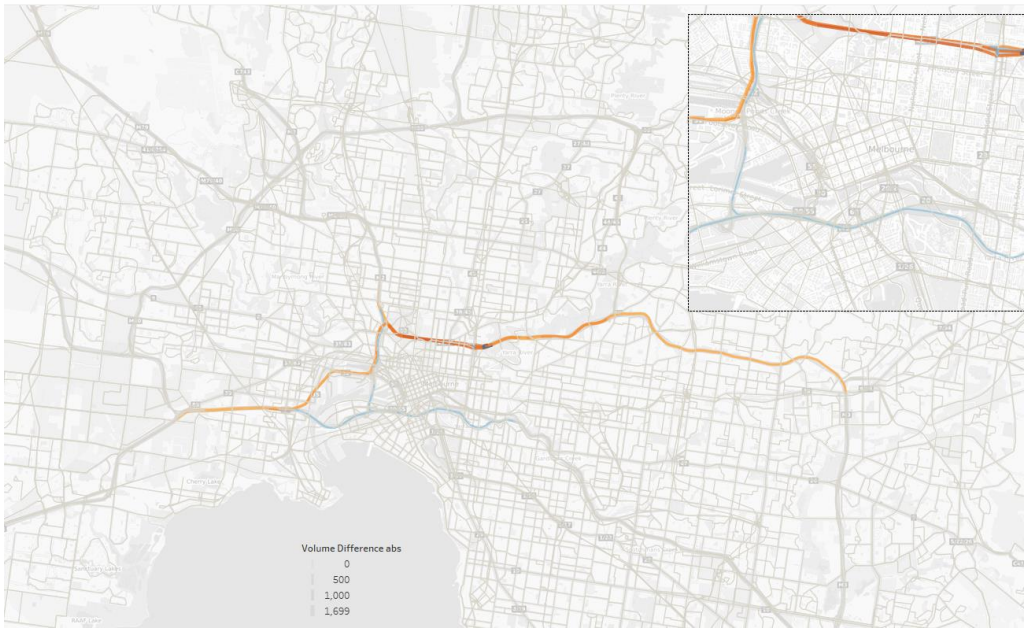
Figure 44: Road congestion due to CCM in 2051 (AM peak)



Source: ARUP AECOM modelling outputs (2021)

CCM results in a shift in freight behaviour, with this new corridor connecting the port and the inner western suburbs to the eastern suburbs. Overall, freight network congestion (total freight kilometres travelled in congested conditions) worsens in 2051 with CCM as average travel speeds reduce across the day. Travel times to SSIPs and key transport gateways increase, reducing overall freight network efficiency and productivity. In spite of this, freight volumes, which reach almost 1,700 vehicles (both directions) during the AM peak in each direction, represent 15%-25% of all traffic on CCM. This suggests that for some freight traffic, CCM becomes an attractive alternative to CityLink and the West Gate Freeway (as shown below).

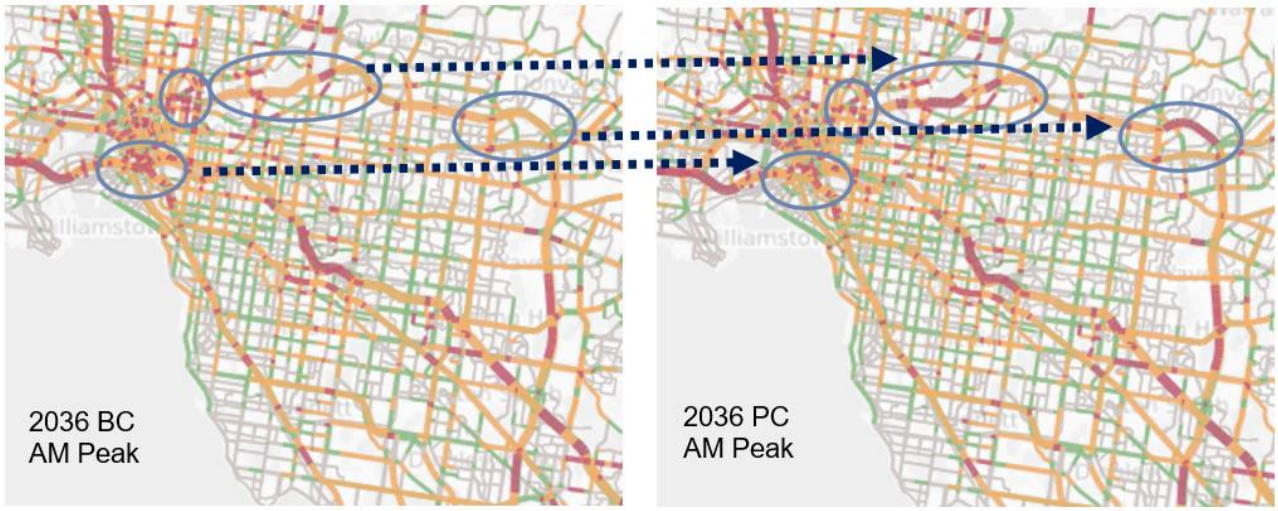
Figure 45: Change in freight traffic due to CCM, 2051 (AM peak)



Source: ARUP AECOM modelling results (2021), Infrastructure Victoria visualisation

As shown below in Figure 46, CCM is expected to result in worsening road network congestion on the Eastern Freeway and the Eastlink Tunnel, freeways which experience the most significant increase in freight traffic. Consistent with these results, there appears to be less congestion in the CityLink / Southbank area, which has seen truck volumes reduce due to CCM.

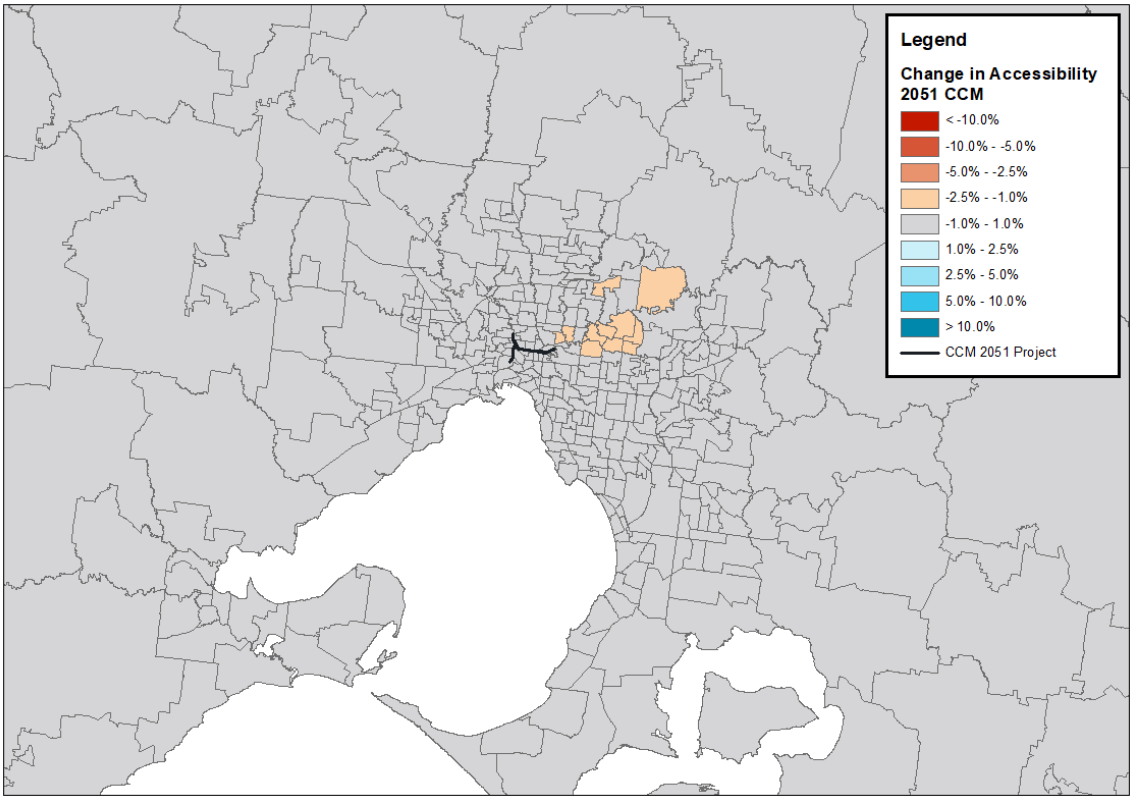
Figure 46: Road congestion due to CCM corridor in the AM peak (2hr)



Source: ARUP AECOM modelling results (2021)

The project does not appear to improve access to jobs for any residents across Melbourne. Modelling results indicate the CCM will result in small accessibility changes in 2051, and residents in the eastern / north-eastern suburbs will have small reductions in access to employment opportunities across Melbourne (they will have access to -2.5% to 1% less job opportunities as a result of CCM). This is likely to be driven by the worsening on-road congestion on the Eastern Freeway resulting in higher travel times to access jobs and overall higher travel costs to access employment.

Figure 47: CCM impact on access to jobs from Place of Residence in 2051 (AM Peak)

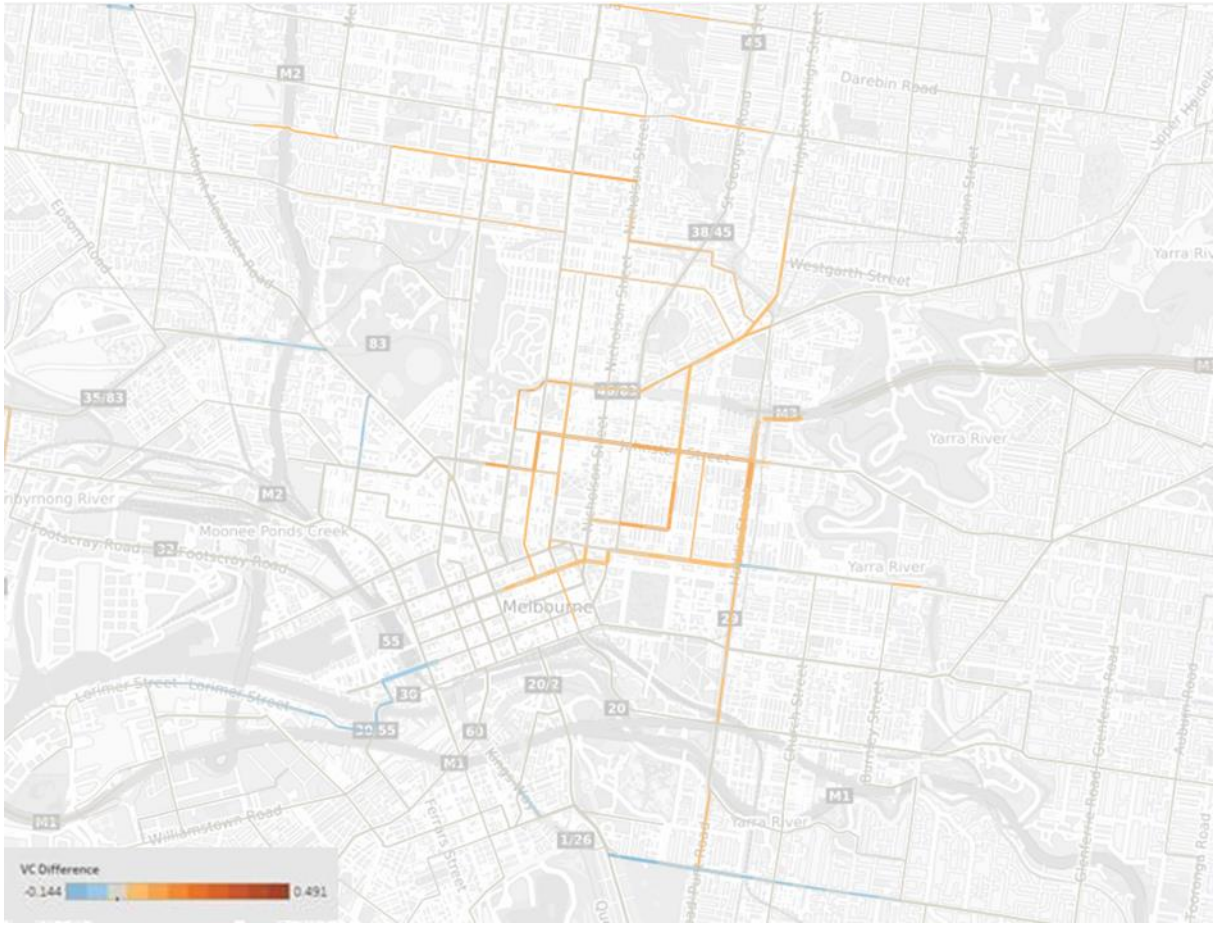


Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

Public transport

CCM does lead to increased public transport use on buses and trams in the inner north heading into the inner city. This includes the tram interchange from Victoria Park Station to bus services heading south on Hoddle Street. These are small changes, largely driven by more people living in Inner Melbourne and the public transport improvements to services across Alexandra Parade. These public transport users result in increases to crowding on public transport, but does not lead to overcrowding. The impact of this demand is shown below in Figure 48.

Figure 48: Change in public transport crowding due to CCM, 2051 AM peak



Source: ARUP AECOM modelling (2021)

Demographic Outcomes and Land Use Implications

Population

The project adds population to Melbourne's established northern suburbs around the southern part of the Upfield rail line and along the Mernda rail line to Lalor. These are areas where the transport base case also projects large increases by 2051. This includes the northern part of the La Trobe NEIC which gains additional residents. CCM results in more people living around Moonee Ponds, Kensington and Collingwood, close to the project's alignment. The elevated western component may attract more residents but is likely to challenge plans for enhanced future open space along the Moonee Ponds Creek unless very carefully managed.[196]

With congestion falling and accessibility improving in Inner Melbourne, more people are attracted to live in these areas. Increased driving in these areas as a result of this project may compromise recent infrastructure investment in public transport and cycling improvements.

With increased use of the Eastern Freeway and associated congestion on roads used to get to and from the freeway, suburbs such as Doncaster and Templestowe are less attractive to new residents and population growth is slower than in the transport base case.

Jobs

The CBD and some parts of Inner Melbourne are the main beneficiary of CCM in relation to job growth, although compared to the transport base case, private vehicle travel does not have any average travel time savings while public transport has a very small benefit. This suggests people are not necessarily driving to these additional jobs, with the project providing more benefit to trips that bypass the CBD. Job increases are more likely to be capitalising on the central city's existing density of businesses and agglomeration, along with jobs that serve increased population.

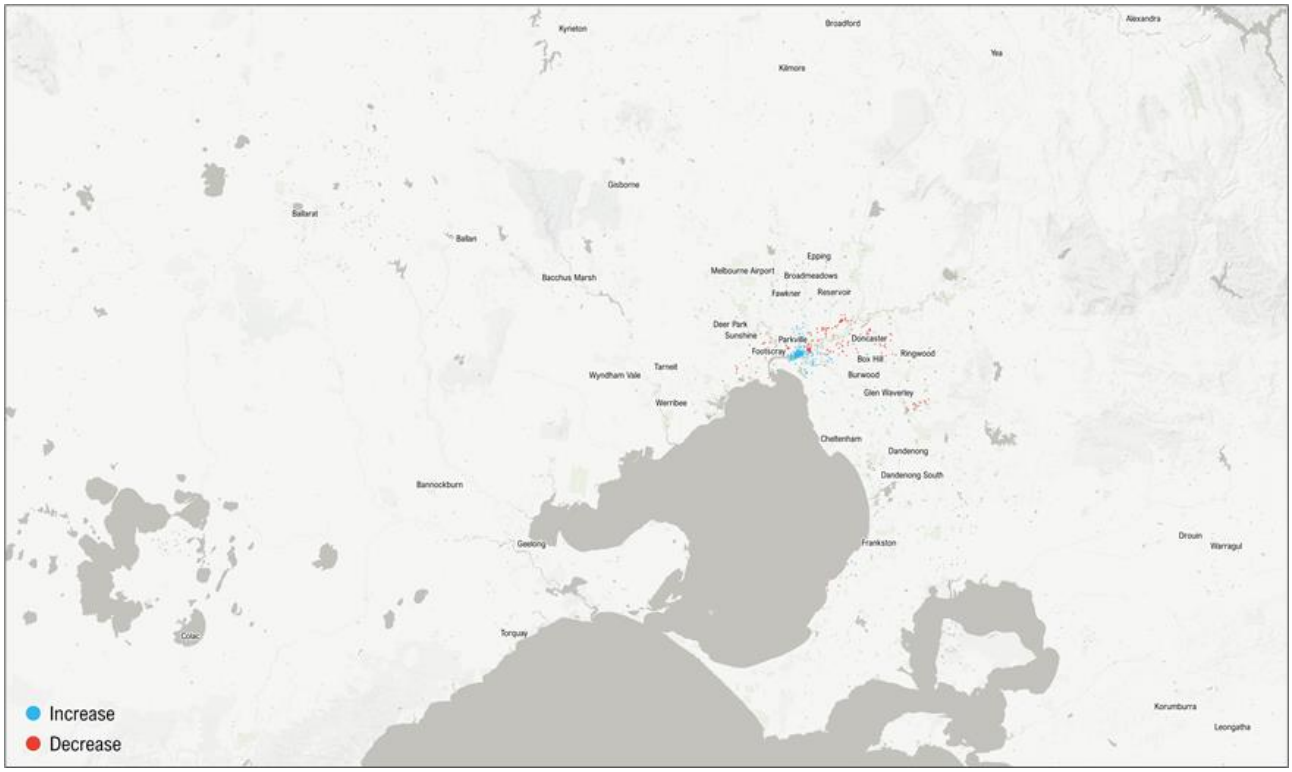
Marginally slower job growth occurs in Docklands, Collingwood and some individual suburban locations where the transport base case forecasts particularly high growth to 2051. However, no clear trend is evident and the changes in jobs numbers are very small.

Figure 49: Population changes due to CCM compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes Report

[196] https://www.melbourne.vic.gov.au/building-and-development/urban-planning/local-area-planning/Pages/moonee-ponds-creek-strategic-opportunities-plan.aspx; https://vpa.vic.gov.au/project/moonee-ponds-creek/

Figure 50: Employment changes due to CCM compared to transport base case, 2051



Source: Arup 2021 Strategic Modelling Outcomes Report

Economic Assessment

Cost benefit analysis

The table below presents a summary of the estimated benefits from CCM, using a discount rate range of 7% and 4%. The largest benefit category is consumer surplus benefits, which includes the reduced travel times and vehicle operating costs for road users.

Table 19: CCM Benefits (Present Value $ million)

Benefit	Static land use	Dynamic land use	WEBs only	Total
Consumer surplus benefits	$2,017 – $4,777	-$79 – -$321		$1,938 – $4,456
Safety benefits	-$108 – -$289	$46 – $126		-$62 – -$163
Environmental benefits	-$106 – -$263	$107 – $338		$1 – $75
Active transport benefits	-$33 – -$86	$2 – -$1		-$31 – -$87
Residual values	$7 – $45	$0 – $0		$7 – $45
WEBs			$385 – $918	$385 – $918
Total benefits	**$1,777 - $4,185**	**$76 - $143**	**$385 - $918**	**$2,238 - $5,246**

Source: AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: The 'Headline' ranges provided using 7% and 4% discount rates

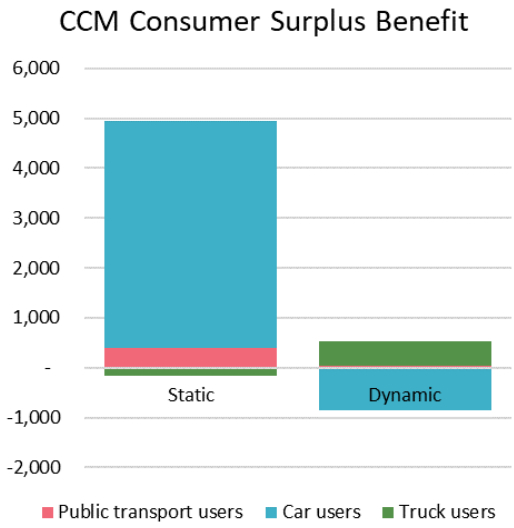
Quantified benefits

Total benefits of this project are made up of *static land use*, *dynamic land use* and *wider economic benefits*. The *static land use* benefits represent the estimated conventional transport benefits arising from this project, without any changes to the location of population and jobs. The *dynamic land use* benefits arise from changes in the location of population and jobs caused by the project.

Dynamic land use benefits are negative for this project. This is due to more people moving to Inner Melbourne, which has greater accessibility because of this project. This results in an increase in both public transport and private vehicle trips from the population living in these areas. As these areas become slightly more congested with the project there are negative impacts to the benefits to car users.

Figure 51 shows the consumer surplus benefits under static and dynamic land use outcomes for public transport users, car users and truck (freight) users. This highlights that the majority of benefits are congestion relief benefits to car users. It also shows the benefits (dis-benefits) arising under the dynamic land use outcome for car users. Figure 53 illustrates these changes in private vehicle consumer surplus across metropolitan Melbourne. This highlights that people living in the outer eastern areas of Melbourne experience the greatest benefits from this project.

Figure 51: CCM Consumer Surplus Benefits for Static and Dynamic Land Use Outcomes

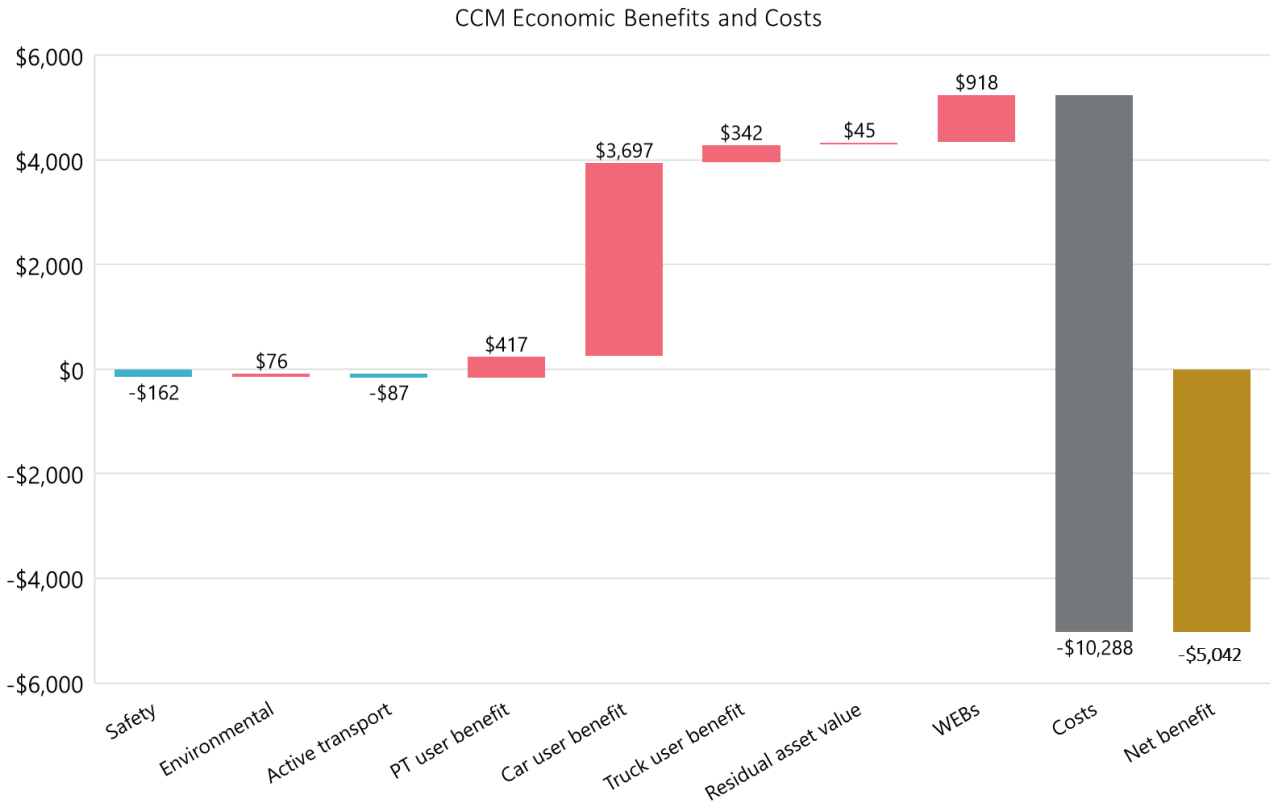


Source: Analysis of AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

WEBs make up 19% of the total benefits of this project. This is driven by an increase in employment in the central city, and improved accessibility to the central city. Agglomeration benefits contribute the largest amount, arising from the productivity improvements from increased density and accessibility of jobs.

Figure 52 shows the economic benefits of this project compared to the total estimated cost in present value terms. This shows the large contributions from car users to the total benefit. It also highlights that the benefits are expected to be smaller than the cost of this project in present value terms. This suggests that based on the modelling conducted for the existing alignment this project will not generate a net community benefit.

Figure 52: CCM Economic Benefits and Costs (Present Value $ millions)



Source: Analysis of AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: Total dynamic land use plus WEBs results presented using upper project costs and 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Summary cost benefit analysis results

Summary results from the cost benefit analysis are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes all quantified benefits outlined in the table above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 0.3 and 0.5 using upper project costs and 0.4 to 0.7 for lower project costs, for the total outcome (dynamic land use including WEBs, ranges provided using discount rates of 7% and 4%). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and WEBs arising from productivity improvements.

Given the inputs used for this evaluation, the CCM project is not likely to be economically viable in its current form. It is expected to generate benefits that are less than the expected cost of this project in the long term.

Table 20: CCM Benefit Cost Ratio and Net Present Value ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	0.3 – 0.4	-$5,330 to -$6,103	0.3 – 0.4	-$5,254 to -$5,960	0.3 – 0.5	-$4,869 to -$5,042
Lower project costs	0.4 – 0.6	-$3,315 to -$3,153	0.4 – 0.6	-$3,239 to -$3,010	0.4 – 0.7	-$2,854 to -$2,092

Source: AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Conventional VITM cost benefit analysis results

This project was also modelled in VITM, using the conventional approach without any land use changes. This was done so that a comparison could be made between the results produced by the VITM and VLUTI models. An economic assessment has been undertaken using these results, to compare to the economic assessment using the VLUTI model. The table below shows the benefit cost ratios for this project using the conventional VITM approach and upper and lower project costs.

The conventional VITM results are slightly higher than the VLUTI results, and there are differences in both public transport user benefits and car user benefits. VITM shows a negative benefit for public transport users whilst VLUTI shows a positive benefit, due to VLUTI predicting that people will move to inner areas which will result in more public transport usage. VITM shows a much larger benefit for private vehicle users than VLUTI, which arises in part due to households not moving into locations that benefit from congestion relief. The overall effect is a higher BCR using the conventional VITM approach.

This comparison highlights the additional insights that the VLUTI model provides in accounting for these land use change effects. However, this assessment does highlight the need to be able to quantify the full set of benefits to households and broader place-based benefits into the cost benefit analysis.

Table 21: CCM Benefit Cost Ratio – Conventional VITM Results

	Conventional BCR	Conventional BCR including WEBs
Upper project costs	0.4 – 0.6	0.4 – 0.7
Lower project costs	0.5 – 0.9	0.6 – 1.1

Source: AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Broader impacts

There are expected to be broader impacts arising from this project which cannot be quantified in a cost benefit analysis. We have assessed metrics from the VLUTI model where available and provided commentary on the expected direction of these impacts. These broader impacts include:

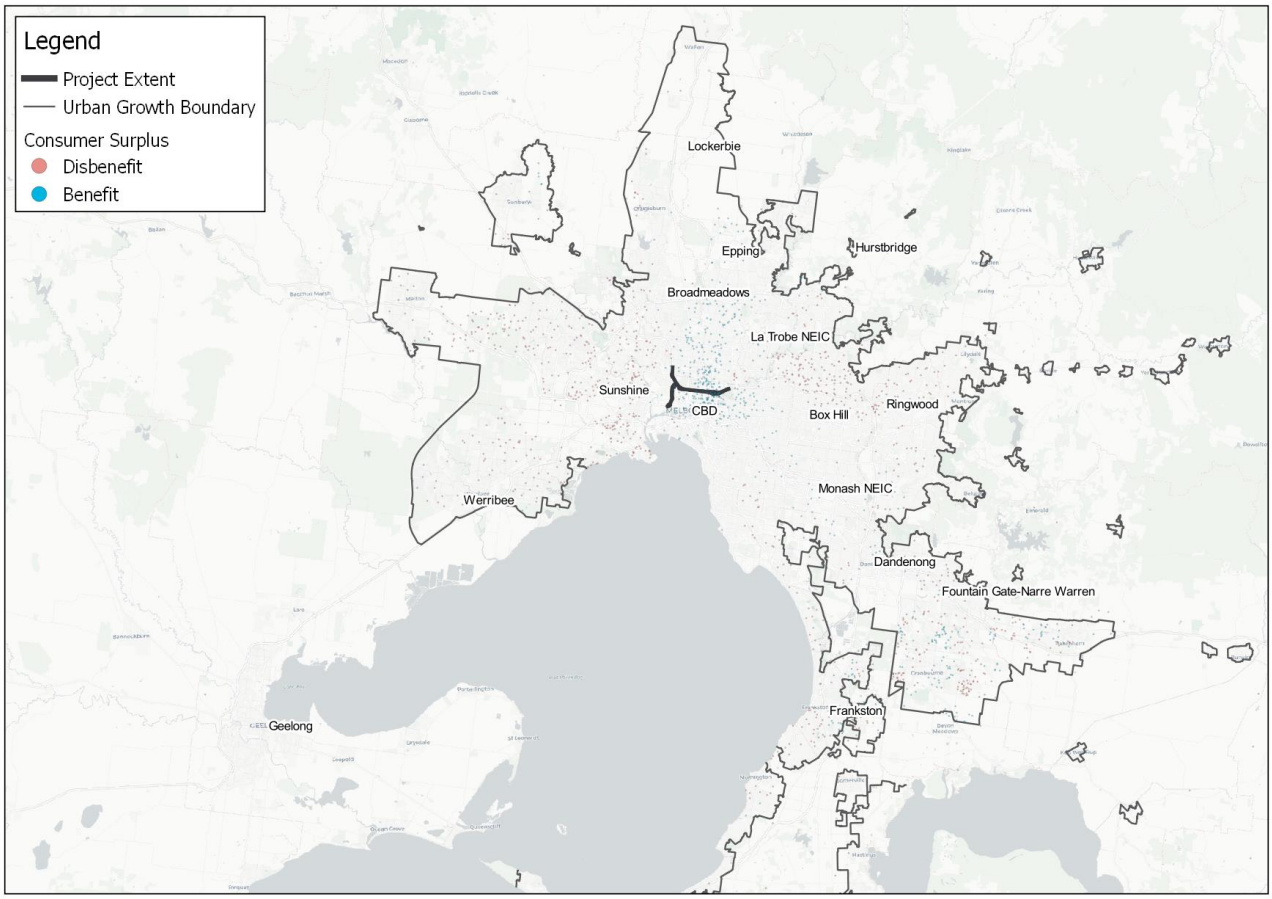
- broader economic benefits
- social and health impacts
- environmental impacts.

Broader economic benefits arise through labour productivity improvements driven by greater accessibility, and improved value chains through better freight reliability and speed. These elements are captured by the VLUTI model, which estimates GSP and productivity improvements resulting from the project.[197] The CCM project is estimated to have a positive impact on GSP, increasing by 0.2% in both 2036 and 2051. This is driven by increases in employment in the central city, particularly in knowledge intensive industries. GSP is also an indicator of the project's contribution to welfare and the broader place benefits that would arise.

Figure 53 shows the distribution of the consumer surplus benefits for private vehicle users across metropolitan Melbourne resulting from the CCM project in 2051. This highlights that most of the economic benefits from this project are concentrated in the inner part of Melbourne, in areas that benefit from improved access on the Eastern Freeway (blue dots on the map).

[197] *The VLUTI model assumes that total population, households, and jobs in Victoria remain fixed in future under all scenarios, and therefore GSP and productivity improvements do not incorporate any additional jobs and households above this level.*

Figure 53: CCM Consumer Surplus Benefits for Private Vehicles (2051)



Note: This map shows change in total consumer surplus by travel zone, not change per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits
Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

Social Assessment

CCM will result in a small amount of additional car travel in 2051, and a small reduction in public transport use. Our assessment shows there is a net reduction in active transport, which includes walking to and from public transport. In addition, with more trips being made by private vehicles, accidents on arterial roads connecting to CCM are more likely.

This project has the potential to negatively impact health and amenity, including for the public housing residents in the Flemington estate due to additional noise, vibration, pollution and traffic with the elevated road section in proximity. It may also conflict with the strategic vision for the Arden and Macaulay urban redevelopment areas which are planned to accommodate 15,000 new residents and 34,000 jobs by 2051.[198] The project would require temporary use of parkland for construction staging which would negatively impact on recreational and sporting uses of those spaces, and potentially on the health of local residents and especially children.[199]

This project is not expected to have any significant impacts to levels of socio-economic disadvantage. Improved road connection between the west, the CBD and the east will provide better access to jobs for residents in the west, but the road only carries a few users. Average public transport travel times for work trips to central Melbourne are slightly faster during the morning peak with this project, and also improve for eastern and south-eastern established area Metropolitan Activity Centres and NEICs. For younger and older people who are not working, public transport trips outside commuting hours will be slightly shorter on public transport to northern centres. The Parkville NEIC will also require shorter journey times for people travelling by public transport to access education and jobs in that area.

[198] https://vpa.vic.gov.au/project/arden/

[199] http://www.melbourne.vic.gov.au/about-council/committees-meetings/meeting-archive/MeetingAgendaItemAttachments/41/755/PC_52_200806030630.pdf

Environmental Assessment

The alignment used for CCM will result in the loss of vegetation in locations such as Royal Park in Parkville. Urban trees provide important ecosystem services, contributing to urban canopy cover which offsets the urban heat island effect caused by impervious surfaces such as roads. Urban trees also provide habitat for biodiversity.[200] For example, Royal Park provides habitat for a number of indigenous animals, including the critically endangered Swift Parrot and threatened species of Flying Fox.[201] The widening of the Eastern Freeway and the elevated section will occur in local government areas which lost tree canopy cover between 2014 and 2018, on residential properties, parkland and streets.[202] Construction of the road may also result in further vegetation loss to establish construction zones.[203]

CCM will impact open space provision in Inner Melbourne. According to the City of Melbourne, the section of road passing through Royal Park will result in additional noise pollution.[204] This will trigger the requirement for additional buffering around the road, resulting in a net loss of usable open space in the park. CCM has also been modelled as a viaduct along the north-south alignment adjacent to Moonee Ponds Creek. The interaction of this viaduct with CityLink would result in significant overshadowing and a negative impact on plans to re-naturalise Moonee Ponds Creek. This area would also contribute to additional public open space for the Arden and Macaulay communities. The Moonee Ponds Creek is also classified as an area of Aboriginal Cultural Heritage Sensitivity.[205]

The project will result in increased stormwater runoff which will carry a range of pollutants and could negatively affect the Moonee Ponds Creek's water flows and quality. Flood risks are projected to increase before CCM is taken into account.[206] In the *Moonee Ponds Creek Strategic Opportunities Plan*, the City of Melbourne has proposed to work with CityLink on stormwater harvesting and water treatment along the creek.[207]

The urban and environmental impacts are key reasons why a preferred corridor warrants reconsideration.

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[200] Infrastructure Victoria (2020). 30-year Infrastructure Strategy Update: draft recommendation 77

[201] City of Melbourne. "Submission to East West Link Assessment Committee." 2013. "https://www.melbourne.vic.gov.au/SiteCollectionDocuments/submission-east-west-link-comprehensive-impact-statement-19dec2013.pdf"https://www.melbourne.vic.gov.au/SiteCollectionDocuments/submission-east-west-link-comprehensive-impact-statement-19dec2013.pdf

[202] https://www.planning.vic.gov.au/__data/assets/pdf_file/0023/441464/Urban-Vegetation-Cover-Change-in-Melbourne-2014-2018_Final.pdf

[203] City of Melbourne. "Submission to East West Link Assessment Committee." 2013. https://www.melbourne.vic.gov.au/SiteCollectionDocuments/submission-east-west-link-comprehensive-impact-statement-19dec2013.pdf

[204] Ibid

[205] https://achris.vic.gov.au/#/onlinemap

[206] City of Melbourne. 2017. Moonee Ponds Creek Strategic Opportunities Plan.

[207] https://www.melbourne.vic.gov.au/building-and-development/urban-planning/local-area-planning/Pages/moonee-ponds-creek-strategic-opportunities-plan.aspx

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity of the project's BCR to a range of potential outcomes. This informs the conditions in which a project should or should not go ahead, and how sensitive a project's viability is to changes.

These tests include varying the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the projects opening year and construction start, and increasing the value of travel time in the future. The BCR under each test for the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below.

This project has a BCR below one under all sensitivity tests. This suggests the project is susceptible to changes in the underlying assumptions used in this analysis.

Table 22: CCM Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static land use	Dynamic land use	Total (Dynamic land use with WEBs)
7% discount rate	0.3	0.3	0.3
4% discount rate	0.4	0.4	0.5
3% discount rate	0.5	0.5	0.6
10% discount rate	0.2	0.2	0.2
20% decrease in capital costs	0.3 - 0.5	0.3 - 0.5	0.4 - 0.6
20% increase in capital costs	0.2 - 0.3	0.2 - 0.4	0.3 - 0.4
40% increase in capital costs	0.2 - 0.3	0.2 - 0.3	0.2 - 0.4
Exclusion of construction cost escalation	0.3 - 0.5	0.3 - 0.5	0.4 - 0.6
40% decrease in total benefits	0.1 - 0.2	0.2 - 0.3	0.2 - 0.3
20% decrease in total benefits	0.2 - 0.3	0.2 - 0.3	0.3 - 0.4
20% increase in total benefits	0.3 - 0.5	0.3 - 0.5	0.4 - 0.6
Delay opening by 5 years	0.2 - 0.4	0.3 - 0.4	0.3 - 0.5
Delay opening by 10 years	0.3 - 0.4	0.3 - 0.4	0.3 - 0.5
Value of travel time	0.3 - 0.5	0.3 - 0.5	0.4 - 0.6

Source: AECOM 2021 Transport Modelling Scenarios - Economics Report
Note: These sensitivity tests are provided for the upper cost and ranges are shown using 4% and 7% discount rates.

Future Scenarios

Across most future scenarios assessed in this report, there is expected to be marginal change on the assessment outcome for CCM. In particular, the introduction of TNP could significantly reduce the need for the project as it has the potential to reduce congestion by about half in Inner Melbourne.[208]

The project may be needed in the longer term with the EAV scenario. The capacity and efficiency benefits of AVs are expected to be particularly significant on the motorway network. This is because it is a more predictable road operational environment as flows and access to and from a motorway are much more controlled and able to be managed. This provides a road environment where efficiency gains have the potential to be greater than other roads in the network.

However, the project should be introduced or enhanced with TNP. The EAV scenario resulted in significant additional congestion, particularly in Inner Melbourne. TNP is needed to help mitigate this outcome and ensure the benefits of this project are realised and not hampered by too many vehicles seeking to leave the motorway to access Inner Melbourne.

A summary of the implications of each future scenario is documented below in Table 23.

Table 23: Resilience of CCM to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	A high growth scenario would drive greater freight and population growth which would increase demand, benefits, and improve the BCR for CCM, but is unlikely to see the BCR approach 1.	+
Low population growth	Under a low population growth scenario, CCM would still be providing marginal relief for localised road network movements, and as such is unlikely to see a change in the benefits and BCR.	~
Working from home	The movements offered by CCM support freight and trips moving across Melbourne, rather than to knowledge-intensive job clusters like Inner Melbourne. As such, it is unlikely that working from home would reduce the need for CCM, diminish the benefits or reduce the BCR.	~
Automated and electric vehicles	Under an EAV scenario, AVs enable increased road network efficiency which generally improves congestion in Melbourne, except in Inner Melbourne where road network congestion hours rise 3% in 2051. This has conflicting implications for CCM. On one hand it could suggest that with higher demand for inner city road use, CCM is more important. Conversely, AVs enable an increase in road network capacity without the need for substantial capital investment, reducing the need for CCM. There is a high degree of uncertainty around this scenario, and its implications for transport projects, as AVs are still an emerging technology.	+<>– **Impact unclear, due to high degree of uncertainty**
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, increasing demand for public transport and slowing population growth in growth areas and outer suburbs. This is likely to result in a marginal decrease in benefits and a reduced BCR.	–
Transport network pricing	This scenario will result in higher public transport mode share for trips to destinations subject to the new cordon charges (Inner Melbourne), increasing demand for public transport. It will therefore reduce congestion in Inner Melbourne, which could be up to 50% according to Infrastructure Victoria's TNP advice. CCM provides a city bypass function to help road users move around and outside the cordon, supporting the objective of reducing traffic on arterial road network in Inner Melbourne. The tolling of CCM becomes very important and should be considered as part of a broader TNP approach for Inner Melbourne, as an incorrect toll point may drive traffic onto other arterials while CCM is poorly utilised. The setting of the TNP toll should also be done in context of a general approach to toll the motorway network to mitigate congestion impacts on other parts of the network, such as the Eastlink tunnels.	+++

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

[208] *Infrastructure Victoria 2020. Good Move – Fixing transport congestion*

Implications

TNP can better utilise existing routes – West Gate / Monash Freeway and North East Link

Inner Melbourne congestion is expected to increase significantly in future. One way of managing this congestion is to introduce TNP, which is a system designed to influence how, when and where people use the transport system. Under TNP, prices can be set to incentivise commuters to travel at quieter times, such as in the off peak, and shift modes from private vehicles to public transport. This will help ease congestion and improve environmental and health outcomes. TNP can also be used to manage demand for the road network through distance-based and cordon charges.

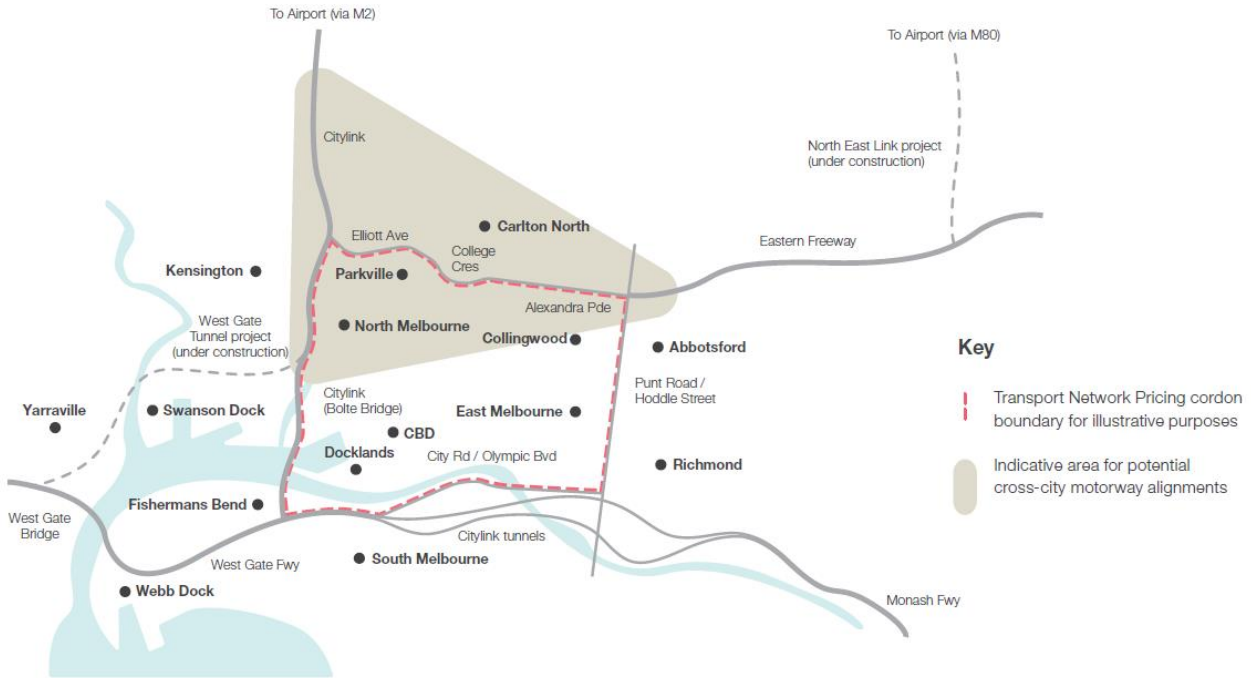
Our previous research on transport network pricing showed that introducing an inner city cordon charge for vehicles entering the inner city reduced congestion, with an average speed increase of up to 25%, partly due to the number of vehicles entering the cordon almost halving in volume. The overall time spent in peak hour congestion also reduced by 8%.[209]

An inner city cordon charge would encourage better use of our existing and under construction motorways, including North East Link and the West Gate / Monash Freeway, to incentivise traffic using these motorways to bypass Inner Melbourne instead of using them for direct access into Inner Melbourne.

Integrate comprehensive TNP with the project, and introduce TNP in conjunction with the project if it is not already in place

TNP can also enhance future infrastructure investments in our transport network, helping these projects to perform at their best once delivered. If it has not been introduced, TNP should be introduced with this project, to manage congestion in the inner city (Alexandra Parade). Prices for both a cordon charge and the CCM should be set to ensure high value vehicle trips (such as medical appointments and commercial deliveries) into the city can continue to be accommodated while other trips are diverted around the city via CCM and existing freeways, or shifted onto the public transport or active transport networks to access the city. This would assist in better network outcomes, particularly into Inner Melbourne.

Figure 54: Example of CCM and transport network pricing integration



Source: Infrastructure Victoria (2021)

[209] *Infrastructure Victoria 2020. Good Move – fixing transport congestion* https://www.infrastructurevictoria.com.au/report/executive-summary/

Protecting the option for a possible need for the long term

Modelling of this project indicates that there is no immediate need for a connection between the Eastern Freeway and CityLink, however one may be necessary in the next 30 years, particularly with the high level of uncertainty related to technology (such as the development and take up of automated vehicles) and evolving transport network demand (COVID-19, changing development due to working from home). Our recommendation is therefore to protect the future option for a new cross-city motorway to ensure the corridor is available to support future transport solutions. However, recent urban planning and developments, along with environmental concerns, means that the alignment assumed for this study may no longer be the preferred corridor. That is why we have recommended that within five years an updated future alignment be determined, and steps be taken to preserve the option for constructing, if required, a new motorway linking the Eastern Freeway and CityLink or West Gate Tunnel.

Determine a preferred alignment to protect

Consideration should be given to reviewing potential alignments that are more cost effective with lower environmental impacts. This includes considering options to extend the tunnel component of this project, so an above-ground section is not required. This could reduce the environmental impacts and loss of open space in this area. Urban renewal in Arden-Macaulay and the Fitzroy Gasworks site, the importance of additional open space and the Moonee Ponds Creek's Aboriginal cultural heritage, biodiversity and water quality must be considered in determining a new alignment. International best practice should be considered in the design of tunnel entrances and exits, including tunnel greening.

Shape the network across all modes

Future planning for this project should consider a range of supporting policies, services and plans that are required to mitigate against potential risks of this project in producing undesirable urban outcomes. This includes considering opportunities to improve public and active transport within the project scope and impacts of induced demand resulting from the project in the longer term, particularly in the surrounding residential areas. Mitigation measures are required for additional local public transport services, pedestrian and cycling priority on local streets, clearer designation of priority streets for accessing the Eastern Freeway, and for provision of open space and vegetated buffers that are adequately maintained.

Residents living close to this corridor already cycle more than other Melburnians and dedicated cycling lanes or off-road paths should be built above the tunnel alignment to facilitate east-west movements. Improvements for pedestrians crossing this corridor should also be incorporated, including signal priorities and new tree planting.

The project presents an opportunity to shift some movements onto CCM, improving the amenity in surrounding areas and transport connections through the corridor by reducing congestion and unlocking public spaces.

This project has the potential to reduce the surface traffic through the corridor, reducing congestion of the road network, supporting mode prioritisation, and reducing the land footprint of the remainder of the transport network. In addition to less traffic lanes, this project could unlock further land for urban amenity, and support increased density along the corridor. There is the potential for increased demand for housing in inner areas close to the project alignment. These areas are suitable for increased density as they are well served by public transport and services. To support this increased density, it is important to ensure that the planning controls are suitable in those places, along with sector plans and infrastructure contribution plans (ICPs).

Consideration should also be given to managing the pressures from an increasing population. This could include public and active transport service improvements to encourage more use of these modes. For example, introducing new Doncaster busway services that operate in their own lane along Alexandra Parade and Princes Street. Tram and bus services crossing Alexandra Parade could also be improved. Rapid bus connections could also be provided to Moonee Ponds and Footscray to provide public transport connections from these suburbs to the east.

Relevant Recommendations in Victoria's Infrastructure Strategy

Recommendation 62: Protect a long-term option for a new cross-city motorway

Victoria's infrastructure strategy recommends that the Government should protect a future option for a new cross-city motorway. That is, within five years, determine an updated future alignment and preserve the option for constructing, if required, a new motorway linking the Eastern Freeway and CityLink. If delivered, implement the project with a transport network pricing scheme, and active and public transport improvements.

Planning for an updated corridor will need to consider the implications of delivery of the West Gate Tunnel Project. It should also assess the likely impact of options such as TNP and AVs, both as potential alternatives and as complementary options. Any potential future business case should also consider opportunities to improve public and active transport. While there is no immediate need for a connection between the Eastern Freeway and CityLink, one may be necessary in future.

Recommendation 49: Reduce Inner Melbourne congestion by further reforming parking pricing

Victoria's infrastructure strategy recommends that within the next two years, review the Melbourne Congestion Levy on parking to increase its value, expand the properties it applies to, and cover a wider area. In the next five years, consider extending the levy to on-street parking and supporting a trial of demand-responsive pricing for Inner Melbourne on-street parking.

Recommendation 51: Incorporate congestion pricing for all new metropolitan freeways

Victoria's infrastructure strategy recommends applying congestion-based peak and off-peak tolling to all new metropolitan freeways, including the North East Link, to better manage traffic flow and impacts on nearby local roads.

Recommendation 52: Trail full-scale congestion pricing in Inner Melbourne

Victoria's infrastructure strategy recommends that in the next five years, trial full-scale congestion pricing in Inner Melbourne to reduce congestion on inner city roads.

Recommendation 53: Phase out fixed road user charges and introduce user pays charging

Victoria's infrastructure strategy recommends to replace fixed road user charges with variable distance-based and congestion charges over the next 10 years, by gradually expanding and reforming the existing electric vehicle charge. Ensure user pays charging reflects the relative costs of road use, encouraging people to adopt beneficial travel behaviour.

4.5 Melbourne Metro Two and Direct Geelong Rail Services

Objectives

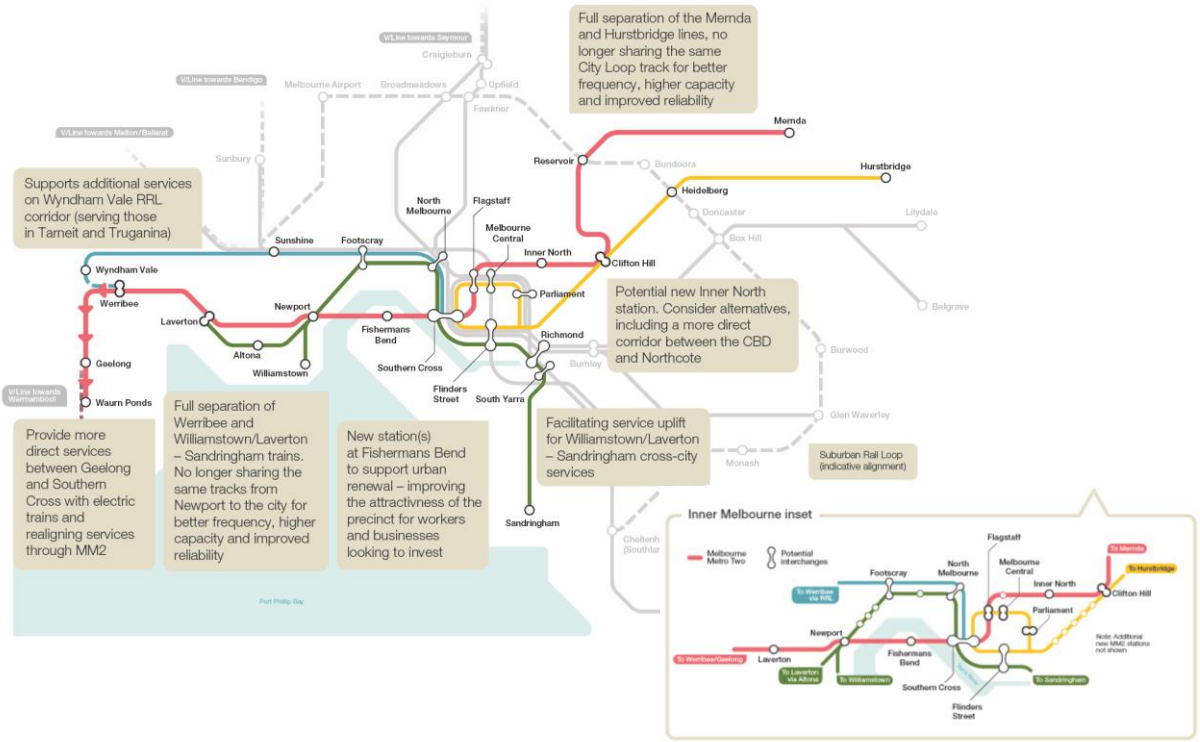
The Melbourne Metro Two and direct Geelong rail services project (MM2G) involves the construction of a new rail tunnel connecting Newport to Clifton Hill, accompanied by electrification to Geelong. It would allow for a significant reconfiguration of the network's service patterns to expand the network to create more lines. This would allow for an additional metro style cross-city service that connects the Werribee line in the west with the Mernda line in the north. This significantly increases accessibility to major destinations that would be served along these two metropolitan corridors. Figure 55 shows the alignment that has been modelled for this project of the new tunnel and the location of two new stations in Fishermans Bend and one in the inner North.

This project would lead to the following service changes:

- The Geelong line, which currently operates on the regional rail link (RRL) corridor as regional services to Southern Cross, alongside Werribee suburban services, would be diverted into the new Newport-Fishermans Bend tunnel via Southern Cross and Flagstaff to connect with the Mernda line, creating a new independent cross-city metro line. This new Geelong – Mernda line will include new stations at Fishermans Bend and in the inner north.
- Mernda services would be taken out of the City Loop, leaving the Hurstbridge line to operate independently on its own City Loop tunnel.
- Wyndham Vale RRL services (which will be extended to Werribee from Wyndham Vale as part of the SRL works) would continue to operate via Manor Lakes and Tarneit, without having to share the track with Geelong services.
- Laverton and Williamstown services would be increased in frequency and continue to run cross city to Sandringham and would become the only train line servicing train stations between Newport and Footscray.

It is proposed to deliver this project in stages, with the first stage involving construction of the tunnel from Newport to Southern Cross to allow for Werribee metro services to go direct to Southern Cross. Stage two involves completion of the tunnel by connecting it to the Mernda line and introducing electrified services to Waurn Ponds. This would result in services from Waurn Ponds and Geelong being diverted into the MM2G tunnel for a more direct service to Southern Cross.

Figure 55: Metro Network Lines and Benefits of MM2G



Note: Suburban Rail Loop Stage 1 corridor (Cheltenham / Southland to Box Hill) has been determined, with subsequent stages and corridors to the north and west to be determined (https://suburbanrailloop.vic.gov.au/). For the purposes of modelling for this study, it has been assumed that Wyndham Vale services will be extended to Werribee Station as per Western Growth Corridor Plans and PSP and will be referred to in this report as 'Wyndham Vale RRL' services.
Source: Infrastructure Victoria Visualisation of Project Specification (2021)

MM2G is assumed to be a subsequent stage of the Geelong Fast Rail project (GFR). The GFR project aims to provide a more direct service with better travel times between Waurn Ponds and Southern Cross by rerouting a number of services through Werribee, Newport and Footscray.

If MM2G were built, it would be possible to run all Geelong services via Werribee to Mernda via Fishermans Bend. It would also enable an uplift in services along the South-West Rail Corridor and other metropolitan lines such as Hurstbridge, Laverton, Williamstown, Sandringham and the Ballarat / Melton corridors.

This project is expected to support the following objectives of *Victoria's infrastructure strategy*:

- **Objective 1:** Prepare for population change – by providing strong transport connections and additional capacity to support growing travel demand in Geelong, Wyndham LGA, and Whittlesea LGA.
- **Objective 4:** Enable workforce participation – by providing transport connections to employment clusters, providing access to training and a range of secure work opportunities in the Melbourne CBD, Fishermans Bend, Parkville, East Werribee, and La Trobe NEICs (all knowledge economy locations as identified by *Plan Melbourne*).
- **Objective 5:** Lift productivity – by supporting Victorians to maintain a good standard of living from an economy boosted by enhanced skills, innovation, market access, and efficient investment, and by increased access to labour force across Melbourne with new metro-style transport connections between residential areas and employment clusters.
- **Objective 6:** Drive Victoria's changing, globally integrated economy – by ensuring Victoria remains an attractive place for business and trade, competitive with other cities across Australia and the world, as Melbourne continues to be one of the most liveable cities in the world.

Need

Growth areas to the west and north will experience significant population growth, with Wyndham LGA projected to grow from 300,000 residents in 2021 to almost 610,000 by 2051 and Whittlesea LGA projected to grow from 240,000 residents in 2021 to almost 450,000 by 2051. In addition, the Greater Geelong LGA is projected to grow from 270,000 residents in 2021 to 440,000 by 2051.[210] Overall, these areas will accommodate 690,000 more people by 2051, which is 18% of Victoria's population growth.

This population growth will lead to significant growth in travel demand, including rail services, for residents in Wyndham, Mernda and Geelong. Job growth is not expected to match population growth in these areas, driving residents to commute to employment clusters, NEICs, and the CBD to access study and work opportunities. While transport infrastructure upgrades are being delivered such as the West Gate Tunnel Project, North East Link and Geelong Fast Rail, there will still be significant pressure on the transport network to ensure these growing regions have access to high quality transport connections that have capacity to support access to jobs, study, and a high quality of life.

Train services from Geelong, Wyndham, and Whittlesea are critical to providing transport connections to employment, and are expected to experience strong passenger growth, resulting in significant overcrowding by 2051 on the RRL and Werribee train services, as shown below in Figure 56.

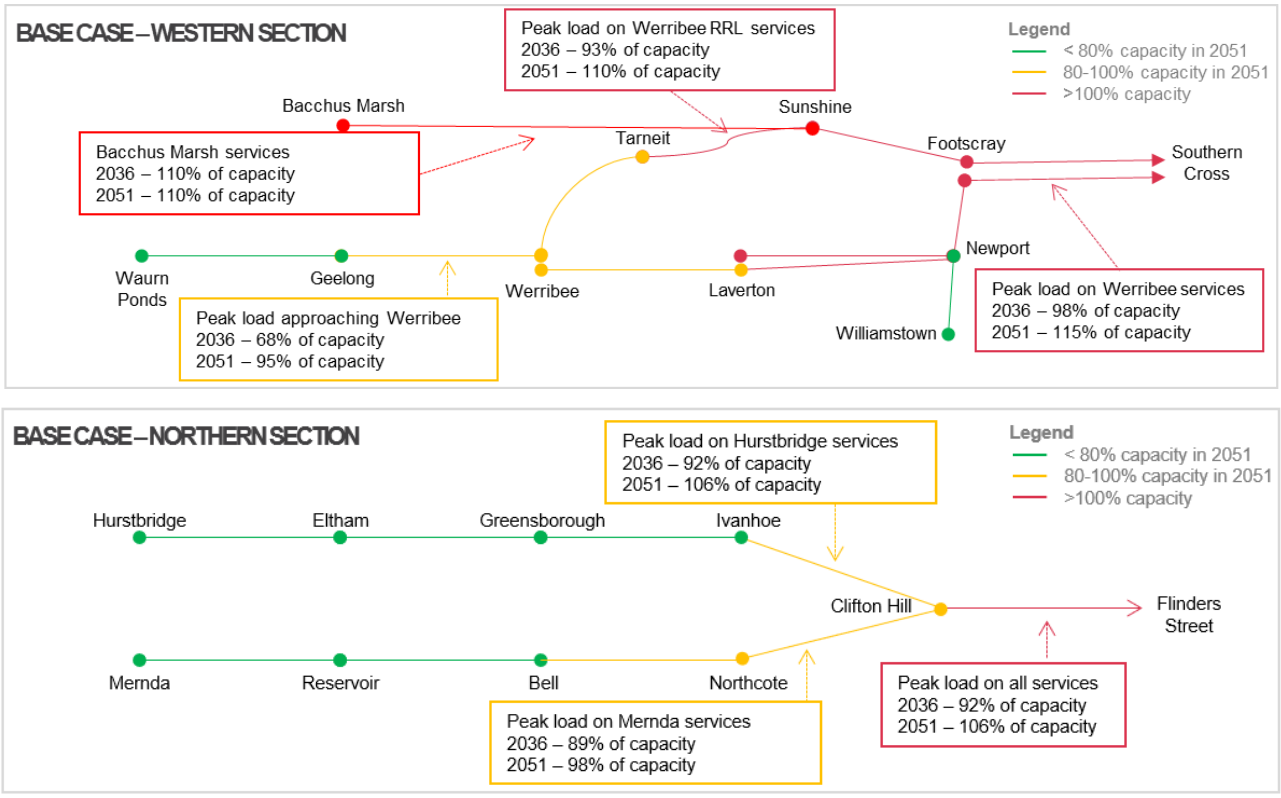
In addition, Fishermans Bend is expected to grow to accommodate 80,000 jobs and 80,000 residents by 2051, placing significant pressure on the proposed tram and bus infrastructure.[211] In 2051, Fishermans Bend tram services are forecast to exceed capacity (120% of capacity) and further transport connections are required to support the demand for travel. A lack of transport infrastructure connections could reduce the attractiveness of the precinct and discourage investment. This could result in outcomes for Fishermans Bend that may hinder the potential of Australia's largest urban renewal site if capacity to meet demand is not available. In addition, a rail option could also provide for faster travel times and connections with the CBD and the broader public transport and rail network, which would boost the attractiveness of the precinct for workers and businesses looking to invest.[212]

[210] *DELWP 2019 Victoria in Future Population Projections*

[211] *https://www.fishermansbend.vic.gov.au/framework*

[212] *https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0009/377127/Plan_Melbourne_2017-2050_Summary.pdf*

Figure 56: Passenger crowding levels on Geelong, Werribee, and Clifton Hill group train services, 2036 and 2051



Source: Infrastructure Victoria analysis of ARUP / AECOM modelling outputs, 2021

Dynamic public transport demand in the South-West Growth Area (Wyndham LGA)

The opening of Regional Rail Link (RRL) in 2016 was a major disruption to train usage with a large population located between two railway lines which both provide access to Inner Melbourne. Passengers have demonstrated over the last five years a willingness to switch between services (Werribee metropolitan trains vs Wyndham Vale RRL trains) in response to reliability changes, capacity of services, and operational performance issues on the corridor (such as VLocity trains being removed from service in 2016).

The modelling and planning tools available for this project analysis are not sufficiently sensitive to reflect this level of volatility, and as such both railway lines servicing the Western Growth Area are being assessed together. This has several implications for the analysis:

- Passenger crowing levels in Figure 56 indicate that the Wyndham Vale RRL services will experience significant crowding, while Werribee services will not experience crowding levels greater than 80% of capacity by the year 2051.
- When train users can choose between stations on different lines, they will regularly adapt their use of train services according to service performance and capacity, and as such, it is important to recognise that across the two corridors, there will be sufficient capacity to accommodate demand for travel. If the Wyndham Vale RRL service is overcrowded, then it would be expected some users would opt to use the Werribee service. This impact could be better reflected in the modelling.
- While there will be sufficient capacity across the two corridors, it is important to recognise that train users may not have access to their preferred service, and as such customer experience is diminished as a result of needing to frequently consider and adjust travel behaviour.

Project Description

MM2G involves the construction of 15km twin tunnels through the Melbourne CBD connecting Newport and Clifton Hill, via Fishermans Bend and Parkville on a new rail corridor. Eight new underground stations would be constructed, including at Newport, two at Fishermans Bend (Employment Precinct and Sandridge), Southern Cross, Flagstaff, Parkville, Inner North (notionally Fitzroy) and Clifton Hill.

The project would enable better and more reliable services and a capacity uplift on the Geelong (Waurn Ponds), Werribee, Hurstbridge, Mernda, Laverton, Williamstown, Sandringham, Wyndham Vale, Grampian (Ballarat) and Melton train lines. The uplift of these services and associated enabling works, and the benefits, have been included in the cost benefit analysis.

The rail tunnel would include the construction of the eight underground stations and also includes their associated fit out, structures to support the tunnel portals and reconfiguration and realignment of existing lines.

Figure 57 shows the following alignments and service level changes included in this project, with all service level improvements included in the operating cost of this project. The scope of works that have been costed for this project assumes that works have already taken place on a number of corridors through state government commitments, such as Geelong Fast Rail and rail improvements between Waurn Ponds and Geelong. It also assumes projects have been completed that realise the capacity benefits of the Metro Tunnel Project on the Sandringham and Werribee lines, including between Newport, Footscray and the city, as well as the Wyndham Vale RRL and Melton lines through projects that include Western Rail Upgrade.

For the purposes of this assessment, we have assumed that MM2G would be delivered in two stages. Capital costs have been estimated for the following for stage 1 and 2:

Stage 1 comprises four components (opening in 2041):

- Melbourne Metro Two Tunnel (MM2) from Newport to Southern Cross with a turnback box at Southern Cross station
- Werribee to Newport Rail Corridor Upgrade
- Manor to Werribee Rail Corridor Upgrade
- stabling and maintenance facilities at Manor to hold 47 High Capacity Metro Trains (HCMTs).

Stage 2 comprises five components (opening in 2044):

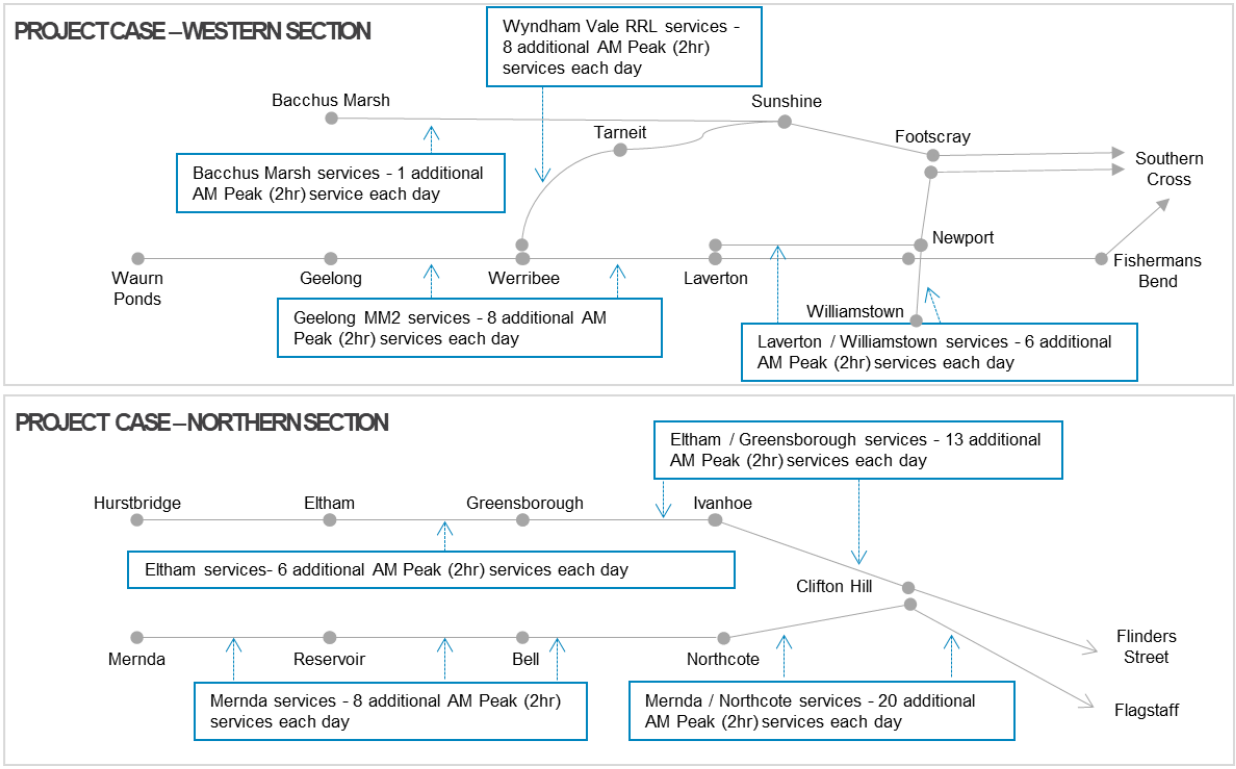
- Melbourne Metro Two Tunnel (MM2) – Southern Cross to Clifton Hill
- Altona Loop Partial Duplication (including second platform at Williamstown)
- Mernda Rail Corridor Upgrade
- Geelong (Waurn Ponds) to Werribee Rail Corridor Upgrade
- Hurstbridge Rail Corridor Upgrade.

Figure 57: MM2G – Corridors with Major Capital Works

Source: Arup 2021

MM2G will deliver significant train passenger capacity for services on the Geelong, Werribee, Laverton, Williamstown, Mernda, and Hurstbridge lines, as shown below in Figure 58.

Figure 58: MM2G passenger capacity uplift (2051) – inbound AM peak (2 hours)



Source: Visualisation by Infrastructure Victoria (2021), Department of Transport Reference Case service plans

Project Costs and Timing

The total estimated cost of MM2G, inclusive of contingencies, 50-years renewal costs and operations and maintenance costs (O&M) are shown in the table below. This includes the capital cost for all of the enabling works required for this project, including upgrades on the Werribee, Geelong, Mernda and Hurstbridge rail lines.

Total capital expenditure cost is estimated to range between $27.4 billion and $36.7 billion (in 2020 values). Large components of this cost include interchanges, buildings and stations, tunnels and rail systems. Land acquisition is also included in this cost. The cost of providing rolling stock is also included. The train fleet is estimated to comprise 63 sets of high capacity metro trains (HCMT), which is assumed to be procured over six years. It has been assumed pre-existing rolling stock have been re-deployed on other lines or life expired. Contingencies for design, construction and prolongation have also been included in the total cost.

Construction of stage 1 has been assumed to start in 2030 and is expected to be completed by 2040, with stage 1 of project operational from 2041. Stage 2 of the project is assumed to be operational from 2044 onwards. Additional operating and maintenance costs have been included in the evaluation.

Table 24: MM2G capital expenditure cost profile (2020 dollars)

Project	Lower Capex ($m)	Upper Capex ($m)
MM2G	27,399	36,682

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

Multi-criteria Analysis

Compared to the other transport projects assessed, MM2G receives a number of High and Exceptional ratings due to its strong performance across many of the transport challenges. The project performs exceptionally in reducing public transport crowding when compared with the other assessed transport projects – largely due to MM2G both accessing new rail patronage markets and relieving pressure along existing public transport corridors. Rail crowding relief is experienced across both metropolitan and regional train services. On metropolitan services, this is most notably located in the Inner Melbourne FUA where the tunnels are located, and in areas of Middle Melbourne.

The project also provides a strong boost to accessing potential job opportunities for many residents located in Inner, Middle and Outer Melbourne, as well as the New Growth Areas by public transport. For businesses, the benefits are the greatest within the Fishermans Bend precinct where new rail tunnels provide greater connection to labour markets and other businesses, including in Central Melbourne. The project also attracts more people towards rail corridors that benefit from the project, particularly to Geelong where more people and jobs are relocated.

The average road travel times to key freight terminals and transport gateways across Melbourne reduce at a similar level to those experienced by the CLR project, realised by the MM2G project through reduced freight congestion. However, it should be highlighted that there are increases in road travel times within Geelong due to people and jobs relocating there as a result of the project. As the MM2G project is not a new link in the freight network, its performance is not assessed against freight connectivity or freight utilisation.

The project performs strongly in reducing vehicle emissions in 2051, in comparison to other assessed projects. However, it is also worth noting that due to population redistribution, especially stronger population growth in the outer west, there is a slight increase in vehicle kilometres travelled in 2036, leading to increased emissions in the 2036 project case.

Table 25: MM2G MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
Melbourne Metro 2 (MM2G)	M/H	E	H	L/M	L/M	~	~	H

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

Transport Outcomes

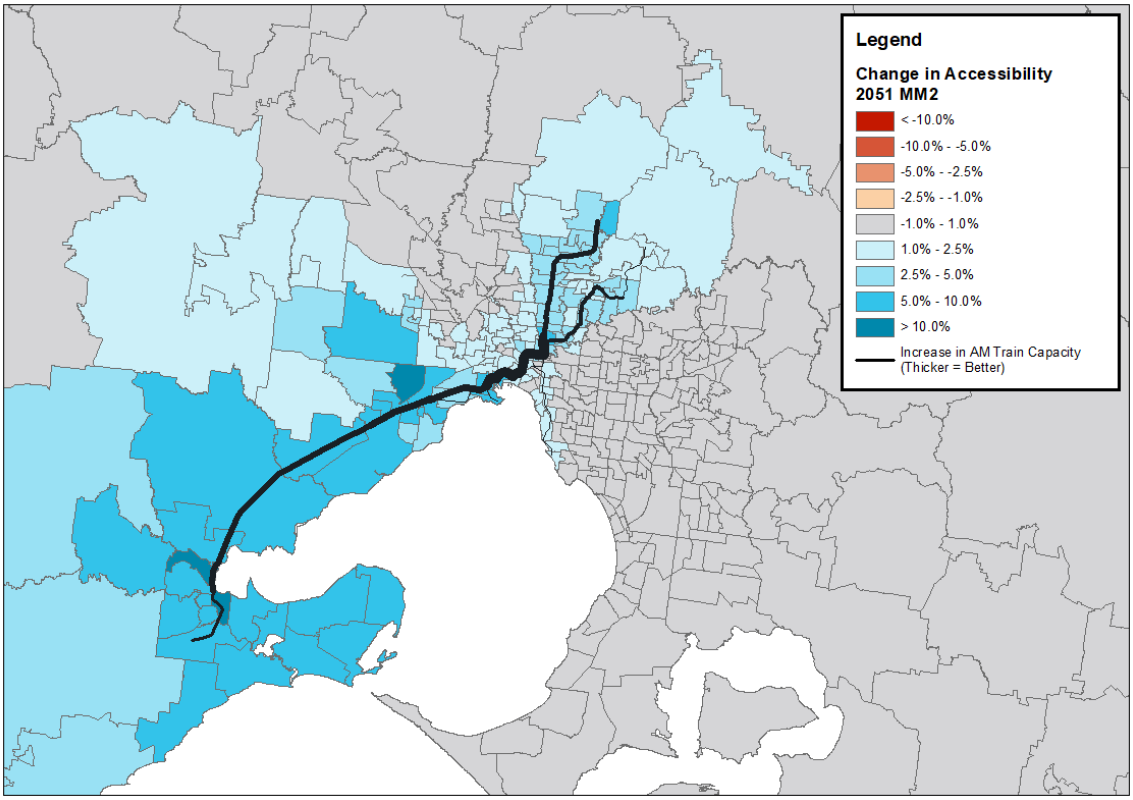
The project is expected to improve transport network reliability, provide additional train services for growing western and northern corridors, and provide a new electrified service to train stations in Geelong and Waurn Ponds. It will provide better access with capacity to carry more people to jobs, study opportunities, and help to reduce social disadvantage. The following sections explore the transport outcomes of MM2G for public transport and private vehicle travel.

Public transport

MM2G is expected to attract new patronage growth in middle suburbs and growth areas, with an additional 2.8 million annual morning peak (2 hour) public transport users predicted by 2051. MM2G delivers significant improvements in accessibility for residents across the west and north, particularly for the Wyndham growth area and Geelong, with improvements of over 10% as shown below in Figure 59. Residents of Wyndham will be able to access more jobs in 2051 because of MM2G, with the number of jobs accessible by public transport within 60 minutes increased by 22% from 715,000 to 880,000, while the overall number of jobs accessible in 60 minutes (public transport and private vehicle) increased by 15% from 1,235,000 to 1,425,000 jobs.

For Geelong, the 60-minute buffer does result in a significant change to overall accessibility (2% increase in 2051), but the number of jobs accessible within 90 minutes (public transport and private vehicle) increases by 15% from 1,403,000 jobs to 1,609,000 jobs in 2051.

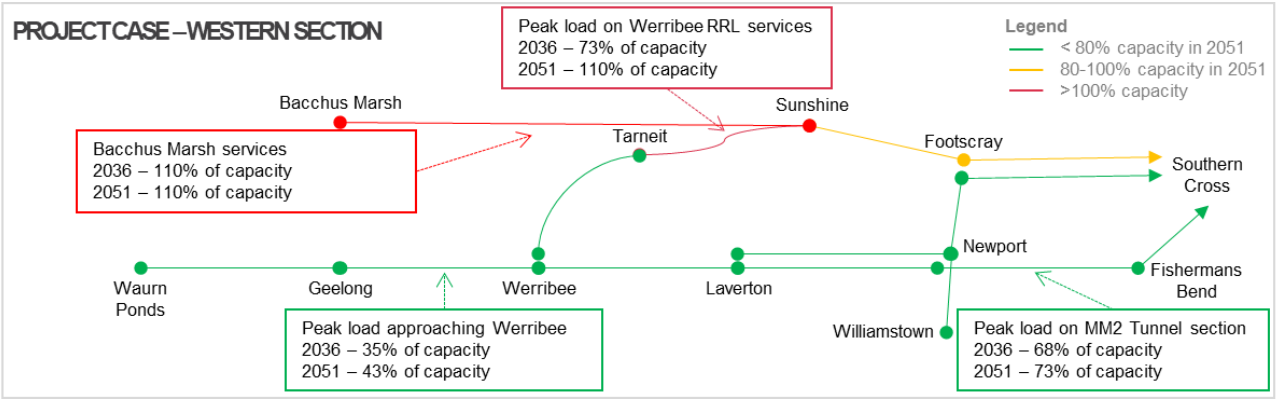
Figure 59: MM2G impact on access to jobs from place of residence in 2051 (AM Peak)



Source: AECOM 2021 Transport Modelling – Economics Report

MM2G is expected to reduce passenger congestion by 80% for train passengers in the Western FER by 2051, with Werribee train services seeing a utilisation improvement from 115% in 2051 to 73% of capacity on services now travelling through the Newport tunnel. The Laverton and Newport services, which now provide the connection from Newport to Footscray, have experienced a significant increase in demand of between 70% and 100% in 2036, and the additional capacity (100% increase on each corridor) is sufficient to support passenger demand beyond 2051 as shown below in Figure 60.

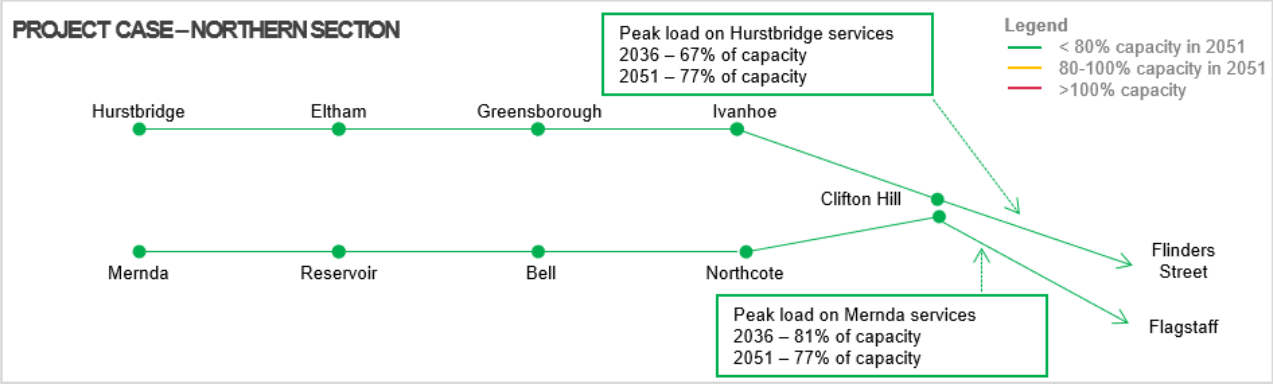
Figure 60: Train service line load projections for Geelong, Werribee, Laverton and Williamstown services (MM2G project case)



Source: Visualisation of ARUP / AECOM modelling results (2021) by Infrastructure Victoria

On the Mernda and Hurstbridge lines, the capacity uplift addresses all overcrowding along both railway lines, with utilisation dropping from 98% for each line in 2036 in the transport base case to 67% for Hurstbridge services and 89% for Mernda services in 2036. The additional capacity is sufficient to accommodate future growth, with utilisation on both lines at 77% in 2051, as shown below in Figure 61.

Figure 61: Metropolitan train service line load projections for Mernda and Hurstbridge services (MM2G project case)



Source: Visualisation of ARUP / AECOM modelling results (2021) by Infrastructure Victoria

New stations and corridor options

The MM2G project included three new stations, two at Fishermans Bend and one in the Inner North, with the expected boarding and interchanges shown in the following table.

Table 26: Average weekday station activity at new MM2G stations in 2051

Station	Year 2051			
	AM Peak boardings	AM Peak alightings	Weekday total (boardings)	Bus/tram transfers (Daily)
Inner North (Fitzroy)	1,800	6,400	17,000	6,700
Fishermans Bend (Employment Precinct)	600	5,800	11,400	500
Fishermans Bend (Sandridge Precinct)	2,800	4,600	16,200	4,000

Source: ARUP AECOM PT VLUTI Modelling Outputs (2021)

Fishermans Bend is Australia's largest urban renewal site and is planned to accommodate 80,000 jobs and 80,000 residents. It is expected that urban development will be well underway over the next 20 years during which time this assessment assumes that the project will progressively open. In 2051, the two new stations at Fishermans Bend are expected to attract over 27,000 average weekday boardings, with 16% interchanging from trams and buses in Fishermans Bend.

The combined average weekday daily boardings for the two new stations in Fishermans Bend are comparable to the top 20 busiest stations in Victoria. This patronage will continue to grow as the area develops. This indicates that the new stations contribute to making Fishermans Bend an attractive workplace destination for residents in the western suburbs and Geelong, particularly with a direct alignment significantly reducing travel times. For comparison, the new Metro Tunnel Station will support the Arden Precinct, planned for 35,000 jobs and 15,000 residents.

However, given the cost of an underground station, options to improve and intensify land use around each of the stations and integrate it so that benefits can be realised soon after opening should be considered.

The service uplift is expected to significantly reduce demand for trams and buses in Fishermans Bend, particularly alleviating significant overcrowding on trams in Fishermans Bend as shown below. Despite this, our modelling indicates that more may need to be done to achieve 80% of trips being made by sustainable transport as envisaged by the Fishermans Bend Framework Plan.[213] In our modelling, public transport's share of motorised trips for Fishermans Bend in 2051 is only 27% (compared to 66% for Docklands).[214]

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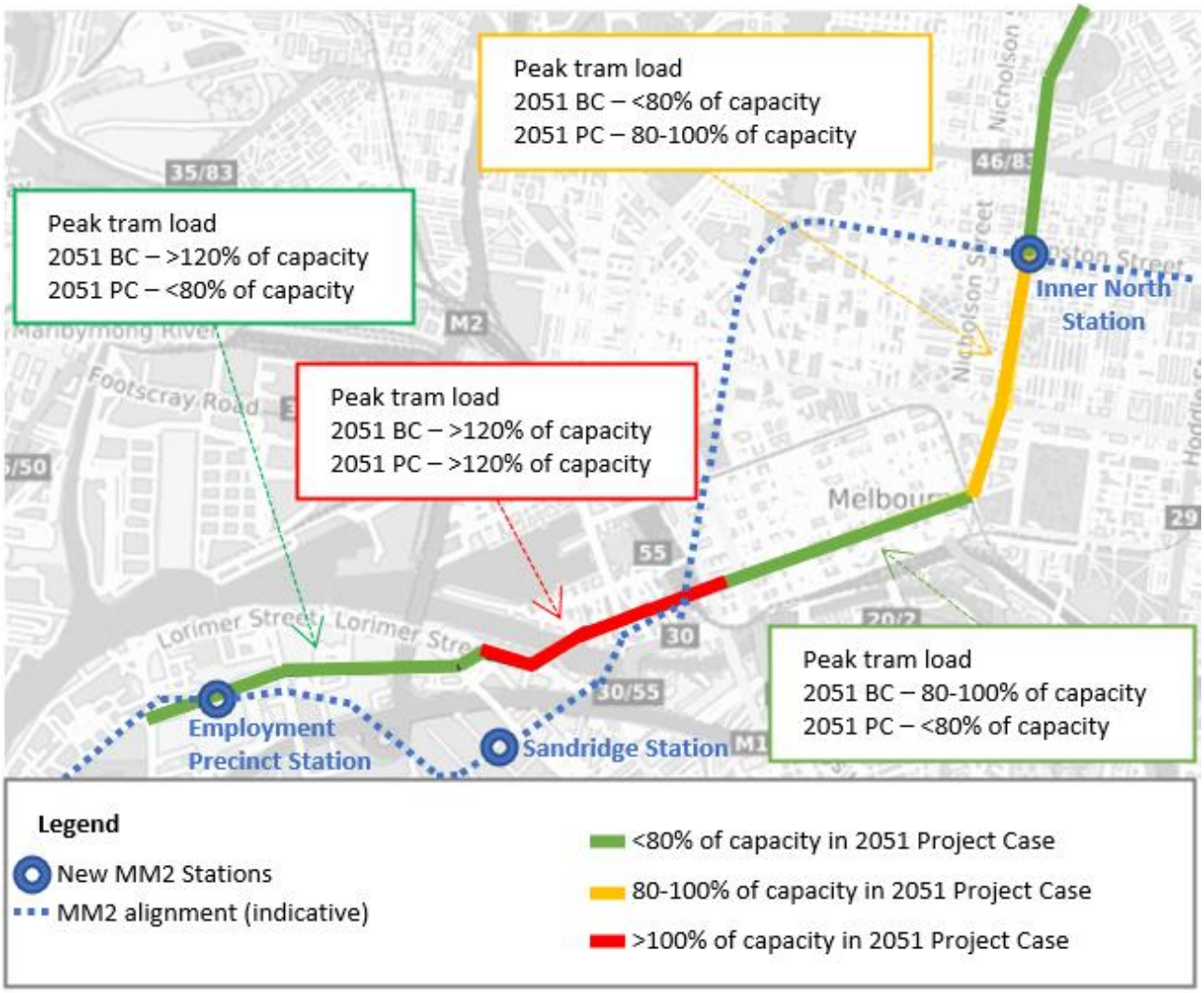
[213] *Victorian State Government, Fishermans Bend Framework Sourced from Fishermans-Bend-Framework.pdf (fishermansbend.vic.gov.au)*

[214] *Public transport mode share measured using modelling outputs for 2051, based on Port Melbourne and Docklands SA4 classifications. The measure considers the percentage of all trips to the SA4 identified across all time periods.*

Figure 62: Public transport overcrowding on Fishermans Bend trams, 2051 AM Peak (2hr)

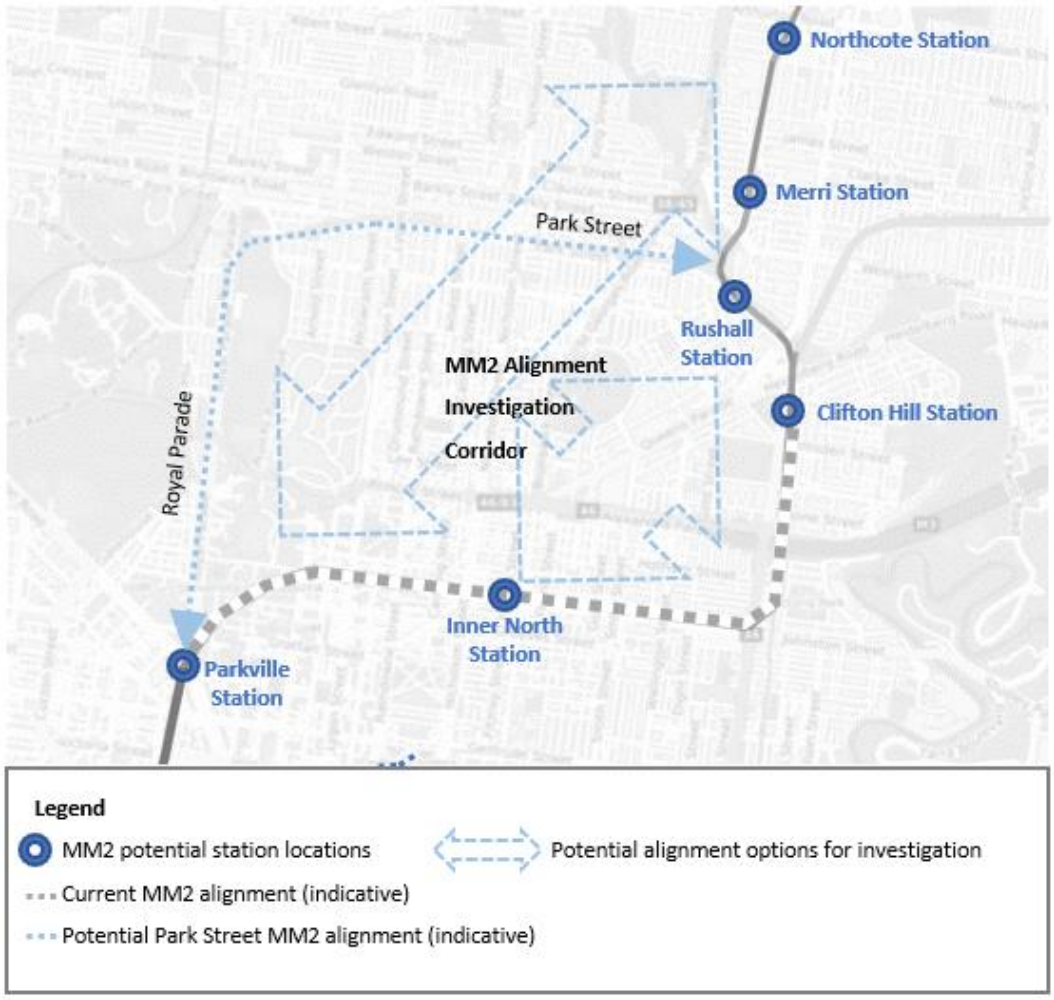


Source: ARUP AECOM, Tableau visualisation (2021)

The new station in the Inner North, notionally at Fitzroy, is expected to be the busiest of the three new stations, with over 4.3 million annual average weekday boardings in 2051, with 40% interchanging from tram and bus to connect to the new MM2G service. With over 17,000 average weekday daily boardings, this station will be amongst the 30 busiest train stations in Victoria, with activity comparable to South Yarra Station.

However, whilst it is within the 30 busiest stations, patronage levels indicate that it may not warrant the extra cost and travel time to align services to travel along an indirect alignment through Clifton Hill and Fitzroy. An alternative more direct or cost-effective corridor in the inner north between Northcote and Parkville with an intermediate station may be a better investment, with potential options presented in the figure below.

Figure 63: Corridor Options for MM2 alignment in the Inner North



Source: Prepared by Infrastructure Victoria (2021) using the 30-year Infrastructure Strategy from 2016 which included the potential Park Street alignment indicated on the map.

Other stations

While they have not been modelled, feeder buses servicing the new MM2G corridor in the Geelong LGA, Whittlesea LGA, and Wyndham LGA will become increasingly attractive. New direct feeder bus services to emerging corridors of interest such as Armstrong Creek, Avalon Airport, and Wollert would provide an opportunity to demonstrate significant demand and help inform future prioritisation of rail extensions. Transport corridor connections from Wollert and Armstrong Creek should also be integrated with planning for this project.

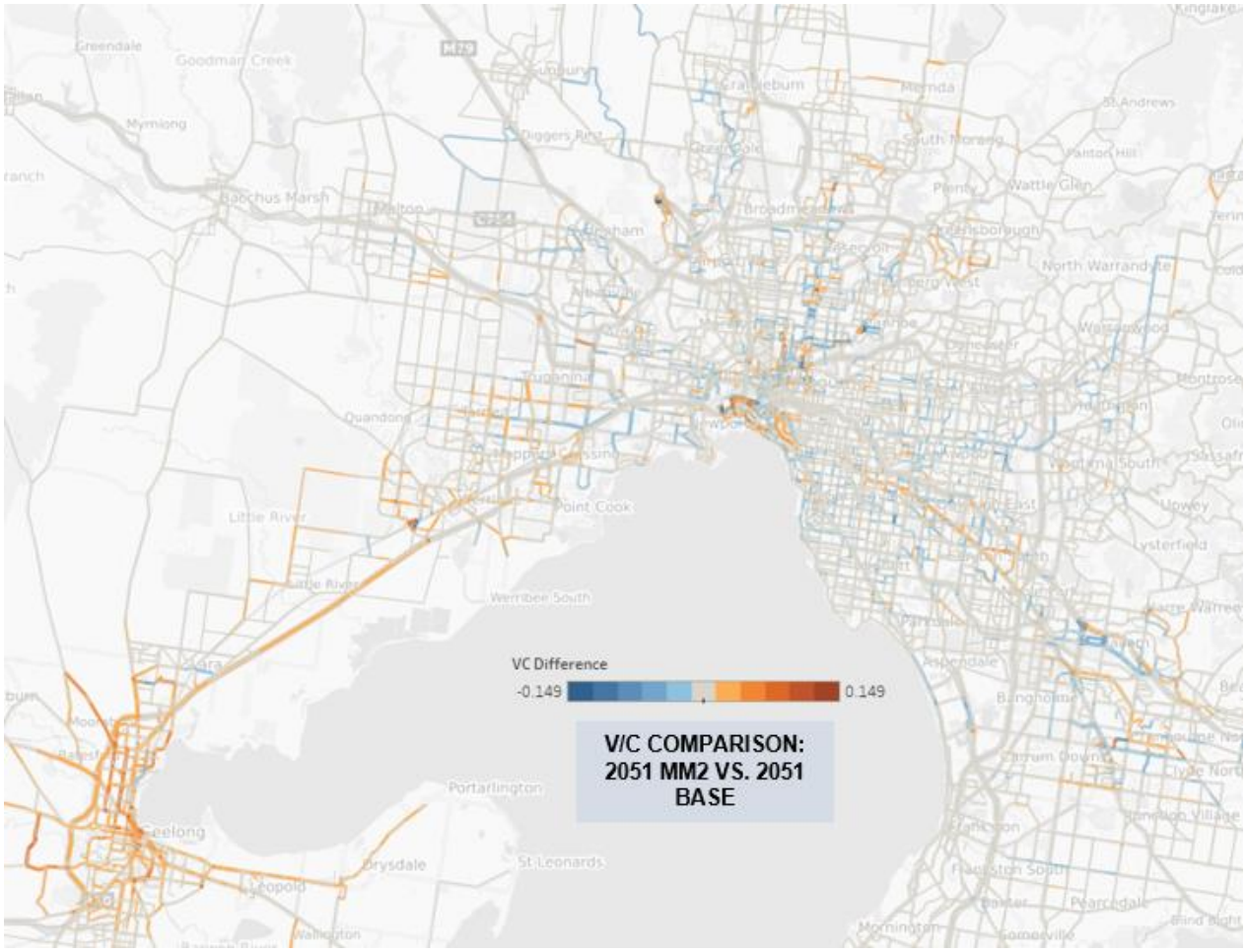
In addition, planning for this project should explore a number of other new stations and station relocations including:

- a new station at Derrimut Road to better serve the East Werribee NEIC
- a new mainline Avalon Airport Station, with a direct shuttle connection to the airport itself (this option should explore relocation of an existing station)
- consideration of the location of Corio Station, which could be relocated to a new location to serve a catchment with more potential rail users.

Private car transport

MM2G is expected to impact car trips during the morning peak, reducing overall private vehicle trips by 1 million annual morning peak (2 hour) trips in the morning peak across Melbourne by 2051. This results in a reduction of the number of hours spent by vehicles in congested conditions for residents across Melbourne. Road congestion is expected to worsen in Geelong and Fishermans Bend (as shown in Figure 64), and the Western Growth Area, as these places become more attractive places to work and live.

Figure 64: Change is road congestion due to MM2G, 2051 AM Peak



Source: ARUP / AECOM Modelling Report (2021)

Determining the Optimal Corridor and Stations

Whilst this study has assessed the MM2G project based on an assumed corridor that passes through Clifton Hill and Fitzroy, there are other corridors that should be considered in a corridor option assessment that could represent better value for money and provide better community benefits.

This includes more direct options to link the Mernda line from Northcote to Parkville and the north of the city. Such an alignment could be more cost effective to construct as it could use part of the former Inner Circle line as a corridor, as well as potentially saving travel times.

Such options will need to consider how to maintain or potentially improve connectivity to the inner north, particularly if the corridor options do not go through Clifton Hill, including connections to stations between Clifton Hill and Jolimont. Areas such as Collingwood, Abbotsford and Fitzroy are well served by an extensive network of trams and buses, and stations planned on alternative corridors should consider connections to these services.

Similarly, each of the potential stations in the inner city and Fishermans Bend should be carefully considered to ensure that they represent value for money given the complex construction environment.

MM2G has significant benefits with a high cost. The next stage should be to do a preliminary business case with the preferred corridor and stations as part of undertaking a more rigorous assessment and case for investment.

Demographic Outcomes and Land Use Implications

Population

The MM2G project results in additional population in Melbourne's Western Growth Corridor, inner west, north-east and Fishermans Bend, as well as in Geelong's centre, north and west.

Fishermans Bend experiences the largest increases in population with MM2G compared to the transport base case, particularly in the Sandridge and Lorimer precincts and in the north-east in Wirraway, close to the tunnel alignment. Even though the gain is modest compared to the transport base case in 2051, this result suggests that major public transport projects can have a catalytic effect on population increases. Other place-based initiatives can help to assist with this growth.[215] In comparison, growth in the adjacent inner city areas slows.

Compared to the other projects, MM2G has the largest positive impact on population in the south-west part of Melbourne's Western Growth Corridor along both the Werribee and Wyndham Vale rail lines. It also results in more population along the Melton corridor, similar in magnitude and trend to WRU (refer to section 4.7). Both projects concentrate additional population along the rail line, in contrast to OMR's more dispersed increases in that area (refer to section 4.6). This project reverses projected population decline in Deer Park, although to a lesser extent. It has a similar effect at Caroline Springs and north of Williams Landing. Currently considered relatively new suburbs in Melbourne, by 2051 they will have ageing and shrinking populations.[216] This project may contribute to accelerating their demographic renewal.

Melbourne's inner north benefits from the rail infrastructure and service improvements with additional population along the Mernda line. Both the Mernda and Hurstbridge lines have more train services and more people living along them, including within the La Trobe NEIC in Heidelberg and around Doreen, which the transport base case projects to lose population between 2018 and 2051. Increasing Werribee services through Newport positively impacts on population from Williamstown to Laverton and Altona Meadows.

Melbourne's east and north-west experience slower population growth as a result of this project, with a few isolated areas losing further population in addition to that projected in the transport base case.

This is the only project that results in increases in Geelong's population. More people move to the centre of Geelong and areas north of the city shift from losing to gaining population by 2051. The transport base case projects substantial growth for the recently approved Northern and Western growth areas and MM2G adds more new residents as far west as Bannockburn.[217] As these residents relocate to Geelong to take advantage of improved rail services, opportunities to live closer to stations in the Geelong area should be considered.

Jobs

Melbourne's inner city has more jobs with MM2G, and particularly close to the new alignment. This includes Fishermans Bend, although it will need more time to reach its target of 80,000 jobs.[218] Increases also occur in Richmond and towards the north-east area, with the latter particularly benefiting from improvements to the Hurstbridge rail line. Opportunities for these jobs to be located within the La Trobe NEIC should be considered. MM2G also provides additional jobs to Parkville and Fishermans Bend NEICs. There is an opportunity to improve access to East Werribee NEIC and better access to Avalon Airport, however these were not apparent from this assessment. Better access to these locations, such as a station on the mainline with good connections to these places, may assist.

Many of these jobs have relocated from Central Melbourne and to the east and south-east of Melbourne, which have higher levels of working residents to jobs compared to the areas served by this project. However, jobs are also relocated from other parts of the north and regional centres aside from Geelong.

Geelong gains almost four times as many additional jobs compared to residents in its CBD centre. Improvements in rail services have attracted working residents and jobs to relocate to Geelong. Some of these working residents will utilise the rail service to Melbourne, whilst other members of that household would seek to work locally. In addition, increased population creates more population-based jobs. Congestion in the outer suburbs of Geelong suggest that they may be driving to these additional jobs or to access other services such as education or shopping. Melburnians may also travel to work in Geelong.

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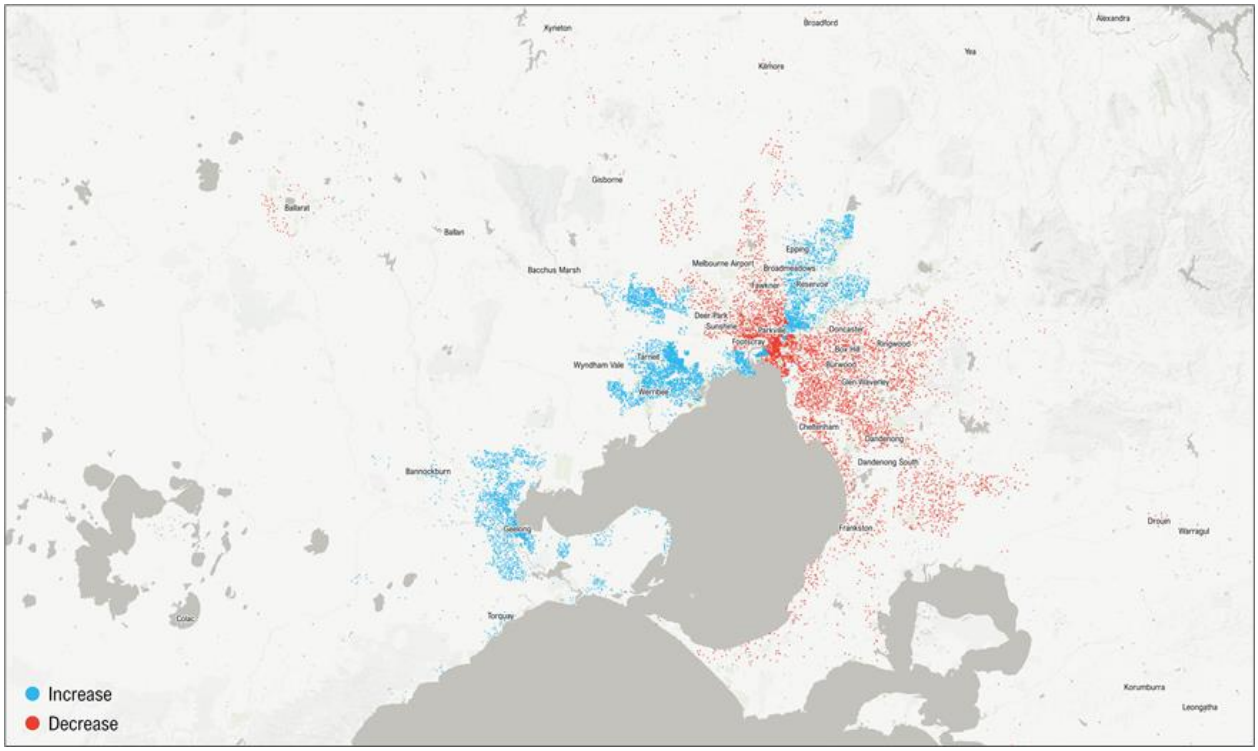
[215] Including those identified in Infrastructure Victoria's previous research published in Growing Together – the case for better integration of land use and infrastructure planning in established areas 2020 *https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/12/Growing-together-December-2020-1.pdf*

[216] Department of Environment, Land, Water and Planning, *Victoria in Future 2019*, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/

[217] https://www.planning.vic.gov.au/schemes-and-amendments/browse-amendments?query=C395ggee&search_mode=id#Amendments--C395ggee

[218] https://www.fishermansbend.vic.gov.au/framework

Figure 65: Population changes due to MM2G compared to transport base case, 2051



Source: Arup 2021 Strategic Modelling Outcomes Report

Figure 66: Employment changes due to MM2G compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes Report

Cost benefit analysis

The table below presents a summary of the estimated benefits from MM2G, using a discount rate range of 7% and 4%. The largest benefit category is consumer surplus benefits, which includes the travel time savings and reduced costs for public transport users, including private vehicle users who switch to public transport.

Table 27: MM2G Benefits (Present Value $ million) – First year of evaluation is 2021

Benefit	Static land use	Dynamic land use	WEBs only	Total
Consumer surplus benefits	$1,662 - $4,666	$3,650 - $6,164		$5,312 - $10,830
Active transport benefits	$345 - $1,017	$386 - $117		$731 - $1,134
Safety benefits	$7 - $20	$260 - $707		$267 - $727
Environmental benefits	-$47 – -$143	$45 - $290		-$2 - $147
Residual values	$35 - $250	$35 - $0		$70 - $250
WEBs			$1,942 - $5,056	$1,942 - $5,056
Total benefits	**$2,002 - $5,811**	**$4,376 - $7,278**	**$1,942 - $5,056**	**$11,434 - $15,031**

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: The 'Headline' ranges provided using 7% and 4% discount rates

Quantified benefits

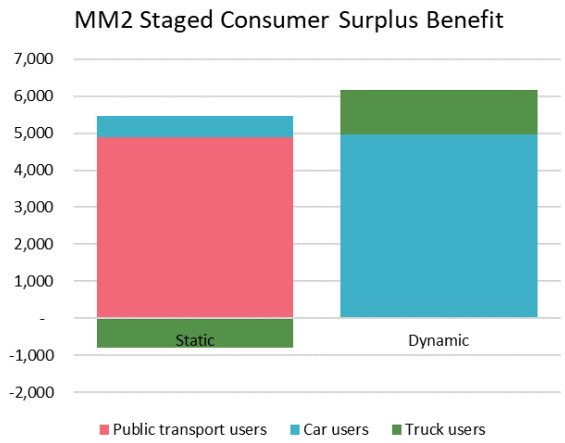
Total benefits of this project are made up of *static land use*, *dynamic land use* and *wider economic benefits*. The *static land use* benefits represent the estimated conventional transport benefits arising from this project, without any changes to the location of population and jobs. The *dynamic land use* benefits arise from changes in the location of population and jobs caused by the project.

Dynamic land use benefits are positive for this project. This is due to more people moving to the New Growth Areas and Geelong because of the improved public transport accessibility in the Western Growth Areas, and between Geelong and Melbourne. This results in an increase in both public transport and private vehicle trips from the population living in these areas.

The *dynamic land use* benefits in this economic assessment only consider the benefits from changes to generalised costs (travel times). People who move further out due to the improved accessibility and other amenity factors will not have a quantifiable transport benefit as their travel costs may not change. They will however receive a benefit from improved wellbeing arising from factors other than transport, such as more affordable housing or better residential amenity. This benefit has not been quantified in this analysis and further research is required to determine an approach to estimating it.

Figure 67 shows the consumer surplus benefits under static and dynamic land use outcomes for public transport users, car users and truck (freight) users. This highlights that benefits to public transport users contribute most of the static land use benefits, with a small benefit to car users. It also shows the larger benefit arising under the dynamic land use outcome, driven mostly by car users, with a small amount of freight users also benefiting. This is due to people moving locations and having shorter or quicker trips compared to their previous residential location. For example, the project results in population moving to Geelong, and while residents who locate there will continue to use public transport (on a different line), other new residents in the household that has relocated are likely to be making local trips which are shorter or quicker than in their previous location.

Figure 67: MM2G Consumer Surplus Benefits for Static and Dynamic Land Use Outcomes

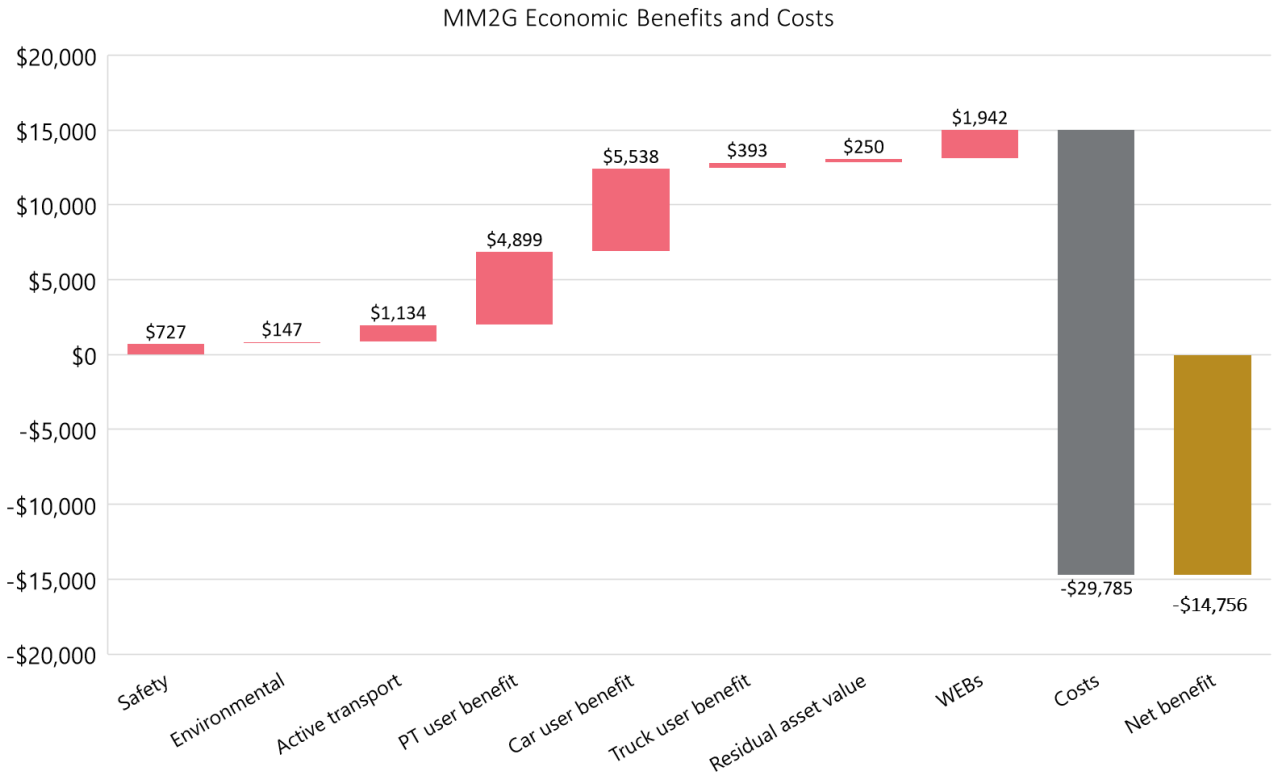


Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

Wider economic benefits make up 16% of the total benefits of this project. This is driven by an increase in employment in the central city including Fishermans Bend, and improved connections between outer / growth areas and the central city. Agglomeration benefits contribute the largest amount, arising from the productivity improvements from increased density and accessibility of jobs.

Figure 68 shows the economic benefits of this project compared to the total estimated cost in present value terms. This shows the contributions from public transport users, car users and WEBs to the total benefit. It also highlights that the large costs are expected to be greater than the benefits of this project in present value terms.

Figure 68: MM2G Economic Benefits and Costs (Present Value $ millions)



Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Total dynamic land use plus WEBs results presented using upper project costs and 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Summary cost benefit analysis results

Summary results from the cost benefit analysis are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes all quantified benefits outlined in the table above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 0.3 and 0.5 for upper project costs and 0.3 and 0.6 for lower project costs, for the total outcome (dynamic land use including WEBs, ranges provided using 7% and 4% discount rates). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and wider economic benefits arising from productivity improvements.

These results are presented for the staged MM2G option, where stage 1 opens in 2041 (including the new tunnel from Southern Cross to Newport stations and upgrades on the Werribee corridor) and stage 2 opens in 2044 (including the connection from Southern Cross to Clifton Hill stations, upgrades on the Hurstbridge and Mernda corridors, and upgrades on the Werribee corridor from Werribee to Geelong).

Table 28: MM2G Benefit Cost Ratio and Net Present Value ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	0.1 – 0.2	-$15,916 – -$23,975	0.2 – 0.4	-$13,542 – -$16,697	0.3 – 0.5	-$12,862 – -$14,756
Lower project costs	0.1 – 0.2	-$12,650 – -$17,898	0.3 – 0.6	-$10,276 – -$10,620	0.3 – 0.6	-$9,596 – -$8,679

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Broader impacts

There are also expected to be broader impacts arising from this project which cannot be quantified in a cost benefit analysis. We have assessed metrics from the VLUTI model where available and provide commentary on the expected direction of these impacts. These broader impacts include:

- broader economic benefits
- place benefits
- social and health impacts
- environmental impacts.

Broader economic benefits arise through labour productivity improvements driven by greater accessibility, and improved value chains through better freight reliability and speed. These elements are captured by the VLUTI model, which estimates GSP and productivity improvements resulting from this project.[219] The MM2G project is estimated to have a positive impact on GSP, increasing by 0.2% in 2036 and 0.4% in 2051. This is driven by increases in employment in the central city, particularly in knowledge-intensive industries. It is also driven by improved accessibility between the growth areas in the west and south-east and the city, particularly Fishermans Bend. This is driven by increases in employment in the central city, particularly in knowledge-intensive industries.

GSP is also an indicator of the project's contribution to welfare and the broader place benefits that would arise. The MM2G project has the largest percentage impact to GSP in 2051 of all the new build projects, highlighting the significant benefits this project is expected to generate.

The Fishermans Bend urban renewal precinct has an important role to play in supporting Victoria's economic growth in the future. Employment growth in an expanded central city will contribute productivity benefits not only for the central city but for the broader Victorian economy.[220] This project will provide an important and fast public transport connection between the existing CBD, Fishermans Bend and the west and south-west growth areas, as well as Geelong. Improving access to higher order jobs to growth area residents will create additional benefits not quantified in this analysis.

[219] *The VLUTI model assumes that total population, households, and jobs in Victoria remain fixed in future under all scenarios, and therefore GSP and productivity improvements do not incorporate any additional jobs and households above this level.*

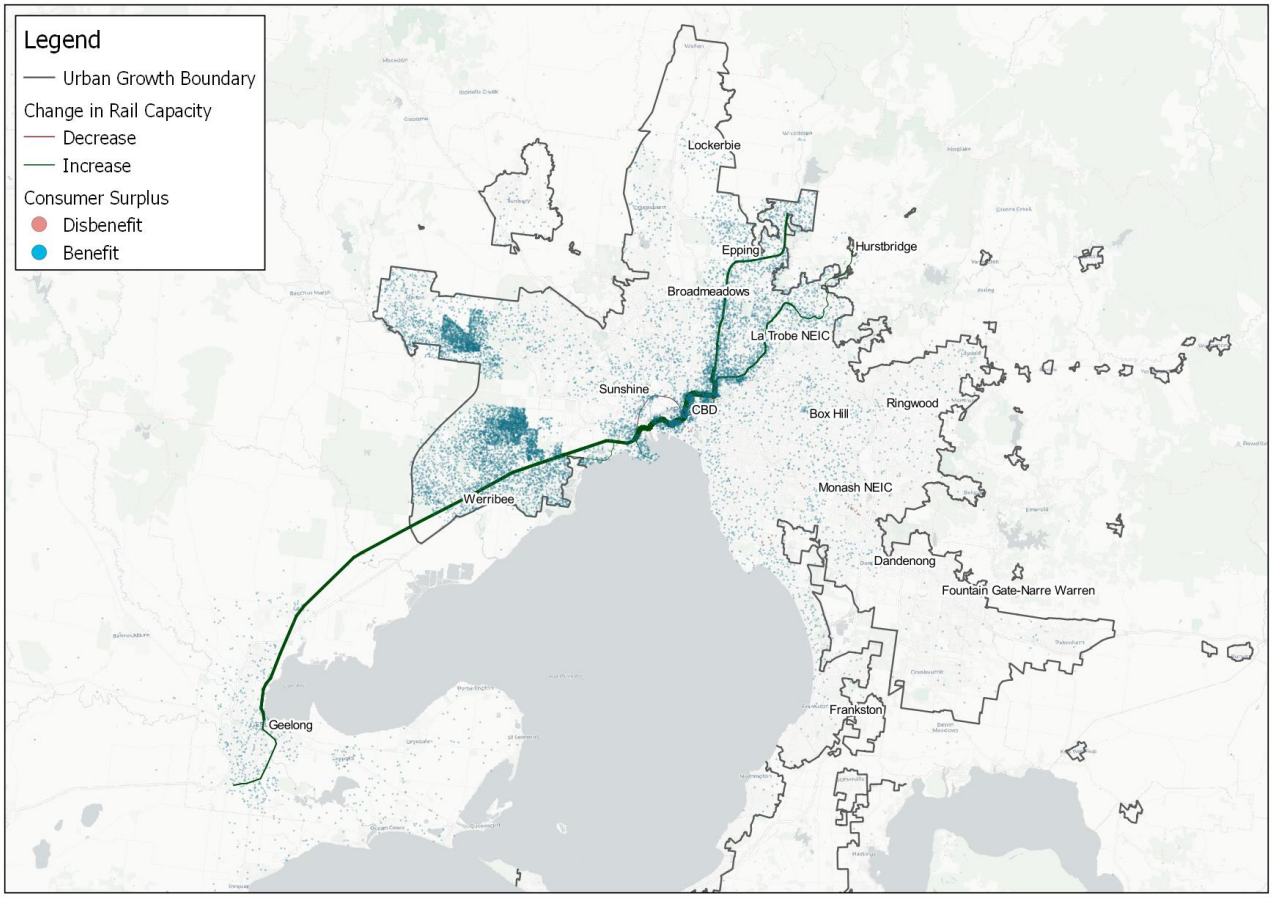
[220] https://www.fishermansbend.vic.gov.au/framework

Place benefits can arise from improved urban amenity in residential areas arising from a change in land use driven by the transport project. The change in land use to residential development is likely to result in higher value use, better amenity and quality of development. Residential development that occurs in areas which have good access to transport and services will generate greater benefits than in locations with poor access. Encouraging suitable residential development in Fishermans Bend in areas with good access to public transport, active transport, services, jobs and open space, will result in place benefits that have not been quantified in this analysis.[221]

Transport projects can improve access to community, social and health services and provide social and health benefits, particularly in areas that currently have poor or limited access to these services. Growth areas, particularly in the west, have poor access to jobs and services. This project will provide greater access to social services in growth areas through the public transport network, in addition to improving the social connections of residents within these areas. The improved transport network will also encourage more services such as health, education and community facilities to locate in these growth corridors, to service the growing population.

Figure 69 shows the distribution of the public transport consumer surplus benefits across metropolitan Melbourne resulting from the MM2G project in 2051. This highlights that most of the economic benefits from this project are concentrated in the west, south-west and north of Melbourne in areas surrounding the rail corridor (blue dots on the map). People in these areas are expected to have the greatest improvements to public transport travel times and therefore have the largest proportion of benefits from this project.

Figure 69: MM2G Public Transport Consumer Surplus Benefits (2051)



Note: This map shows change in total consumer surplus by travel zone, not change per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits.
Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

[221] *Handy, S. (2003), "Amenity and Severance", Hensher, D.A. and Button, K.J. (Ed.) Handbook of Transport and the Environment, Emerald Group Publishing Limited, Bingley, pp. 117-140*

Social Assessment

Transport projects improve access to employment opportunities, education, health care, and community and social services.[222] This can begin to address some of the drivers of disadvantage where increased access is achieved in places where there is transport disadvantage.[223]

The west and south-west growth corridors are some of the most disadvantaged parts of Melbourne, as measured by the socio-economic index for areas (SEIFA). These areas currently have relatively poor access to jobs through the limited road and public transport networks, particularly in the west. The MM2G project improves access from these areas to a greater range of jobs, education and services, including higher skilled jobs.

MM2G results in shorter average travel times to jobs in the morning peak for almost all employment centres in Melbourne. This includes all NEICs and all Metropolitan Activity Centres in the Western Growth Corridor. Fishermans Bend NEIC has a particularly notable decrease in travel time with its new station located along the MM2 tunnel. Travel to most parts of the central city is also faster to access jobs. High quality, separate active transport infrastructure and limits on station car parking may also encourage people to change how they travel to stations, which can contribute to improved health outcomes from incidental exercise.[224] [225]

This project also supports population and employment growth in Geelong, helping to grow this important regional city in the future. Consideration should be given to managing this growth in Geelong, to ensure that development occurs within identified growth areas and does not expand into non-residential areas. As part of implementing the City of Greater Geelong's Settlement Strategy, land use settings should be reviewed to ensure that development is encouraged close to train stations, such as North Geelong, South Geelong and Geelong.[226]

Travel times for public transport trips for education are generally shorter to Metropolitan Activity Centres and NEICs only in the AM peak, consistent with improvements for work trips at that time. Education trips to the Fishermans Bend NEIC are about 10 minutes shorter with MM2G. On average they are over an hour, except during the evening peak when they fall to 55 minutes. Universities developing new campuses in the NEIC should take into account these travel times when considering their potential courses and students, as out-of-work-hours scheduling may be better supported by public transport travel to this area. This could benefit people who need to take classes outside work hours and are reliant on public transport.[227]

Research has found that tertiary educated women living in growth areas are less likely to be in a job that reflects their level of qualification both compared to men and compared to women living in inner and middle areas. [228] This project has the potential to provide greater access to jobs that better suit the skills of women in the west and south-west growth areas, through providing increased capacity on the rail corridors connecting to the city.

This project will also provide more transport options for women in growth areas. Improved bus connections from residential areas to the impacted train stations should also be provided to allow greater access for those without a car and for primary caregivers who are more likely to take multi-modal trips with multiple destinations.[229] Consideration should also be given to designing the train stations for personal safety and security, including access to the station from residential areas.[230]

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[222] Pope, Jeanette. "The role of infrastructure in addressing regional disadvantage in Victoria." (2019). [website] https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/11/Background-paper_The-role-of-infrastructure-in-addressing-regional-disadvantage.pdf

[223] Ibid

[224] Guillen, P., Loyola, M., & Komac, U. (2020). What Australia can learn from bicycle-friendly cities overseas. *The Conversation*.

[225] Engels, Benno, and Gang-Jun Liu. "Social exclusion, location and transport disadvantage amongst non-driving seniors in a Melbourne municipality, Australia." *Journal of Transport Geography* 19.4 (2011): 984-996.

[226] https://www.geelongaustralia.com.au/common/public/documents/amendments/8d6f0bcb1cec127-C395-SettlementStrategyFINALAdoptedVersionAugust2020(minorcorrectionFeb2021).pdf

[227] Palm, Matthew, Katrina Raynor, and Carolyn Whitzman. Project 30,000: producing social and affordable housing on government land. University of Melbourne, 2018. P.25

[228] SGS Economics & Planning 2018. Gender Equity in Employment – Report prepared for City of Whittlesea

[229] McCarthy, L., Delbosc, A., Currie, G., & Molloy, A. (2017). Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature. Transport reviews, 37(6), 767-781.

[230] *Whitzman CA, Marathe RE, Thompson JA. (2019). "Tertiary Students' Public Transport Safety in Melbourne, Australia."* Melbourne, VIC, Australia: Transport, Health and Urban Design Researching Hub, Faculty of Architecture, Building and Planning, The University of Melbourne

Environmental Assessment

Carbon emissions are reduced overall as a result of fewer private vehicles trips associated with this project. However localised increases may occur given more private vehicle movements, particularly in Geelong's north and west growth areas. As this project results in more people living in Melbourne's Western Growth Corridor and Geelong's recently approved new growth areas, this places an emphasis on adequate planting of vegetation, and particularly canopy trees to mitigate existing high temperatures.[231]

Service frequency increases along the Mernda and Hurstbridge rail corridors could lead to further dispersal of introduced plant species and reduced animal movements along and across these corridors.[232] Landcare and VicTrack's Whittlesea to Mernda corridor weed control project to protect critically endangered and threatened species should also be used in the Hurstbridge corridor.[233]

Precinct structure planning for the western growth corridors and Geelong's additional growth areas have an opportunity to improve open space connectivity. This project is likely to increase demand for homes in these areas, which will also result in more demand for social and community infrastructure, including open space. As Melton and Wyndham receive subdivision applications, they should carefully consider areas designated for drainage in approved PSPs to have multiple functions, including to connect open spaces and for active transport corridors, including getting to stations. Connected open spaces provide opportunities for people and animals to travel along green corridors and adequately sized patches provide important habitat for plant and animal species.[234] The City of Greater Geelong and the Victorian Planning Authority should apply these principles from the beginning of the precinct structure planning process for Geelong's newly approved growth areas.[235]

Some existing suburbs with improved rail services and additional population in Melbourne's north-east are relatively unconnected to public open spaces. With additional population growth as a result of this project likely in this area, opportunities to connect to (and better maintain) large open spaces immediately outside Melbourne's urban growth boundary, such as Plenty Gorge Park, should be explored. Improved access to Wyndham and Hobsons Bay's coastal parks and wetlands will be important for the larger than projected populations in these areas as a result of MM2G.

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity of the project's BCR to a range of potential outcomes. This informs the conditions in which a project should or should not go ahead, and how sensitive a project's viability is to changes.

These tests include varying the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the project's opening year and construction start, and increasing the value of travel time in the future. The BCR under each test for the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below.

This project has a BCR below one under all sensitivity tests when tested individually. This suggests the project is susceptible to increases in capital costs or decreases in benefits. Future assessments of this project should consider opportunities to further investigate the project scope, alignment and staging to reduce capital costs. There are also opportunities to widen the scope of benefits that are quantified in the economic assessment. This analysis does not include place benefits arising from improved land use outcomes as a result of this project (i.e. non-transport related place benefits). This project presents several opportunities to shape land use in Fishermans Bend and the inner north corridor which would generate benefits over and above what has been quantified in this assessment.

The project has a BCR above one when a combination of sensitivity tests are undertaken. That is, if construction costs are reduced by 40%, construction cost escalation is excluded, and benefits increase by 30% the BCR ranges between 0.8 and 1.4 (using 7% and 4% discount rates). This highlights the need to consider changes to project scope, value engineering opportunities and broadening the benefits in tandem.

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[231] See Infrastructure Victoria (2020) Victoria's Draft 30-Year Infrastructure Strategy, draft recommendation 77

[232] Tikka, P. M., Högmander, H., & Koski, P. S. (2001). Road and railway verges serve as dispersal corridors for grassland plants. Landscape ecology, 16(7), 659-666

[233] https://landcareaustralia.org.au/our-partners/corporate-partners/victrack/

[234] See Infrastructure Victoria (2020) Victoria's Draft 30-Year Infrastructure Strategy, draft recommendation 37

[235] https://www.planning.vic.gov.au/schemes-and-amendments/browse-amendments?query=C395ggee&search_mode=id#Amendments--C395ggee

Table 29: MM2G Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static land use	Dynamic land use	Total (Dynamic land use with WEBs)
4% discount rate	0.2	0.4	0.5
7% discount rate	0.1	0.2	0.3
3% discount rate	0.3	0.5	0.6
10% discount rate	0.1	0.2	0.2
20% decrease in capital costs	0.1 - 0.2	0.3 - 0.5	0.4 - 0.6
20% increase in capital costs	0.1 - 0.2	0.2 - 0.4	0.2 - 0.4
40% increase in capital costs	0.1 - 0.1	0.2 - 0.3	0.2 - 0.4
Exclusion of construction cost escalation	0.2 - 0.3	0.3 - 0.6	0.4 - 0.7
40% decrease in total benefits	0.1 - 0.1	0.2 - 0.3	0.2 - 0.3
20% decrease in total benefits	0.1 - 0.2	0.2 - 0.4	0.2 - 0.4
20% increase in total benefits	0.1 - 0.2	0.3 - 0.5	0.3 - 0.6
Delay opening by 5 years	0.1 - 0.2	0.3 - 0.5	0.3 - 0.6
Delay opening by 10 years	0.1 - 0.2	0.3 - 0.5	0.4 - 0.6
Value of travel time	0.1 - 0.3	0.3 - 0.6	0.3 - 0.6
Hybrid test: 40% decrease in capital costs, Exclude construction cost escalation, and 30% increase in total benefits	0.3 – 0.5	0.7 – 1.2	0.8 – 1.4

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: These sensitivity tests are provided for the upper cost and ranges are shown using 4% and 7% discount rates.

Future Scenarios

MM2G is considered to be generally resilient to the future scenarios assessed in this report, with risks associated with low population growth and extreme autonomous vehicle scenarios. The project provides significant benefits for public transport users by alleviating overcrowding, but a number of scenarios are likely to reduce public transport demand for travel, which in turn could reduce the demand for the project and delay the need for investment.

MM2G is at risk of less demand from growth areas around Greater Geelong LGA, Whittlesea LGA and Wyndham LGA into the city using public transport, which may occur under the low population growth or in the EAV scenario. Under the WFH scenario, population growth in outer suburbs and growth areas will increase demand for public transport, strengthening the case for investment.

Policy scenarios are likely to support the need for the project, with targeted density outcomes driving higher public transport mode share in key locations and TNP increasing the cost of driving into Inner Melbourne.

A summary of the implications of each scenario is documented below in Table 30.

Table 30: Resilience of MM2G to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	A high population growth scenario will bring forward issues with road network congestion and public transport crowding, driving greater public transport usage and higher economic benefits. This would also likely increase the BCR for the project. This would be largely driven by the impact on growth along the Werribee rail corridor (Metro and RRL).	~
Low population growth	Even under a low population growth scenario, train services from Werribee (Metro and RRL) are still likely to experience overcrowding in the 2030s. However the growth in demand for public transport over time is likely to result in diminished benefits reducing the BCR overall.	-
Working from home	The WFH scenario indicates that residents will need to commute to the office less, resulting in a shift in residential location to reflect an alternative lifestyle. This scenario indicates that population is likely to increase in middle and outer suburbs, increasing demand for road travel in these areas. Outer suburbs and growth areas experience an increase in public transport demand. This is expected to increase the benefits of the project and improve the BCR.	+
Automated and electric vehicles	The EAV scenario does not have significant implications in the opening years of MM2G, but AV and ZEV take up is expected to be more substantial by 2051, at which point AVs are expected to make Geelong, Whittlesea and Wyndham LGAs more attractive places to live. Under the EAV scenario, public transport mode share drops significantly from 12% to 9% across Melbourne, and such a significant drop is likely to have a negative impact on project benefits and the BCR. However, the scale of congestion in Inner Melbourne is significant and community acceptance of this is unclear, along with the uncertainty that AV users will tolerate longer journey times because passengers are able to undertake other activities instead of driving whilst travelling in the AV. There is a high degree of uncertainty around this scenario, and its implications for transport projects, as AVs are still an emerging technology.	-
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, increasing demand for public transport and resulting in greater benefits, likely increasing the BCR. The increase is expected to be modest due to high costs.	+
Transport network pricing	Infrastructure Victoria's TNP research indicates that private car trips into Central Melbourne could be reduced by up to one half, and the peak is expected to grow but at a slower rate with higher peak fares. Building the MM2G tunnel provides flexibility for the system to then respond to demand along the corridors. This scenario is likely to focus on travel demand management to the inner city, and will result in higher public transport mode share for trips to destinations subject to the new cordon charges, increasing demand for public transport (resulting in greater benefits), and increasing the BCR. The increase is expected to be modest due to high costs.	+

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

Implications

Melbourne Metro Two and Geelong direct rail line address looming overcrowding and completes the transformation of the network

MM2G will deliver significant transport network capacity that addresses overcrowding issues that progressively emerge on different lines and to Fishermans Bend from the 2030s and 2040s. This project will deliver significant improvements to the accessibility and attractiveness of key locations, such as Fishermans Bend and Geelong, and will play an important role in how they develop over the next 15 to 30 years. When combined with the CLR project, the MM2G project completes the transformation of Melbourne's rail network into a metro network, providing sufficient capacity for many decades to come and metro style services across the metropolitan area, including to lines to the north east, west and south.

The realignment of more Geelong services on the more direct MM2G corridor provides the opportunity for additional services on the Regional Rail Link serving Ballarat, Bendigo along with Wyndham Vale RRL and Melton lines.

There are substantial accessibility and land use benefits

Our modelling shows that this project generates significant land use change benefits related to reduced transport costs. There are also expected to be further land use change benefits that have not been quantified, arising from the improved amenity and wellbeing of residents who benefit from this project.

This project has an important role to play in the development of Fishermans Bend. It will provide an alternative public transport option to the tram link, for movement both into and within the precinct. It also provides access to a larger labour market catchment for the precinct. Fishermans Bend is an important urban renewal site for Melbourne, and employment growth in this precinct will support Melbourne's economic growth in the long term.[236]

Melbourne's central city has grown over time, expanding to Southbank, Docklands and Parkville. This allowed greater economic growth not only for the city, but for Melbourne and Victoria more broadly.[237] In recent years, competition between residential development and commercial development in areas immediately surrounding the city may have hindered future expansion and urban renewal.[238] Transport and land use planning can support employment growth in urban renewal sites surrounding the city to enable further economic and productivity growth.[239]

In addition to supporting growth in the central city, the MM2G project also provides improved access to jobs for people in the west and south-west growth areas. This will provide a greater range of employment opportunities for residents living in these areas, which are expected to grow significantly in the future.

Supporting growth in priority locations along the MM2G route will provide even greater benefits. The Hurstbridge and Mernda corridors are expected to see growth in population as a result of this project. Consideration should be given to ensuring that planning settings are right in those places to support increased density in priority areas, including sector plans and ICPs.

There are particular benefits for Geelong and the west

This project encourages more people to move to the centre of Geelong, and areas north of the city shift from losing to gaining population by 2051. The transport base case projects substantial growth for the recently approved northern and western growth areas and MM2G adds more new residents as far west as Bannockburn.[240] As these residents relocate to Geelong to take advantage of improved rail services, opportunities to live closer to stations in the Geelong area should be considered.

Geelong gains almost four times as many additional jobs compared to residents in its CBD centre. Improvements in rail services have attracted working residents and jobs to relocate to Geelong.

Some of these new working residents to Geelong will utilise the rail service to Melbourne, whilst other members of that household would seek to work locally. In addition, increased population creates more population-based jobs. Therefore, the relocation of population and jobs to Geelong will result in some working residents travelling to Melbourne, whilst others will be working locally. In addition, more jobs in Geelong could result in more rail users utilising services in the Geelong peak direction (Melbourne counter-peak) from areas such as Wyndham, thereby improving the utilisation of services in both directions.

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[236] https://www.fishermansbend.vic.gov.au/framework

[237] *SGS Economics and Planning 2012, Long run economic and land use impacts of major infrastructure projects*

[238] *SGS Economics and Planning 2018, Analysing Melbourne's Enterprise Precincts https://www.planning.vic.gov.au/__data/assets/pdf_file/0020/326711/Analysing-Melbournes-Enterprise-Precincts-SGS-Economics-and-Planning.pdf*

[239] *Infrastructure Victoria (2019) Growing Victoria's Potential, www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/GrowingVictorias-Potential-April-2019.pdf*

[240] https://www.planning.vic.gov.au/schemes-and-amendments/browse-amendments?query=C395ggee&search_mode=id#Amendments--C395ggee

The assessment indicates that there are opportunities to improve the project's value, including considering alternative alignments, transport network pricing and new train technology

The scale of investment required to deliver this project is currently a major barrier to a favourable project BCR assessment. Options should be developed and considered to reduce costs and increase benefits.

This project presents several opportunities to shape land use in Fishermans Bend and the inner north corridor. It is expected this would generate benefits over and above what has been quantified in this assessment. Consideration should be given to developing a suitable approach to quantifying these place benefits arising from improved land use outcomes (i.e. non-transport related place benefits), to recognise and improve the project's value.

This needs to be considered alongside further value engineering work to determine the most cost-effective alignment for this project, which could be more direct alignments in Fishermans Bend and the northern section (stage 2), between Southern Cross and Mernda. The inner north areas are already well served by public transport and therefore a more direct or lower cost connection that could also have a new station(s) may represent better value for money. These options were presented in Figure 63 above.

There are a number of value engineering opportunities to reduce the cost of this project which need to be explored. This includes power and signalling solutions which will have long-term implications for all future rail projects. This includes meaningful investigation of AC electrification, battery operated trains, in-cab signalling, and other innovative technologies which have been adopted in other parts of the world which are suitable for our network and can be provided at a lower cost (refer to breakout box on the following page).

TNP should also be considered for this project. This could include implementing differing fares for the various types of public transport modes to encourage use of the new train line and supporting buses. This could also include adopting permanent off-peak discounts for public transport fares, incentivising people to utilise the new train line and supporting buses during quieter times of the day. This would further reduce crowding, complementary to the new services brought about by the project. Pricing for parking at train stations should also be considered to manage demand.

Shaping benefits and managing costs early

Consideration should also be given to interim measures that can be taken before commencement of construction of the MM2G project, to manage demand in the short to medium term and develop future demand along the proposed MM2G corridor. This could include direct bus links between Newport, Fishermans Bend and the CBD, and from Victoria Park Station to Parkville. This will also help to reduce crowding on the Werribee and Clifton Hill train lines.

Relevant recommendation in Victoria's infrastructure strategy

Recommendation 61: Prepare for Melbourne Metro Two and direct Geelong rail services

Victoria's infrastructure strategy recommends that within five years a business case for the Melbourne Metro Two tunnel project be completed, and the land required to construct it protected. Consider using the tunnel to re-route Geelong services direct to Southern Cross, and building new stations including at Fishermans Bend and redevelopment / relocation of stations at Corio and near Avalon Airport. To shape demand for the project in the next five years, enable more intensive land use around the rail network, and introduce next generation bus services between Newport and Fishermans Bend, and Victoria Park and Parkville.

The business case should identify and protect the preferred corridor and station sites, particularly where development pressures threaten to inflate land prices or complicate construction. MM2G, or a similar project, may be required as soon as 15 years from now, and may take a decade or more to deliver.

Our modelling suggests realigning Mernda services through an underground tunnel through Clifton Hill and Fitzroy may not represent best value for money. An extensive tram network already serves this area, so a new rail tunnel delivers fewer transport benefits and limited land use changes relative to cost. Instead, explore connections between Parkville and the Mernda line to minimize tunnelling and reduce costs, improving the viability of any project option.

In the next five years, it should also introduce 'next generation' bus services to connect the train stations on the proposed MM2G corridor. These will help manage existing demand, help reduce crowding on the Werribee and Clifton Hill train lines and develop future demand. They should link Victoria Park station to Parkville station, and Newport station to Fishermans Bend, and on to central Melbourne. A similar bus service from Armstrong Creek and Wollert to nearby rail lines would also support the project. Once complete, existing bus routes should also be reconfigured to make best use of the new rail connection.

Case Study – Energy transformation has the potential for greener and more cost-effective rail infrastructure and services

Melbourne Metro Two and the Western Rail Corridor Upgrade are projects which will require significant investment in infrastructure, technology, and systems to support future network performance. While large sections of the rail network are operating using aged technology for power supply and signalling, each of these projects represents an opportunity to innovate and investigate new technologies to solve old problems.

Many countries are looking at options for clean energy to power our trains, and these opportunities may result in lower infrastructure and operating costs. With AC electric powered trains commonly used in a number of countries rather than diesel, progress is being made internationally to realise the potential of battery and hydrogen powered trains to replace diesel trains that are costly to operate and have a greater environmental impact.

This case study explores several examples of opportunities to reduce project costs, and test out new technologies which could set a new status quo for future projects on the network.

25kV AC Electrification

AC electrification is an option being considered for projects where metro services are being extended out towards growth areas in the south-west (Geelong), west (Melton), and the north (Mitchell). Over long distances, AC electrification requires less investment in corridor infrastructure to support the operation of trains and can support more services on a corridor with less investment in substations.

Any attempt to implement AC electrification would need to include procurement of compatible rolling stock, which would need to be able to operate on both AC and DC electrified corridors. In addition, there are several safety and compatibility complexities which mean that the first project to attempt delivery of AC electrification will be forced to take on significant project uncertainty and risk. Noting these risks, it is difficult to definitively state the cost savings related to adopting an AC electrification solution. However this technology represents a clear example of an opportunity to innovate and test technology which could be the future of the network.

Battery Powered Trains

There could be **an opportunity to** utilise battery-powered trains to minimise or defer electrification costs by investing in a rolling stock solution which will support expansion of metropolitan services into growth areas across Melbourne. These trains would be able to operate using existing power supply, and then utilise battery for the additional section of network which is unpowered.

This opportunity would again require new rolling stock to be procured, noting that the cost effectiveness of battery powered trains when compared to electrified services will largely be driven by the asset maintenance and replacement costs for batteries and infrastructure. Given the complexity and cost of procuring rolling stock to be compatible with multiple traction solutions, it will be necessary to contain the fleet to specific lines to minimise the system flexibility required. Any lines set up for battery powered trains would need supporting recharge facilities in stabling at termini.

4.6 Outer Metropolitan Ring Road

Objectives

The Outer Metropolitan Ring Road and E6 transport corridor (OMR) is a major orbital high-speed transport link connecting people and freight, travelling through Melbourne's outer north and west. The project is proposed to link the existing M80 Ring Road to the north with the Hume Freeway and continue with an outer ring down to the Princes Freeway in Melbourne's west. Planning for the OMR includes both road and rail links, connecting growth areas and major employment corridors, major freight terminals and transport hubs, and enhancing connectivity to interstate and major regional destinations.

This includes new links connecting international transport hubs including Melbourne Airport, the Port of Melbourne, and the proposed Bay West Port with intermodal freight terminals like the proposed Beveridge Intermodal Freight Terminal (BIFT) and Western Intermodal Freight Terminal (WIFT). The project also provides new interchange opportunities for users on the Princes, Western, Calder and Hume Freeways, better serving major regional destinations such as Bendigo and Ballarat. Access is also improved in growth areas like Wyndham Vale and Donnybrook and employment corridors such as Werribee, Truganina and Melbourne Airport.

For the purposes of modelling, the focus of this assessment has been on the road component only. Assessment of the rail line is integrated with the interstate rail network and Inland Rail Project, and therefore needs to be considered from a national perspective with the Australian Government.

The OMR project is expected to support the following objectives of *Victoria's infrastructure strategy*:

- **Objective 1**: Prepare for population change through increasing access and road provision for orbital journeys, especially for Melbourne's outer north and western suburbs.
- **Objective 4**: Enable workforce participation through better connecting people and jobs by providing new high-speed road links to significant industrial and commercial employment clusters.
- **Objective 5:** Lift productivity by boosting market access and improving connectivity to enhanced labour skills with new key transport links between growth areas and employment corridors.
- **Objective 6:** Drive Victoria's changing, globally integrated economy through efficient high-speed connected key freight links between transport gateways, industrial precincts, and logistics centres.

Need

Early development of the OMR

The OMR was developed as part of the 2008 *Delivering Melbourne's Newest Sustainable Communities* initiative, an integrated approach to land use, transport and the environment for Melbourne's growth areas. It was one of four components which also included a review of the urban growth boundary (UGB), planning the Regional Rail Link (RRL) alignment and defining the boundaries of the western grasslands reserve.[241] It followed the Victorian Government's release of *Melbourne 2030: a planning update – Melbourne @ 5 million*, *The Victorian Transport Plan* and the *Victorian Freight Network Strategy*. [242]

The 2008 Planning Assessment Report describes the road as providing "the backbone for the future transport network planning in Melbourne's growing northern and western suburbs in coming years."[243] This report notes the reservation is planned for a freeway standard road and high standard railway, which will manage significant anticipated increases in freight and people movements around the state.[244] The planning assessment considered (land use) planning policies, corridor options and design options. Desktop studies of flora and fauna, cultural heritage and geotechnical issues were conducted, along with brief site visits.[245] It also noted that replacement or better managed habitat will replace vegetation cleared as a result of the project and VicRoads will provide noise and water quality protections.[246] A Public Acquisition Overlay for the reservation was approved by the Minister in 2010, protecting the corridor for the projected long-term

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[241] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrexecutiveforward.ashx?la=en&hash=35485D61AE03C2BFFD3E18CD2712EA96*

[242] *https://www.planning.vic.gov.au/policy-and-strategy/planning-for-melbourne/melbournes-strategic-planning-history/delivering-melbournes-newest-sustainable-communities*

[243] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrexecutiveforward.ashx?la=en&hash=35485D61AE03C2BFFD3E18CD2712EA96, p.2*

[244] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrchapter1.ashx?la=en&hash=B99FA45611979076E62D8289E46C865C, p.8*

[245] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrchapter2.ashx?la=en&hash=AD863630A09BD9051BCD672E5C44FD4D*

[246] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrexecutiveforward.ashx?la=en&hash=35485D61AE03C2BFFD3E18CD2712EA96, p.3*

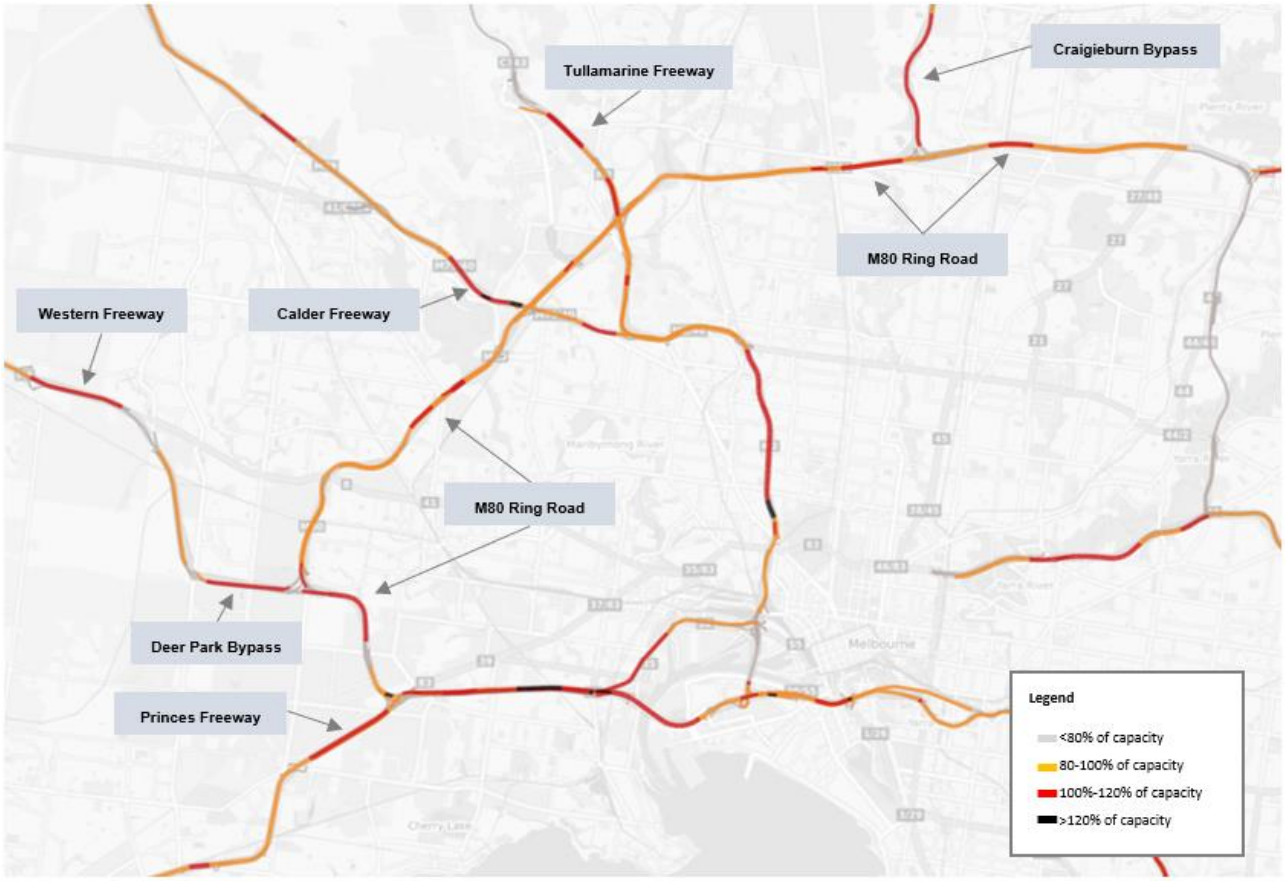
future transport needs. Further work to prepare an Environmental Report and obtain planning permits and approvals will be required prior to any construction.[247]

Population growth in Melbourne's outer north and west will put significant pressure on the existing freeway networks

Melbourne's outer northern and western suburbs are expected to attract over 800,000 new residents to the area immediately surrounding the OMR alignment between 2018 and 2051.[248] These parts of Melbourne currently have an underdeveloped road network, without equivalent road options to the well-developed system of motorways and freeways in other parts of metropolitan Melbourne. In 2051, traffic projections indicate that the freeway network will be under significant pressure with sections of the Princes Freeway, Western Highway, Calder Freeway, Tullamarine Freeway, and Craigieburn Bypass all with traffic volumes exceeding the capacity of the road. These freeways are required to support inbound traffic and orbital traffic, heading in towards and across the city and Inner Melbourne, or to use the M80 Ring Road to complete trips around Melbourne (as shown below). The M80 Ring Road experiences traffic volumes exceeding the capacity of the road in several sections, as shown below in Figure 70.

This limits the opportunities for both movement of people and freight, while also limiting the choices for where transport and logistics firms can reasonably locate. Connectivity, reliability, and efficiency of the transport network enables transport costs to be kept low and support trade. As these industrial areas develop and expand, underdeveloped networks limit the capacity of extra freight volumes and can result in higher costs for transport and logistics.

Figure 70: Traffic congestion on freeway network in 2051 (transport base case)



Source: Infrastructure Victoria Visualisation in Tableau (2021)

[247] *https://www.vicroads.vic.gov.au/planning-and-projects/melbourne-road-projects/outer-metropolitan-ring-e6-transport-corridor*

[248] *Analysis of Arup 2021 Strategic Modelling Outcomes*

Freight in Victoria will experience a loss of productivity as road network congestion makes travel less reliable

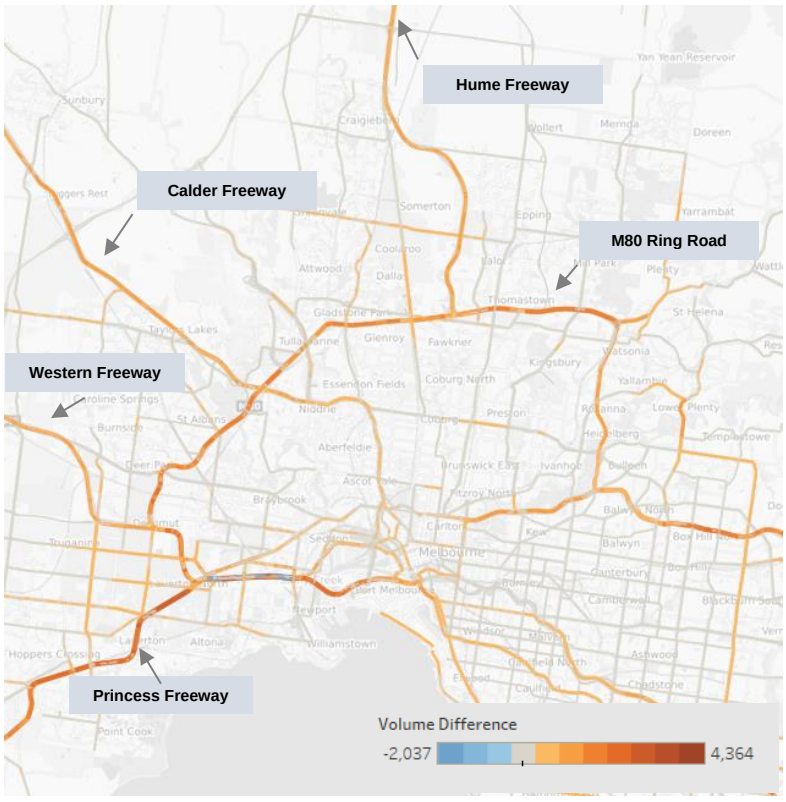
Freight is a vital component of Victoria's economy, and improving how Victorian goods are moved between local, interstate and overseas markets is a key enabler to enhance the state's economic prosperity and liveability. From dairy to wheat, wool to timber, Victoria exports goods are valued at over $26 billion per year.[249] Freight volumes across the state are predicted to increase from 360 million tonnes recorded in 2014 to nearly 900 million tonnes in 2051.[250] As highlighted in the Victorian Freight Plan: *Delivering the Goods,* competitiveness and sustainability of the freight industry means that the network must be fit for purpose, facilitate efficient movement of domestic and international goods and not inflate supply chain costs due to inefficiency or capacity constraints.

Most of the growth in freight volumes is also expected to take place in metropolitan Melbourne. An average annual growth rate of freight volumes in regional Victoria is forecast at 1.5% while metropolitan Melbourne is forecast at 2.6% over the same period.[251] This includes many of the import containers coming through existing facilities, like the Port of Melbourne, which are then delivered to destinations in metropolitan Melbourne. By better connecting transport gateways like the Port of Melbourne through delivering the OMR/E6 corridor, the high-speed road and potential rail connection will contribute to highly desirable supply chain efficiencies.

By 2051, the existing M80 Ring Road will see increases of up to 1,800 trucks in the morning peak alone, along with increased pressure on the West Gate Freeway accommodating movements in and out of the Port of Melbourne. Figure 71 shows this increase in heavy vehicle volumes by 2051, forecast to also increase demand on key congested regional and interstate freight links like the Hume, Calder, Western and Princes Freeways. Unlike demand for passenger vehicles that can potentially be transferred onto the public transport network or to walking and cycling, freight has limited alternatives to being transported by heavy vehicles.

When constructed, the OMR will act as the backbone to developing areas in the north and west, ensuring that freight movements around the area are accommodated on high quality built-for-purpose roads.

Figure 71: Comparison of truck volumes, 2051 Base vs. 2018 Base, AM peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

[249] *Department of Transport, Victoria Freight Plan 2018–50: Delivering the Goods, July 2018, transport.vic.gov.au/ports-and-freight/freight-victoria*

[250] *Department of Transport, Victoria Freight Plan 2018–50: Delivering the Goods, July 2018, transport.vic.gov.au/ports-and-freight/freight-victoria*

[251] *Department of Transport, Victoria Freight Plan 2018–50: Delivering the Goods, July 2018, transport.vic.gov.au/ports-and-freight/freight-victoria*

Improving access to more job opportunities

The project will also enhance accessibility for new residents, workers and visitors in both metropolitan Melbourne and regional Victoria, contributing towards the first strategy objective of preparing for population change. Proposed connections from the OMR to Melbourne Airport and the Deer Park Bypass through Truganina would also enable better journey times to the key transport gateway and industrial precinct, respectively. This will contribute to addressing strategy objectives 4 and 5, enabling workforce participation and lifting productivity.

Connectivity with intermodal terminals and transport gateways

While the road network will continue to be well suited in delivering consignments to dispersed locations, rail freight also plays an important role in transporting bulk consignments to specific and important freight markets.[252] The proposed intermodal terminals, WIFT and BIFT, are points on the freight network where both rail and road work together, with road transport providing local pick up and delivery from the rail terminal. OMR will facilitate the distribution of rail freight between ultimate origin or destination and the intermodal terminal.

These intermodal terminals will enable very long double-stacked freight trains in and out of Victoria on the east coast interstate network.[253] The potential of rail freight connected to these intermodal terminals also means that heavy vehicles and freight trains can bypass congested areas of Inner Melbourne, thereby lowering freight costs and improving competitiveness.[254] Providing an alternate link for freight rail also has the potential to boost reliability and frequency for metropolitan and regional passenger rail services that share the corridor, as well as other freight uses for the inner part of the rail network. The establishment of these intermodal terminals also has the potential to co-locate with other freight and logistics activities, likely to use the rail terminal. The project will therefore contribute directly to addressing strategy objective 6, driving Victoria's changing, globally integrated economy.

Project Description

The OMR is planned to be the major 'outer ring' road for Melbourne in the future. The project has been a part of Melbourne's long-term freeway planning for some decades and is expected to serve as both a commuter and major freight corridor.

For our assessment, the project has been split into three phases, shown in Figure 72.

Phase A, referred to as the E6 corridor, includes a 27.2km road corridor from the M80 Ring Road in Bundoora to the Hume Freeway near Beveridge, with two lanes in each direction. Supporting upgrade works will include:

- M80 Ring Road widening from E6 to Greensborough Bypass
- Bridge Inn Road widening from Epping Road to Cravens Road
- Donnybrook Road widening from Hume Freeway to E6
- Gunns Gully Road extension from the Hume Highway to the E6.

Phase B, referred to as OMR north, continues from the E6 at the Hume Freeway south-west through Mickleham, Diggers Rest and connecting to the Melton Highway, north of Rockbank. The corridor is 32.3km long and includes two lanes in each direction. OMR north also includes widening of Sunbury Road from Lancefield Road to OMR, and an extension of the Tullamarine Freeway, connecting up with Melbourne Airport.

Phase C, referred to as OMR south, continues south from the Melton Highway, passing to the west of Tarneit and Wyndham Vale before connecting up to the Princes Freeway, west of Werribee. This phase is approximately 40km long, with two lanes in each direction including a connection from OMR south to the Deer Park Bypass, just north of Truganina.

Phase A and B (E6 and OMR north) are assumed to be built by 2036 while Phase C (OMR south) is assumed to be built by 2051. The OMR project also includes new interchanges, bridges, and road upgrades at interfaces with existing roads.

The entire length of the OMR and E6 corridor is assumed to be tolled with gantries at every major interchange.

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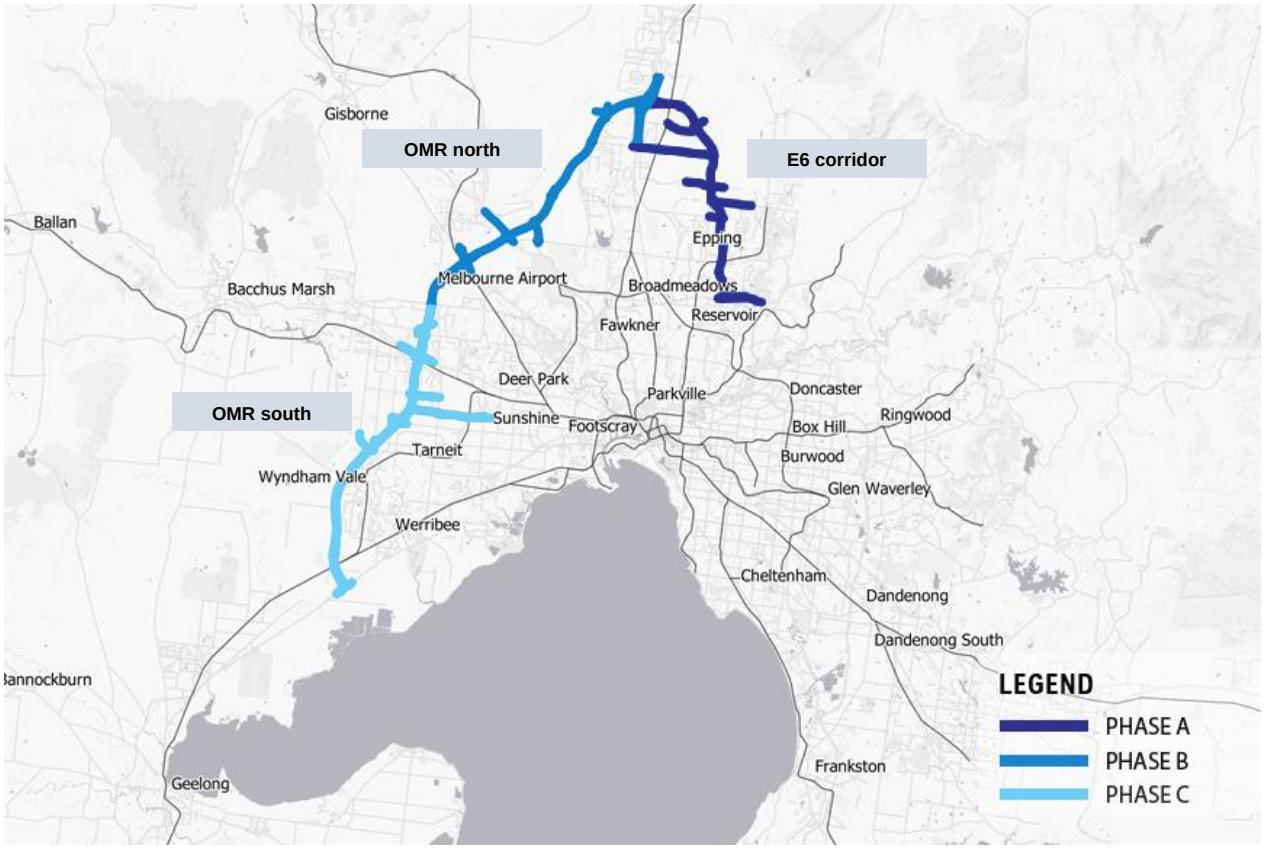
[252] *Bureau of Infrastructure, Transport and Regional Economics, Road and rail freight: competitors or complements?, July 2009, https://www.bitre.gov.au/sites/default/files/is_034.pdf,*

[253] *Department of Transport, Victoria Freight Plan 2018–50: Delivering the Goods, July 2018, transport.vic.gov.au/ports-and-freight/freight-victoria*

[254] *https://www.vicroads.vic.gov.au/-/media/files/documents/planning-and-projects/melbourne/omr/omrchapter3.ashx?la=en&hash=40C3E0736046BCE523C18A8421C93233*

Figure 72: OMR project alignment and phases



Source: Arup 2021, annotated by Infrastructure Victoria

Project Costs and Timing

The total estimated cost of OMR, inclusive of contingencies, 50-years renewal costs and operations and maintenance costs (O&M) are shown in the table below. This cost also includes supporting upgrade works outlined above.

Total capital expenditure cost is estimated to range between $17.2 billion and $34.7 billion in total (including phases A, B and C). Capital expenditure for phase A is estimated to cost between $4.7 billion and $8.6 billion, phase B is estimated to cost between $5.6 and $13.5 billion and phase C is estimated to cost between $6.9 billion and $12.7 billion (in 2020 values). Large components of this cost include bulk earthworks, pavements and bridges. For the corridor where it is planned both road and rail will operate, some of the formation works and costs are expected to be borne by the infrastructure that is built first, of which is assumed to be a greater proportion of the higher cost. Land acquisition costs are also significant. Contingencies for design, construction and prolongation have also been included in the total cost.

For the purposes of this assessment, construction of phases A and B has been assumed to start in 2029, with completion in 2035 for opening of this section of the project in 2036. Phase C has been assumed to start construction in 2045, with completion in 2050 for opening of the full OMR in 2051.

Table 31: OMR capital expenditure cost profile (2020 dollars)

Project	Lower Capex ($m)	Upper Capex ($m)
OMR Phase A	4,695	8,556
OMR Phase B	5,591	13,496
OMR Phase C	6,921	12,656
OMR (Total)	**17,207**	**34,708**

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

Multi-criteria Analysis

Given the scale of the OMR project, from both a vehicle capacity and road length perspective, the project performs exceptionally when compared to all other assessed projects in reducing road network congestion. Even when considering the project in 2036, modelled as the E6 and OMR north sections, the project far exceeds the congestion reduction effects of other road projects such as CCM. Crowding on metropolitan public transport services is largely unaffected by the project, however, regional rail services experience crowding relief, which could be due to population and job redistribution as a result of the project.

Freight is one of the strongest beneficiaries of the project, with average travel time savings to key destinations potentially twice that of the RMS project and far greater than any other rail project. This is reflected in the OMR project's Exceptional and High scores in freight congestion relief and connectivity to key industrial and transport gateways, respectively. While much longer than CCM, the OMR supports a significant logistics and freight market in Melbourne's growing north and west, including the proposed Beveridge and Western intermodal freight terminals, Melbourne Airport and the Northern and Western State Significant Industrial Precincts. Given it is also located in the outer north and west, it supports slightly fewer freight origin and destination pairs compared with the CCM project (65%), at about 40% of all freight routes. Despite this, utilisation of the corridor is high, expected to support up to 20,000 trucks a day in both directions, along some sections. This is comparable with projected volumes on CityLink and the future West Gate Tunnel.

The OMR project also scores well in jobs and labour force, scoring Medium-High in providing additional opportunities to access jobs and labour force. New Growth Areas experience the strongest improvement when it comes to accessing new job opportunities via private vehicle for households.

Where the OMR project only scores poorly is in its contribution to reducing vehicle emissions. While relatively low in 2036, the project generates the largest increase in vehicle emissions of all projects assessed by 2051 as the whole alignment including OMR south comes online. The take up of ZEVs has the potential to help mitigate this in later years.

Table 32: OMR MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight connectivity	Reduced vehicle emissions
Outer Metropolitan Ring Road (OMR)	E	M/H	M/H	H	E	M/H	H	N

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

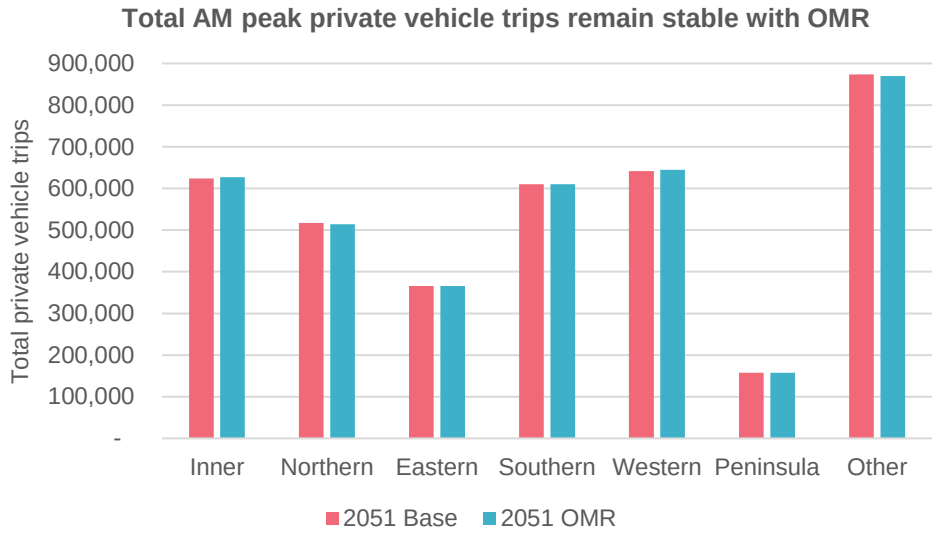
Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

Transport Outcomes

Private vehicle usage

During the busiest hours of the morning, private vehicle trips remain relatively stable, even with the inclusion of the full E6 corridor and OMR north and south corridors in 2051, as shown in Figure 73. The Inner and Western FER experience a small increase of around 3,000 new originating private vehicle trips while the Northern FER experiences a decrease of similar magnitude. This is likely due to changes in population discussed in the following section, along with improved car accessibility provided by the project, especially to the west of Melbourne.

Figure 73: Total private vehicle trips (originating), AM peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

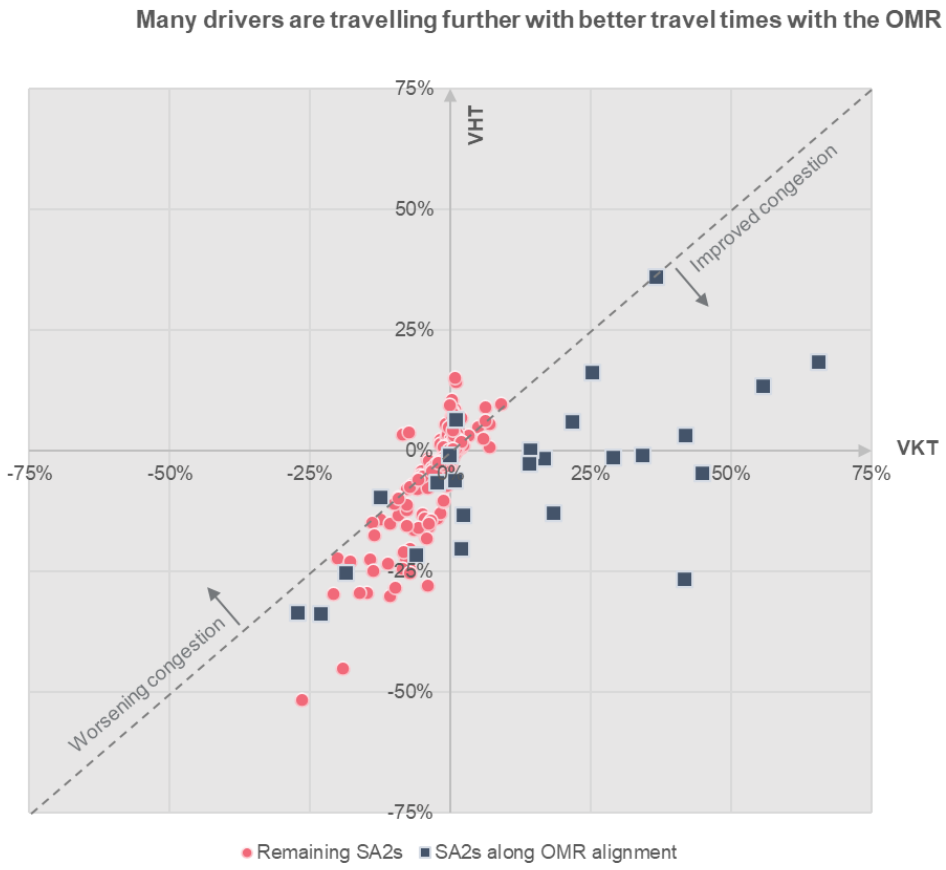
Private vehicle congestion reduction

Figure 74 shows the percentage change in VKT and VHT for all SA2s between the 2051 OMR and 2051 transport base case. While many SA2s show some change to travellers' trip length or trip time, the SA2s directly along the OMR (blue squares) experience a large change in how far and fast trips become. The SA2s directly along the OMR alignment suggest that while people are generally travelling greater distances, journeys are generally faster than they were in the transport base case. Even in areas where both VKT and VHT increase, the proportional increase in kilometres travelled is often greater than the proportional increase in hours travelled, suggesting that trips, on average, were occurring with better travel times.

These changes in time spent and kilometres travelled also contribute to an easing of congested conditions on the roads. Figure 75 below shows a comparison between congestion relief in both 2036 and 2051. In 2036, the Northern FER experiences the greatest reduction in congested kilometres (due to the completion of the OMR north and E6 corridor). By 2051, significant congestion relief is also experienced in the Western FER, coinciding with completion of OMR south.

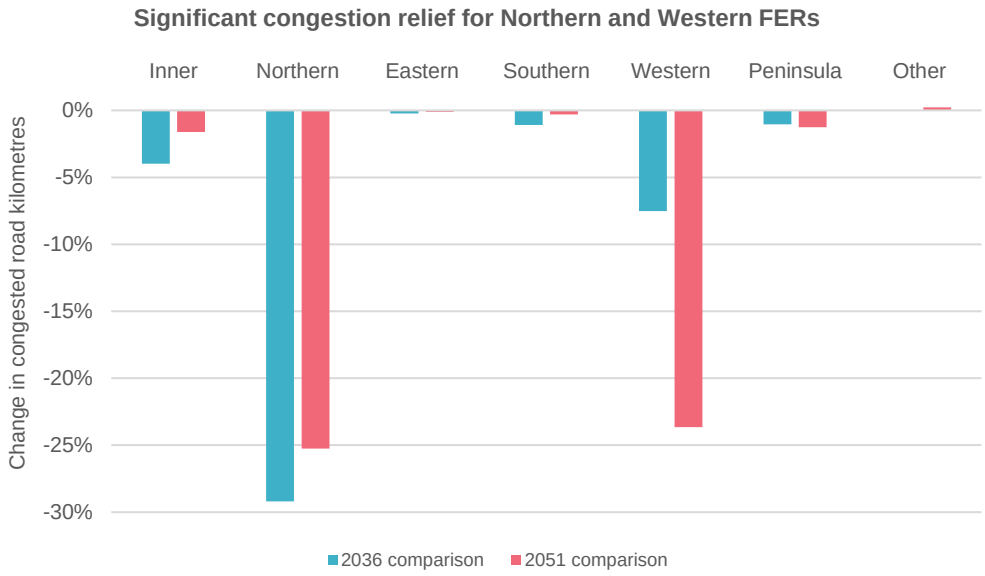
Regional cities, centres and rural areas also benefit from the project, experiencing faster travel times for both trips originating and terminating within the regions. This is likely due to some regional trips now benefiting from more direct and faster route options once on the OMR alignment. Overall, average journey durations have decreased with OMR, given the allocation of a more direct, high capacity and faster orbital route around metropolitan Melbourne.

Figure 74: Comparison of VKT and VHT, 2051 OMR vs. 2051 Base



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

Figure 75: Comparison of congested kilometres, 2051 OMR vs. 2051 Base



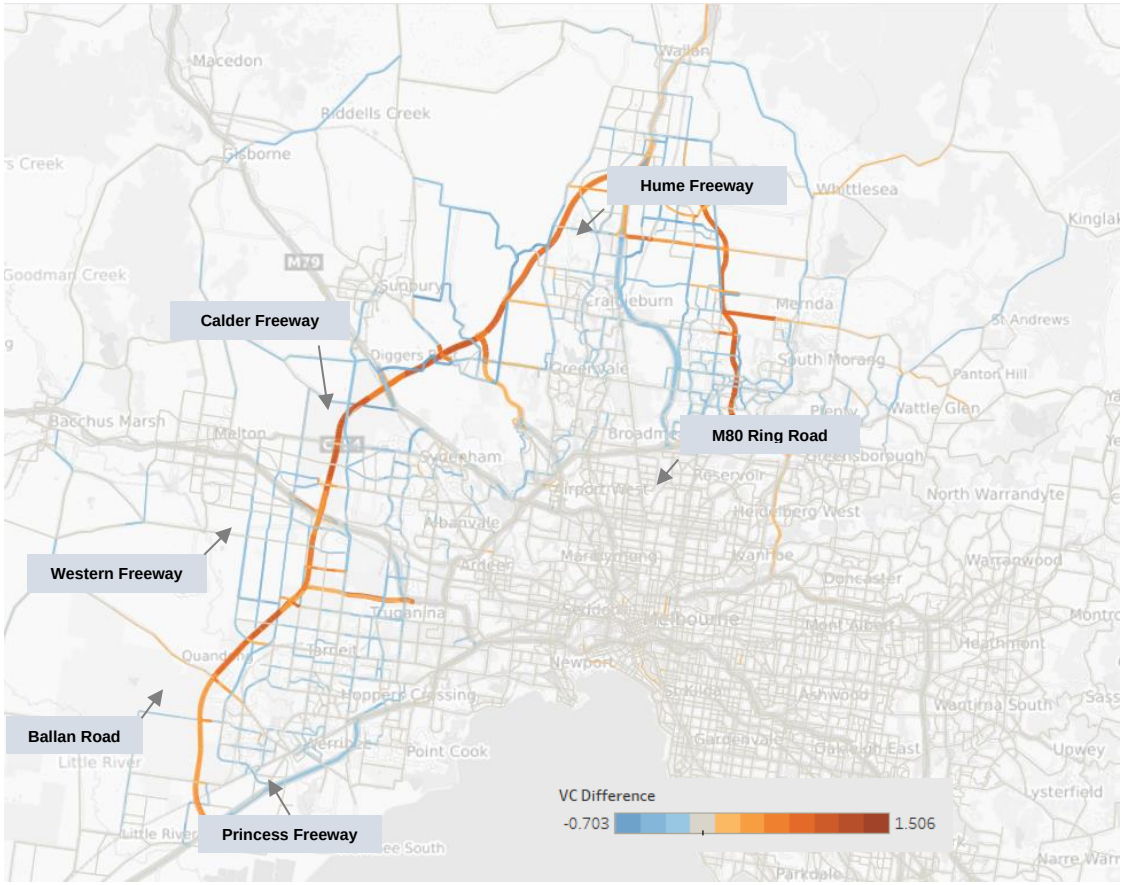
Source: Analysis of Arup 2021 Strategic Modelling Outcomes

Rerouting of private vehicles

Modelling suggests that a large proportion of traffic travelling along the OMR/E6 corridor is a result of private vehicles that are already travelling on the network, simply rerouting onto the new OMR alignment. Unlike major road projects that may compete heavily with other modes like public transport, the OMR alignment creates a new, more attractive orbital route for many existing drivers who are already using the network.

The spatial distribution of re-routed vehicle volumes comparing 2051 OMR with the 2051 transport base case is shown in Figure 76 below, represented by a change in volume/capacity ratio (V/C). V/C is calculated as a ratio of vehicle volumes travelling on a road compared to the total capacity of the road. A reduction of V/C means reduced demand while an increase represents greater demand, and potentially worsening congestion. Operation of the full OMR by 2051 also eases pressure on major corridors like the Hume Freeway to the north and Princes Freeway to the west. During the AM peak, these freeways experience a total reduction of vehicle volumes between 2,000 to 3,000 vehicles along some sections. However, there is also some increased demand on highways and arterials feeding into the new OMR alignment, noting that construction of the OMR is complemented with significant interchange upgrades.

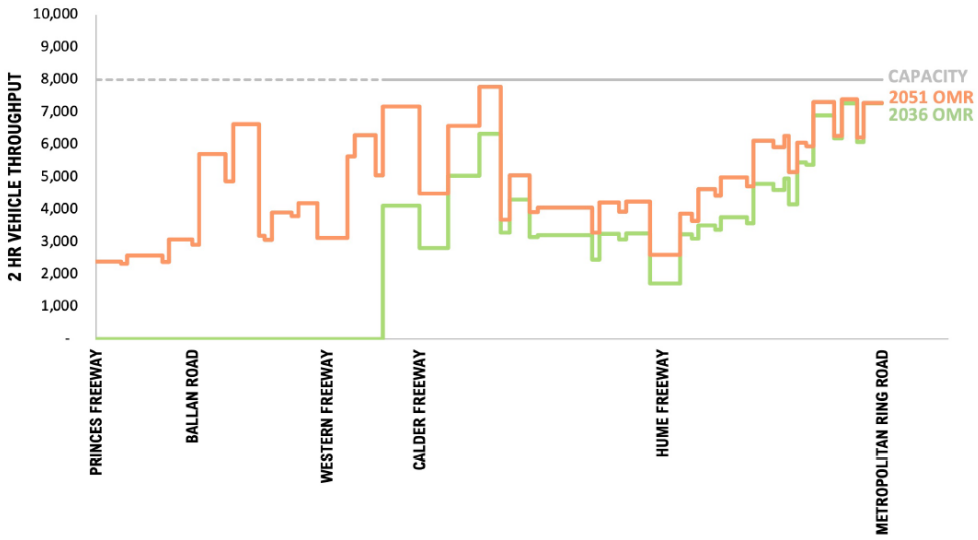
Figure 76: Volume Capacity Ratio (V/C) comparison, 2051 OMR vs. 2051 Base, AM peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

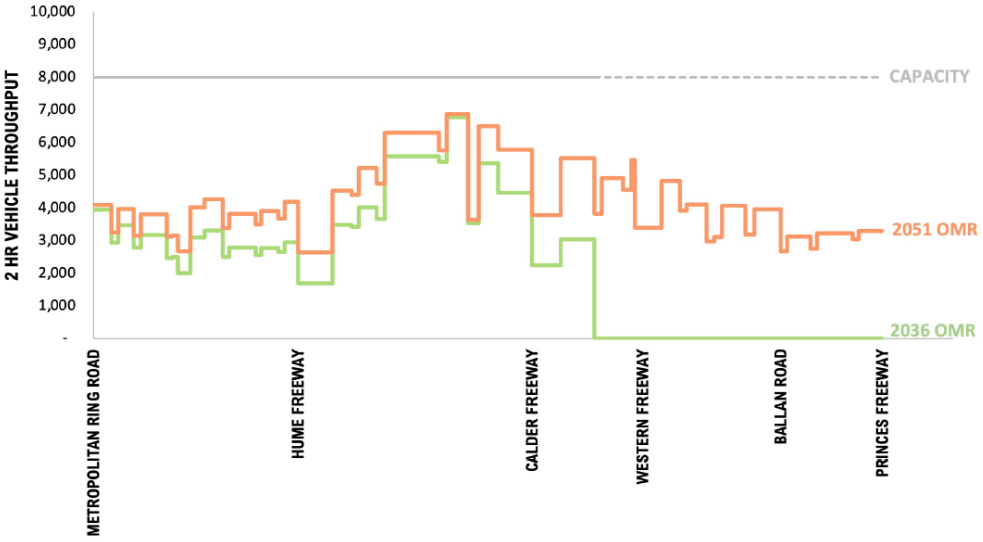
Along the corridor itself, Figure 77 and Figure 78 show vehicle volumes along both OMR and E6 sections in clockwise and anti-clockwise directions during the AM peak. By 2051 (orange line), sections around the Western and Calder Freeways experience volumes close to capacity (two-hour vehicle throughput is 8,000 vehicles for two lanes in each direction). Morning peak northern Metropolitan Ring Road-bound (clockwise from west to north) traffic along the E6 also brings volumes close to capacity. With the remainder of the road, heading anti-clockwise, volumes vary around 50% of available capacity.

Figure 77: Volumes along the OMR and E6 corridors, AM period clockwise



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

Figure 78: Volumes along the OMR and E6 corridors, AM period anti-clockwise



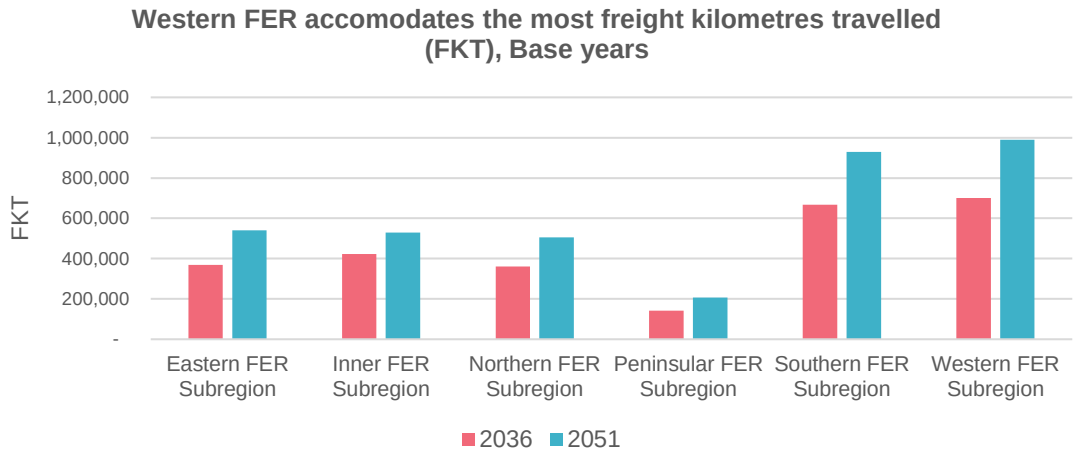
Source: Analysis of Arup 2021 Strategic Modelling Outcomes

OMR supporting freight movement

On-road heavy vehicle freight trips across Greater Melbourne are expected to increase from levels of almost 300,000 per weekday in 2018 to around 600,000 in 2036. By 2051, this could further increase to nearly 900,000 trips, placing more pressure on existing highways and arterials.

While the increase of freight trips on Melbourne's roads is a sign of positive economic activity, heavy vehicles also have a significant social and environmental impact to areas directly adjacent to their path. This commonly includes noise pollution, CO_2 emissions and loss of local amenity. The greatest proportion of freight kilometres travelled, in both 2036 and 2051, is found in the Western FER, as shown in Figure 79. Arguably underdeveloped when compared to Melbourne's established areas, the outer west and northern road networks will be enhanced with introduction of the OMR.

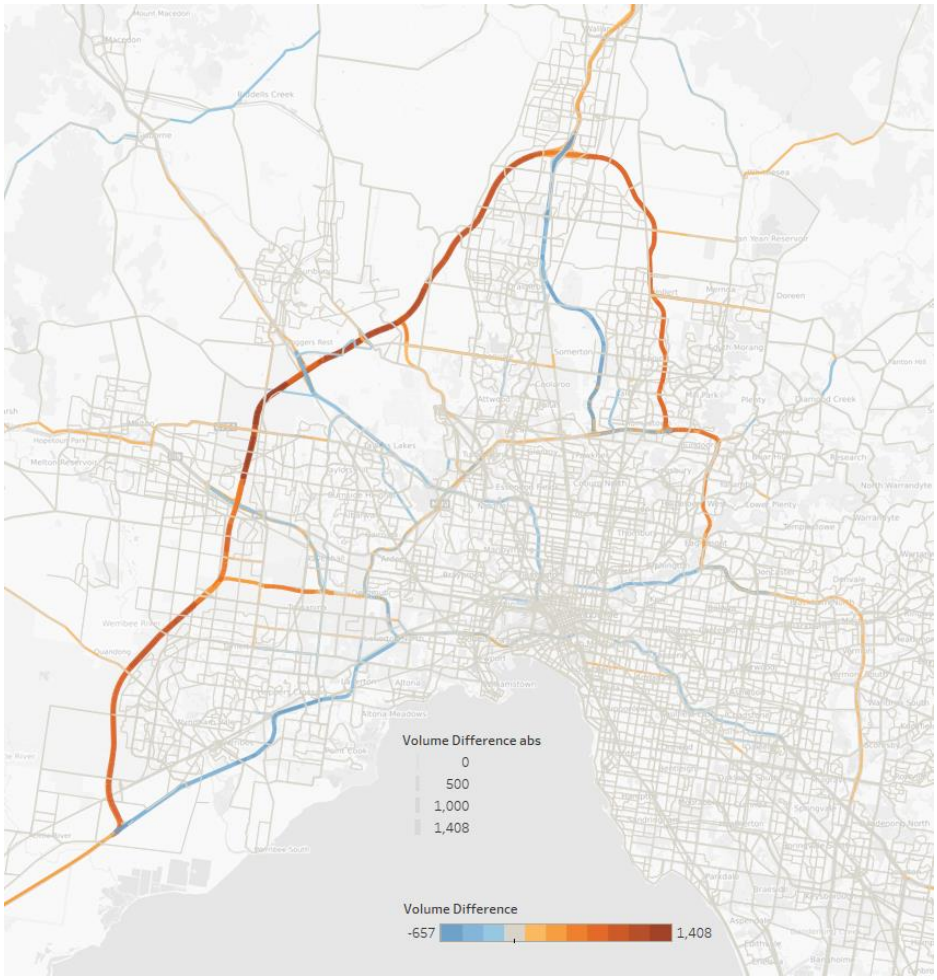
Figure 79: Freight Kilometres Travelled in 2036 and 2051 Base Case



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

As an orbital road project, OMR reduces freight volumes along other roads that are used to make this orbital movement, which are primarily located in Outer Melbourne and regional Victoria. This draws heavy vehicles towards the OMR alignment as a new alternative with better travel times. With the completed OMR by 2051, highways such as the Princes Highway in the west and Hume Highway in the north experience reductions in freight volumes by up to 600 trucks in the AM peak, as shown in Figure 80. The project also creates a general trend of reducing freight volumes travelling on key links towards Inner Melbourne such as the Tullamarine and Monash Freeway. There is a notable increase in truck volumes utilising the North East Link and connecting through to the E6 corridor, diverting heavy vehicles away from congested parts of the Craigieburn Bypass and the end of the Eastern Freeway.

Figure 80: Comparison of truck volumes, 2051 OMR vs. 2051 Base, AM peak



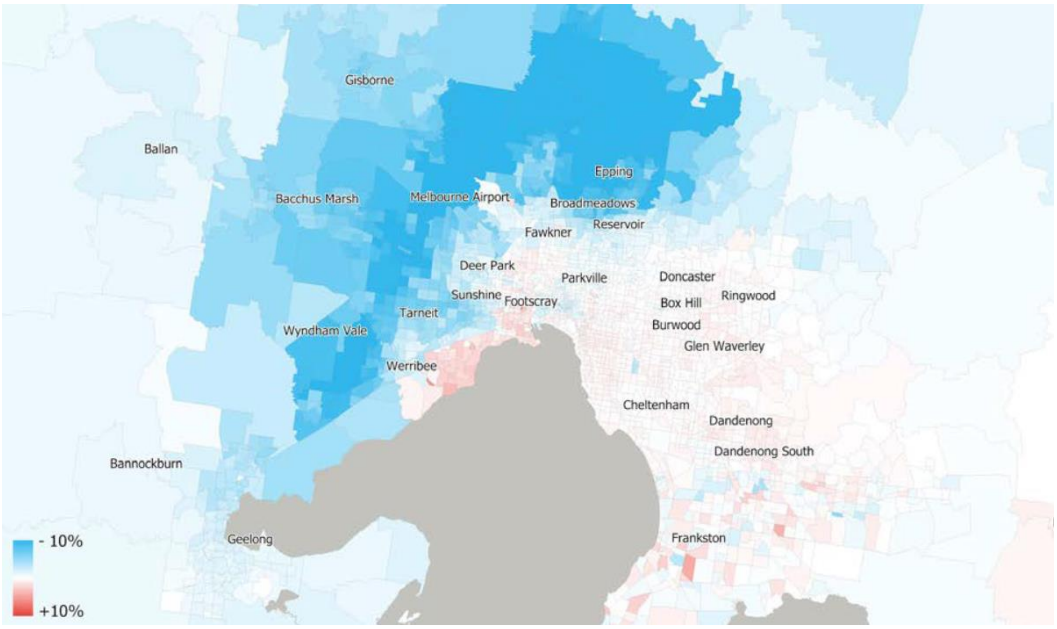
Source: Analysis of Arup 2021 Strategic Modelling Outcomes

The OMR/E6 project also boosts freight network connectivity to both the proposed WIFT and BIFT, directly connecting the two terminals to the corridor. This would enable more efficient, faster, and more direct freight travel across Greater Melbourne and connectivity to regional Victoria and the interstate network, strengthening and safeguarding Victoria's capacity to support a growing economy. Modelling also shows high demand for the OMR corridor around the new Melbourne Airport and Deer Park Bypass links.

Boosting private vehicle accessibility

The project and resultant redistribution of traffic provides significant relief to roads across the north and west of Melbourne. It also results in enhanced access to major employment and retail precincts in the north and west, including NEICs in East Werribee, Sunshine, and Latrobe well as Melbourne Airport. Figure 81 shows the change in average private vehicle travel times across Greater Melbourne with the OMR project by 2051, compared with the transport base case.

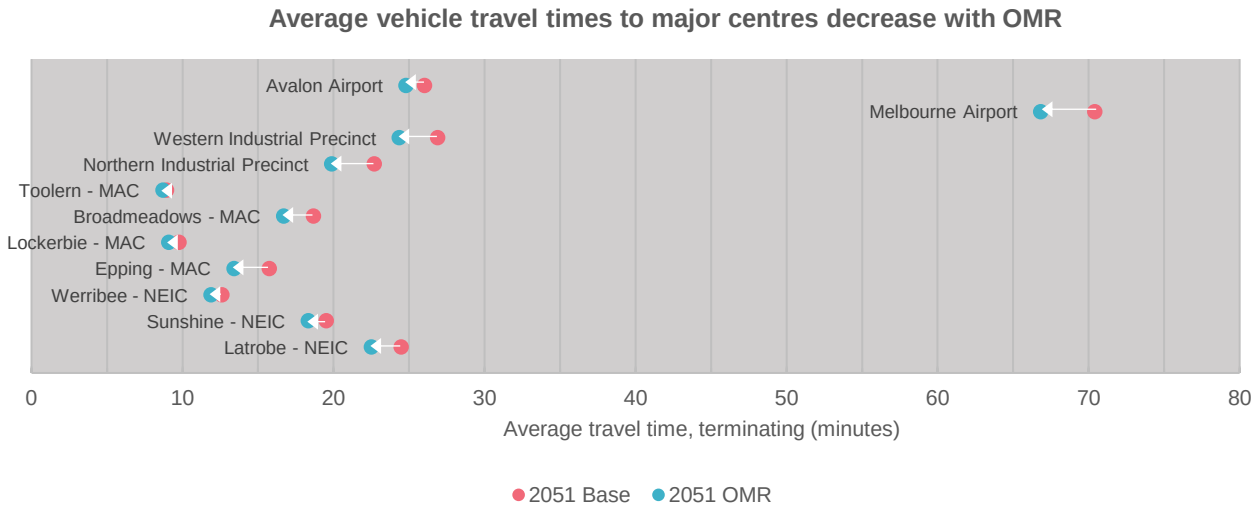
Figure 81: Changes in private vehicle travel time, 2051 OMR vs transport base case



Source: Arup 2021 Strategic Modelling Outcomes Report

Figure 82 shows the change in average AM peak travel times to major centres in proximity to the OMR/E6 project. Of the selected centres, Epping Metropolitan Activity Centre experiences some of the biggest time savings on average, with a reduction of close to 15% in time spent on the roads, given it is now bordered by both the Hume Freeway and new E6 corridor. Melbourne Airport also experiences strong travel time savings, partly due to the new direct connection to the OMR through the Tullamarine Freeway extension. Northern and Western Industrial Precincts (including WIFT), bordered by the OMR, also benefit from the project in travel time savings.

Figure 82: Average travel times (terminating), 2051, AM peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

The benefits of reduced road congestion, improved road travel times and more direct links for drivers, enables improved accessibility to jobs for suburbs in Melbourne's New Growth Areas and Outer Melbourne. Similarly, this means the labour force catchment of key centres also improves. The following figures show that new growth area workers overwhelmingly benefit the most from an increased accessibility perspective. Key centres like Sunshine and transport gateways like Melbourne Airport also benefit from the largest increases to accessing the labour force. These areas are able to access over 240,000 new workers within a 45 minute drive with the OMR project.

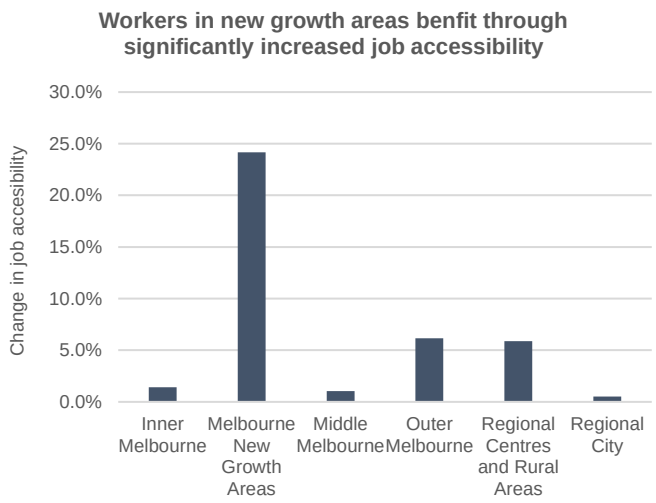


Figure 83: Percentage change in jobs accessibility (45min by PV), 2051 OMR vs 2051 Transport Base, AM peak

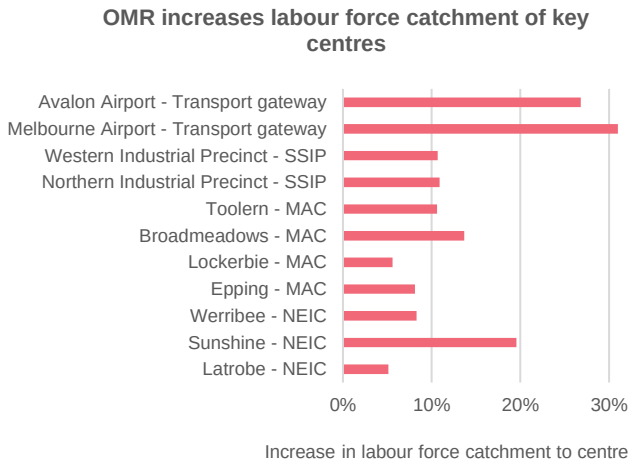


Figure 84: Percentage change in labour force catchment (45min by PV), 2051 OMR vs. 2051 Transport Base, AM peak

Public transport

Public transport is largely unaffected by the OMR as modelled in this assessment, although there are a number of trends that can be observed.

The first trend is bus use. Due to increased road supply and reduced congestion, on-road public transport journeys like local buses experience faster travel times in areas north and west of Melbourne. This is accompanied by an approximate increase of 1,500 bus boardings in the AM peak as services become more attractive.

The second trend is train use, especially for metropolitan services in Outer Melbourne, which experiences patronage reductions of up to 1,500 passengers in the AM peak. As train speeds are unaffected by the level of congestion on roads, this change in patronage is likely attributable to the change in distribution of population across Greater Melbourne, rather than any change to the attractiveness of rail services.

This redistribution of population away from regions and growth areas towards established parts of the city (as discussed in the next section) also drives a reduction in the level of crowding on V/Line rail services. Crowded passenger kilometres travelled on V/Line reduce by 12% in the AM peak. Although V/Line boardings only reduce by up to 500 in the project case, it is likely that many existing V/Line users continue using these services, only boarding at stations closer into the city. This is because their household location has now changed and this contributes to a reduction in crowded passenger kilometres travelled.

Opportunities to Improve OMR

From the modelling and cost assessment undertaken for this study, a range of opportunities have been identified that would improve the benefits and costs of this project. They include:

a) Considering the number of motorway interchanges and ramps to get on and off the OMR – as some interchanges and ramps were more utilised than others. Interchanges make up a significant proportion of the project's cost.

b) Applying transport network pricing principles to optimise flow and benefits, and help mitigate congestion and potentially capital works in other parts of the network.

c) Whilst planning a road and rail line results in better integrated transport corridor outcomes and contain broader suburban impacts to one corridor, it can present design challenges. For example, trains which carry very heavy loads do not climb gradients as steep as roads. There are opportunities for cost efficiencies with better design.

d) Considering alternative staging options, such as considering whether Phase 2 should go to Melton Highway or Western Freeway to provide a continuous motorway network.

e) Opportunities for on-road public transport services that may use the motorway or use the surrounding network better through on road priority.

Demographic Outcomes and Land Use Implications

Population

The OMR results in a small redistribution of population from Victoria's regions and growth areas towards established parts of Melbourne. Population change is driven by improved accessibility on the arterial road network after freight and other private vehicle travel is redirected onto the OMR, particularly in 2051. This improvement in congestion primarily benefits established parts of Melbourne (Figure 85), and results in increased population within the alignment spreading in a radial fashion from central Melbourne towards Hobsons Bay in the south-west, and Darebin in the north. Very small positive changes also occur across eastern and south-eastern Melbourne, some distance from immediate accessibility improvements. Places closer to the OMR and its interchanges become more congested, which will impact local movements. This results in many new greenfield suburbs in the western and northern growth corridors experiencing slower population growth when compared to the transport base case.

There is a tendency for the project to result in population uplift in established areas inside the road alignment.

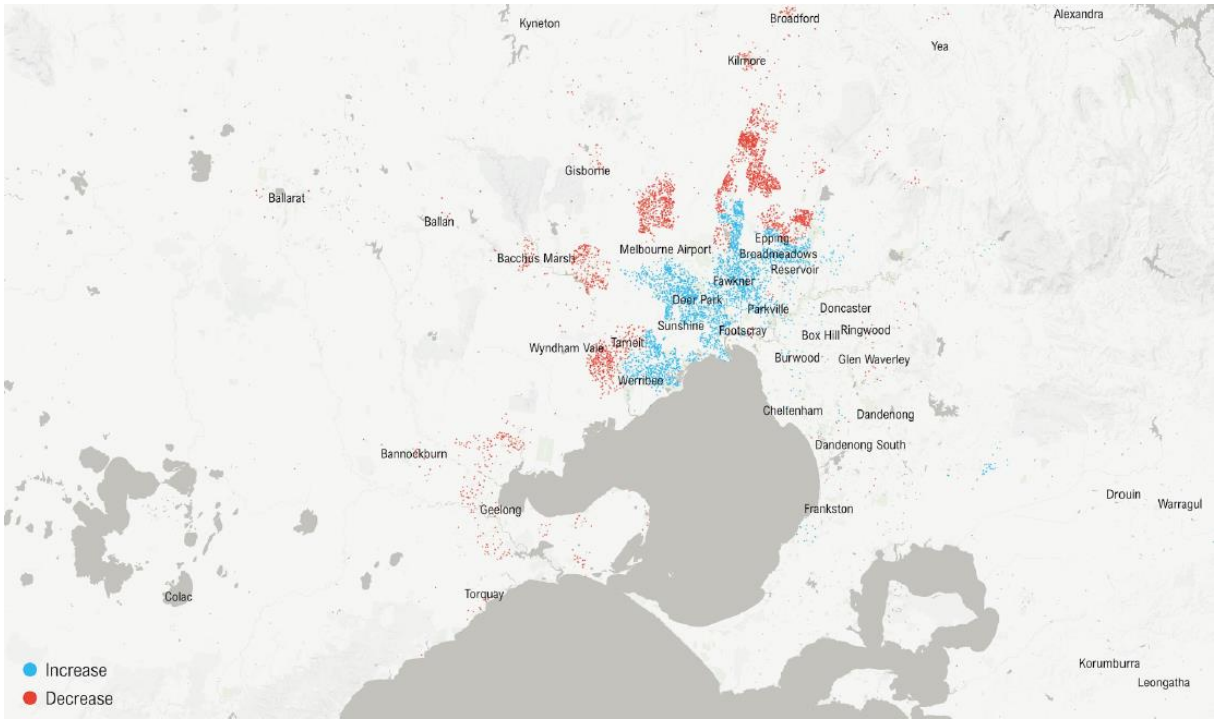
Jobs

The project reduces congestion in areas such as Airport West, Melbourne Airport and Campbellfield, and combined with well-developed existing road networks, these become more attractive locations for businesses. Reduced congestion also improves access to the central city, with jobs also increasing in the CBD, Docklands and Parkville NEIC. These locations are also all projected to have some of Melbourne's highest job growth in the transport base case.

This differs to a previous study on the impacts of the Western Ring Road and increased effective job density around its interchanges. The OMR results in additional jobs within Melbourne's established urban area (refer to case study below).

Job growth slows in Melbourne's newest suburbs and outside central Geelong as a result of these places becoming less attractive for people to live under the OMR project.

Figure 85: Population changes due to OMR compared to transport base case, 2051



Source: Arup 2021 Strategic Modelling Outcomes report

Figure 86: Jobs changes due to OMR compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes report

Case Study: Modelling Land Use Impacts of Ring Roads and the Broader Road Network in Outer Areas

Some of the predicted land use impacts of the modelling of OMR in this assessment contrast with previous studies of orbital roads. These differing results reflect the complex inter-relationship between the suburban development plans and the development of metropolitan transport corridors and local transport infrastructure.

Other studies of orbital roads have shown there is a complex relationship between roads, development at the edge of cities and urban expansion. A useful comparison is the Western Ring Road which was constructed between 1989 – 1999. It extends from the Princes and West Gate Freeways in the west, to Sydney Road/Hume Freeway in the north, and connects all of north and west Melbourne's highways. SGS Economics and Planning have studied the long-term land use impacts of the Western Ring Road, finding that it had the greatest positive influence on population in outer suburban Melbourne, including in Craigieburn and Whittlesea north of the alignment. This trend closely correlates with the intensity of employment impacts and increased accessibility produced by the Western Ring Road. Whilst the focus was on the Western Ring Road, implied in this study was the associated development of the arterial and local road network that accompanied the development of these places where these additional houses and jobs located to.

Whilst this study's modelling results for OMR indicated that population and jobs would tend to relocate inwards towards established areas, modelling results for broader network-wide improvements such as Road Management Systems and Autonomous Vehicles show that these initiatives encourage more Victorians to relocate in outward areas. This suggests that the development of the arterial road network improvement in outer areas will also cause more people and jobs to relocate in these growth areas.

For this study, these road networks in growth areas are already in place in the modelled OMR base case. In reality, suburban growth and the development of the local road network and motorways are complex and heavily inter-related. In some instances, motorways will be a catalyst to suburban development and the road network. Current urban fringe growth area developments around Cobblebank, Woodlea and Beveridge probably would not have occurred without the Western and Hume Freeways and associated rail services. In these cases it appears that good motorway and rail access can encourage outward development, as was the case with the way that SGS approached its assessment of the Western Ring Road. Suburban development settings also allow this development to occur.

In contrast, in what has been modelled for this study's assessment of the OMR, these suburban developments and road networks are assumed to be already in place in the transport base case which is why there was relocation towards established areas. In reality, it is most likely that only some of these roads will be in place, whereas others will be developed around the time that the OMR is delivered.

This suggests that the Victorian Government should consider both potential population outcomes and at a minimum, ensure that the urban growth boundary does not change as ultimately it is land use planning settings that determine where development can take place.

Image 1: Western Ring Road alignment

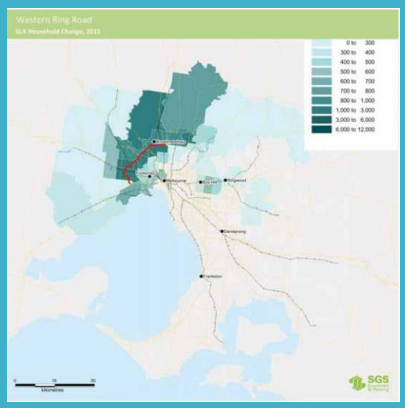


Image 2: Western Ring Road household impacts 2011

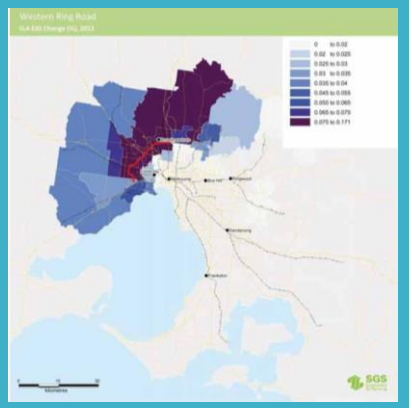


Image 3: Western Ring Road effective job density 2011

Source: SGS Economics and Planning 2012, Long run economic and land use impacts of major transport projects, Department of Transport

Economic Assessment

Cost benefits analysis

The table below presents a summary of the estimated benefits from OMR, using a discount rate range of 7% and 4%. The largest benefit category is consumer surplus benefits, which includes the travel time savings and associated reductions in vehicle operating costs for road transport. Most of these road transport benefits are for private vehicle users, with freight users being a smaller component. This project is expected to have negative environmental and active transport benefits, due to the increase in kilometres travelled by private vehicles.

Table 33: OMR Benefits (Present Value $ million)

Benefit	Static land use	Dynamic land use	WEBs only	Total
Consumer surplus benefits	$14,246 - $35,381	$3,201 - $8,832		$17,447 - $44,213
Safety benefits	$132 - $300	-$9 – -$10		$123 - $290
Environmental benefits	-$161 – -$458	$93 - $246		-$68 – -$212
Active transport benefits	-$123 – -$333	$66 - $172		-$57 – -$161
Residual values	$56 - $346	$0 - $0		$56 - $346
WEBs			$1,405 - $3,361	$1,405 - $3,361
Total benefits	**$14,151 - $35,237**	**$3,351 - $9,241**	**$1,405 - $3,361**	**$18,907 - $47,839**

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: The 'Headline' range is provided using 7% and 4% discount rates

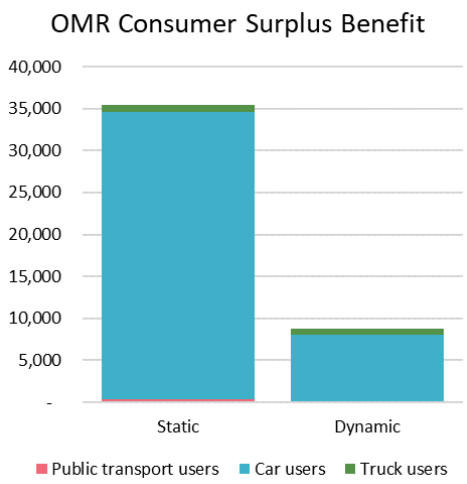
Quantified benefits

Total benefits of this project are made up of *static land use*, *dynamic land use* and *wider economic benefits*. The *static land use* benefits represent the estimated conventional transport benefits arising from this project, without any changes to the location of population and jobs. The *dynamic land use* benefits arise from changes in the location of population and jobs caused by the project.

Dynamic land use benefits are positive for this project. This is due to more people moving to areas that have greater accessibility in the western and northern established areas of Melbourne because of this project. This results in an increase in both public transport and private vehicle trips from the population living in these areas. As these areas become slightly less congested with the project there are small land use benefits to car and truck users.

Figure 87 shows the consumer surplus benefits under static and dynamic land use outcomes for public transport users, car users and truck (freight) users. This highlights that the majority of benefits are congestion relief benefits to car users. It also shows the additional benefits arising under the dynamic land use outcome for car users. Figure 89 illustrates these changes in private vehicle consumer surplus across metropolitan Melbourne. This highlights that people living in areas closest to the OMR, as well as in established areas that see reduced congestion, experience the greatest benefits from this project.

Figure 87: OMR Consumer Surplus Benefits for Static and Dynamic Land Use Outcomes

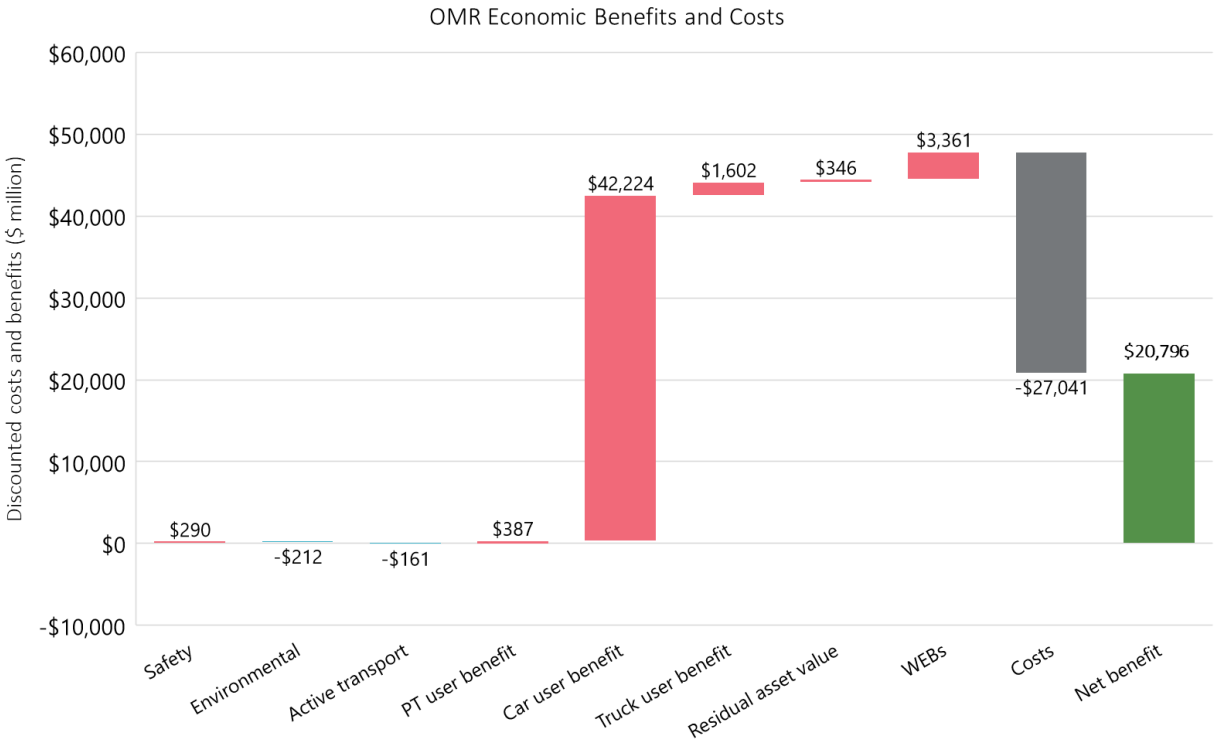


Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

WEBs make up 7% of the total benefits of this project. This is driven by an increase in jobs and accessibility to employment areas. Agglomeration benefits contribute the largest amount, arising from the productivity improvements from increased density and accessibility of jobs.

Figure 88 shows the economic benefits of this project compared to the total estimated cost in present value terms. This shows the large contributions from car users to the total benefit. It also highlights that the benefits are expected to be greater than the cost of this project in present value terms, indicating this project will generate a net community benefit.

Figure 88: OMR Economic Benefits and Costs (Present Value $ millions)



Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Total dynamic land use plus WEBs results presented using upper project costs and 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Summary cost benefit analysis results

Summary results from the cost benefit analysis are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes the quantified benefits outlined in the table above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 1.1 and 1.8 for upper project costs and 2.2 and 3.4 for lower project costs, for the total outcome (dynamic land use including WEBs, ranges provided using 7% and 4% discount rates). The net present value (NPV) is expected to range between $1.8 to $21 billion for upper project costs and between $10.4 and $34 billion for lower project costs (ranges using 7% and 4% discount rates). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and wider economic benefits arising from productivity improvements.

This analysis indicates that the OMR project is likely to be economically viable, expected to generate benefits that are greater than the expected cost of this project in the long term.

Table 34: OMR Benefit Cost Ratio and Net Present Value ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	0.8 – 1.3	-$3,006 to $8,195	1.0 – 1.6	$345 to $17,436	1.1 – 1.8	$1,750 to $20,796
Lower project costs	1.7 – 2.5	$5,641 to $21,336	2.1 – 3.2	$8,992 to $30,576	2.2 – 3.4	$10,397 to $33,937

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Broader impacts

There are also expected to be broader impacts arising from this project which cannot be quantified in a cost benefit analysis. We have assessed metrics from the VLUTI model where available and provide commentary on the expected direction of these impacts. These broader impacts include:

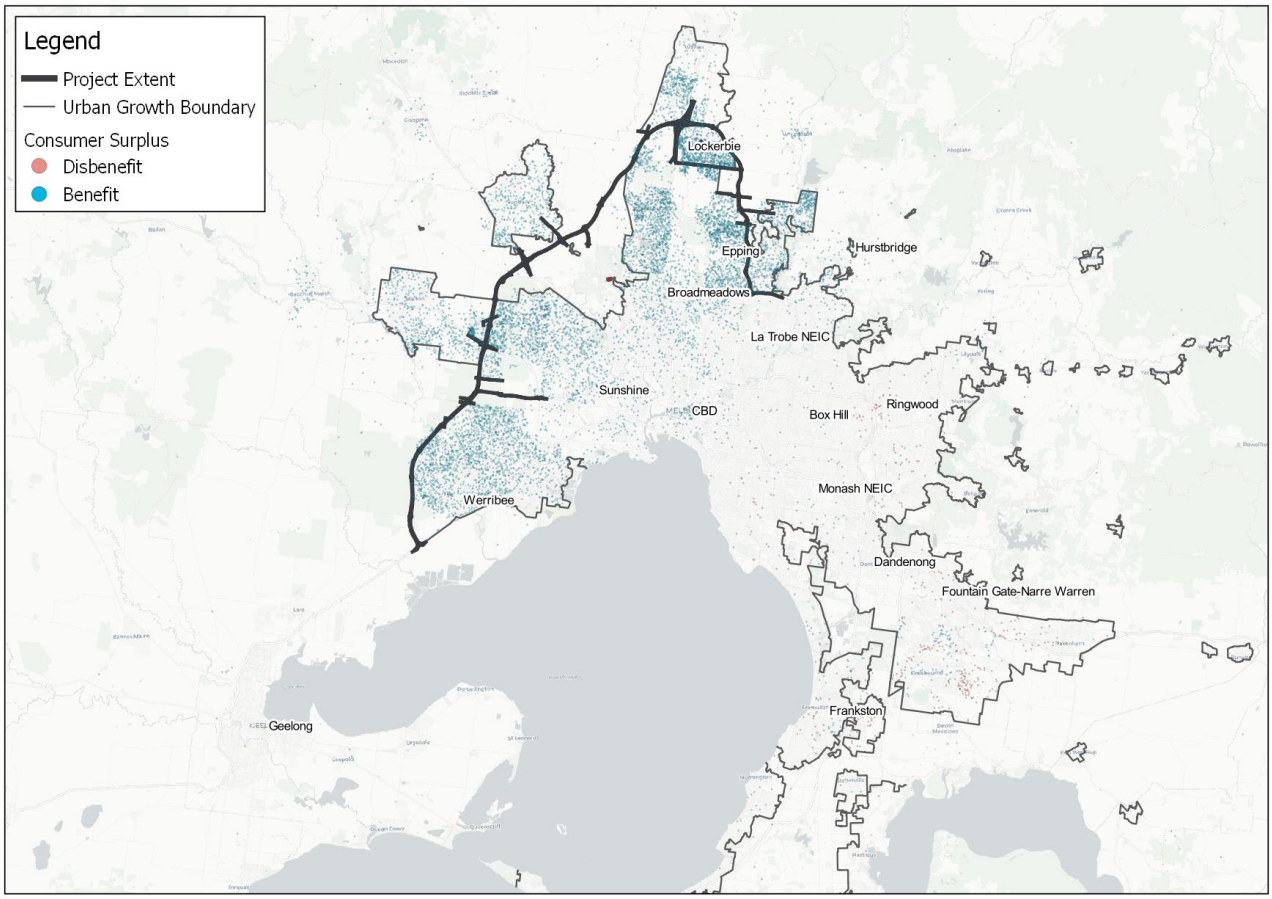
- broader economic benefits
- infrastructure cost changes
- place benefits
- social and health impacts
- environmental impacts.

Broader economic benefits arise through labour productivity improvements driven by greater accessibility, and improved value chains through better freight reliability and speed. These elements are captured by the VLUTI model, which estimates GSP and productivity improvements resulting from this project.[255] The OMR project is estimated to have a positive impact on GSP, increasing by 0.3% in both 2036 and 2051. This is driven by increases in employment in the central city and improved accessibility between the growth areas in the west and north and the CBD. GSP is also an indicator of the project's contribution to welfare and the broader place benefits that would arise.

Figure 89 shows the distribution of consumer surplus benefits across metropolitan Melbourne resulting from the OMR project in 2051. This highlights that the majority of the economic benefits from this project are concentrated in the north and west of Melbourne in areas surrounding the road corridor (blue dots on the map). Parts of the established western suburbs of Melbourne and regional Victoria to the west and north of the OMR alignment also see small benefits from the improved connectivity. Generalised costs increase in the established areas of the inner west and north, and in some parts of Werribee due to increasing congestion and shifts in population to these areas.

[255] *The VLUTI model assumes that total population, households, and jobs in Victoria remain fixed in future under all scenarios, and therefore GSP and productivity improvements do not incorporate any additional jobs and households above this level.*

Figure 89: OMR Consumer Surplus Benefits for Private Vehicles (2051)



Note: This map shows change in total consumer surplus by travel zone, not per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits.
Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

Social Assessment

Transport projects improve access to employment opportunities, education, health care, and community and social services.[256] This can begin to address some of the drivers of disadvantage where increased access is achieved in places where there is transport disadvantage.[257]

The areas served by the OMR are some of the most disadvantaged parts of Melbourne, as measured by the socio-economic index for areas (SEIFA). These areas currently have relatively poor access to jobs through the limited road and public transport networks, particularly in the west. The OMR project improves access from these areas to a greater range of jobs, education and services, including industrial and higher skilled jobs. This includes jobs that are in existing and planned industrial precincts and Melbourne Airport that are along the OMR corridor. The OMR project results in shorter average travel times to jobs in the morning peak for almost all employment centres in the north and west of Melbourne.

In considering the localised impacts of OMR, consideration should be given to:

a) Population cohorts in the area and how it will impact them. It is forecast that there will be an over-representation of younger people in the area, with almost 280,000 people aged 19 and under living along the corridor by 2036, almost a third of the area's population.[258] Being unable to drive, consideration about how this cohort will safely travel to work and study opportunities must be considered in planning for the corridor. This will include managing accessibility to activity centres, schools, and other key social infrastructure including libraries, and sport and recreation facilities to help minimise their interaction with roads and vehicles. When accessing and crossing the motorway, safe pedestrian and cycle crossings points and paths along the road will be needed.

b) Planning the location of local services including social infrastructure, retail, education and aquatic centres including planning for the distribution of facilities, local street and open space networks to help minimise severance issues. There is also the opportunity to plan the location of facilities and crossings of the corridor together to make best use of integrated planning with streets, walking and cycling bridges across the corridor. In particular, planning for a number of very large interchanges, such as between two motorways, will be extremely challenging to link and connect communities. In these areas, the planning and location of community and social infrastructure is critical to minimise the likelihood of social isolation of communities either side of these interchanges.

c) There are a number of areas in proximity to the corridor that do not have a completed PSP, and opportunities exist for the VPA and local governments to prepare and update improved plans that explicitly take the OMR alignment's barriers to non-vehicle movements into consideration, particularly how the location of facilities and street design can reduce the severance impacts of the road.[259] This is specifically relevant to the Merrifield North and Beveridge South West PSPs in the northern growth corridor and also needs to be addressed between the Warrensbrook PSP and the completed Plumpton plan. The VPA could undertake a full review of approved and proposed PSPs along the corridor to ensure any potential impacts can be mitigated. This would include working with other key agencies such as the Department of Education and Training, Department of Transport, and relevant Councils.

d) Consideration of the role, catchments, and services provided at different activity centres, and the modes used to access them. Some town centres are quite close to interchanges, such as those in the Kororoit and Mt Atkinson PSPs. There is an opportunity to shape the design of these town centres and integrated transport access by all modes to help ensure that the interface with busy roads that access the OMR are safe.

e) Consider opportunities to improve other modes, including public transport, walking and cycling, and help mitigate the adverse impacts on roads where traffic movements increase.

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[256] Pope, Jeanette. "The role of infrastructure in addressing regional disadvantage in Victoria." (2019). [website] https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/11/Background-paper_The-role-of-infrastructure-in-addressing-regional-disadvantage.pdf

[257] *Ibid*

[258] Department of Environment, Land, Water and Planning, *Victoria in Future 2019*, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/

[259] https://vpa-web.s3.amazonaws.com/wp-content/uploads/2019/02/PSP-status-map-February-2019.pdf

Environmental Assessment

Like any large scale infrastructure, major transport projects can cause environmental harm and result in the generation of additional carbon emissions both during and after construction.[260] Some impacts can be avoided through spatial planning and design, for example, decisions about route alignment. Unavoidable impacts may require actions for mitigation, including offsets and restoration.[261] Encouraging increased public and active transport use, along with development that occurs close to the train stations, will contribute to better environmental outcomes.[262]

Increasing traffic is expected to result in increasing CO_2 emissions and small particle air pollution if traffic users continue to use internal combustion engines. This can be mitigated with increased uptake of EVs. With many trips on the OMR expected to be longer trips, there is an opportunity to plan for service stations that are capable of fast-charging EVs, including freight vehicles.

The impact of native vegetation removal on biodiversity, as a result of the project, was assessed as part of the Melbourne Strategic Assessment (MSA) which came into effect in 2010.[263] As outlined in the MSA, the proposed OMR and E6 alignment will result in the removal of critically endangered grasslands and grassy woodlands, including habitats for keystone species such as the Golden Sun Moth and Growling Grass Frog.

To result in a net positive gain in habitat for these fauna and flora communities, the OMR should contribute to the purchase of land in the Western Grasslands Reserve and Grassy Woodlands Reserve.[264] To date, land acquisition for these reserves has progressed more slowly than expected.[265] This is likely to result in deterioration of habitats within the proposed reserve, resulting in further uncertainty about the cost of offsetting the environmental impacts of projects assessed in the MSA.[266]

The OMR's alignment through rural and natural landscapes, which includes rivers and major creek valleys, requires consideration of its impact on Aboriginal cultural heritage. The road and rail corridor crosses a number of waterways which are areas of Aboriginal cultural sensitivity and noted as such in the relevant PSPs.[267] Planning for the OMR corridor should include an objective to identify, retain and celebrate Aboriginal cultural heritage, with opportunities to improve community understanding enhanced by potentially providing local access. This could include walking and cycling paths linked to appropriate locations or through architecture for transport structures in the area celebrating indigenous culture.

Waterways can also be impacted by increased and polluted water runoff from large new roads. Non-point source pollution comes from vehicles and road materials, and is also affected by rainfall and surrounding land uses.[268] The Victorian Government is yet to release a final action plan for the *Waterways of the West,* although the discussion paper notes that urban development has contributed to increases in untreated stormwater runoff. Planning for the OMR project should consider impacts on water quality in context of this action plan.[269]

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[260] *Albuquerque, F. D., Maraqa, M. A., Chowdhury, R., Mauga, T., & Alzard, M. (2020). Greenhouse gas emissions associated with road transport projects: current status, benchmarking, and assessment tools. Transportation Research Procedia, 48, 2018-2030; https://www.atap.gov.au/parameter-values/environment/index*

[261] *Department of Environment, Land, Water and Planning (2017) Guidelines for the removal, destruction or lopping of native vegetation, Victorian Government, East Melbourne, https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/91146/Guidelines-for-the-removal,-destruction-or-lopping-of-native-vegetation,-2017.pdf*

[262] *Brand, C., Dons, E., Anaya-Boig, E., Avila-Palencia, I., Clark, A., de Nazelle, A., Gascon, M., Gaupp-Berghausen, M., Gerike, R., Götschi, T. and Iacorossi, F. (2021). The climate change mitigation effects of daily active travel in cities. Transportation Research Part D: Transport and Environment, 93, 102764*

[263] https://www.msa.vic.gov.au/introduction

[264] https://www.msa.vic.gov.au/__data/assets/pdf_file/0032/64787/Biodiversity-Conservation-Strategy-Jun-2013.pdf

[265] Victorian Auditor General's Office (VAGO) Protecting Critically Endangered Grasslands, [website] "https://www.audit.vic.gov.au/report/protecting-critically-endangered-grasslands?section=33498--audit-overview"https://www.audit.vic.gov.au/report/protecting-critically-endangered-grasslands?section=33498--audit-overview [Accessed 13 May 2021]

[266] *https://www.msa.vic.gov.au/melbourne-strategic-assessment-act-2020 "The framework under the MSA Act allows for broad flexibility in setting payment due dates for future stages"*

[267] https://achris.vic.gov.au/#/onlinemap; https://vpa.vic.gov.au/greenfield/

[268] Opher, T., & Friedler, E. (2010). Factors affecting highway runoff quality. Urban Water Journal, 7(3), 155-172

[269] https://www.water.vic.gov.au/waterways-and-catchments/wow

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity of the project's BCR to a range of potential outcomes. This informs the conditions in which a project should or should not go ahead, and how sensitive a project's viability is to changes.

These tests include varying the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the projects opening year and construction start, and increasing the value of travel time in the future. The BCR under each test for the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below.

This project has a BCR above one under most sensitivity tests, except for the following changes:

- 10% discount rate
- 20% increase in capital costs
- 40% increase in capital costs
- 40% decrease in total benefits
- 20% decrease in total benefits.

This suggests the project is susceptible to increases in capital costs or decreases in benefits. Further design and delivery of this project should consider these factors and opportunities to mitigate risks. There are opportunities to further investigate the project scope and alignment to reduce capital costs. The scope modelled for this project had a lot of interchanges which contributes to the high cost and could potentially be reduced without impacting the project's benefits.

Table 35: OMR Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static land use	Dynamic land use	Total (Dynamic land use with WEBs)
4% discount rate	1.3	1.6	1.8
7% discount rate	0.8	1.0	1.1
3% discount rate	1.6	2.0	2.1
10% discount rate	0.6	0.7	0.7
20% decrease in capital costs	1.0 - 1.6	1.3 - 2.0	1.4 - 2.2
20% increase in capital costs	0.7 - 1.1	0.9 - 1.4	0.9 - 1.5
40% increase in capital costs	0.6 - 0.9	0.7 - 1.2	0.8 - 1.3
Exclusion of construction cost escalation	1.1 - 1.8	1.4 - 2.2	1.5 - 2.4
40% decrease in total benefits	0.5 - 0.8	0.6 - 1.0	0.7 - 1.0
20% decrease in total benefits	0.7 - 1.0	0.8 - 1.3	0.9 - 1.4
20% increase in total benefits	1.0 - 1.6	1.2 - 2.0	1.3 - 2.1
Delay opening by 5 years	0.9 - 1.4	1.1 - 1.8	1.2 - 1.9
Delay opening by 10 years	1.0 - 1.5	1.3 - 2.0	1.3 - 2.1
Value of travel time	1.0 - 1.7	1.3 - 2.1	1.4 - 2.3

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: These sensitivity tests are provided for the upper cost and ranges are shown using 4% and 7% discount rates.

Future Scenarios

OMR is considered to be highly resilient to the future scenarios assessed in this report. The project provides significant benefits for road network users (including freight efficiency) and will do so in high and low population growth scenarios. The transport network movements serviced by the OMR do not have competing modes, and as such are unlikely to be sensitive to improved public transport offerings, which are typically providing strong connections along existing corridors to Inner Melbourne, or along the new SRL corridor.

Table 36: Resilience of OMR to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	A high growth scenario would drive greater freight and population growth which would increase demand, benefits, and likely improve the BCR for OMR.	+
Low population growth	Under a low population growth scenario, OMR would still be providing critical movements for freight and employment, and as such while growth is slower, the benefits and BCR are likely to see only minor changes.	~
Working from home	The movements offered by OMR support freight and job types that are less likely to work from home, such as industrial / manufacturing, transport and logistics, and import export sectors. As such, it is unlikely that working from home would reduce the need for the road or diminish the benefits or BCR.	~
Automated and electric vehicles	The EAV scenario sees a more dispersed population, resulting in higher populations of 1% in the Northern FER and 1.9% in the Western FER respectively at 2051. This population dispersion suggests greater use of OMR, and as such consumer benefits could be higher. The modelled network efficiency gains from AVs are pronounced in outer areas of Melbourne, meaning that the transport benefits of OMR could also be higher with AVs, as there is not an existing equivalent road link to OMR. However, there is a high degree of uncertainty around this scenario, and its implications for transport projects, as AVs are still an emerging technology.	+
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, increasing demand for public transport and slowing population growth in growth areas and outer suburbs. This is likely to result in marginal decreases in benefits and a slightly reduced BCR.	~
Transport network pricing	One of the most influential components of TNP for this project are dynamic, demand-responsive tolls applied to the full OMR corridor. This could include higher tolls to manage demand and maximise road efficiency during the peak and lower tolls during quieter periods of the day and during the night, to draw traffic away from local roads and onto the OMR alignment. For Outer Melbourne, transport network pricing can also involve network-wide time and distance-based charges. These can be used to inform drivers through price signals around better times to travel to help manage congestion. It is proposed that this would be introduced through the removal of fixed charges such as registration fees. Such an approach will have a minimal impact on the BCR, but may have a positive affect as it aims to encourage better utilisation of the road across the day making it less susceptible to congestion and flow breakdown.	~

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

Implications

The OMR has vast spatial reach and delivers significant road capacity improvements. It provides exceptional performance in reducing road congestion and better connecting the freight network in comparison to other projects. The project also provides substantial improvements to jobs and labour force accessibility.

Value engineering the corridor

There are opportunities to value engineer the corridor to reduce the overall capital cost of the project, and stage the works required for the road and rail infrastructure. This could include reducing the number of interchanges and grade separations or delaying some interchanges and grade separations, including to align the delivery or design with the rail infrastructure.

This study has assumed two lanes in each direction and future-proofing for four lanes for the entire length of the road. Under the staged approach to construction, there is the potential to deliver lower capacity sections of the road (one lane in each direction, for example) for lower priority sections of the OMR, establishing demand for new freight routes prior to full build-out of the corridor. Future-proofing the road for four lanes in each direction for the entire length may also not be required.

Further opportunities to value engineer the corridor should be studied as part of the OMR staging plan, with further detailed opportunities explored within the detailed business case for the whole corridor.

The E6 corridor should be a priority

Utilisation of the E6 corridor between the M80 Ring Road and Hume Freeway is extremely high immediately after the opening of the freeway, modelled for 2036. The northern end of North East Link expected to be complete by 2027. [270] Following this, the future E6 corridor would provide a high-speed, alternate link for freight and private vehicles to bypass parts of the M80 Ring Road and travel north towards the upper extents of the North SSIP. Construction of the E6 corridor would also reduce reliance on the nearing-capacity Craigieburn Bypass, boosting network resilience, especially for freight. Residential estates in growth areas of Wollert and Epping North also benefit through a more direct connection to both the M80 Ring Road and future OMR phases.

With the full OMR construction complete (modelled to open in 2051), the northern section of the E6 corridor experiences even more growth in demand from freight and private vehicles. This aligns with growth of residential, commercial and industrial areas surrounding the alignment. Benefits to the network are also widespread. No longer do east-to-north freight movements need to travel through the inner city, with North East Link and the E6 corridor connecting to provide high capacity direct access to industrial precincts in Melbourne's outer north. Benefits are experienced downstream of North East Link too, with a reduction in vehicle volumes at the Alexandra Parade end of the Eastern Freeway. Reductions in heavy vehicle volumes are also experienced as far south as the Monash Freeway as a result of the OMR.

The delivery of OMR should generally be staged from the north-east to the south-west, and consider appropriate upgrades to the local road network.

Our strategic assessment identified that some of the greatest demand on completion of the project occurred around the E6 corridor and the connection to the M80 Ring Road. However, sections to the west of the Hume Freeway, linking the north and western growth areas to Melbourne Airport, also experienced strong demand, along with interchanges distributing vehicles between the Calder Freeway and Melton Highway. This project is expected to change travel behaviour along the corridor, and it is critical to ensure local traffic changes to direct OMR-bound traffic on main arterials away from local roads connecting to growth areas in the north and west. This will also assist with the OMR keeping freight on the Principal Freight Network, and away from local communities.

An OMR section to the north-west of Werribee also experiences high demand, inbound into the Deer Park Bypass connector during the AM peak, and outbound during the PM peak. This suggests that while heavy vehicle volumes are using the E6 and OMR north sections, there are also sections along the OMR south alignment that may merit development prior to 2051.

A staging plan will help to address and accommodate for these demand fluctuations across the whole OMR corridor. The plan would identify specific links, especially in the outer west where there are significant gaps in the arterial road network, to align with future growth.

[270] *https://bigbuild.vic.gov.au/projects/north-east-link-project*

Transport network pricing will better utilise the project

There are also opportunities to introduce TNP initiatives to enhance the benefits of this project. This could include congestion management tolls to manage the use of the road and potential flow-on effects to the broader motorway network. This could help the project better achieve its outcomes and prevent new constraints. Congestion management tolls would utilise variable pricing throughout the day to help manage traffic demand and overall flow performance of the freeway. Prices would be set to help manage the number of trips taken during AM and PM peak periods, where demand is highest, and incentivise trips during the interpeak and off-peak periods when there is less traffic. This could further help to alleviate pressure points across the full OMR alignment, such as around Melbourne Airport and the M80 Ring Road section of the E6 corridor, leading to a more efficient project outcome. The combination of lower prices and a high-quality, high-speed link would contribute to drawing traffic away from local communities and local roads, and onto the OMR alignment.

In combination with demand management tolls, full transport network pricing, including reformed public transport fares, parking charges and distance-based charges for road use also have the potential to manage overall demand across the full OMR alignment. Through price signals designed to encourage people to consider changing the time of day, destination, mode or route of their journey, we can prevent worsening congestion and lead to more efficient use of the state's current and future transport investment.

Encourage the use of zero emission vehicles along the corridor

This project is expected to increase car usage and vehicle emissions. As part of a broader strategy to encourage ZEV's, OMR could be an opportunity to encourage ZEV take up and help mitigate the impact of additional emissions from increased car use induced by the project. This will be especially important in the earlier phases, while ZEV uptake is still developing.

As OMR is expected to be used as part of longer cross-city and cross-region trips, there should be well-located fast charging stations across OMR to ensure it is an attractive route for freight and light ZEVs and address concerns about range anxiety. Consideration could also be given to other measures to encourage ZEVs on OMR, including restricting some lanes to ZEVs or applying a cheaper toll for ZEVs, reflecting their environmental benefits of producing less air, carbon, and noise pollution.

ZEVs currently create 20% lower emissions, on a lifecycle basis, than internal combustion engine (ICE) vehicles, and this will only improve in favour of ZEVs as Victoria's energy grid continues to de-carbonise.[271] Transitioning to ZEVs also creates benefits to human health, especially for communities with high vehicle volumes, such as those adjacent to OMR. Infrastructure Victoria has previously estimated that the transition to ZEVs could create health benefits, from avoided mortality and morbidity, of over $700 million annually by 2046.[272] To ensure these benefits are realised, it will be important for major road projects such as OMR to further encourage ZEV use and uptake.

Active transport opportunities

New and upgraded freeway projects often provide a good opportunity to incorporate high quality active transport connections with minimal disruption to existing road space. The North East Link project is an example of this, including over 25km of new and upgraded walking and cycling paths.[273] Walking and cycling trails can be located close to existing road reserves, utilising space along the corridor and smaller number of interchanges along the freeway's alignment, when compared to conventional arterial roads.

Similar to the M80 trail, a shared use path for pedestrians and cyclists delivered along the full M80 Ring Road,[274] construction of the OMR presents an opportunity to integrate a trail along the full, or key sections of the proposed alignment. Given the gentle and largely flat topography of the outer north and west, this is likely to appeal to a broader catchment of cyclists, avoiding the substantial physical effort and loss of travel time cycling up hills.[275] The OMR trail would help to connect town centres along the corridor, as well support active transport use in new growth areas. The trail could potentially facilitate improved cycling and walking access to future schools and sporting facilities, along with connections to where people work, shop and socialise in the outer north and west.

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[271] *Infrastructure Victoria (2021),* Driving down emissions: accelerating Victoria's zero emission vehicle uptake*)*

[272] *Infrastructure Victoria (2018)* Automated and Zero Emissions Vehicles Infrastructure Advice

[273] *https://bigbuild.vic.gov.au/projects/north-east-link-project*

[274] *https://www.vicroads.vic.gov.au/traffic-and-road-use/cycling/bicycle-network-planning*

[275] *Vandenbulcke, I Thomas et al. Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium, Transport Policy, Volume 16, Issue 2, 2009, pp. 77-87.*

Maximise the project's interaction with surrounding land uses

Strict enforcement of the current urban growth boundary will prevent urban development occurring beyond the project's alignment. This is key to controlling inappropriate land uses on environmentally sensitive green wedge land and in farming areas. The project risks accelerating land banking by developers in these areas in anticipation of improved accessibility.

Residential development will occur in precinct structure plan areas adjacent to the project. Areas without existing plans and those with them should be reviewed to consider the appropriate location of and residents' access to activity centres, schools, libraries, sports and recreation facilities and other social infrastructure. Severance of access because of the project should be addressed through safe pedestrian and cycling routes and crossing points, the integrated transport mode design of local street networks and connections using the open space network.

When delivering intermodal terminal facilities near the OMR corridor it is important to change land use planning settings early to protect terminals from encroaching on residential development. Surrounding land should be secured as incompatible development nearby to these industrial precincts can lead to delays and high future land acquisition costs.

Grow state-significant precincts and identify opportunities to access centres with a range of transport modes

Consideration should also be given to supporting jobs growth in SSIPs, which may benefit from this project. These are places with low job density that are primarily accessed by car and would benefit from the OMR. These largely industrial-based jobs will continue to be important for the state's economy and freight movements.

Consideration should also be given to implementing rapid bus services to connect the northern growth areas with the airport, Latrobe NEIC, Sunshine NEIC and other key activity centres in the west, with some of these routes potentially being on the OMR. This will support greater public transport use.

Our assessment shows an increase in jobs growth in Inner Melbourne because of improved access with reduced congestion. This could increase demand for car parking if private vehicle trips also increase. This could be a problematic outcome given the existing investment in public transport (and growing active transport investment) to support access to Inner Melbourne.

Infrastructure planning must continue to minimise impacts on significant cultural and environmental landscapes

Consideration should be given to minimizing the impacts to the environment as much as possible. Environmental offsets need to be acted on as early as possible to account for loss of natural grasslands and biodiversity areas. Desktop analysis in 2009 found that approximately 3,225 hectares of plains grassland and 300 hectares of plains grassy woodland would be required for offsetting for this project. A full offset plan will need to determine the exact area and sites appropriate to be counted towards offsets. It is also highly likely to affect two threatened ecological communities listed under the Flora and Fauna Guarantee Act, 1988 but the exact areas of those communities would need to be investigated.[276] As VAGO has recommended, DELWP needs to accelerate acquisition and preservation of the 15,000 hectare Western Grasslands Reserve to avoid increasing costs as a result of increased land value and additional restoration required due to ecological degradation.[277] Options for other local tree planting and open space provision should also be considered to mitigate the impacts on new residential communities.[278]

The project should also consider how it can appropriately address and minimise impacts on Aboriginal and other cultural heritage areas such as rivers and major creek valleys. To date, no project-related field investigations have taken place, with desktop analysis relying on heritage registers, available histories and existing heritage reports about the affected areas and ethno-historical accounts of Aboriginal presence. No comprehensive model of Aboriginal site distribution has been developed, but additional sites may exist given the landforms such as elevated areas adjacent to swamps, land adjacent to ephemeral water sources, eruption points and basalt plains. A total of 100 known non-Aboriginal cultural heritage sites and overlays are also within close proximity of the project. Further ground proofing and assessment will be required.

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[276] *Brett Lane and Associates (2009) Outer Metropolitan Ring Road and E6 Transport Corridor. Flora and Fauna Desktop Report. Report prepared for VicRoads*

[277] *Victorian Auditor-General's Office (2020)* Protecting Critically Endangered Grasslands. *Independent assurance report to Parliament 2019-20:16*

[278] *Andrew Long and Associates (2009) Outer Metropolitan Ring (OMR) Transport Corridor. Cultural Heritage Desktop Study. Report prepared for VicRoads*

Relevant Recommendations in Victoria's Infrastructure Strategy

Recommendation 66: Construct an outer metropolitan road and rail corridor

Victoria's infrastructure strategy recommends that within two years, the Victorian Government should determine staging for the outer metropolitan rail and road corridor. Subject to detailed business cases, commence construction of priority sections, starting with the E6 motorway by the end of this decade. Progressively stage corridor development for completion in the next 30 years. Provide a freight rail link to coincide with the opening of the Western Intermodal Freight Terminal.

Recommendation 65: Deliver a new intermodal freight terminal for Inland Rail

Victoria's infrastructure strategy recommends to immediately determine the preferred new intermodal terminal and facilitate its delivery, transport links and the surrounding precinct to operate soon after the Melbourne to Brisbane Inland Rail project is completed. Progress planning for another intermodal freight terminal and precinct, and secure necessary land.

Recommendation 64: Act now to protect the future Bay West Port option

Victoria's infrastructure strategy recommends to immediately identify and secure land and apply planning protection for transport corridors and buffers for a future Bay West Port, particularly for future road and rail connections. Monitor and report on the triggers to develop a new port and commence and continue environmental assessment and monitoring. Around 2040, begin detailed planning

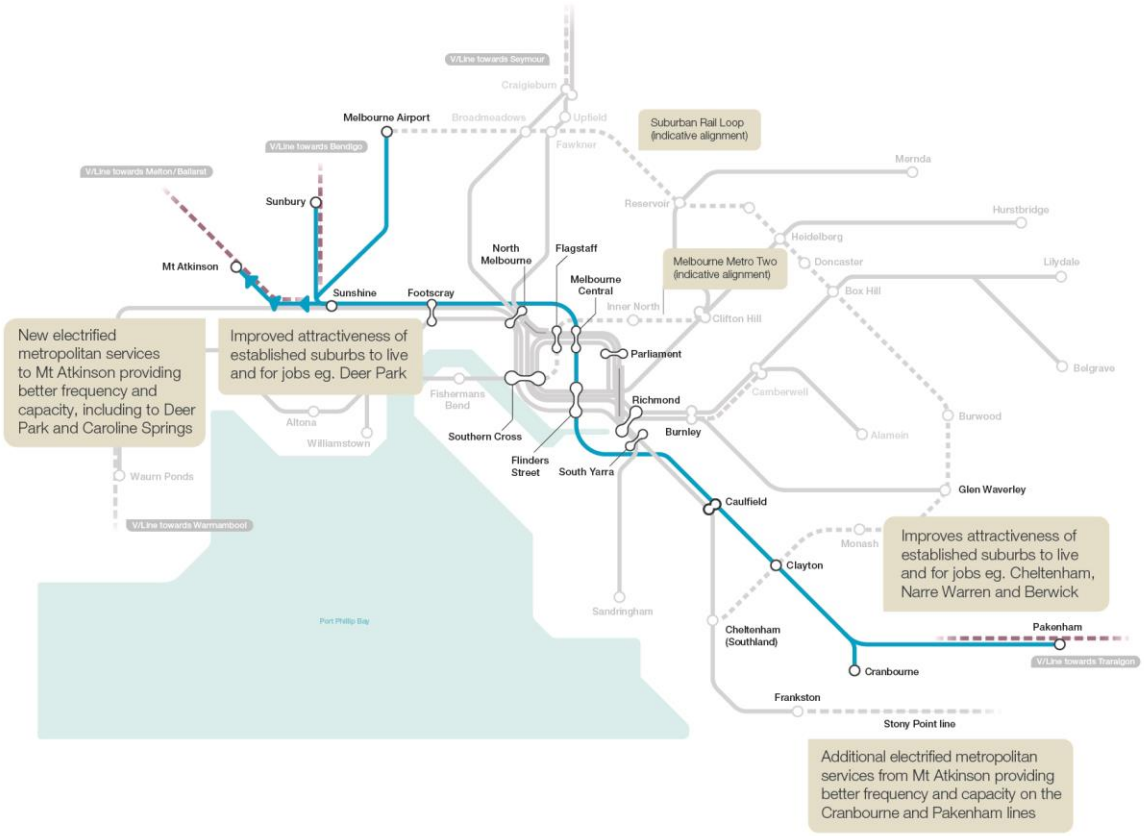
4.7 Western Rail Corridor Upgrade

Objectives

The Western Rail Corridor Upgrade project (WRU) will provide a metro-style train line for growing communities in the western growth corridor, including Melton LGA, as well as provide similar services in the south-eastern growth corridor, including Casey LGA and Cardinia LGAs. These LGAs are among Victoria's fastest growing, and the current V/Line services are insufficient to meet future commuter needs.

Planning for the WRU project will help prepare for population change in growth areas and reduce disadvantage by providing critical train network capacity to enable access to jobs and opportunities, and other key destinations.

Figure 90: Benefits of WRU



Source: Infrastructure Victoria Visualisation of Project Specification (2021)

This project is expected to support the following objectives of *Victoria's infrastructure strategy*:

- **Objective 1:** Prepare for population change by providing strong transport connections and additional capacity to support growing travel demand in growth areas in Melton LGA.
- **Objective 3:** Reduce disadvantage for communities in the local government areas of Melton, Casey and Cardinia by providing more frequent metropolitan train services for these communities.
- **Objective 4:** Enable workforce participation by providing transport connections to employment clusters in Dandenong, Monash, Inner Melbourne, Parkville, and Sunshine, providing access to training and a range of secure work opportunities.

Need

Strong population growth in the west and south-east growth areas of Melbourne

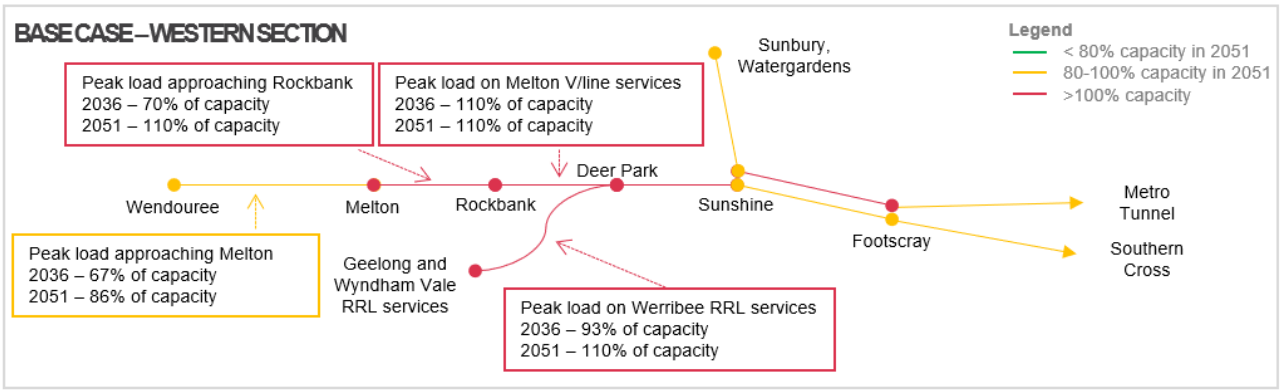
The growth area in the Western Growth Corridor, particularly the Melton LGA, will experience significant population growth, projected to grow from 180,000 residents in 2021 to 470,000 by 2051.[279] This population growth will lead to significant growth in travel demand for new residents, as jobs growth is not expected to match population growth in these areas, driving residents to commute to employment clusters, NEICs, and the CBD to access study and employment.

Similarly, the growth area in the south-eastern growth corridor, particularly the Casey and Cardinia LGAs, will experience significant population growth, projected to grow from 500,000 residents in 2021 to 700,000 by 2051.[280] It is estimated that in the 2040s there will be insufficient capacity on Cranbourne/ Pakenham train services to meet demand.

Bacchus Marsh and Melton V/Line train services projected to be full in coming years

V/Line train services originating from Bacchus Marsh and Melton are expected to exceed capacity even with new higher capacity regional trains,[281] due to the significant growth forecast in the Western Growth Corridor. Public transport demand is expected to recover from the COVID-19 pandemic in the medium to long term, with passenger demand expected to peak at 110% of capacity before 2036. There will be insufficient capacity on Melton and Bacchus Marsh services to meet the significant passenger demand emerging at new stations between Melton and Rockbank. This crowding, which occurs in the morning peak on inbound services, will restrict public transport use in the fast-growing Melton LGA, increasing car dependency and limiting access to jobs, study, and a broader range of destinations.

Figure 91: Passenger crowding levels on Ballarat, Bacchus Marsh, Melton, and Metro Tunnel train services, 2036 and 2051 Transport Base Case



Source: ARUP AECOM modelling (2021), Infrastructure Victoria visualisation

Cranbourne / Pakenham corridor train services projected to be overcrowded in the early 2040s

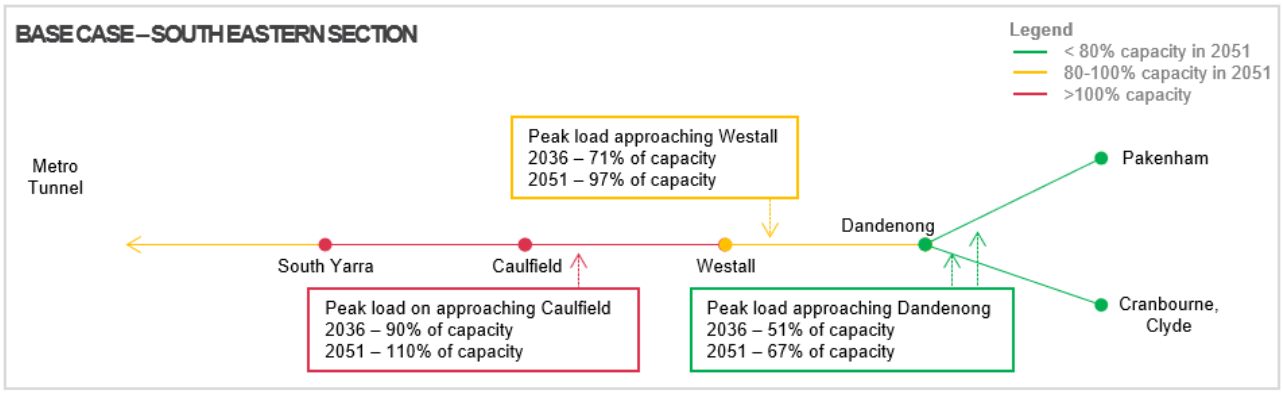
The Metro Tunnel Project will deliver significant capacity uplift to passengers on the Cranbourne / Pakenham corridor, providing sufficient capacity to accommodate a growing population and demand for services in Casey LGA and Cardinia LGA beyond 2051. This growth will put pressure on sections of the corridor between Westall and South Yarra, which will experience overcrowding in the early 2040s, as shown below in Figure 92.

[279] *DELWP 2019 Victoria in Future Population Projections*

[280] *DELWP 2019 Victoria in Future Population Projections*

[281] *The Victorian Government in the 2021-22 Budget announced the development of regional trains with higher capacity to serve the Melton and Wyndham Vale lines. Whilst details of this service is yet to be developed, the modelling undertaken for this study has assumed that the capacity of current regional services has been increased by 50%.*

Figure 92: Passenger crowding levels on Cranbourne/Pakenham Corridor Metro Tunnel train services, 2036 and 2051 Transport Base Case



Source: ARUP AECOM modelling (2021), Infrastructure Victoria visualisation

Project Description

The WRU project incorporates upgrades to the Melton corridor associated with electrification from Sunshine to a new station in the vicinity of Rockbank and the proposed Mt Atkinson Major Activity Centre at Hopkins Road by 2036. This project will support an increase in the number of train services departing from the Melton corridor. Additional Pakenham and Westall train services will also support patronage growth in Melbourne's Southern FER. The services operating from the new Mt Atkinson station will be High Capacity Metro Trains (HCMT), which will operate through the Metro Tunnel.

The WRU project seeks to increase rail capacity for growing communities in the Melton, Casey, and Cardinia LGAs. It recognises that the Melton LGA is among Victoria's fastest growing, and that the current V/Line service is insufficient to meet future commuter needs.

The WRU train services originating from Mt Atkinson / Hopkins Road will also enable Bacchus Marsh, Melton and Ballarat RRL V/Line train services to run express through Caroline Springs, Deer Park, and Ardeer stations (RRL train services) improving operational performance and reliability of these V/Line services.

Significant capital works required to support delivery of the WRU

This project has two sections of capital works, including:

- *Sunshine to Mt Atkinson:* A new station would be built at Mt Atkinson / Hopkins Rd including building 13 kilometres of new twin track, adjacent to the existing V/Line tracks. The work also encompasses the electrification of two tracks, road and rail junction works at Sunshine, upgrading of Deer Park and Ardeer Stations including relocation onto the electrified pair of tracks, and a bridge over Kororoit Creek.
- *Pakenham line upgrades:* This component would include new substations and power upgrades, communications and signalling upgrades, predominantly between Westall and South Yarra Stations, allowing for additional services along the line to Pakenham.

In addition to the opening of the Metro Tunnel Project, there is recognition that major station redevelopment at Sunshine Station with significant track realignment will be required to support the future growth of metropolitan, V/Line, and freight train services. As such, while this project includes costs related to the above works, it is recognised that other rail projects will play an important role in the scoping of these works, which are critically interdependent to WRU.

Figure 93: WRU Alignment

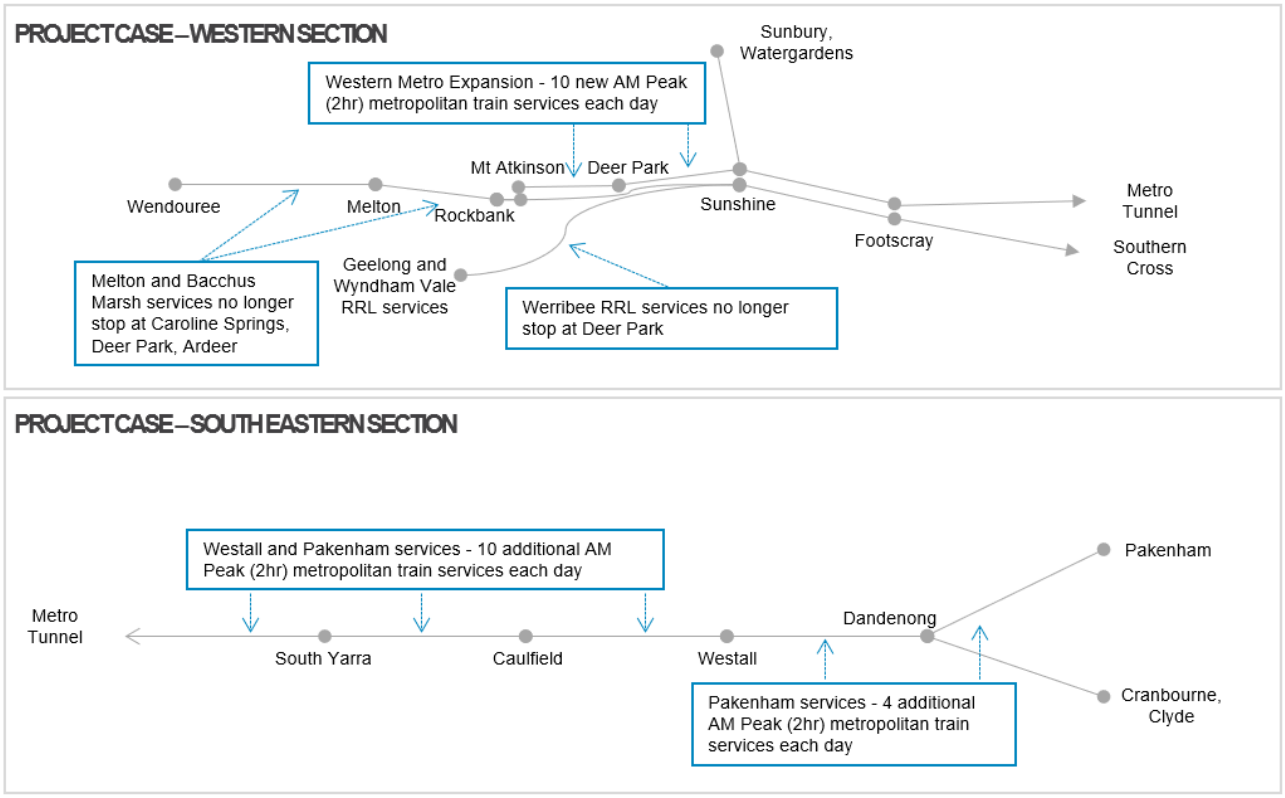
Source: Arup 2021

Additional train services during peak periods originating from Mt Atkinson / Hopkins Rd, Pakenham and Westall

These works are expected to result in significant changes to network services and capacity, supporting an additional 20 peak hour metropolitan train services in 2036, and the use of HCMT trains which will almost double the capacity of each service for train passengers at stations from Hopkins Rd / Mt Atkinson to the CBD as shown below in Figure 94. In addition, regional train services originating at Bacchus Marsh and Melton will no longer stop at Caroline Springs, Deer Park and Ardeer, while services originating on the Wyndham Vale line will no longer need to stop at Deer Park.

A new station at Mt Atkinson / Hopkins Rd was modelled as the terminus for suburban services for this project, as it is proposed to be a major activity centre and therefore a destination station with major interchange. However, further studies need to be undertaken to determine where the terminating station should be with consideration of the different loads between V/Line and suburban services.

Figure 94: WRU service frequency changes (2036 and 2051) – inbound AM peak



Source: Analysis of Arup 2021 Strategic Modelling Outcomes

Project Costs and Timing

The total estimated cost of WRU, inclusive of contingencies, 50-years renewal costs and operations and maintenance costs (O&M) are shown in the table below.

Total capital expenditure cost is estimated to range between $1.9 billion and $2.8 billion (in 2020 values). Key components of this cost include overhead wiring, trackwork, bridges and signalling. The cost of providing rolling stock is also included. The train fleet will comprise 12 sets of High Capacity Metro Trains (HCMT), which would be procured over three years. Contingencies for design, construction and prolongation have also been included in the total cost.

Construction has been assumed to start in 2031, and expected to be completed in 2035, with the project operational from 2036.

Table 37: WRU capital expenditure cost profile (2020 dollars)

Project	Lower Capex ($m)	Upper Capex ($m)
WRU	1,887	2,829

Source: Infrastructure Victoria 2021 Major Transport Program Capital Cost Report

Note: Sunshine Station and Precinct are subject to works in relation to a number of projects in development and in delivery, and as such it is assumed that significant reconfiguration works have been undertaken either as part of other projects or as a standalone project in itself. The extent to which significant works are required at Sunshine Station would need to be investigated as part of further project development, which would consider all interdependent projects and works planned to deliver them. It is assumed that Sunshine Station and Precinct has been reconfigured.

Multi-criteria Analysis

The project performs strongly in reducing public transport crowding – reducing the ratio of crowded travel to total travel on rail due to the strong growth on the western corridor, and subsequently the south-eastern corridor.

As the project is mainly a capacity upgrade rather than an introduction of a new alignment (like MM2G and OMR), there is little change in access to jobs or labour force by 2051. In most cases, there is little change in accessibility to labour force for businesses – one of the factors influencing this is likely more residents moving further out into growth areas that receive a service uplift, rather than into established areas. While these residents benefit through public transport service uplift, their improved services counterbalance the fact that they may now be travelling further. The project does provide a small improvement in access to jobs for workers in 2036.

The project has a low impact on freight in comparison to the other projects and was not assessed against freight connectivity or freight utilisation given it does not provide any new freight network links.

Mild reductions in vehicle emissions in 2051 as a result of reduced vehicle travel is also experienced in the project case. It should be highlighted that in 2036, the project performs strongly in reducing vehicle emissions, likely attributable to the immediate benefits of public transport uplift and smaller population redistribution to the outer suburbs compared with 2051.

Table 38: WRU MCA results 2051

Transport Challenges	*Challenge 1*			*Challenge 2*	*Challenge 3*			*Challenge 4*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased accessibility to jobs	Increased access to labour force	Reduced freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
Western Rail Upgrade (WRU)	L/M	H	~	~	L	~	~	L

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes Report

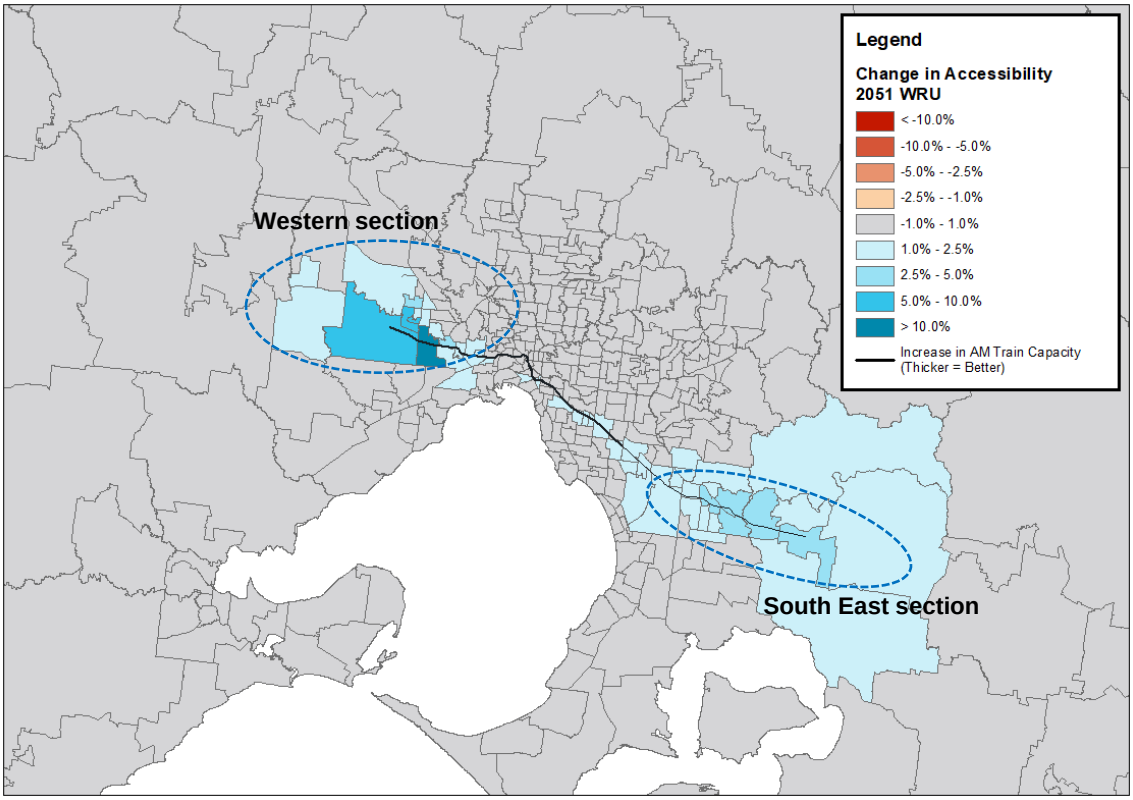
Transport Outcomes

The WRU is expected to improve public transport access for residents in growing outer suburbs in the Melton, Casey and Cardinia LGAs. Overall, WRU supports the growing demand created by population increases in growth areas, providing access to jobs, study opportunities, and reducing social disadvantage. The following sections explore the transport outcomes for WRU for public transport and road network impacts.

Public transport

The WRU is expected to attract an additional 1.1 million annual public transport users in the morning peak period in 2036 across the Western and Southern FERs, growing to almost 1.9 million annual public transport trips in the morning peak by 2051. This represents a 4.8% increase in public transport users in the Western FER, and a 2.8% increase in public transport users in the Southern FER. This is due to changes in capacity that alleviates overcrowding and improves accessibility, as a result of residents in the affected areas having access to improved transport options as shown below in Figure 96.

Figure 95: WRU impact on access to jobs from place of residence in 2051 (AM Peak)



Source: AECOM 2021 Transport Modelling Scenarios - Economics Report

Impact of new services originating on the Melton Corridor

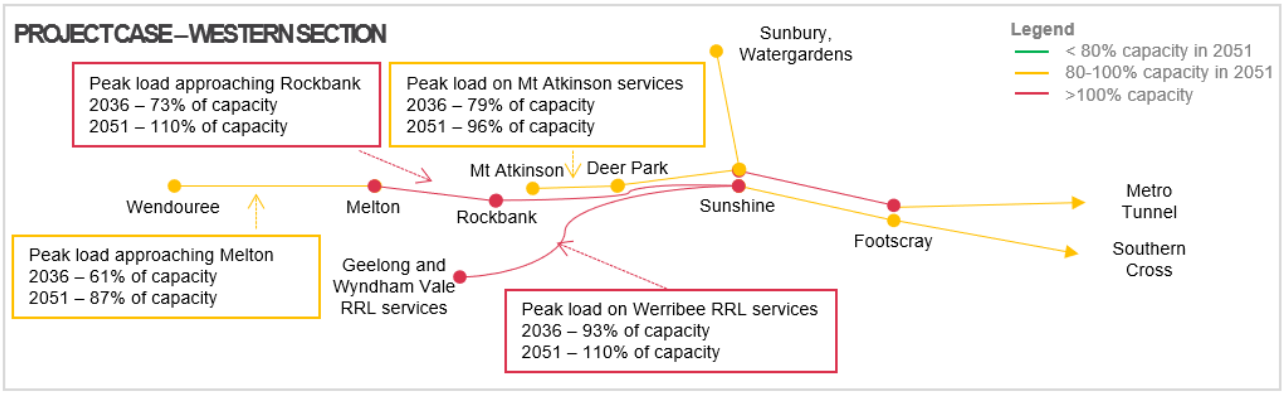
The WRU will offer 10 new morning peak (2 hour) high capacity metropolitan train services for passengers, stopping at all stations to Footscray, and then using the Metro Tunnel to Pakenham as shown below in Figure 96. In 2036, this new service will operate at 78% of capacity, and growing travel demand will see this capacity utilised at 96% by 2051. The introduction of this new service attracts residents who live between the Melton and Sunbury railway lines who previously used Ballarat V/Line and metropolitan services originating on the Sunbury / Watergardens corridor.

By 2051, the Mt Atkinson / Hopkins Road train services result in a small reduction in crowding to Sunbury (still at 100% capacity) and Watergardens (reduced from 95% to 89% capacity). Ballarat, Bacchus March and Melton services will experience significant public transport congestion relief in 2036, with utilisation dropping from 110% on services departing Rockbank to 73%. This relief is short lived, and by 2051 utilisation has again risen to 110% of capacity. Services will be overcrowded when departing Rockbank, but service patterns will be modified to reflect this, by not allowing boarding at stations at Mt Atkinson / Hopkins Rd, and expressing from Mt Atkinson / Hopkins Rd to Sunshine (this timetable change would occur simultaneously with the opening of WRU).

In both 2036 and 2051 this project supports travel demand arising from the population growth forecast for the Western Growth Corridor, including Melton LGA. These services, which run via the Metro Tunnel to Pakenham, have sufficient capacity to accommodate future growth in demand for public transport for a few years beyond 2051. They will provide direct access to jobs and study opportunities in the CBD, the Monash NEIC and the Dandenong NEIC.

By 2051, existing services become overcrowded when departing Cobblebank station (110% of capacity), resulting in limited boarding opportunities for passengers at Toolern East (new station), Rockbank, and Caroline Springs, in addition to Deer Park and Ardeer. These stations will not be serviced by the new metropolitan service (crowding levels shown in Figure 96). These levels of crowding, expected between 2040 and 2050, suggest that further infrastructure investment is required, such as high capacity regional trains or extending the electrification out to Melton and should be investigated further.

Figure 96: Passenger crowding levels on Ballarat, Bacchus Marsh, Melton, and Metro Tunnel train services, 2036 and 2051 WRU Project Case

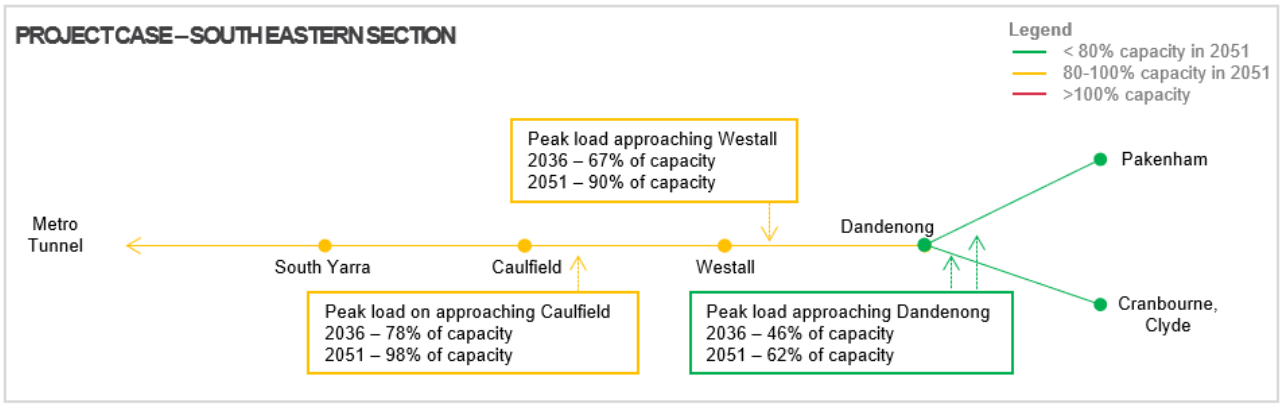


Source: ARUP AECOM modelling (2021), Infrastructure Victoria visualisation

Impact of additional services on the Cranbourne / Pakenham Corridor

The additional services on the Cranbourne / Pakenham Corridor are expected to reduce overcrowding, including between Westall Station and South Yarra Station, which was projected to be overcapacity at some point between 2036 and 2051. The new services will be approaching capacity by 2051, when services departing Westall Station will be at 98% capacity.

Figure 97: Impact of additional services on the Cranbourne / Pakenham Corridor, AM peak



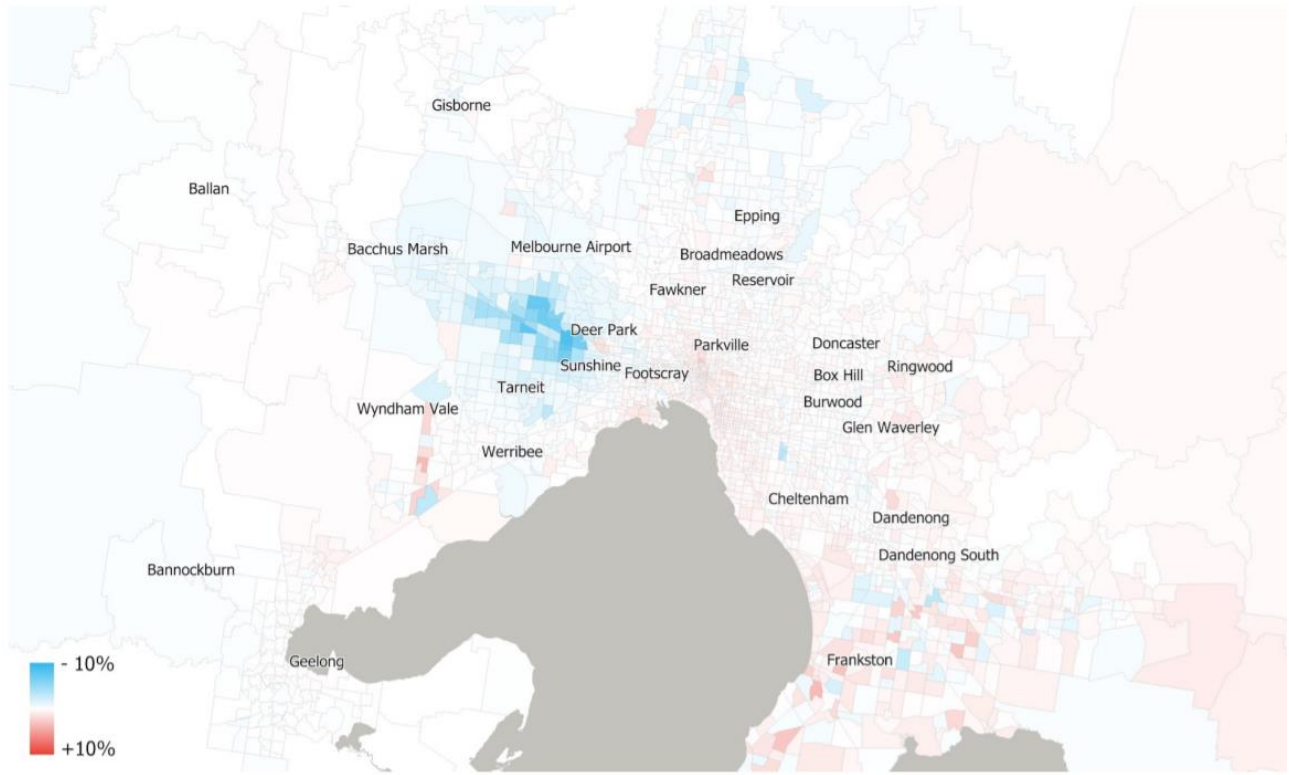
Source: ARUP AECOM modelling (2021), Infrastructure Victoria visualisation

Private car transport

WRU is forecast to provide improvements in travel times for private vehicles, particularly in the western corridor. There are appreciable travel time savings for areas between Melton and Sunshine. Whilst these may appear modest compared to CLR and MM2G, they are appreciable compared to most other public transport projects, including those that are smaller in scale.

The project results in some Victorian households relocating into the Western and South-Eastern Growth Areas, as discussed in the following section. While working residents may catch the train, there are others in the household that may increase the number of private vehicle trips in those local areas as they may use private vehicles to get to work and for other trip purposes.

Figure 98: WRU change in private vehicle travel time, 2051 WRU vs transport base case (AM peak)



Source: Arup 2021 Strategic Modelling Outcomes report

Demographic Outcomes and Land Use Implications

Population

In general, the WRU project attracts more people to live in growth areas rather than established areas. This project results in population uplift along the Melton line, in the west, and along the Pakenham line, in the south-east, where service and station improvements occur. Places experiencing greater improvements in transport accessibility are likely to become more attractive places to live. This results in more population relocating to the outer south-eastern and western suburbs, including in the new western growth areas of Mt Atkinson and Rockbank. There are PSP areas along the Sunshine to Melton rail corridor (currently outside the metropolitan train network) which will have greater capacity with the introduction of high capacity trains and metro frequency services.

The project also provides the capacity to accommodate population growth in established suburbs along both lines, where growth is currently limited by lower transport accessibility. For example, the project significantly helps to improve the potential for population growth in the western suburb of Deer Park, which is currently serviced only by V/Line services (see Figure 99). In the transport base case, this area is projected to lose population between 2018 and 2051, whereas with the WRU project, its population grows. To gain the full benefits, land use planning should be integrated with transport planning at an early stage to ensure that more homes can be located close to the station, while identifying opportunities for further local community benefit from the project.[282]

The project will likely result in further opportunities to increase density and housing diversity in other established middle and outer suburbs, such as Sunshine, which is identified as an NEIC, and Dandenong, a Metropolitan Activity Centre in *Plan Melbourne*. Additional population growth in the south-eastern corridor does extend to beyond Pakenham, but is more concentrated in established outer suburban areas between Officer and Hallam, and between Dandenong and Springvale.

Given the extent of projected and additional population growth because of the WRU project, a proportion of new growth area residents will use 'park-and-ride' facilities to access the improved train services. Some stations may have land uses that could be suited for car parking, but at other stations large areas around train stations allocated to 'at grade' car parking may be a poorer outcome compared to other land uses such as mixed-use or commercial spaces. Attractive options to get to stations using other modes including active transport, personal mobility modes and buses are important to help alleviate the pressure on car parking and reduce local congestion.

Jobs

As shown in Figure 100, the project is unlikely to have a large impact on the location of jobs across Melbourne in 2051. In the case of suburban jobs, some small increases in population-serving jobs occur along the corridor where population increases, such as in proximity to Fountain Gate. Figure 100 also highlights some benefits to additional employment in existing job clusters in Dandenong and Sunshine. The greatest uplift occurs in Inner Melbourne which benefits from improved accessibility and consequently larger workforce catchments. This is concentrated in the CBD and around the Parkville NEIC. However, these changes are proportionally small when compared to the underlying rate of growth forecast by the transport base case.

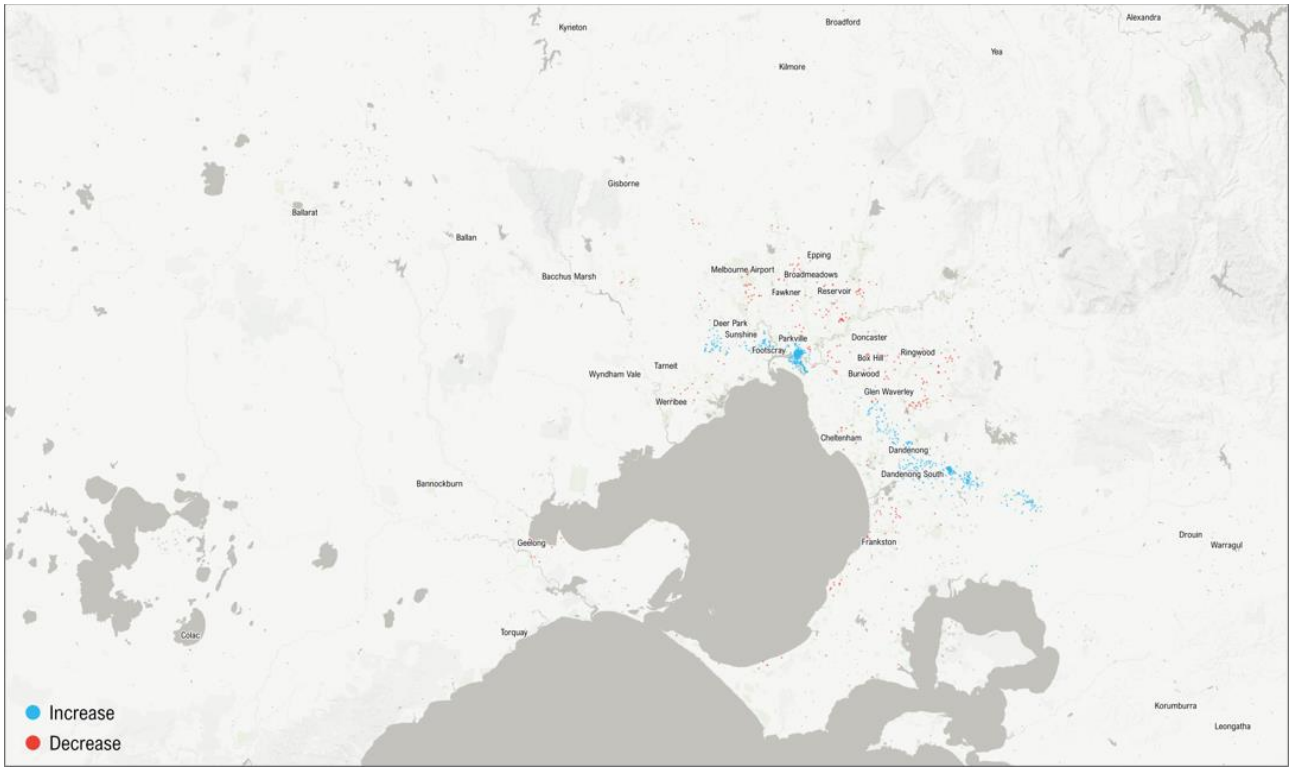
It is notable that Cobblebank, a greenfield Metropolitan Activity Centre southeast of Melton, experiences little increase in jobs. This is because as modelled in this assessment it remains serviced by V/Line services. The WRU project reaches capacity by 2036 and a subsequent project to meet demand may result in service improvements, including to Cobblebank, which may produce a different result for Cobblebank.

[282] *Infrastructure Victoria Density Done Well engagement*

Figure 99: Population changes due to WRU compared to transport base case, 2051

Source: Arup 2021 Strategic Modelling Outcomes report

Figure 100: Employment changes due to WRU compared to transport base case, 2051



Source: Arup 2021 Strategic Modelling Outcomes report

Economic Assessment

Cost benefits analysis

The table below presents a summary of the estimated benefits from WRU, using a discount rate range of 7% and 4%. The largest benefit category is consumer surplus benefits, which includes the travel time savings for public transport users, including private vehicle users who switch to public transport. Safety, environmental and active transport benefits are positive given the increase in public transport usage and contribute approximately 5% to the total benefit.

Table 39: WRU Benefits (Present Value $ million)

Benefit	Static land use	Dynamic land use	WEBs only	Total
Consumer surplus benefits	$2,841 - $7,095	-$2,416 – -$841		$2,000 - $4,679
Active transport benefits	$137 - $342	$12 - $25		$149 - $367
Safety benefits	$10 - $34	-$50 – -$155		-$40 – -$121
Environmental benefits	$11 - $30	$13 - $23		$24 - $53
Residual values	$5 - $33	$0 - $0		$5 - $33
WEBs			$936 - $2,162	$936 - $2,162
Total benefits	**$3,004 - $7,535**	**-$2,523 – -$866**	**$936 - $2,162**	**$3,074 - $7,174**

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: The 'headline' ranges provided using 7% and 4% discount rates

Quantified benefits

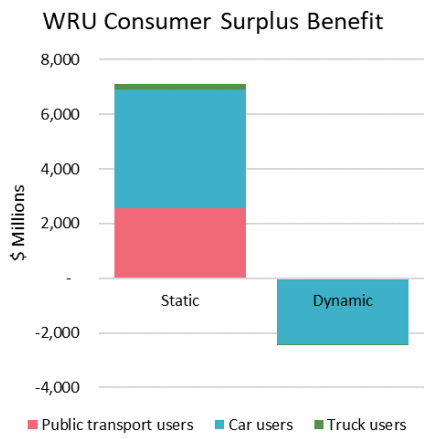
Total benefits of this project are made up of *static land use*, *dynamic land use* and *WEBs*. The *static land use* benefits represent the estimated conventional transport benefits arising from this project, without any changes to the location of population and jobs. The *dynamic land use* benefits arise from changes in the location of population and jobs caused by the project.

Dynamic land use benefits are negative for this project. This is due to more people moving to the New Growth Areas and Outer Melbourne because of the improved public transport accessibility in the western and south-eastern growth areas. This results in an increase in both public transport and private vehicle trips from the population living in these areas. These areas such as Melton, Narre Warren and Pakenham are slightly more congested and therefore have negative impacts to the generalised costs for car users.

The dynamic land use benefits in this economic assessment only consider the benefits from changes to generalised costs (travel times). People who move further out due to the improved accessibility and other amenity factors will not have a quantifiable transport benefit as their travel costs may not change. They will however receive a benefit from improved wellbeing arising from factors other than transport, such as more affordable housing or better residential amenity. This benefit has not been quantified in this analysis and further research is required to determine an approach to estimating it.

Figure 101 shows the consumer surplus benefits under static and dynamic land use outcomes for public transport users, car users and truck (freight) users. This highlights that congestion relief benefits to car users contribute almost two thirds of the static land use benefits, followed by public transport users. It also shows the disbenefit arising under the dynamic land use outcome for car users.

Figure 101: WRU Consumer Surplus Benefits for Static and Dynamic Land Use Outcomes

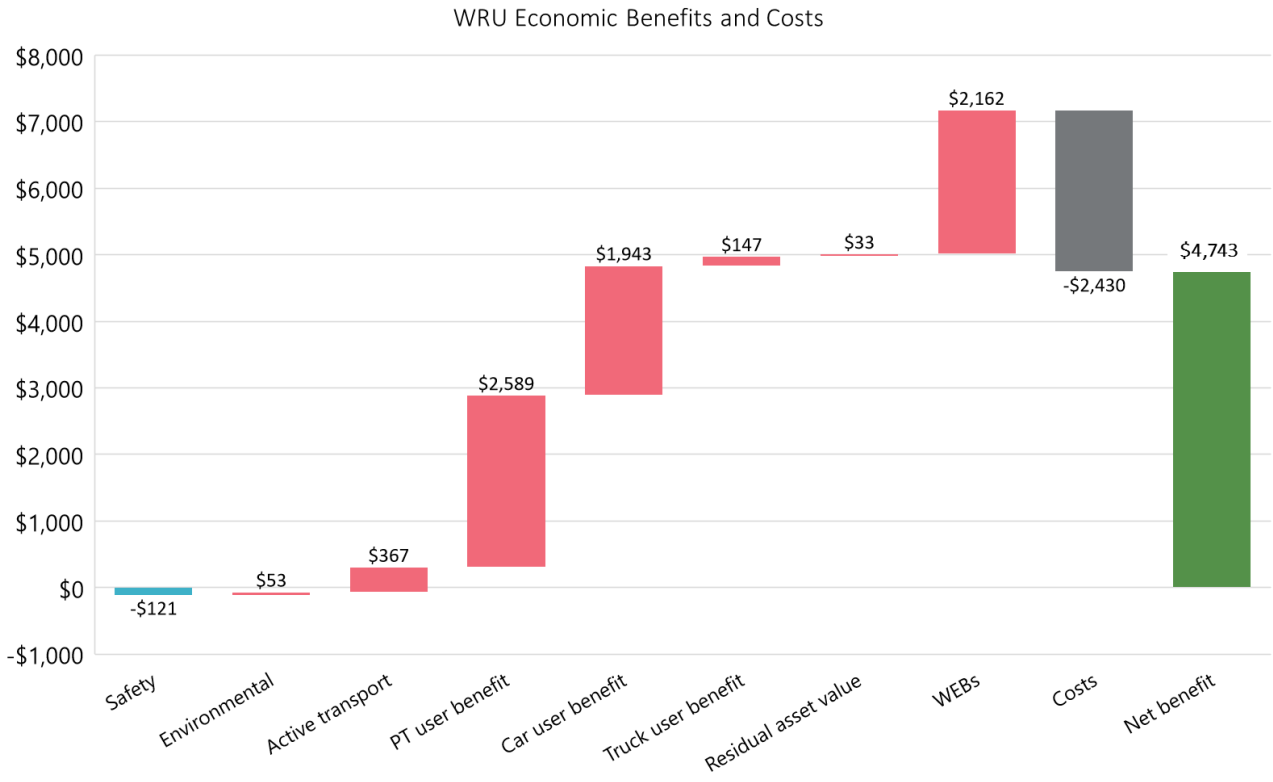


Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Results presented using 7% discount rate, showing present value in millions. This is one of the assessments within the reported headline range of the economic assessment results.

WEBs make up 30% of the total benefits of this project. This is driven by an increase in employment in the central city, and improved connections between outer / growth areas and the central city. Agglomeration benefits contribute the largest amount, arising from the productivity improvements from increased density and accessibility of jobs.

Figure 102 shows the economic benefits of this project compared to the total estimated cost in present value terms. This shows the large contributions from public transport users, car users and wider economic benefits to the total benefit. It also highlights that the benefits are expected to be greater than the cost of this project in present value terms, indicating this project will generate a net community benefit.

Figure 102: WRU Economic Benefits and Costs (Present Value $ millions)



Source: Analysis of AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Total dynamic land use plus WEBs results presented using lower project costs and 4% discount rate. This is one of the assessments within the reported headline range of the economic assessment results.

Summary cost benefit analysis results

Summary results from the cost benefit analysis are shown in the table below for upper and lower project costs using a 7% and 4% discount rate. This analysis includes all the quantified benefits outlined above and excludes non-monetizable economic benefits that have not been quantified for this project.

The benefit cost ratio (BCR) for this project is expected to range between 1.5 and 2.2 for upper project costs and 2.0 and 3.0 for lower project costs, for the total outcome (dynamic land use including WEBs, ranges provided using 7% and 4% discount rates). This includes the conventional transport benefits, land use change benefits arising from changing locations of people and jobs, and wider economic benefits arising from productivity improvements.

With a BCR above 1 and a positive NPV, the WRU project is expected to be economically viable. That is, the project is expected to generate benefits that are greater than the expected cost of this project in the long term.

Table 40: WRU Benefit Cost Ratio and Net Present Value ($ million)

	Static land use		Static and dynamic land use		Total (including WEBs)	
	BCR	NPV	BCR	NPV	BCR	NPV
Upper project costs	1.5 – 2.4	$959 - $4,342	1.0 – 1.6	$93 - $1,819	1.5 – 2.2	$1,029 - $3,980
Lower project costs	2.0 – 3.1	$1,502 - $5,104	1.4 – 2.1	$636 - $2,581	2.0 – 3.0	$1,572 - $4,743

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: Ranges provided show results using a 7% and 4% discount rate

Broader impacts

There are also expected to be broader impacts arising from this project which cannot be quantified in a cost benefit analysis. We have assessed metrics from the VLUTI model where available and provide commentary on the expected direction of these impacts. These broader impacts include:

- broader economic benefits
- infrastructure cost changes
- place benefits
- social and health impacts
- environmental impacts.

Broader economic benefits arise through labour productivity improvements driven by greater accessibility, and improved value chains through better freight reliability and speed. These elements are captured by the VLUTI model, which estimates GSP and productivity improvements resulting from this project.[283] The WRU project is estimated to have a positive impact on GSP, increasing by 0.3% in 2036 and 0.2% in 2051. This is driven by increases in employment in the central city and improved accessibility between the growth areas in the west and south-east, and the CBD. This GSP uplift also captures some of the benefits that flow to individuals who change housing location due to the transport project, in addition to the transport benefits already quantified in the cost benefit analysis.

This project encourages increased residential development in New Growth Areas and Outer Melbourne. These areas have infrastructure capital costs that tend to be higher than in established areas on average (excluding transport costs).[284] This project could have additional costs in providing infrastructure for new growth areas, depending on the amount of household growth that occurs. This impact has not been quantified due to lack of suitable data.

Place benefits can arise from improved urban amenity in residential areas arising from a change in land use driven by the transport project. The change in land use to residential development is likely to result in higher value use, better amenity and quality of development. Residential development that occurs in areas which have good access to transport and services will generate greater benefits than in locations with poor access.

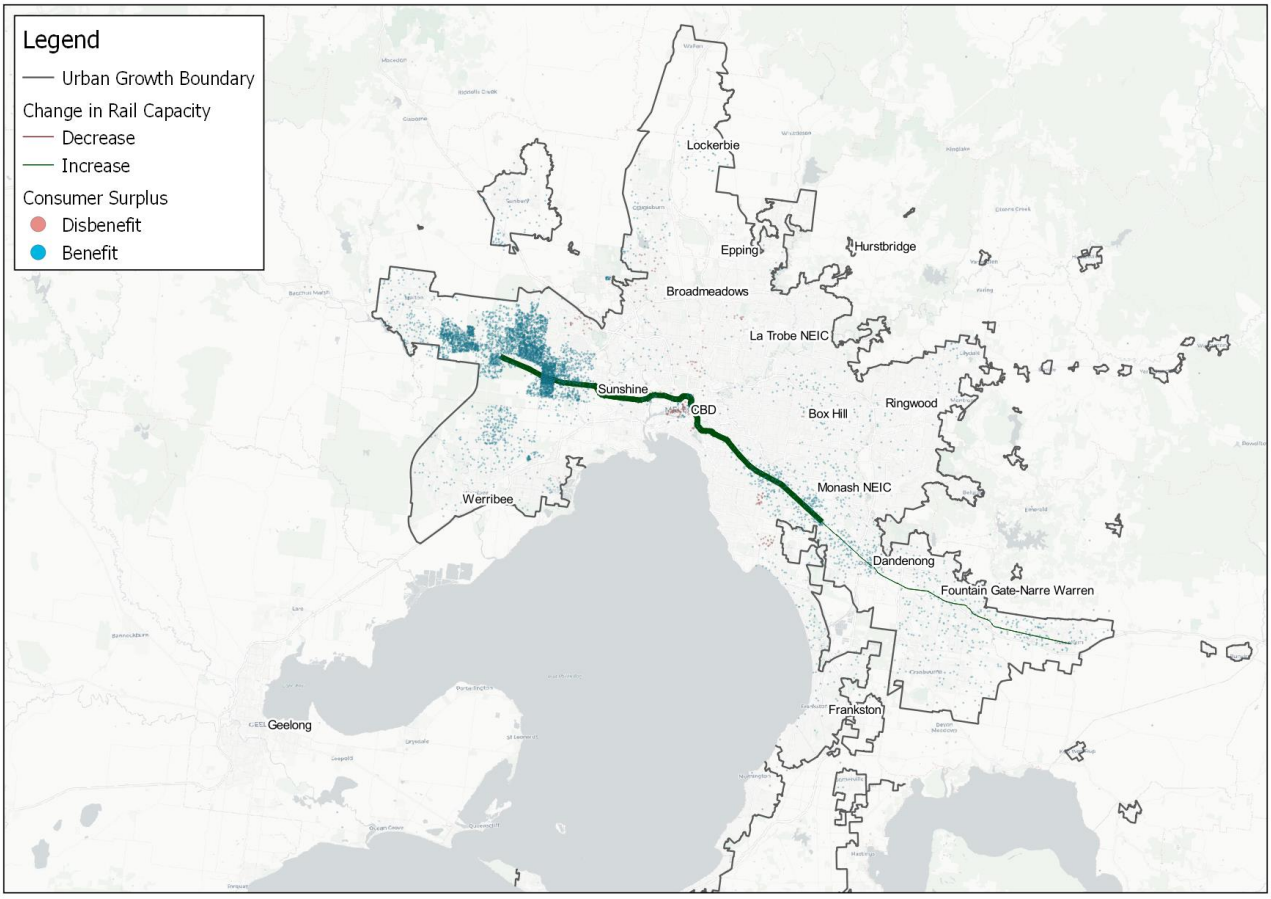
Land values have been used as an indicator of the distribution and magnitude of place benefits, acknowledging the limitations of this approach. The largest impact is expected in Deer Park – Derrimut, in line with the increase in population also expected for this area. Increases are generally focused along the rail corridor and are largest in the west and south-east growth areas.

[283] *The VLUTI model assumes that total population, households, and jobs in Victoria remain fixed in future under all scenarios, and therefore GSP and productivity improvements do not incorporate any additional jobs and households above this level.*

[284] *Infrastructure Victoria 2018, Infrastructure provision in different development settings*

Figure 103 shows the distribution of the public transport consumer surplus benefits across metropolitan Melbourne resulting from the WRU project in 2051. This highlights that most of the economic benefits from this project are concentrated in the west and south-east of Melbourne in areas surrounding the rail corridor (blue dots on the map). People in these areas are expected to have the greatest improvements to public transport travel times and therefore have the largest proportion of benefits from this project.

Figure 103: WRU Public Transport Consumer Surplus (2051)



Note: This map shows change in total consumer surplus by travel zone, not change per individual users. It is therefore affected by the change in travel time and generalised cost along with differences in number of residents and jobs, some of whom may relocate due to the project. One dot equals 120 minutes of consumer surplus benefits.
Source: AECOM 2021 Transport Modelling Scenarios – Economics Report

Social Assessment

Transport projects improve access to employment opportunities, education, health care, and community and social services.[285] This can help to address disadvantage for residents in areas that have improved access, while also impacting disadvantage for residents who may have reduced levels of access.[286] The project will have particular benefits for transport user groups such as children, the elderly and people with a disability as a result of an increase in rail service frequency, which will also relieve crowding. The 210,000 young people in the western and south-eastern growth corridors in 2036 will have better rail services, but they will also need frequent connecting buses to access trains given that their families may live in new suburbs well away from the rail corridor.[287]

The west and south-east growth corridors are some of the most disadvantaged parts of Melbourne, as measured by the socio-economic index for areas (SEIFA). The WRU project improves access from these areas to a greater range of jobs, education and services, including higher skilled jobs. This will contribute to reducing levels of disadvantage. Average incomes of residents living in the west and south-east growth corridors are expected to increase because of this project.

The WRU project improves access to jobs in the west and south-east growth corridors that currently have relatively poor access to jobs through the limited road and public transport networks. With this project, average travel times for work trips by public transport to the majority of south-eastern and eastern Metropolitan Activity Centres and NEICs improve compared to the transport base case, and for some centres this is due to the project facilitating interchanges onto the SRL. In the west, trips to western centres and the central city are faster, but travel times increase for work trips to Toolern (Cobblebank), a future Metropolitan Activity Centre. The project provides broad support for growth area residents' public transport to access suburban and central city jobs.

WRU has some travel time improvements for people accessing important centres for purposes other than work and outside commuting times. This is particularly important for people who do not or cannot drive, such as young people. Average public transport travel times to Fountain Gate – Narre Warren are noticeably shorter, while trips are also shorter to Dandenong and Ringwood. Some travel times do increase, which could be caused by more households living in certain areas due to the project. Opportunities to improve travel times, including through better bus services and connections, should be considered, including to western activity centres and key destinations that may include social facilities and open spaces of regional significance, which can have subsequent positive impacts on health outcomes and liveability.[288]

Travelling in the morning peak by public transport for education is consistent with the improved commute times for a number of centres with tertiary institutions. WRU results in shorter average travel times to Footscray and Sunshine, which helps to improve access to Victoria University campuses. Trips to Parkville NEIC are also faster and are under an hour, and while travel to Frankston is quicker, on average it would require over 80 minutes. Trips to Box Hill for education, which could include using the SRL, in the evening peak are the shortest for any centre at any time, and trips to Monash, Parkville and Broadmeadows are also shorter at that time. This suggests that WRU provides improved public transport access for people who need to study outside of work hours. The project improves travel times during the day for education trips in the east and to Footscray.

Because this project makes growth areas more accessible, increased demand for housing in these locations may increase land values and property prices.[289] This could make housing in these areas less affordable.[290] Recent data shows that homeowners in Melbourne's New Growth Areas are already more likely to experience mortgage stress, increasing the likelihood that prospective homeowners may be priced out of the market.[291] It is likely they would have to relocate further away from the metropolitan area for a given type of dwelling, as house prices increase with proximity to the CBD.[292] The level of impact should be considered and, where necessary, offset through mechanisms to increase the supply of affordable housing in locations close to public transport, services and jobs.[293]

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[285] *Li, T., & Dodson, J. (2020). Job growth, accessibility, and changing commuting burden of employment centres in Melbourne. Journal of Transport Geography, 88*

[286] *Lucas, K. (2012). Transport and social exclusion: Where are we now? Transport policy, 20, 105–113*

[287] Department of Environment, Land, Water and Planning, *Victoria in Future 2019*, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/

[288] Giles-Corti B, et al. Increasing walking: How important is distance to, attractiveness, and size of public open space? American Journal of Preventive Medicine. 2005;28(2, Supplement 2):169-76

[289] *Grace, Renan, and Meead Saberi. "The value of accessibility in residential property." Australasian Transport Research Forum (ATRF), 40th, 2018, Darwin, Northern Territory, Australia. 2018.*

[290] *Whitzman, C., Legacy, C., Martino, E., Raynor, K., Palm, M., Wiesel, I., Davison, G. and Woodcock, I., 2018. Can Australian governments steer 'just intensification'? Evaluating Victorian affordable housing policy.*

[291] *Digital Finance Analytics (2021). "Mortgage heat stress maps" [website] https://digitalfinanceanalytics.com/blog/tag/mortgage-stress-heat-maps/*

[292] *Ibid*

[293] *Palm, Matthew, Katrina Raynor, and Carolyn Whitzman. Project 30,000: producing social and affordable housing on government land. University of Melbourne, 2018. P.25*

WRU will result in increased overall public transport use and less driving, except in Melbourne's growth areas. This will result in a net increase in active transport, which includes walking to and from public transport. The benefits of increased active transport are a major positive contributor to the benefits case for this project.

People living in Melbourne's established outer west and south-east along the Pakenham train line will have improved rail services as a result of this project, and more residents are also attracted to live in those locations. It may particularly benefit the forecast higher proportions of elderly Melburnians in places such as Caulfield and Dandenong, making these locations even better suited to those who do not drive.[294] Ensuring high quality walking and on-road public transport access to stations will be particularly important to this group.[295]

Separated active transport infrastructure and station car parking management may also encourage people to change how they travel to stations which receive service improvements, and this can contribute to improved health outcomes from incidental exercise.[296] These types of locations should also be priorities for a wider range of housing types and at higher than current densities, particularly close to stations with service improvements. This should include the corridor to Pakenham as it has the highest increase in passenger capacity in this project. These approaches should also consider lessons from level crossing removals in the south-east.[297]

Research has found that tertiary educated women living in growth areas are less likely to be in a job that reflects their level of qualification compared to both men and to women living in inner and middle areas.[298] This project has the potential to provide greater access to jobs that better suit the skills of women in growth areas, through providing increased capacity on the rail corridors connecting to the city.

This project will also provide more transport options for women and primary carers in growth areas. Improved bus connections from residential areas to the train station should also be provided to allow greater access for those without a car and for primary caregivers who are more likely to take multi-modal trips with multiple destinations.[299] Consideration should also be given to designing the train stations for personal safety and security, including access to the station from residential areas.[300]

Environmental Assessment

Carbon emissions are reduced overall as a result of fewer private vehicle trips associated with this project. However localised increases may occur given more private vehicle movements in growth areas. These will contribute to further raising temperatures in Melton and Casey LGAs which in 2016 already experienced mean urban temperatures 8 to 12 degrees hotter than a non-urban baseline.[301] As this project results in more people living in the western and south-eastern growth corridors, this makes more urgent the adequate planting of vegetation, and particularly canopy trees, to mitigate existing high temperatures. Progressive take up of ZEVs may also help mitigate these emissions.

Existing suburbs with improved rail services and additional population in the south-east have relatively poor walking access and unconnected public open spaces. There are some parcels of public land with restricted access close to the Pakenham rail alignment which should be considered for opening up to communities, as higher than projected populations move into these areas. In particular, those parcels that facilitate the completion of an open space network that provide more direct connections to stations by active transport should be considered.

An opportunity also exists to improve open space connectivity for the remaining Warrawee and Ravenhall PSPs in the west. Given this project's impact on population change in Deer Park, further attention to open space and vegetation cover, which could include its industrial areas, will benefit both people and ecosystem services.

There was a loss of tree canopy cover between 2014 and 2018 in the western LGAs that benefit from improved rail services and experience population increases.[302] Any additional development that occurs as a result of this project should be required to contribute to at least maintaining but preferably increasing the number of trees in local areas.[303]

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[294] Department of Environment, Land, Water and Planning, *Victoria in Future 2019*, Melbourne, Victorian Government, 2019, www.planning.vic.gov.au/__data/assets/

[295] *Martens, Karel, Jeroen Bastiaanssen and Karen Lucas (2019), 'Measuring transport equity: key components, framings and metrics', in Karen Lucas, Karel Martens, Floridea Di Ciommo and Ariane Dupont-Kieffer (eds.) (2019), Measuring Transport Equity, Amsterdam: Elsevier, pp. 13–36*

[296] Department of Economic Development, Jobs, Transport and Resources (2017). Victorian cycling strategy 2018-28 : increasing cycling for transport.

[297] mams.rmit.edu.au/51zakugpfi4ez.pdf

[298] SGS Economics & Planning 2018. Gender Equity in Employment – Report prepared for City of Whittlesea

[299] McCarthy, L., Delbosc, A., Currie, G., & Molloy, A. (2017). Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature. Transport reviews, 37(6), 767-781.

[300] Whitzman CA, Marathe RE, Thompson JA. (2019). "Tertiary Students' Public Transport Safety in Melbourne, Australia." *Melbourne, VIC, Australia: Transport, Health and Urban Design Researching Hub, Faculty of Architecture, Building and Planning, The University of Melbourne*

[301] https://www.planning.vic.gov.au/policy-and-strategy/planning-for-melbourne/plan-melbourne/cooling-greening-melbourne/mapping-and-analysis-of-vegetation,-heat-and-land-use

[302] https://www.planning.vic.gov.au/__data/assets/pdf_file/0023/441464/Urban-Vegetation-Cover-Change-in-Melbourne-2014-2018_Final.pdf

[303] Department of Environment, Land, Water and Planning. (2017). "*Protecting Victoria's environment - biodiversity 2037*." [Melbourne, Victoria] https://www.environment.vic.gov.au/__data/assets/pdf_file/0022/51259/Protecting-Victorias-Environment-Biodiversity-2037.pdf

Brimbank City Council has already introduced tree planting requirements for new homes' front and backyards to help increase canopy cover where new residential development occurs.[304]

Sensitivity Tests

Sensitivity tests have been conducted on this project to test the sensitivity of the project's BCR to a range of potential outcomes. This informs the conditions in which a project should or shouldn't go ahead, and how sensitive a project's viability is to changes.

These tests include varying the discount rate, increasing and decreasing the capital costs, increasing and decreasing total benefits, delaying the projects opening year and construction start, and increasing the value of travel time in the future. The BCR under each test for the static land use, dynamic land use and dynamic land use with WEBs outcomes are shown in the table below.

This project has a BCR above one under all sensitivity tests (including total benefits – dynamic land use with WEBs).

This highlights that whilst there is some variation in the BCRs, there is not expected to be a large impact from changes in costs and benefits. This suggests there are strong drivers for this project in addressing capacity constraints in the western rail corridor.

Table 41: WRU Sensitivity Tests – Benefit Cost Ratio

Sensitivity Test	Static land use	Dynamic land use	Total (Dynamic land use with WEBs)
4% discount rate	3.1	2.1	3.0
7% discount rate	2.0	1.4	2.1
3% discount rate	3.6	2.4	3.4
10% discount rate	1.4	1.0	1.5
20% decrease in capital costs	2.4 - 3.6	1.7 - 2.4	2.4 - 3.4
20% increase in capital costs	1.7 - 2.7	1.2 - 1.8	1.8 - 2.6
40% increase in capital costs	1.5 - 2.4	1.1 - 1.6	1.6 - 2.3
Exclusion of construction cost escalation	2.4 - 3.6	1.7 - 2.4	2.5 - 3.5
40% decrease in total benefits	1.2 - 1.9	0.8 - 1.2	1.2 - 1.8
20% decrease in total benefits	1.6 - 2.5	1.1 - 1.7	1.6 - 2.4
20% increase in total benefits	2.4 - 3.7	1.7 - 2.5	2.5 - 3.5
Delay opening by 5 years	2.2 - 3.4	1.4 - 2.1	2.0 - 2.9
Delay opening by 10 years	2.4 - 3.7	1.4 - 2.1	2.0 – 3.0
Value of travel time	2.4 – 4.0	1.7 - 2.6	2.2 - 3.5

Source: AECOM 2021 Transport Modelling Scenarios – Economics Report
Note: These sensitivity tests are provided for the lower cost and ranges are shown using 4% and 7% discount rates.

[304] https://www.parliament.vic.gov.au/images/stories/committees/epc-LA/Inquiry_into_Environmental_Infrastructure_for_Growing_Populations/Submissions/103_2020.09.25_-_Submission_-_Brimbank_City_Council.pdf

Future Scenarios

WRU is considered to be generally resilient to future scenarios that have been assessed in this report. The project provides significant benefits for public transport users by alleviating overcrowding. However, some scenarios are likely to reduce public transport demand for travel, which in turn will reduce demand for the project and delay the need for investment.

WRU is at risk of less demand from Melton LGA into the city using public transport, which may occur under the low population growth scenario. Under the WFH scenario, population growth in outer suburbs and growth areas will increase demand for public transport, strengthening the case for investment. Under the EAV scenario there is expected to be greater population growth in outer suburbs and growth areas, however public transport mode share is expected to decline, which may result in greater demand for roads in outer areas.

Policy scenarios are likely to support the need for the project, with targeted density outcomes driving higher public transport mode share in key locations and transport network pricing increasing the cost of driving into Inner Melbourne.

A summary of the implications of each future scenario is documented below in Table 42.

Table 42: Resilience of WRU to future scenarios

	Assessment of scenario	Impact
External Scenarios		
High population growth	A high population growth scenario will bring forward issues with road network congestion and public transport crowding, driving greater public transport usage and higher economic benefits. This would also likely increase the BCR for the project. This would be largely driven by the impact on growth along the Melton / Bacchus Marsh services.	~
Low population growth	Even under a low population growth scenario, train services from Melton and Bacchus Marsh are still likely to experience overcrowding in the 2030s due to the strong underlying population growth. However the growth in demand for public transport over time is likely to result in lower benefits reducing the BCR overall.	-
Working from home	The WFH scenario indicates that residents will need to commute to the office less, resulting in a shift in residential locations to reflect an alternative lifestyle. This scenario indicates that population is likely to increase in middle and outer suburbs, increasing demand for road travel in these areas. Outer suburbs and growth areas experience an increase in public transport demand with population growth offsetting reductions in travel due to working from home, expected to increase the benefits of the project and improve the BCR.	+
Automated and electric vehicles	The EAV scenario is unlikely to have an impact on the opening years of WRU. AV and ZEV take up is expected to be more substantial by 2051, at which point AVs are expected to make Melton LGA a more attractive place to live. However, under the EAV scenario, public transport mode share drops significantly from 12% to 9% across Melbourne, and such a significant drop is likely to have a negative impact on project benefits and the BCR. There is a high degree of uncertainty around this scenario, and its implications for transport projects, as AVs are still an emerging technology.	-
Policy Scenarios		
Targeted density outcomes	Concentration of population growth into key centres will result in higher public transport mode share for key precincts, increasing demand for public transport and resulting in greater benefits, likely increasing the BCR.	+
Transport network pricing	This scenario is likely to focus on travel demand management to the inner city, and will result in higher public transport mode share for trips to destinations subject to the new cordon charges, increasing demand for public transport (resulting in greater benefits), and increasing the BCR. The increase is expected to be modest due to high costs.	+

Legend

+++	+	~	-	---
Significant positive impact anticipated	**Slight positive impact anticipated**	**Minimal impact anticipated**	**Slight negative impact anticipated**	**Significant negative impact anticipated**

Source: Analysis based on Arup 2021 Strategic Modelling Outcomes report and AECOM 2021 Transport Modelling Scenarios – Economics Report

Implications

Providing critical capacity to support patronage growth

WRU will provide critical capacity to support patronage growth along the western corridor. Further investment is required subsequent to this project to address overcrowding to Melton Station as population continues to grow. Some options to consider include high capacity regional trains, further electrification out to Melton Station, or innovative rolling stock solutions (battery operated trains). In addition, detailed design is required to inform more accurate costings to support a future funding submission.

The Cranbourne / Pakenham corridor is forecast to exceed capacity in the late 2030s, and the additional services from Mt Atkinson / Hopkins Rd will also provide additional capacity for this corridor.

A supporting network to access the stations with transport network pricing

From a transport perspective, it is important to have good bus and active transport connections to the train stations that are impacted by this project, particularly newer stations in growth areas. It is also important to consider better use of the area surrounding the train station, including for commercial or residential uses along with car parking. This mitigates the fact that some stations are located far from residential areas, and without a good bus connection to the station people will have to drive and require car parking.

TNP should also be considered for this project. This could include implementing differing fares for the various types of public transport modes to encourage use of the new train line and supporting buses. This could also include adopting permanent off-peak discounts for public transport fares, incentivising people to utilise the new train line and supporting buses during quieter times of the day. This would further reduce crowding, complementary to the new services brought about by the project. Pricing for parking at train stations should also be considered to manage demand.

Taking advantage of infill opportunities and managing outward growth

The project also supports population growth in established areas such as Deer Park, Dandenong, Fountain Gate-Narre Warren and Sunshine. Further planning should occur to ensure that new housing is supported within a walkable distance of station precincts with improved accessibility because of the project. There should also be consideration of opportunities for increased housing density around the new station precincts to encourage less car-dependent housing. This is supported by the recommendation in *Victoria's infrastructure strategy* to provide more homes in priority locations.

Where the transport project facilitates land to be rezoned to accommodate a more productive use, such as housing at an increased density, value capture options should be considered. This ensures that some of the additional value which occurs as an outcome of the project can be redirected back to local infrastructure to serve these growing communities.

As this project supports further population growth in the west and south-east growth areas it will be important to ensure adequate services are available to growth area residents in the future. This includes medical services, schools and other education facilities, community facilities such as libraries and open space. Providing more social and affordable housing in growth areas will also be important to offset against the expected increase in housing costs arising from the improved access provided by this project.

There are also several considerations from a land use planning perspective. This project results in increased population growth in the growth areas, particularly in the west and south-east. To mitigate against the risk of population growth occurring outside of the urban growth boundary, existing settlement boundaries should be strictly adhered to. Further planning work should be done to identify peri-urban towns at risk of expansion to ensure that land supply is adequately constrained to encourage urban consolidation.

Relevant Recommendation in Victoria's Infrastructure Strategy

Recommendation 74: Extend rail services in Melbourne's western and northern growth areas

Within two years, the Victorian Government should complete detailed feasibility studies and business cases to determine the best approach to provide more train service capacity in Melbourne's western growth areas. They should include options to electrify the lines in stages, and include better bus connections, and active transport improvements. The project should include better bus connections to nearby areas, such as Rockbank North and Plumpton. The Victorian Government should then secure the necessary land, including for stations and stabling.

This analysis indicates there is a compelling case to introduce electrified suburban services along the western corridor as far as Rockbank, or alternatively to a new station at the proposed Mt Atkinson activity centre. Assuming higher capacity regional trains continue to service Melton, terminating a new electrified service at Mt Atkinson encourages more gradual westward housing growth, compared to complete electrification to Melton. Our modelling suggests that strong underlying population growth may require later electrification of the western line to Melton in the 2040s.

Services on this newly electrified line can operate a continuous service to Pakenham, using the Melbourne Metro Tunnel. This extension of the electrified rail service primarily meets demand from population growth in the western and south-eastern growth areas. Our modelling indicates it has the extra benefit of improving the attractiveness of established suburbs along the corridor, such in Deer Park, from Noble Park to Dandenong, and from Narre Warren to Berwick. These places can be priority locations for denser housing (see recommendation 35). The extension of electrified trains to the west also means V/Line trains no longer need stop at many of these stations, producing more reliable regional services to Ballarat.

5. Conclusions

5.1 Multi-criteria Analysis Summary

The multi-criteria analysis (MCA) considered the impacts of each transport project across the network in 2051, compared to the transport base case.

It shows that many major transport projects make a High or Exceptional contribution towards one or more metrics. No single project achieves an Exceptional contribution against all of the transport challenges, while some projects make a negative contribution (Table 43).

The OMR, one of the largest projects assessed, is a stand-out, performing strongly against many of the transport metrics. The only exception is for vehicle emissions, which increase with the project. Whilst the WRU does have positive impacts on most criteria, these are smaller scale compared to other projects. This resulted in the WRU project being benchmarked at the 'lower end' compared to the other projects which had greater impacts. The compelling economic assessment results for WRU reflects the breadth of impacts this project has.

All transport projects contribute positively to improving access to potential job opportunities and labour force catchment for businesses (Challenge 1 & 2). This is achieved through varying methods – some projects create more direct new links connecting people and jobs that provide better travel times, including from residential areas and employment locations with low accessibility (e.g. OMR and MM2G). Other projects improve overall network performance, improving access for a large portion of metropolitan Melbourne (e.g. RMS and OMR). OMR had the most significant impact on jobs and labour force accessibility of all projects.

While WRU significantly improves the capacity for more people to get to work, it doesn't considerably change employers' access to their potential workforce catchment. This is generally due to the project concentrating jobs into Central Melbourne whilst encouraging more residents to move outwards. However, not reflected in this assessment is the broader welfare benefits of moving further out, such as housing choice and amenity that would be at least the same level of benefit, if not more, than the forgone travel time benefits provided by the project. Therefore, these MCA results should be considered alongside the economic and social assessment results which present a compelling case.

Rail projects consistently perform well in reducing public transport crowding – either through providing additional services, new transport connections or relieving crowding across broader network services. Road projects also alleviate public transport crowding through mode shift to private vehicles.

Most transport projects contributed to improvements to business-to-business, including freight travel, with the exception of WRU. Increasing congestion on motorways either side of the project leading to CCM, such as the Eastern Freeway, resulted in longer travel times for certain trips. Improving the modelled tolls along CCM, broader TNP such as dynamic motorway tolls and Inner Melbourne congestion pricing should therefore be considered as part of the project. In addition, TNP should be considered on the motorway approaches to CCM rather than adding more lanes. Given the number of lanes that exist or are under construction on the Eastern Freeway as part of the North East Link Project, it was not considered an option to substantially widen these approaches further through 'enabling projects' as part of CCM. However, when it comes to enabling freight connectivity, the CCM corridor has the potential to support the widest range of freight movements across Greater Melbourne, largely due to its central location. This is in comparison to OMR which serves the large northern and western freight market. This is also reflected in how these two new road corridors perform when analysing the utilisation of trucks along their respective sections. OMR performs strongly, with high volumes of freight projected to utilise the corridor, compared to CCM as modelled in this assessment.

Road projects negatively impact Challenge 4 (transport's contribution to achieving net zero emissions) with most projects causing an increase in vehicle emissions when compared with the transport base case – noting the exception of CCM in 2051. It should be noted that the emissions quantified in each scenario are based on a fleet of internal combustion vehicles. With uptake of ZEVs in the future, this is likely an over-estimate of changes in vehicle emissions.

Table 43: Multi-criteria analysis summary of all projects 2051

Transport Challenges	*Challenge 1 - Access to jobs from place of residence*			*Challenge 2 - Employers' accessing potential workforce*	*Challenge 3 - Business to business travel (including freight)*			*Challenge 4 - Transport's contribution to achieving net zero emissions*
Assessment criteria	Reduced road network congestion	Reduced public transport crowding	Increased access to jobs	Increased access to labour force	Improved freight congestion	Improved freight connectivity	Improved freight utilisation	Reduced vehicle emissions
Road Management Systems (RMS)	M/H	L/M	H	H	M/H	~	~	N
City Loop Reconfiguration (CLR)	H	H	L/M	L/M	H	~	~	E
Cross City Motorway (CCM)	M/H	L/M	L	L/M	~	H	L/M	H
Melbourne Metro 2 (MM2G)	M/H	E	H	L/M	L/M	~	~	H
Outer Metropolitan Ring Road (OMR)	E	M/H	M/H	H	E	M/H	H	N
Western Rail Upgrade (WRU)	L/M	H	~	~	L	~	~	L

Legend:

Negative (N)	Negligible (~)	Low (L)	Low-Medium (L/M)	Medium-High (M/H)	High (H)	Exceptional (E)

Summary by Project

- **Road Management Systems (RMS)** – provides a strong boost to jobs and labour force accessibility through better use of infrastructure. Widespread road network improvements also benefit the freight network, reducing heavy vehicle travel times to key freight terminals through reduced freight congestion.
- **City Loop Reconfiguration and Northern Rail Corridor Upgrade (CLR)** – provides capacity relief to multiple metropolitan and regional rail lines while also attracting many drivers onto the public transport network. This reduces road congestion and therefore improves freight efficiency across key industrial precincts. Mode shift also contributes to a strong reduction of vehicle emissions, the largest of any project assessed.
- **Cross City Motorway (CCM)** – although a small number of users experience faster travel times for east-west cross city movements, the majority experience little to no aggregate travel time benefit. This also limits accessibility benefits to households and businesses, but still delivers some marginal improvements. The new link also has the potential to support a wide range of freight movements across Greater Melbourne. While overall vehicle emissions reduce compared to the transport base case in 2051, total vehicle emissions in 2036 record some of the largest increases, especially in Inner Melbourne.
- **Melbourne Metro 2 and direct Geelong rail services (MM2G)** – the strongest performer of all projects in reducing rail crowding through capacity uplift and new rail links, reducing pressure on existing public transport corridors. The project also leads to small improvements on freight network efficiency through reduced freight congestion and has a positive impact on reducing vehicle emissions.
- **Outer Metropolitan Ring Road (OMR) –** a transport project with vast spatial reach and significant road capacity improvements. It provides exceptional performance in comparison to other projects in reducing road congestion and better connecting the freight network. The project also provides substantial improvements to jobs and labour force accessibility. The project does however increase vehicle emissions due to additional road use in the project case.
- **Western Rail Upgrade (WRU)** – provides strong relief to public transport crowding and a respectable improvement to road network efficiency. Given the project is largely focused on rail capacity uplift, job accessibility and access to labour force is largely similar to the transport base case.

5.2 Land Use and Network Implications

The use of VLUTI modelling has enabled a stronger insight into potential direction of change to the location of housing and jobs as a result of major transport projects. These include:

a) Working from home and improvements to the road network, such as network-wide road management systems and autonomous vehicles, encourages the dispersion of population and job locations, including the outward relocation of population and associated jobs.

b) Road projects that perform bypass functions, such as the OMR and, to a lesser extent, CCM encourage housing and jobs to locate in bypassed areas that experience congestion relief including the western and northern established suburbs for OMR and the inner north for CCM. Increased congestion on arterial roads used to access these projects compromises amenity and deters some people from living in these areas. However areas more distant from these projects do experience population increases due to the accessibility benefits offered by these projects.

c) The OMR will improve accessibility to significantly more industrial land and major existing and proposed international and interstate freight gateways.

d) In defining road networks and the major transport projects, the combined effects of corridor road projects along with road network upgrades should be considered. The development of the surrounding road network can be triggered upon a major motorway being constructed in the area.

e) Projects resulting in rail service improvements including to outer areas and regional centres, such as Geelong, encourage people to move along the rail corridors benefitting from the project. As well as encouraging people to move outwards to growth areas, rail projects also encourage a net relocation of people and jobs to established areas of Melbourne, particularly the middle suburbs, and regional centres such as Geelong. People and jobs were attracted to established areas where there was already a critical mass of housing and employment, including to the north, south-east and some parts of the west, but not in other parts of the west in proximity to industrial areas which impacted on amenity.

f) Rail extensions closer to the UGB placed more outward housing pressure in these locations, which became apparent when comparing projects that involved extending rail services to Wallan with Mt Atkinson. These results were used to inform the impacts of other potential rail extensions considered by *Victoria's infrastructure strategy*.

g) Improving rail services to regional cities can have significant impacts, such as improving the directness of services between Geelong and Melbourne. There was a net change that increased the number of people and jobs to Geelong as a result of the modelling run for the MM2G project.

While the modelling provides an indication of the direction of changes, the scale of the change may appear small but warrants further investigation. Improved data collection, particularly in the Australian context, would assist in further development of the modelling to provide more evidence on land use changes arising from transport projects that have already been built. The resultant changes arising from these transport projects appeared to be reasonable in the context of the contribution to the economic evaluation. It is also consistent that other place-based interventions may need to accompany a transport intervention to fully realise a change catalysed by a transport project, such as those interventions found in our *Density Done Well* study.

Our assessment has highlighted several broader considerations from a social, environmental and economic perspective to ensure the projects deliver the most value, and potential risks associated with less desirable directions of land use change are minimised. These are specific to each project, however there are key considerations across the major transport projects.

It is important to support and encourage residential development in priority locations close to train stations, particularly at new stations along the impacted corridors. In addition, it is important to ensure there are good public transport connections to new train lines such as bus links or park-and-ride at stations.

There is a need to ensure Melbourne's UGB is strongly enforced. Many projects encourage a population to move outwards to growth areas, placing pressure on expansion in these areas. This could be through better land use planning controls, whilst also supporting housing options and jobs growth in activity centres and NEICs. This also applies for Geelong, where opportunities for housing options in established areas, particularly near rail stations, should be considered.

It is also important to manage the environmental impacts of these projects, especially projects that induce additional road users, and projects that go through protected natural landscapes.

Planning and Reserving Land for Projects

The cost of construction of major infrastructure projects has significantly increased in recent years. As well as the level of construction activity, another cause has been more projects having to develop a corridor through built up areas which has introduced significant costs and risks that have also impacted on project timing. There are also examples when recently completed residential apartment buildings have or will need to be purchased. For example, the SRL project has contacted property owners in Box Hill to inform them that their property was likely to be required for Stage One of SRL.[305] Having a transport plan and reserving land for projects can de-risk a project and provide improved certainty for surrounding land use development.

In contrast, uncertainty of the corridor for a transport project can result in under-development of areas that would compromise the benefits of a future project. For example, changes to the alignment of trams in Fishermans Bend has contributed to the government revisiting urban design guidelines relating to density, creating developer uncertainty.[306]

Reserving land for projects

A common planning approach for governments has been to undertake planning activities to identify an appropriate corridor or solution and preserve the corridor to support the project delivery at a later stage. This can include land acquisitions and using planning overlays to restrict development activities along the corridor. In the event that the state government were to deliver a transport project, an unprotected corridor would introduce a number of challenges including:

1. Property development along the corridor may restrict the design and delivery of the proposed solution.
2. Land acquisition costs would be higher, reflecting the unrestricted development levels possible in the corridor.
3. Interfacing the project with land owners and stakeholder groups are much more likely to present complications, as the impact to the community is more complex.

Examples of the benefits of protecting corridors include OMR and Melbourne Airport Rail Link whose costs would have been higher had land protections not been put in place. Previous projects benefitting from reserved land include Eastlink and the Western Ring Road.

MM2G does not currently have any corridor protections in place. Corridor protections should be implemented to preserve the option of this project once the preferred alignment has been identified.

While CCM is not recommended for further project development at this stage, we recommend that a preferred alignment is determined so the future option to build the project is protected along with the preserved corridor.

[305] *https://suburbanrailloop.vic.gov.au/Library/Have-you-received-a-letter-from-SRLA/March-2021-SRL-Stage-One-Stations-Area-of-Interest-Update-Letter*

[306] *Hodyl & Co (2017). Fishermans Bend Urban Design Strategy. Department of Environment, Land, Water and Planning. Retrieved from: https://engage.vic.gov.au/download_file/7187/1426.*

5.3 Economic Assessment

The economic assessment presents a range of outcomes using a range of costs and different discount rates. It found that the largest benefit across all projects is consumer surplus, that is, user benefits derived through reduced generalised costs and travel times.

Four of the major transport projects have a BCR above 1 for both the upper and lower cost ranges: RMS, WRU, OMR and CLR. These projects are expected to generate benefits that outweigh the costs over a 30-year appraisal period. The other two major transport projects, MM2G and CCM, have BCRs below 1 and as scoped for this modelling are not expected to generate benefits that outweigh the costs. Further value engineering work to reduce the costs, and rescoping the projects to provide greater benefits should be undertaken for these two projects.

Our innovative modelling approach has expanded the economic framework to include transport-related benefits from changes in the spatial distribution of population and jobs, based on changes estimated in the VLUTI model. This is an evolution of our approach to economic assessment since the 2016 infrastructure strategy was developed. The assessment of changes in the locations of population and jobs has been limited to transport benefits. Further work should be undertaken to consider broader non-transport related benefits, such as from improved wellbeing arising from factors other than transport including better residential amenity and affordability.

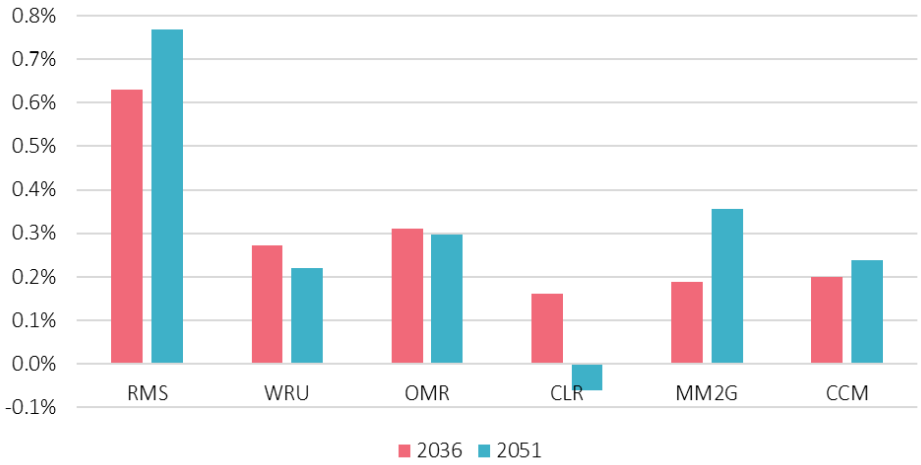
Impacts to gross state product (GSP) provide an indication of the improvements to economic growth arising from these projects (see Figure 104). This highlights the large benefit to GSP arising from the RMS project, along with benefits from MM2G, OMR, WRU and CCM. The MM2G project has the largest percentage impact to GSP in 2051 of all the new build projects.

Table 44: Summary benefit cost ratio (BCR) results by project

	RMS	WRU	OMR	CLR	MM2G	CCM
Upper costs						
BCR (static land use)	9.3 – 14.5	1.5 - 2.4	0.8 - 1.3	0.9 - 1.4	0.1 - 0.2	0.3 - 0.4
BCR (dynamic land use)	8.0 – 12.4	1.0 - 1.6	1.0 - 1.6	1.1 - 1.9	0.2 - 0.4	0.3 - 0.4
BCR (dynamic + WEBs)	8.1 – 12.6	1.5 - 2.2	1.1 - 1.8	1.1 - 1.8	0.3 - 0.5	0.3 - 0.5
Lower costs						
BCR (static land use)	10.6 – 16.6	2.0 – 3.1	1.7 - 2.5	1.0 – 1.6	0.1 - 0.2	0.4 - 0.6
BCR (dynamic land use)	9.1 – 14.2	1.4 – 2.1	2.1 - 3.2	1.3 – 2.1	0.3 - 0.6	0.4 - 0.6
BCR (dynamic + WEBs)	9.3 – 14.4	2.0 – 3.0	2.2 - 3.4	1.2 – 1.9	0.3 - 0.6	0.5 - 0.7

Source: AECOM 2021 Economics Report
Note: Ranges shown use 4% and 7% discount rates

Figure 104: Percentage change in gross state product by project, Victoria



Source: Arup modelling outcomes 2021
Note: The CLR project has a negative impact to GSP in 2051 due to the VLUTI model shifting population and jobs away from the city.

5.4 Future Scenarios

Most of the major transport projects are resilient to a range of different future scenarios. This is primarily due to the state's underlying population growth being the main driver of increasing demand, and therefore the need and assessment outcomes for these initiatives. It was generally found that the future scenarios affected the timing of projects.

The CCM project was most affected by the future scenarios, particularly being affected by TNP and EAV. The impact of different scenarios would need to be further considered for MM2G given its scale.

The COVID-19 pandemic has seen a reduction in public transport use, which is gradually returning, albeit at a slower pace than private transport use. There are also trends such as working from home, or evolving technologies like road management systems and autonomous vehicles that may reduce the need, cost and inconvenience of travel. The EAV scenario sees a dispersion of population and employment out of Inner Melbourne due to the increased attractiveness of car travel. However, countering these are the advantages of businesses being in proximity to each other and the housing choices and preferences of Victorians, many who want to live in established areas.

If this trend persists beyond the short term, or these technologies get deployed, it may become particularly important to incentivise public transport use and manage private vehicle demand to avoid worsening congestion.[307] Several of the adjacent recommendations in *Victoria's infrastructure strategy* support this, including off peak and reduced public transport fares, increased and better public transport services, provision of cycling and walking infrastructure, and the introduction and progression of road user charging. Many of these recommendations to manage demand fall under the broader category of TNP, designed to build in the impact of transport use on society or 'externalities' through pricing of public transport and road use.

[307] *See Transporting Melbourne's Recovery, Infrastructure Victoria 2021. https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/01/Transporting-Melbournes-Recovery-January-2021-FINAL.pdf*

Encouraging more homes in established areas can mitigate outwards expansion

While Melbourne's population is only 5 million people, it is geographically the 29th largest city in the world. If planning for key infrastructure sectors is not integrated with clear policy directions for the future location of jobs and housing, we risk failing to meet *Plan Melbourne's* aspiration for 70% of new housing to be built in established suburbs by 2051.

We have undertaken detailed modelling of several future scenarios and found that technological changes that support working from home, autonomous vehicles and road management systems reduce the need, cost or the inconvenience of travel. These could encourage more Victorians to move outwards into greenfield, peri-urban and regional locations. By 2051, Melbourne's metropolitan area could potentially extend from Torquay to Wallan to Warragul. Regional cities face similar pressures for outward expansion. While these changes may increase housing choice and make new growth and regional areas more attractive, continued outward expansion will have social, environmental and economic costs. (Infrastructure Victoria, *Growing together – The case for better integration of land use and infrastructure planning in established areas,* December 2020, p.34, www.infrastructurevictoria.com.au/wp-content/uploads/2020/12/Growing-together-December-2020.pdf)

We have found that infrastructure costs are two to four times more in greenfield than established areas to support new housing, and that major transport infrastructure connections to new suburbs in Melbourne and regional cities are very expensive. In new suburbs, new residents move in more quickly than new jobs, and local jobs do not always match their skills or training. And the land on which new suburbs are built is no longer available for other productive uses such as agriculture.

While some Victorians will always want to live in new suburbs, our *Density Done Well* research and modelling show that more people may choose to live in existing suburbs where they have housing choices with good access to transport, employment, services and recreation. Victoria's cities and towns will need more housing options in well-serviced locations. Decision makers need to understand that simply meeting housing demand through greenfield development is not enough.

But we also need better insights into the capacity of existing infrastructure, land supplies, and the range of factors that households consider when choosing places to live, especially in a post-COVID-19 world. These should inform improved and integrated infrastructure and land use planning to achieve the Victorian Government's visions for the state's urban development.

Victoria's infrastructure strategy sets out priority infrastructure policies, reforms and projects to make the most of opportunities in established urban areas. Our *Growing Together* report and our recommendations emphasise choice and better use of the transport network, including transport network pricing.

5.5 Recommendations for *Victoria's infrastructure strategy 2021-2051*

Victoria's infrastructure strategy 2021-2051 includes recommendations for all types of infrastructure to support future growth. This report provides the evidence to support several recommendations in the strategy pertaining to major transport projects. These relate to transport recommendations that address the key challenges outlined in this report, including supporting parts of the network which are expected to have strong growth in the future.

This report assessed six major transport projects that address the mobility challenges outlined in chapter 2. These transport projects have been chosen as they:

- support future population growth and travel demand in areas expected to come under the greatest pressure or experience the fastest rates of growth
- improve access to jobs and services between the city and middle, outer and growth areas
- encourage better use of existing assets through improved road network operation systems.

The strategic assessment outlined in this report shows strong support for four of the major transport projects, these being road management systems (RMS), City Loop reconfiguration and northern rail corridor upgrade (CLR), Outer Metropolitan Ring Road (OMR) and the western rail corridor upgrade (WRU).

Victoria's infrastructure strategy recommends undertaking further planning and business cases for these projects. The other two projects, Melbourne Metro Two and direct Geelong rail services (MM2G) and Cross City Motorway (CCM), did not perform as well in the strategic assessment based on the project scope outlined in chapter 4. However, these projects do address several objectives and long-term challenges and are therefore recommended to be kept as future options, with further work undertaken in exploring value engineering, alternative route alignments and interim measures.

The recommendations from *Victoria's infrastructure strategy* developed from this assessment of major transport project include:

- introduce new on-road demand management technology (recommendation 24)
- reconfigure the City Loop (recommendation 60)
- prepare for Melbourne Metro Two and direct Geelong rail services (recommendation 61)
- protect a long-term option for a new cross-city motorway (recommendation 62)
- construct an outer metropolitan road and rail corridor (recommendation 66)
- extend rail services in Melbourne's western and northern growth areas (recommendation 74).

No single intervention can solve Melbourne's transport and land use challenges. The transport network is interconnected, and a suite of solutions will be required to address future transport challenges, and improve connections between where people live and jobs, education, services and recreation.

Growth area rail extensions combined with bus service reforms, rail line capacity upgrades and new connections to suburban jobs will improve access to and from Outer Melbourne. Improving rail capacity in the inner city will expand the central city and provide more job opportunities and access to services for Victorians. Other recommendations of *Victoria's infrastructure strategy* that are also relevant to major transport projects include:

- accelerate consumers purchases of zero emissions vehicles (recommendation 1)
- prepare for increasingly automated vehicle fleets (recommendation 21)
- support more homes in priority established places (recommendation 35)
- reallocate road space to priority transport modes (recommendation 41)
- steering changes in travel behaviour through transport network pricing (recommendations 45, 46, 47, 48, 49, 50, 51, 52, 53)
- connect suburban jobs through 'next generation' buses and road upgrades (recommendation 58)
- improve off peak frequencies in suburban rail corridors (recommendation 59).

5.6 Sequencing and Timing

Our assessment highlights that there is a strategic sequencing of these six major transport projects, given their impacts, benefits, and the challenges that each address.

There is clear merit in making better use of our existing infrastructure assets through road management systems and road space reallocation. Our assessment of road management systems highlighted the significant benefits to be gained and this should be implemented in the short term. This should be accompanied by improving public transport services outside of the peak. These measures would provide further benefit with the introduction of TNP to mitigate adverse outcomes.

Two of the major transport projects present opportunities to build upon existing projects already under construction. These are the Outer Metropolitan Ring Road and E6 corridor (OMR) and the City Loop reconfiguration and northern rail corridor upgrade (CLR) projects.

Following construction of North East Link (NEL) there is a compelling case to construct phase A of the OMR, which is the E6, to continue the link between the east and north of Melbourne. A staging program should be developed, with our assessment indicating that the project should progressively continue to develop westwards, although there may be selected western sections that warrant earlier delivery.

There are also significant opportunities to commence construction of the City Loop reconfiguration immediately following completion of the Melbourne Metro Tunnel project, to minimise disruptions and take advantage of the additional capacity. This project provides a metro-style service between the growing north to the east and south-east parts of Melbourne, while also preventing overcrowding on the regional Shepparton and Seymour lines. The acceleration of PSPs in the northern growth area means that a business case should be completed in the next two years to determine timing.

Other projects that increase the capacity of existing rail lines, including the western rail corridor upgrade (WRU) which also benefits the south-east growth areas, are also important to provide access to the growing populations. This project would be the next step following the committed project of introducing higher capacity V/Line trains on the Melton corridor. Given the rate of demand growth, a business case should be undertaken to consider how these capacity improvements should be developed. A rail upgrade involving introducing electrification to Mt Atkinson presents a compelling case. Improvements to Wyndham Vale will need to be considered with the planning for SRL West. These support growth patterns and those outlined in *Plan Melbourne* for the future.

Further development of the Melbourne Metro Two and direct Geelong rail services project (MM2G) should be considered with opportunities to provide more direct and better services to Geelong, which could be the next step following delivery of Geelong Fast Rail. This project presents significant opportunities for the west of Melbourne and Geelong as well as expanding the central city to Fishermans Bend. It would also complement a new tram connection to Fishermans Bend that would otherwise be overcrowded. There are important value engineering, scoping, and staging opportunities that should be considered in the development of the preliminary business case for the MM2G project, and if found to be compelling, reserving land and adjusting land use planning settings should be considered to reduce costs and improve land use integration.

North East Link coupled with the Monash / West Gate Freeway will meet cross-city demand for some time. This would be further prolonged with the introduction of TNP which would help manage traffic coming into Inner Melbourne, including on the motorway network. This would therefore allow these roads to facilitate more cross-city movements. However, in the longer term, a new cross-city connection may be necessary particularly with automated vehicles. A cross-city motorway should be considered with TNP. This future option should be protected, and consideration given to alternative alignments, given recent urban developments and mitigation of environmental impacts.

6. Appendices

6.1 Appendix A – Future Scenarios

The modelling completed and assessed for the major transport projects makes assumptions about future growth and trends, based on historical trends and other known factors. However, there remains a high level of uncertainty about the future, particularly in the longer term, and the extent of impact that external shocks can have. To plan for infrastructure with this uncertainty, it is useful to examine a range of scenarios that test the impact of both external shocks on the network and on proposed infrastructure projects. External shocks could include higher or lower population growth and economic growth, a global pandemic impacting the way we work, and technological changes in the transition to zero emissions vehicles and automated vehicles. Policy changes can also impact future outcomes. Two policy scenarios have also been considered, including supporting more homes in priority established areas and implementing transport network pricing. This section assesses the likely impacts of these future scenarios, particularly on the future transport network and land use patterns.

6.2 High and low population growth scenarios

6.2.1 Context

Population is a key driver of demand for infrastructure. Baseline population growth forecasts have been used in the previous chapters of this report, which assume a continuation of recent trends in births, life expectancy, migration and living arrangements across all of Victoria. These official state government forecasts are sourced from the Department of Environment, Land, Water and Planning (DELWP), released in their *Victoria in Future 2019* publication. These comprehensive forecasts are developed using mathematical models and expert knowledge, relying on trend analysis and assumptions about future change.

As noted in *Victoria in Future 2019*, there is uncertainty about future increases over longer projection horizons, and with smaller geographic areas. Different policy settings and changes in the economy could result in changes to the expected size, distribution and composition of the population.[308] In particular, migration levels are more sensitive to changes in policy or economic conditions than births or deaths and are therefore expected to have a bigger impact on future population growth. The COVID-19 pandemic has shown a significant drop in international migration resulting from closed international borders, which caused population growth to slow in Victoria in 2020. Population growth is projected to recover to close to what was forecast prior to the COVID-19 pandemic by 2023-24.[309]

Higher or lower levels of population growth will impact not only economic growth, but also demand for transport infrastructure, including congestion levels and average travel times, as well as patterns of where people live and work. Two population growth scenarios (high and low growth) have been assessed to provide insight on the impacts and opportunities of alternative population growth on future infrastructure demand and use, and on the need and timing for major transport projects.

6.2.2 Scenario specification

Two alternative population growth scenarios have been developed:

- high growth scenario – assumes Victoria's population grows **faster** than baseline growth rates
- low growth scenario – assumes Victoria's population grows **slower** than baseline growth rates.

The low and high growth scenarios are based on the official forecasts published by the ABS for Victoria, using the low and high series forecasts. [310]

Under the baseline scenario, Victoria's population is forecast to reach 8.7 million by 2036. Under the high growth scenario, the population reaches 8.7 million by 2032, four years earlier. Conversely, under the low growth scenario, the

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[308] *DELWP 2019 Victoria in Future publication*

[309] *Australian Government Centre for Population December 2020, Population Statement https://population.gov.au/publications/publications-population-statement.html*

[310] *ABS Population Projections, Australia 2017 – 2066, released Nov 2018 https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release#victoria*

population is not expected to reach 8.7 million until 2043, almost seven years later than the baseline. The baseline scenario assumes an annual average growth rate of 1.8% per year to 2036, whilst the high scenario assumes a 2.2% annual growth rate and the low scenario assumes a 1.3% annual growth rate.

Victoria's annual growth rate has been at the middle and upper end of this range for some time prior to the COVID-19 pandemic. The State Budget forecasts that population growth will gradually increase from no growth in 2020-21 to an average of 1.7% in 2023-24 and that rate thereafter.[311] These growth rates would see Victoria's population reach 6.9 million in 2022-23, around 300,000 lower than the government forecast in its last budget, and historically this represents three to four years of population growth.[312] Whilst Victoria's population forecasts will be reset in the near term to take account of this, this short-term reduction in growth rate will fall within the long-term annual average low to high population forecasting range used for this study towards the end of this decade.

These short-term impacts to population as a result of the COVID-19 pandemic would be more prevalent in places such as Inner Melbourne. The baseline population growth used in this report could give a sense of a possible outcome where slightly more people live in central Melbourne because of changes due to the COVID-19 pandemic. That is, it is conceivable more people might move to central Melbourne in the short term to take advantage of relatively more affordable housing that becomes available due to lower demand for office space due to behavioural changes caused by the COVID-19 pandemic. This could be accompanied by property owners converting commercial property for residential uses. While we do not consider this outcome to be the most likely one, if it were to occur then this would not alter the prioritisation and overall conclusions made regarding the major transport projects we assessed.

The differences between the high and low population scenarios become more pronounced in the longer term. By 2051, Victoria's population is forecast to reach 10.5 million people. Under the higher growth scenario, a population of 10.5 million is reached seven years earlier, by 2043. Under the lower growth scenario, the population is not expected to reach 10.5 million until 2066, almost 15 years later than the baseline scenario.

We have assumed that the transport and land use model outcomes from the baseline scenario occur in line with the high and low population growth scenarios. That is, expected 2036 model outcomes are now assumed to occur in 2032 in the high growth scenario, and in 2043 in the low growth scenario. This simplifying assumption has been used to demonstrate the variation in demand, rather than provide a specific result under alternative growth scenarios.

[311] *Department of Treasury and Finance, 2021 Victorian State Budget Paper 2*

[312] *Parliamentary Budget Office website accessed 1/6/2021* *Victorian Parliamentary Budget Office (pbo.vic.gov.au)*

6.3 Working from home scenario

6.3.1 Context

In recent years, working from home has become more popular as businesses in different industries have discovered its benefits. The adoption of remote working has varied substantially across industries and occupations. Before the COVID-19 pandemic, people in some professions worked at least part of their working hours from home. The widespread adoption of working from home arrangements has been hypothesized to reduce congestion, ease the burden on public transport systems, decrease commute times and reduce carbon footprints, all as the result of fewer trips being made to and from the office. The likelihood that working from home arrangements will achieve these objectives is contingent on how they affect the housing decisions made by individuals, the frequency at which workers perform their duties at home, and the location at which telework (working from home) is performed.

Across the world, the COVID-19 pandemic has disrupted how and when people travel, and how goods and services are supplied by businesses to consumers. This disruption has possibly accelerated changes that were already underway. Some industries have rapidly adapted to this changing economic climate—for example, by making greater use of working from home arrangements for some occupations. This could lead to further changes in how and where economic activity takes place and the infrastructure required to support these changes. In Victoria, there was a partial shift to working from home from mid-March 2020 that was followed by a more comprehensive shift in early August 2020 which only started to be relaxed from late September 2020 and remains present in some occupations.

An ABS survey of businesses with employees found that before the COVID-19 pandemic, 71% of businesses had no staff teleworking. More than 90% of businesses with at least 20 employees had less than 25% of employees teleworking. Only 6% of businesses had 75 to 100% of employees teleworking. The industries with the largest shares of teleworking before the COVID-19 pandemic were Professional, Scientific and Technical Services (59%), Information Media and Telecommunications (52%), Administrative and Support Services (46%) and Financial and Insurance Services (43%).[313]

During the COVID-19 pandemic, the share of businesses with no workers teleworking fell from 71% to 56%. In addition, the share of businesses with at least 75% of employees working from home increased from 7% to 17%.[314] Whilst the situation in Victoria is evolving, there is speculation that even after the impacts of the COVID-19 pandemic are lessened, the incidence and frequency of working from home may remain much higher than before the pandemic. The largest shifts to working from home have occurred in industries that already featured the greatest share of employees working from home pre-pandemic. It is expected that an increase in working from home arrangements post the COVID-19 pandemic will lead to an ongoing hybrid approach to flexible work, with some people choosing to split their time between the office and working from home. This will reduce the number of commuters using public transport and driving into work, causing a decrease in peak hour congestion as well as reducing the weekly commute times for workers.

Some of the changes we have seen since mid-March 2020 from greater numbers of employees working from home are likely to be permanent, with a greater number of businesses and households investing in new ways of working and trading. In the September 2020 ABS survey, businesses were asked if they expected to have employees teleworking "once restrictions are lifted and conditions stabilise". Before the COVID-19 pandemic, 71% of businesses reported no teleworking, whilst after the onset of the COVID-19 pandemic, 66% of businesses expect no teleworking in the longer term. Of those businesses employing at least 200 workers, the share of businesses with no teleworkers is expected to fall from 47% to 35%.

Changes resulting from greater numbers of employees working from home are likely to result in a medium to long-term restructuring of the economy. This restructuring is likely to shift the underlying demand for infrastructure and land use and have different impacts on industries, cohorts, and regions. For example, with less commuting there will be changes in where people choose to live and shop and what mode of transport they use.

6.3.2 Scenario specification

A working from home (WFH) scenario has been developed to assess the impacts of working from home arrangements on the economy, transport and land use outcomes, and on major infrastructure projects. Infrastructure Victoria has used the integrated land use and transport interaction (VLUTI) model to investigate the potential medium to long-term infrastructure and land use implications of increased working from home for some industries/professions in Victoria. Detail on how the changes made for this scenario in the VLUTI model can be found in Appendix E, with further description of the VLUTI model provided in the *Infrastructure Victoria VLUTI Model Architecture report*.

The following adjustments were made to the VLUTI model to create the WFH scenario, to model the impacts on transport and land use outcomes:

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[313] *ABS Survey of Businesses 2020*

[314] *ABS Survey of Businesses 2020*

1. Identification of the share of workers within each occupation able to work from home. These occupations were selected and estimated based on international evidence and ABS data. All further adjustments were only made to these selected occupations.
2. Adjust the commuting cost coefficient in the model to account for the reduced cost of commuting when working from home for approximately two additional days per week. The reduced commuting costs impact the choices that working households make around where to live and work, as well as in what occupation.
3. Adjust other indirect cost shares associated with working from home in the model. These include household transport costs, household internet costs and firm internet costs.
4. Adjust the number of trips made in the transport model (VITM) by two days per week (on average) for those in working from home occupations.

Occupations that can work from home

To model medium to long-term behaviour change (working from home) resulting from the COVID-19 pandemic, occupations were selected which had the most tasks that could be performed from home. Occupations that involved physical activities, direct contact with the public, specialised equipment or premises, were hazardous or involved a lot of walking/running or wearing specialised protective/safety equipment were classified as not able to be performed at home. All other occupations were assumed to be able to be conducted from home. The estimated share of workers in each occupation who can work from home is outlined in the following table. This is based on international evidence and ABS data, which is further described in Appendix E.

Table 45: Estimated share of workers in each occupation who can work from home

ANZSCO 2-digit level Occupations	Share of workers who can work from home
Chief Executives, General Managers and Legislators	71.6%
Farmers and Farm Managers	0.0%
Specialist Managers	69.0%
Hospitality, Retail and Service Managers	0.0%
Arts and Media Professionals	81.3%
Business, Human Resource and Marketing Professionals	100.0%
Design, Engineering, Science and Transport Professionals	73.9%
Education Professionals	28.6%
Health Professionals	5.7%
ICT Professionals	100.0%
Legal, Social and Welfare Professionals	81.4%
Engineering, ICT and Science Technicians	65.6%
Automotive and Engineering Trades Workers	0.0%
Construction Trades Workers	0.0%
Electrotechnology and Telecommunications Trades Workers	0.0%
Food Trades Workers	0.0%
Skilled Animal and Horticultural Workers	5.3%
Other Technicians and Trades Workers	9.2%
Health and Welfare Support Workers	0.0%
Carers and Aides	0.0%
Hospitality Workers	0.0%
Protective Service Workers	0.0%
Sports and Personal Service Workers	0.0%
Office Managers and Program Administrators	100.0%
Personal Assistants and Secretaries	100.0%
General Clerical Workers	100.0%
Inquiry Clerks and Receptionists	14.5%
Numerical Clerks	83.8%
Clerical and Office Support Workers	37.2%
Other Clerical and Administrative Workers	83.6%
Sales Representatives and Agents	60.7%
Sales Assistants and Salespersons	0.0%
Sales Support Workers	16.0%
Machine and Stationary Plant Operators	0.0%
Mobile Plant Operators	0.0%
Road and Rail Drivers	0.0%
Storepersons	0.0%
Cleaners and Laundry Workers	0.0%
Construction and Mining Labourers	0.0%
Factory Process Workers	0.0%
Farm, Forestry and Garden Workers	0.0%
Food Preparation Assistants	0.0%
Other Labourers	0.0%

Source: Analysis of ABS Census data

Commuting cost coefficient

To model increased working from home in the SIRCV model, the frequency of working from home is endogenized by reducing coefficient zeta (ζ) – a commuting cost coefficient (commuting disutility). An increased propensity for working from home was modelled by lowering the value of commuting cost coefficient for relevant occupations.

Indirect costs

As well as considering the direct effects of working from home, Infrastructure Victoria also modelled the following three indirect effects:

1. *Changes in household transport costs* – resulting from no longer paying for transport to work. This is reflected in a reduction in household expenditure on transport-related industries. VISTA data was used to estimate the change, calculated to be approximately a 13% reduction.
2. *Changes in household internet costs* – resulting from increased use of home internet and videoconferencing software. It is assumed expenditure will vary directly with usage. This was calculated as the total of fixed internet usage for a typical household as well as additional internet usage for working from home two days per week.
3. *Changes in firm internet costs* – resulting from less employees using the internet in an office. This was estimated using the change in household internet costs based on working from home two days per week.

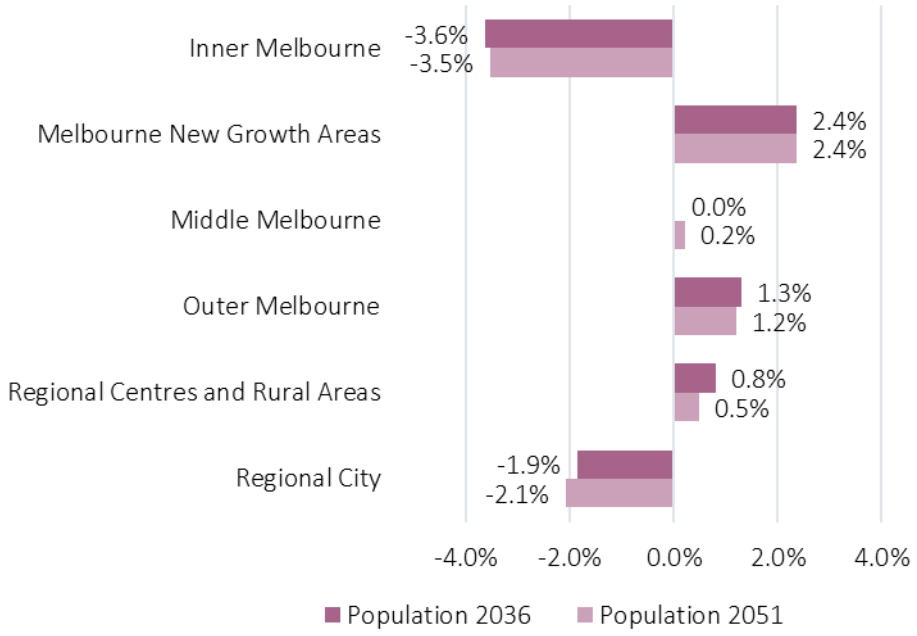
Further detail on how these costs were estimated is provided in Appendix E.

6.3.3 Working from Home Modelling Outcomes

Land use changes

Total Victorian population and employment in the WFH scenario remains the same as the base case into the future, however the spatial distribution of population and employment differs under the WFH scenario. The WFH scenario increases the number of people in specific industries and locations that are working from home. The primary impact of this is a redistribution of population away from centralised areas such as the CBD and regional cities, as the need to access defined employment hubs is reduced. There are expected to be slight increases in population in a number of Functional Urban Areas including Middle Melbourne, Outer Melbourne, New Growth Areas, and Regional Centres and Rural Areas in 2036 and 2051, compared to the base case.

Figure 105: WFH scenario population differences by Functional Urban Area (2036 and 2051)

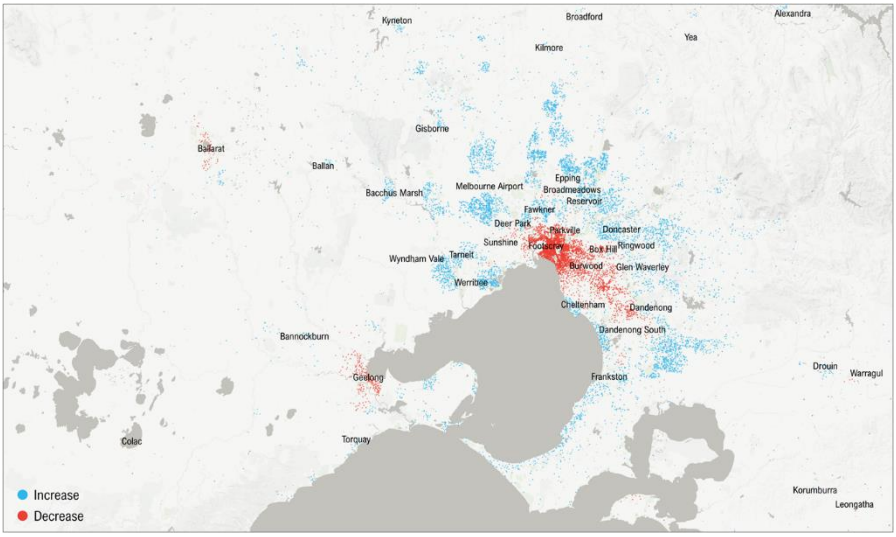


Source: Arup 2021 Strategic Modelling Outcomes

Inner Melbourne is modelled as experiencing the largest impact with smaller populations by 3.6% and 3.5% in 2036 and 2051 respectively, compared to the base case. The shift to working from home also results in around 2% less population living in Regional Cities in 2036 and 2051 compared to the base case. In all other FUAs, the shift to working from home results in a larger population in both 2036 and 2051, compared to the base case.

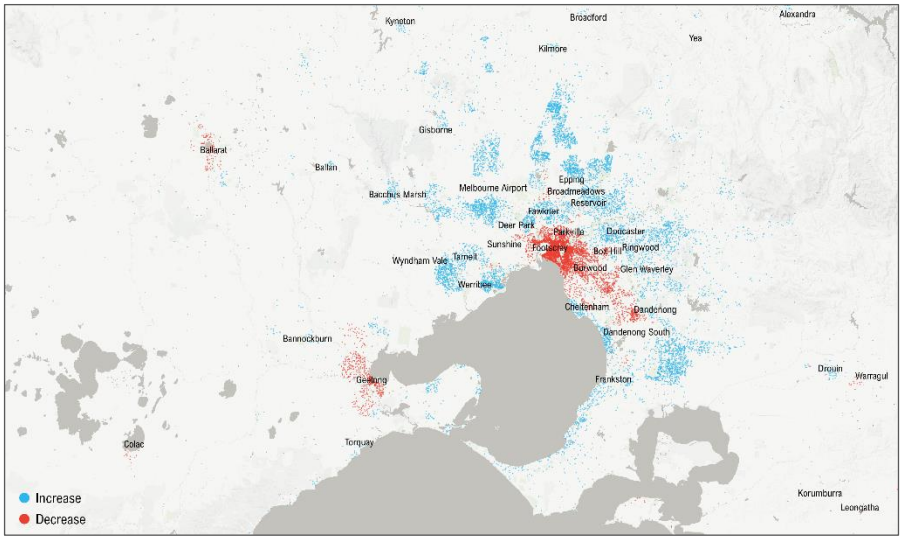
The following two figures show changes in resident population compared to the base case in 2036 and 2051. The outer northern western and south eastern regions of Melbourne and the New Growth Areas gain the most residents, while Inner Melbourne loses the most residents under the WFH scenario.

Figure 106: Working from home – change in population vs. base case 2036



Source: Arup 2021 Strategic Modelling Outcomes

Figure 107: Working from home – change in population vs. base case 2051



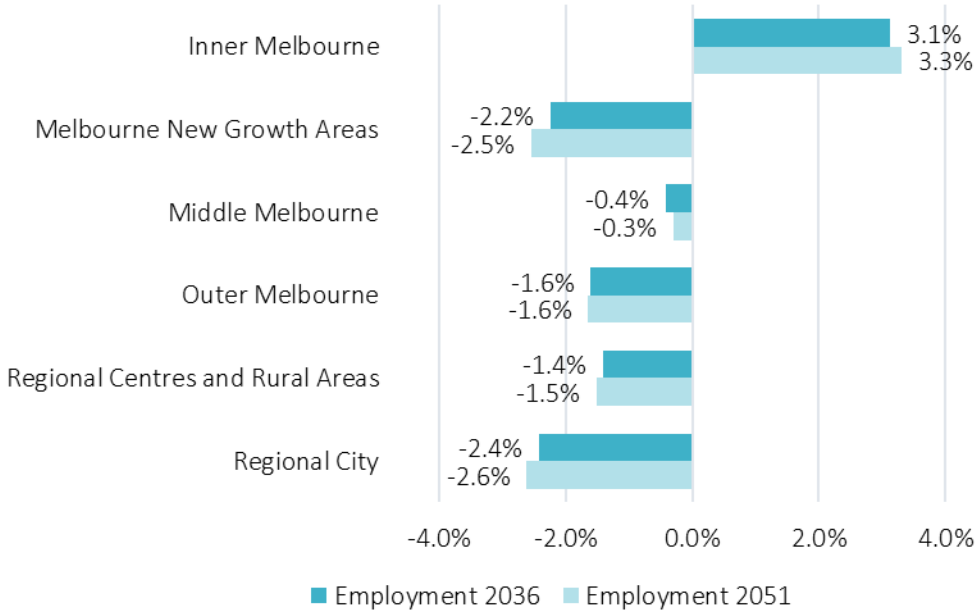
Source: Arup 2021 Strategic Modelling Outcomes

Given the reduced need to commute due to the shift to working from home, residents are more comfortable moving further away from their place of employment. Whilst population is redistributed away from Inner Melbourne and Regional Cities in 2036 and 2051, employment (based on the location of the employer or firm) increases in these regions. Inner Melbourne areas such as Melbourne CBD, Southbank, Docklands, and many of Melbourne's inner city suburbs are forecast to have a larger number of jobs, primarily in the sectors of professional, scientific and technical services, financial and insurance services, information media and telecommunications, and accommodation and food services. These sectors and industries with growth in central city areas have occupations that are able to work from home, such as professional services.

The location of employment represents where the employer or firm is located, rather than where the work is done. Therefore, whilst employment is growing in the central city under this scenario, people working in these jobs, and these locations, are more likely to be working from home. In general, occupations with more jobs able to work from home experience greater employment as they have become relatively more attractive to work in.

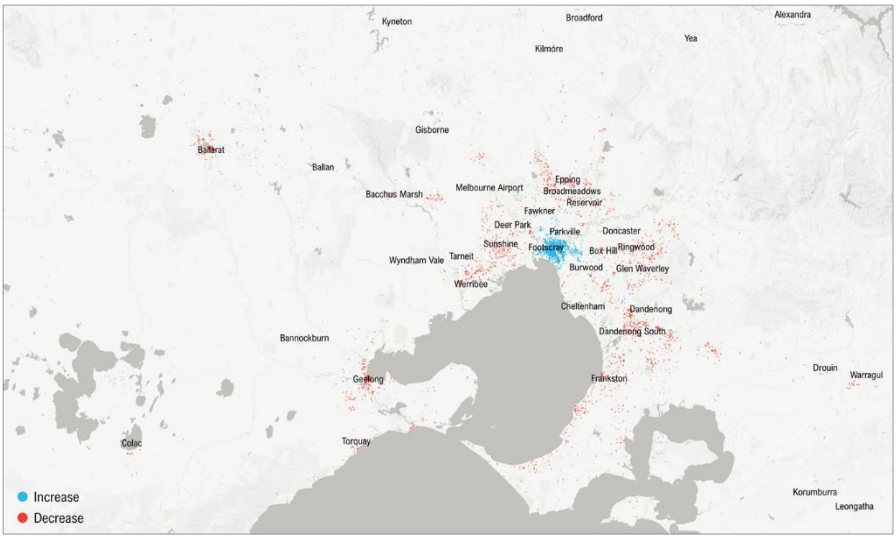
In terms of employment, Inner Melbourne is modelled as experiencing the largest impact, with an increase in employment of around 3.1% (or 42,550 jobs) and 3.3% (or 53,870 jobs) in 2036 and 2051 compared to the base case respectively. In all other FUAs, the shift to working from home results in lower employment in 2036 and 2051, compared to the base case.

Figure 108: WFH Scenario employment differences by Functional Urban Area (2036 and 2051)



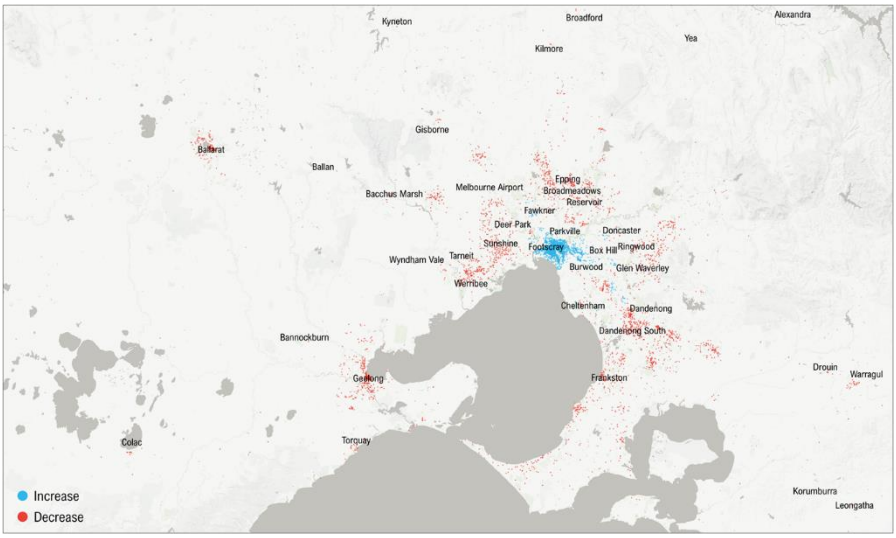
Source: Arup 2021 Strategic Modelling Outcomes

Figure 109: Working from home – change in employment vs. base case 2036



Source: Arup 2021 Strategic Modelling Outcomes

Figure 110: Working from home – change in employment vs base case 2051

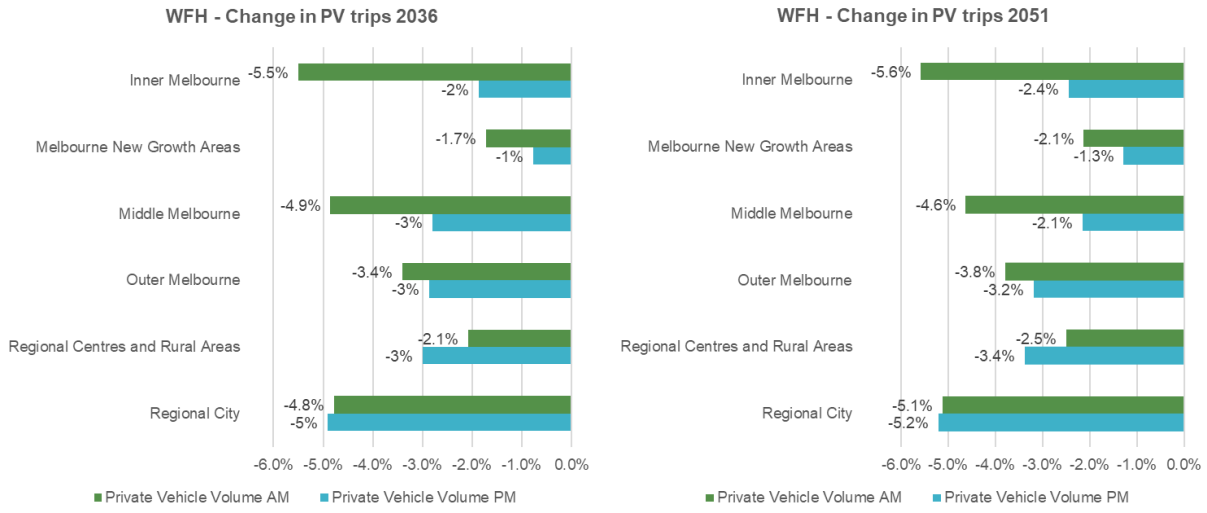


Source: Arup 2021 Strategic Modelling Outcomes

Transport impacts

One of the impacts of the shift to working from home is the change in passenger transport demand. Working from home is expected to reduce private vehicle trips across the entire network as less people are required to travel to work every day. The following two figures show the change in private vehicle trips under the WFH scenario in 2036 and 2051. As shown in the figures below, the assumptions underpinning the WFH scenario lead to a moderate reduction in private vehicle trips in Inner and Middle Melbourne and regional cities during the morning peak in 2036 and 2051, compared to the base case. Melbourne's New Growth Areas, Outer Melbourne, and regional centres and rural areas also see small reductions in private vehicle trips during the morning and afternoon peaks in 2036 and 2051.

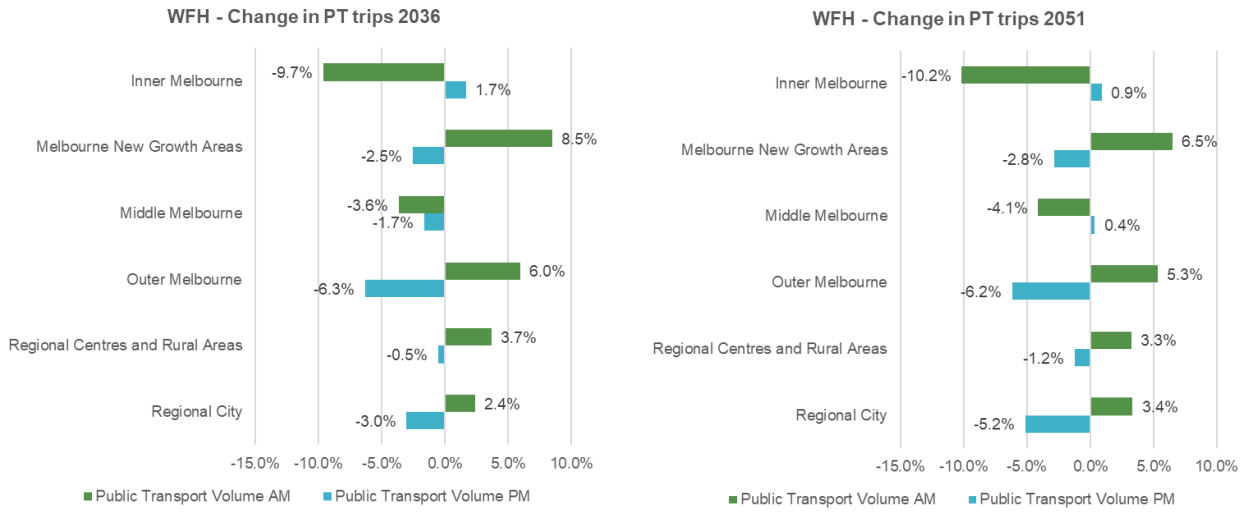
Figure 111: Change in private vehicle trips (originating) vs. base case by Functional Urban Area



Source: Arup 2021 Strategic Modelling Outcomes

Changes in the number of trips are seen across the public transport network under the WFH scenario. Public transport trips have a more significant change compared to the change in private vehicle trips. This leads to a modestly increased public transport mode share. The assumptions underpinning the WFH scenario lead to a moderate reduction in public transport trips in Inner and Middle Melbourne during the morning peak in 2036 and 2051, compared to the base case. Public transport originating from Melbourne's New Growth Areas, Outer Melbourne, regional centres and rural areas, and regional cities experience a moderate increase in the morning peak, while these regions see small reductions in public transport trips during the afternoon peak in 2036 and 2051.

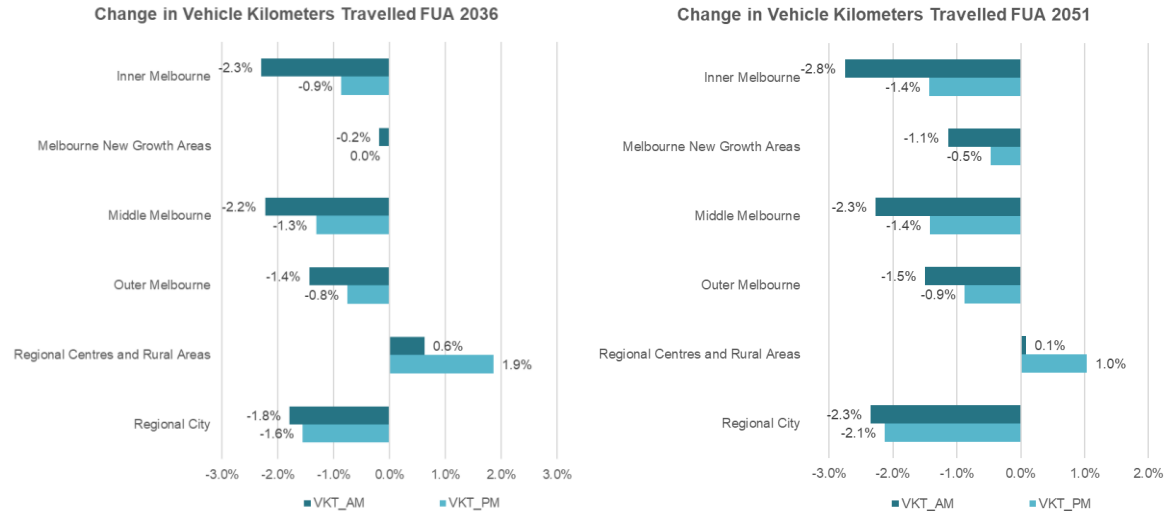
Figure 112: Change in public transport trips (originating) vs. base case by Functional Urban Area



Source: Arup 2021 Strategic Modelling Outcomes

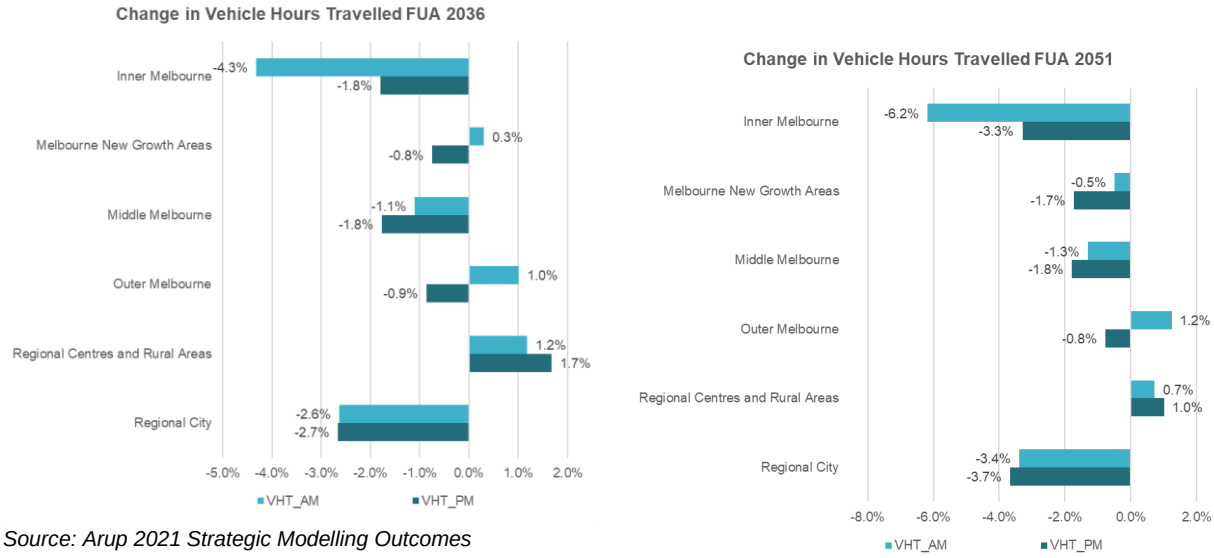
As expected, the shift to working from home leads to a reduction in road transport. A reduction in both vehicle kilometres travelled (VKT) and vehicle hours travelled (VHT) is observed in almost all regions (except regional centres and rural areas) under the WFH scenario during the morning and afternoon peaks. The modelling results also show that the magnitude of change in the reduction of VKT and VHT is less than that of private vehicle trips. This is because whilst there are less people travelling, they are generally travelling further due to the population redistribution to outer and growth areas.

Figure 113: Change in vehicle kilometres travelled vs. base case by Functional Urban Area



Source: Arup 2021 Strategic Modelling Outcomes

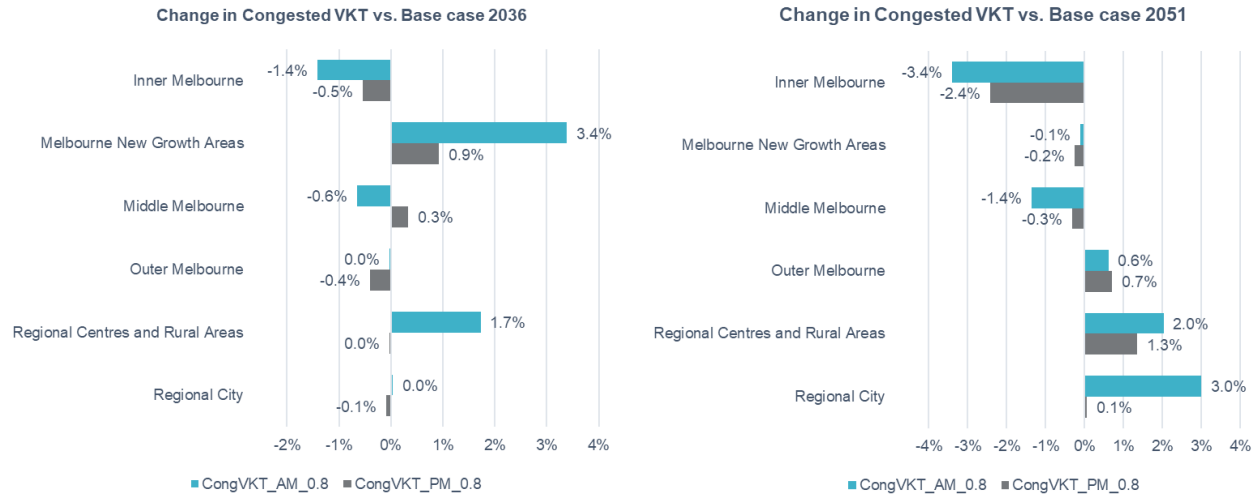
Figure 114: Change in vehicle hours travelled vs. base case by Functional Urban Area



Source: Arup 2021 Strategic Modelling Outcomes

The shift to working from home results in the movement of residents toward specific areas. This causes changes in road congestion in different areas. The following two figures present change in congested VKT under the WFH scenario. As expected, the shift to working from home results in a slight reduction in road congestion across most of the network as less people are required to travel to work. However, the movement of population toward specific areas leads to a level of increased road congestion in some areas. Melbourne's New Growth Areas and Outer Melbourne, regional centres and rural areas, and regional cities experience a slight increase in road congestion in both modelled years (2036 and 2051). It is noted that changes in road congestion under the WFH scenario are not necessarily consistent across modelled horizon years. This is likely due to the fact of changing infrastructure across the network between 2036 and 2051 leading to variation in the areas of congestion within the base case.

Figure 115: Change in congested VKT vs. base case by Functional Urban Area

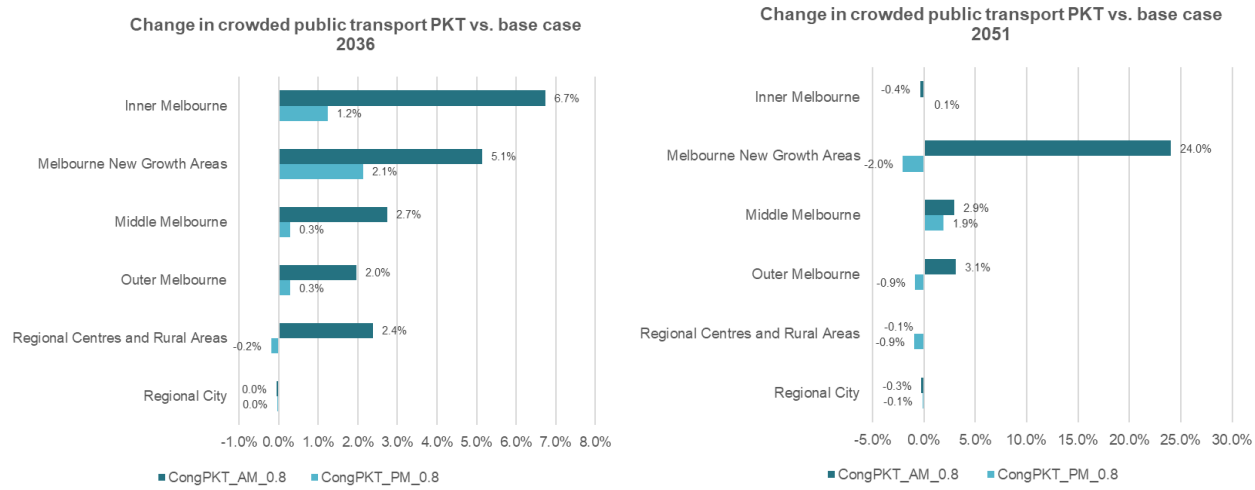


Source: Arup 2021 Strategic Modelling Outcomes

The following two figures show the change in crowding across the public transport network under the WFH scenario in both modelled years. The shift to working from home leads to a moderate increase in crowding across the public transport network in Inner Melbourne and Melbourne's New Growth Areas during the morning peak in 2036 compared to the base case. This is likely because whilst there are less people travelling overall due to the shift to working from home, the increase in Inner Melbourne employment, more households living in outer areas and longer trip distances result in people shifting to public transport to take advantage of the better travel time and convenience it offers for long distance Inner Melbourne trips. While public transport trips are reduced, people are travelling from further away, increasing total passenger kilometres travelled. This increases congested kilometres travelled, especially because crowding now occurs earlier with more people travelling from the extremities of the network. All other FUAs see a slight increase in crowding across the network during the morning peak in 2036. Melbourne's New Growth Areas experience a significant increase

in crowding across the network under WFH scenario in 2051 which may be due to a large degree of population redistribution occurring.

Figure 116: Change in crowded public transport PKT vs. base case by Functional Urban Area

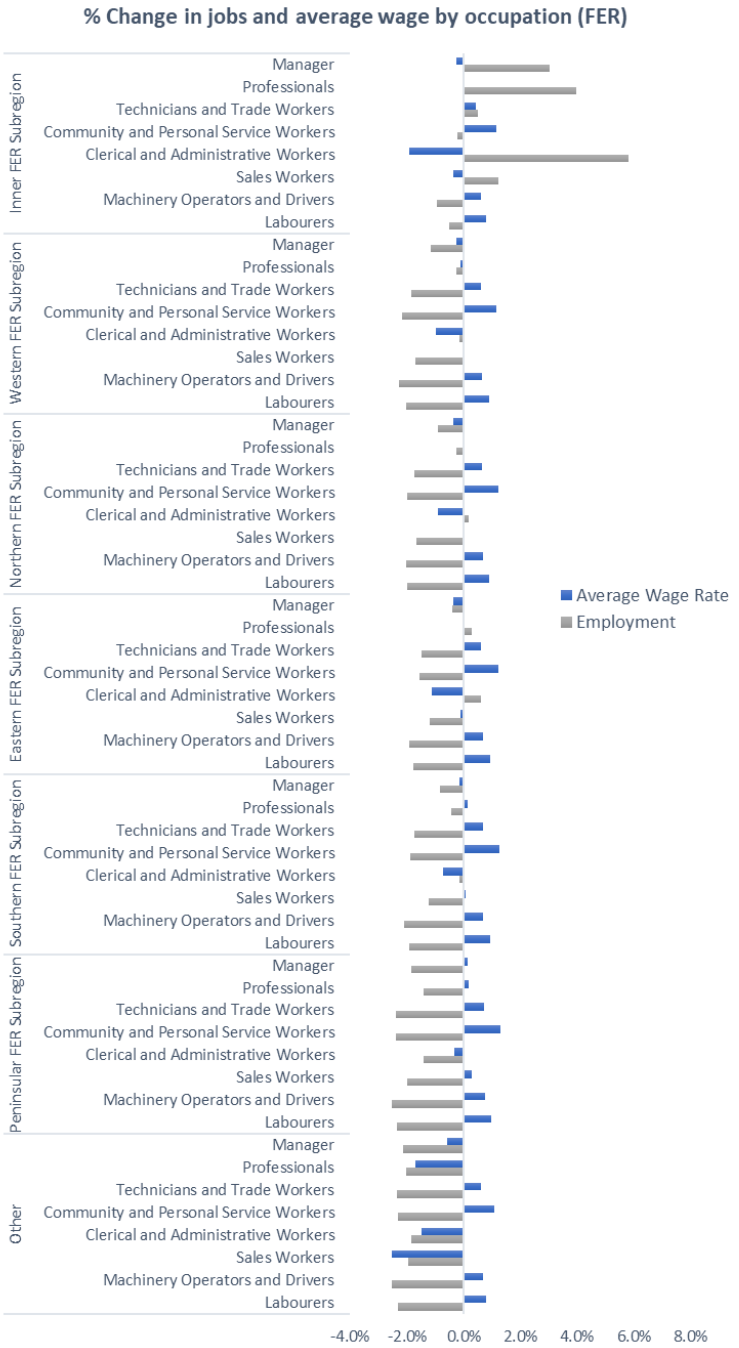


Source: Arup 2021 Strategic Modelling Outcomes

The economic impact of the shift to working from home

As population and employment in the WFH scenario are held fixed, population and employment gains in some regions imply losses in others. Figure 117 shows changes in jobs and average wage rates by occupation in Functional Economic Regions (FER). Employment tends to increase in inner FER subregions' industries that are intensive users of teleworking occupations and decrease in all other FERs. This reflects changes in labour costs and possibilities to substitute WFH occupational labour for non-WFH occupational labour. Average wage rates for some occupations including Manager, Clerical and Administrative Workers, and Sales Workers decline in almost all FERs. While industry-average wage rates in other occupations rise in almost all FERs (such as Technicians and Trade Workers, Community and Personal Service Workers, Machinery Operators and Drivers, and Labourers). These patterns explain many of the differences in employment losses across non-WFH occupations.

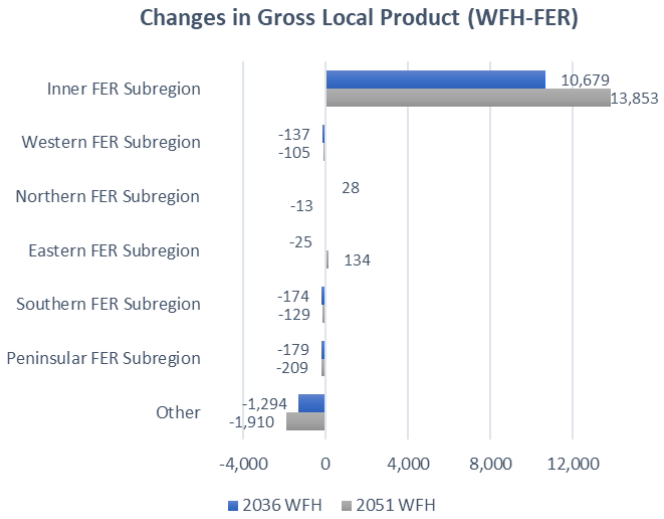
Figure 117: Changes in jobs and average wage by occupation – FER (%)



Source: Arup 2021 Strategic Modelling Outcomes

In terms of overall economic impact, the shift to working from home leads to an increase in gross state product (GSP). Changes in gross local product (GLP) range from over $10 billion increase in the inner FER subregion in 2036 and 2051 to over $1 billion decrease in other regions. Figure 127 shows changes in GLP under the WFH scenario in 2036 and 2051. The inner FER experiences the largest changes in GLP. This is mainly because the inner FER experiences the largest employment impact under the WFH scenario, with an increase in employment of around 2.7% (or 4,248 jobs) and 2.9% (or 5,424 jobs) in 2036 and 2051 compared to the base case respectively.

Figure 118: Changes in gross local product - FER ($million)



Source: Arup 2021 Strategic Modelling Outcomes

6.4 Support more homes in priority established places – policy scenario

6.4.1 Overview

A key recommendation in *Victoria's infrastructure strategy* is to support more homes in priority established suburbs for residential intensification to better use existing infrastructure. That is, encouraging residential development in areas in proximity to the existing transport network, that will support better use of the network.

Prioritising home building in established suburbs ultimately costs Victorians less than expanding in new growth areas. Infrastructure costs in established suburbs with the capacity to support growth can be two to four times cheaper than in new growth suburbs, excluding transport and open space.[315] *Plan Melbourne* supports housing choices in locations close to jobs and services, with integrated transport systems providing connections for people, goods and services.[316]

Previous research undertaken by Infrastructure Victoria modelled different scenarios of development patterns across Melbourne to determine the impacts on the transport network. This section summarises the key findings of this research. Better use of the existing network to meet the transport challenges should be considered first, before constructing new infrastructure.

6.4.2 Research findings

A scenario that simulated land use zoning changes which allowed for more homes near the principal public transport network in 2036 was modelled in preparing the draft infrastructure strategy in 2020.[317] The results of this scenario testing showed more people and jobs in Inner Melbourne compared to the network development scenario (NDS - base case). Our modelling shows that enabling more people to live closer to jobs and services can grow Victoria's economy and increase the efficiency of our transport networks.[318]

This scenario drew people towards Inner Melbourne where more densification was now permitted, whilst population from the regional cities and centres was lower (see Figure 119). It also demonstrated a larger consolidation of employment towards Inner Melbourne, whereas growth was slower in regional areas and Outer Melbourne. Stonnington and Boroondara LGAs, in Melbourne's inner east, gained the most additional jobs in this scenario.

As this scenario resulted in more population within inner areas of Melbourne, the overall number of motorised trips was lower than that of other scenarios, as residents in these areas were more likely to use active transport. However, the network performance of this scenario did not differ substantially from that of the base case, despite the increased density of residents and jobs. Under this scenario, congested VKT is still higher than in 2018, even though the share for other modes increases. Population increases result in traffic volumes shifting towards areas that already had an existing level of congestion. However, the increase in congestion is less than expected given the population increases.

This scenario results in increased public and active transport use due to the increase in residents in Inner Melbourne, where these modes of transport are more viable and prevalent compared to private vehicles. Public transport trips are shorter on average and the tram network plays a slightly larger role in moving people around Inner Melbourne. Shorter public transport trips in 2036 result in half the public transport crowding experienced in 2018. Increased active transport use also contributes to reduced road congestion.

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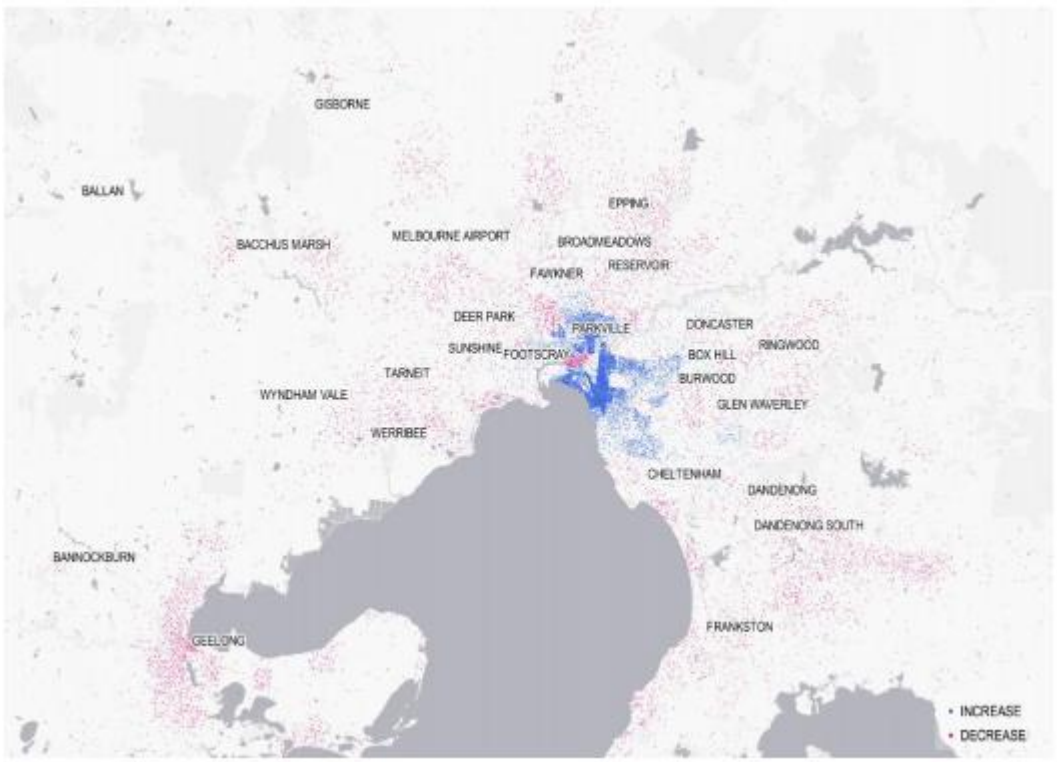
[315] *Infrastructure Victoria 2018. Infrastructure provision in different development settings*

[316] *DELWP, Plan Melbourne p.12*

[317] *See Arup Problem Definition Modelling Outcomes report (Nov 2020) for full detail and analysis of modelling conducted for Infrastructure Victoria's draft strategy. This VLUTI model was a previous iteration of the current version used in assessing the major transport projects in this report. https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/12/ARUP-Problem-Definition-Modelling-26-October-2020.pdf*

[318] *Arup Problem Definition Modelling Outcomes report (Nov 2020)*

Figure 119: Population changes in 2036 between the *Density Done Well* scenario and network development scenario (base case)



Source: Arup 2020 Problem Definition report

6.4.3 Implications

Modelling of this scenario demonstrated that a higher density of residents within Inner Melbourne could be accommodated with minimal impacts to broader network performance. Policy interventions like this can have a significant impact on accessibility, through better use of existing infrastructure.

The recommendation to support more homes in priority established places should be undertaken in conjunction with other transport recommendations within *Victoria's infrastructure strategy*, to ensure that the benefits of upgraded and new transport infrastructure and improved network outcomes integrate with land use considerations.

Demand management policies that influence travel behaviour should also be considered alongside this recommendation, including road management systems and transport network pricing.

6.5 Transport Network Pricing – policy scenario

6.5.1 Background

Transport network pricing (TNP) was one of the top three recommendations in Infrastructure Victoria's first 30-year infrastructure strategy released in 2016 and continues to be one of our core research areas. Our research shows that comprehensive network-wide changes to the pricing of roads, public transport and parking is required to get the most out of our existing and future transport system, manage demand and change the way Victorians use the transport system.

TNP is a system designed to influence how, when and where people use the transport system by including the impact that people's travel has on others into a price signal. Under TNP, prices can be set to incentivise commuters to travel at quieter times, such as in the off peak, and shift mode from private vehicles to public transport. TNP will help to ease congestion and crowding, and improve environmental and health outcomes. TNP will also enhance existing and planned large government infrastructure investments in our transport network, helping these projects to perform optimally once delivered.

Our past research utilising the MABM to measure pricing policy responses provides a strong evidence base to help infer the expected benefits from implementing TNP alongside the major transport projects. We have not explicitly modelled TNP in the project scenarios using the VLUTI model (apart from various tolls on major new roads such as CCM and OMR). A selection of results from our past research is summarised below.

Each major transport project in this report also brings a unique perspective in how to integrate these projects with TNP. This was explored in section 4 for each major transport project.

6.5.2 Research and publications

To support TNP recommendations to the Victorian Government, Infrastructure Victoria has released multiple reports relating to pricing and demand management techniques for the transport system. These include:

- *The Road Ahead: How an efficient, fair and sustainable pricing regime can help tackle congestion,* released November 2016
- *Five Year Focus: Immediate actions to tackle congestion,* released in April 2018
- *Good Move: Fixing transport congestion,* released March 2020
- *Fair Move: Better public transport fares for Melbourne,* released September 2020.

The research covered in these reports includes direct access to community opinion, transport modelling, international case studies and the advice of policy decision-makers to help inform not only the fundamentals of a transport network pricing scheme, but also the implementation pathway.

To analyse the transport and equity impacts of a reformed TNP system, we used the Melbourne Activity and Agent Based Model (MABM). One of the greatest strengths of the MABM is that it is an agent-based model, capable of tracing the movements of individual 'agents' or travellers as they move around Greater Melbourne throughout the day. By using the MABM to model future scenarios we can identify not only the overall impact on the transport network from pricing reform, but also identify who is better off, and by how much.

Our recommendations range between short to long-term options, changes to the way users pay for public transport and parking, reforms for private vehicle charges and options in delivering pricing infrastructure and governance.

6.5.3 Key findings from transport network pricing

The key finding from our TNP work has been consistent throughout all aspects of our research: changing the way we pay for transport can have long lasting benefits to optimising the efficiency of our transport system and progressing equity for users of the network. Whether it's about spreading peak demand or incentivising travellers to utilise alternative modes available to them, making the best use of Victoria's current and future infrastructure is a necessary, effective, and fair policy.

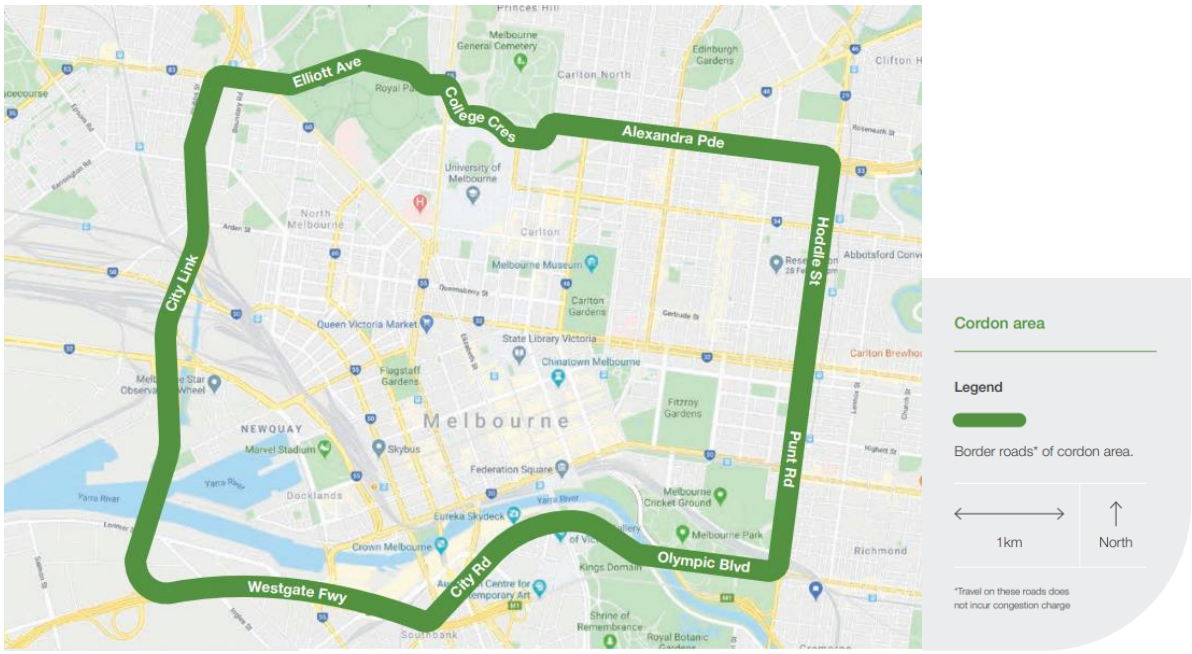
Road user charges – changing the way motorists pay

Our research in *Good Move* demonstrated that network-wide changes to the pricing of roads, public transport and parking was required to get the most out of our current transport system and future transport projects. Traditional fixed charges like car registration and flat public transport fares were replaced with different, flexible ways of paying including charges based on how, when and where individuals travelled, driving behaviour change.

To understand the impacts of pricing reform, especially on private vehicles, we used the MABM to test different transport network pricing mechanisms. Alongside public transport fare reform, the implementation of a cordon charge around Inner Melbourne and a distance-based road charge for all vehicles had the greatest impact on reducing congestion. The figure below shows the extent of the inner city cordon around central Melbourne where vehicles are charged a higher per

kilometre rate during the peak periods compared to the rest of Greater Melbourne, to better reflect the higher cost of congestion in the area.

Figure 120: Inner City Cordon used in TNP Modelling



Source: Infrastructure Victoria 2020. Good Move: Fixing transport congestion

The figure below shows the per kilometre costs for private vehicles for both Greater Melbourne and the inner city cordon. Car parking at train stations and park-and-ride facilities were also charged a flagfall value for the day. This illustrative TNP scenario was also designed to raise, as closely as possible, equal revenue to what the current set of public transport and road use charges would raise in 2031. For example, this means the per kilometre rate would return a similar level of revenue as earned from existing charges such as registration, TAC, car stamp duty and fuel excise. We also designed a scenario where a set of equity measures including quantity discounts, daily spending caps and free trips were included for eligible low income and concession groups. This was called the TNP with discounts scenario and is shown in Figure 123.[319]

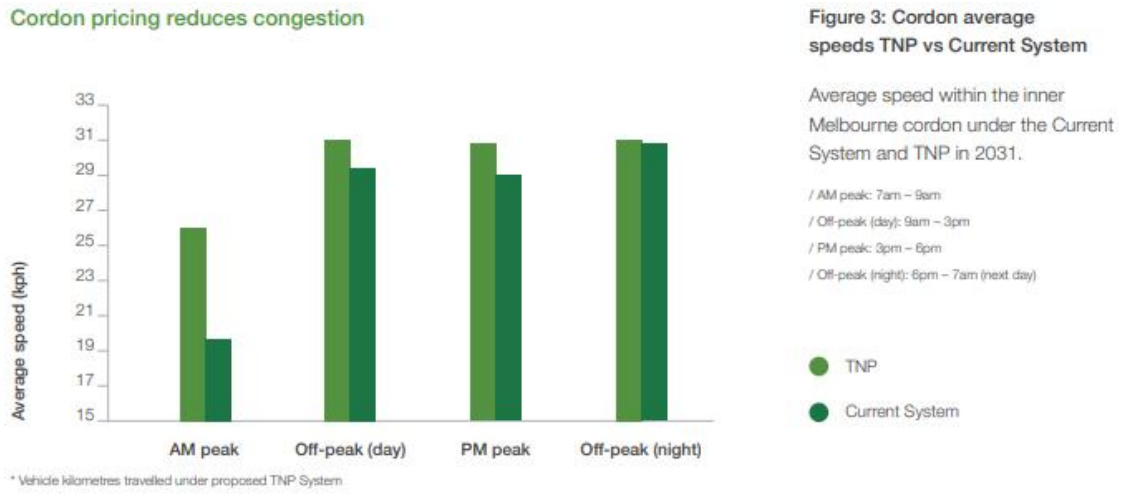
Figure 121: Costs for Private Vehicles and Parking used in TNP Modelling

Mode/service	Price
Cars	\ All day: $0.155 per kilometre \ Additional AM & PM peak cordon charge: $1.00 per kilometre (within the cordon)
Train station and Doncaster Park-and-Ride parking charges	\ Zone 1 stations: $3.00 flagfall \ Zone 2 stations: $1.00 flagfall

Source: Infrastructure Victoria 2020. Good Move: Fixing transport congestion

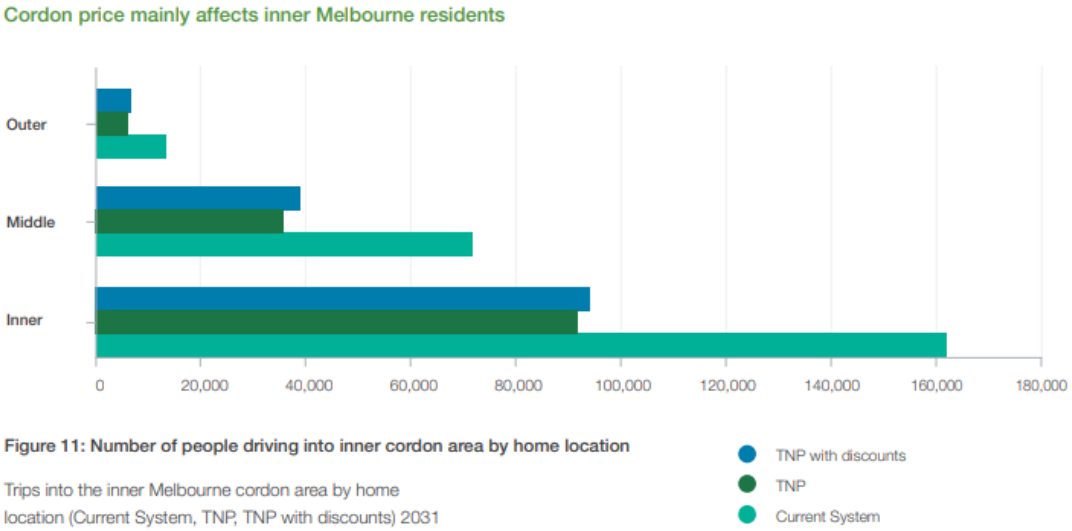
[319] For more detail on the TNP with discounts scenario, see chapter 5 of Infrastructure Victoria 2020. *Good Move: Fixing transport congestion*

Figure 122: Average speeds within Inner Melbourne Cordon with and without TNP



Source: Infrastructure Victoria 2020. Good Move: Fixing transport congestion

Figure 123: Number of people driving into inner city cordon area by home location



Source: Infrastructure Victoria 2020. Good Move: Fixing transport congestion

With reform, vehicles within the Inner Melbourne cordon experienced average speed increases of up to 25% (see Figure 122), partly due to the number of vehicles entering the cordon almost halving in volume (see Figure 123). This was roughly equivalent to 168,000 trips taken off Victorian roads and onto public transport each day, leading to better train, tram and bus utilisation. The overall time spent in peak hour congestion also reduced by 8%. By changing how we pay for transport, the majority of middle and low income households also experienced cheaper transport costs.

As discussed earlier, TNP must be measured and analysed as part of a comprehensive transport network outcome. While improvements to private vehicle travel are an aspect of travel in Greater Melbourne, other modes such as public transport must be considered.

Public transport fares – a potential future

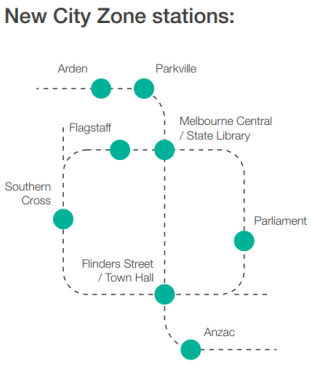
As part of *Fair Move,* Infrastructure Victoria modelled a series of illustrative scenarios to replace Melbourne's current public transport fare structure with one that provides stronger incentives for travellers to make better use of the network.

One illustrative scenario we modelled in the MABM integrated peak and off-peak pricing, location-based pricing, and mode-based pricing into a single fare structure (the *Fare Reform* scenario). The scenario also removed certain elements of the existing myki system, such as the Free Tram Zone, and was designed to demonstrate the benefits to both the overall transport network and society from purposeful fare reform. A new City Zone was also introduced to reflect the greater levels of congestion, crowding pre-COVID, and increased costs of expanding the train network in and around the

CBD. Implementation of the City Zone should be contingent on CBD public transport travel patterns returning to pre-COVID levels, with significant crowding during peak times. The table below shows a comparison between the Current System and Fare Reform scenario.

Figure 124: Fare Reform Scenario

Model 1: Current system	Model 2: Fare reform
\ All modes have the same prices	\ Each mode has a different price
\ Price reflects some congestion elements based on zones travelled through (Zone 2 or Zones 1/2)	\ Three metropolitan zones: Zone 1, Zone 2 and a new City Zone
\ Concession prices available for all trips	\ Peak and off-peak fares
\ Same price all day in Melbourne – except for Early Bird free train travel and within the Free Tram Zone	\ Concession prices available for all trips



Source: Infrastructure Victoria 2020. Fair Move: Better public transport fares for Melbourne

Modelled public transport fares, shown in the table below, were heavily influenced by both the benefits of additional public transport use and the costs associated with providing additional public transport services (known as the social marginal cost pricing approach). Benefits of greater public transport use include reduced road congestion and environmental impact while the costs of additional public transport use include the extra funding required to run these services, infrastructure costs and the impact of taxation on people and businesses required to provide more subsidised fares. For example, train services that operate during peak periods in the busiest sections of the network face higher net social costs, which are additional costs of extra use minus additional social benefits, from more comparative use, and are therefore priced the highest. Services such as underutilised bus or off-peak public transport are priced lower to reflect the lower cost of adding additional trips to these services, and the benefits they still provide (such as reduced congestion).

Figure 125: Modelled public transport fares

	Train		Tram		Express Bus		Bus
City Zone + any other zone	$5.00 (peak)	$2.50 (off-peak)	$2.50 (peak)	$1.25 (off-peak)	$2.50 (peak)	$1.25 (off-peak)	$1.25 (all times)
City Zone only	$4.00 (peak)						
Zone 1 only							
Zone 1+2							
Zone 2 only	$2.50 (peak)				$1.25 (peak)		

Source: Infrastructure Victoria 2020. Fair Move: Better public transport fares for Melbourne

The benefits of implementing fare reform by the early 2030s are extensive, including spreading peak demand, increasing off-peak public transport patronage, reducing road congestion, cutting greenhouse gas emissions and progressing fairness and equity. With Fare Reform, up to 71% of public transport users pay less to travel on public transport than they do today, with households on the lowest incomes benefitting the most.

Over 96,000 car trips are taken off Melbourne roads on a typical weekday, leading to a reduction of 78,000 tonnes of greenhouse gas emissions. Bus networks are better utilised with over 90,0000 new boardings, while the removal of 30,000 trips from peak train services takes some pressure off those overcrowded services. Overall an additional 100,000 new off-peak public transport trips boost patronage during the quieter hours of the day. Heavily influenced by cheaper fares, lower household income groups represent some of the strongest cohorts of public transport uptake.

Applying TNP and network implications

Each transport project included in this report brings an opportunity to further enhance the role of TNP in Victoria's future network. To help apply TNP to these scenarios, we developed five pricing principles – from Australian and international literature on pricing – to ensure that prices are set to influence where people travel at times, to places and by modes that provide the greatest benefits relative to the costs. The principles are also designed around fairness and equity, which is essential to gaining community support.

The five principles of transport network pricing

Principle 1: All modes, routes and parking are priced

Prices should be the central tool for allocating trips within the transport network. A trip that isn't priced is effectively under-priced, distorting the choice made by travellers to take that trip instead of a more efficient one. This principle also implements the beneficiary pays equity principle.

Principle 2: All costs are priced

Congestion, pollution, and contribution to road trauma are all included in the price. This principle ensures that prices include the social marginal costs linked to externalities related to each trip.

Principle 3: Provide choices but not too complex

There should be a range of products that provide choices to consumers. It should be possible to use the transport system without it being too hard to choose and make informed decisions.

Principle 4: Different prices for different products in different markets

Prices should reflect demand and cost conditions, and permit different prices to be charged by mode, time of day or location.

Principle 5: Equity

This principle implements vertical equity (different groups of people are treated differently). Lower prices are set for groups of people identified as less able to pay and in places where demand from low income users is higher.

As explored earlier, TNP elements such as Inner Melbourne cordon charges are likely to have a large impact on car movements travelling in and around the city – while also complementing major road projects in the area. Demand on public transport can also be managed through TNP elements like peak and off-peak fares.

There are also a range of potential TNP opportunities that should be implemented alongside the delivery of major transport infrastructure projects. For example, if establishing a new road link that provides a cross-city alternative for motorists, TNP can be used to manage demand along the new road link and surrounding network, particularly around Inner Melbourne. For public transport, once travel patterns return to pre-COVID levels with significant crowding during peak times, fares for travel on trains going through the busiest and most costly-to-expand sections of the line (like in and around the CBD) could bet set higher than the rest of the network. Discounts could also be provided for travel during off-peak periods and around less congested areas of the public transport network to incentivise better use.

The five principles, along with further practical examples of how TNP may be integrated with future transport infrastructure are discussed within each of the project-specific sections in this report within chapter 4.

6.6 Automated and Zero Emission Vehicles Scenario

Overview and Context

AVs and ZEVs, together and individually, have profound implications for the way people travel locally and across the state. These technology changes represent a potential opportunity for all Victorians to enjoy a better quality of life through greater accessibility, lower operating costs, improved road safety, cleaner air, lower greenhouse gas emissions, better health, and a stronger economy. A future with AVs and ZEVs could have significant infrastructure and land use implications. While these technologies and the market models that come with them are still uncertain, the electric and automated vehicle (EAV) scenario explores some of the potential transport and land use impacts, as well as the broad implications for projects. We note that this scenario tests the implications of a transport network-wide technology change, rather than a traditional transport project which has a defined spatial scope.

The EAV scenario combines a number of assumption changes, compared to the network development scenario (NDS – base case) that seek to capture the potential implications of the transition to AVs and ZEVs. These include:

- A reduction in private vehicle operating cost to reflect a transition towards a fleet with a higher proportion of ZEVs (such as electric vehicles which have lower operating costs).
- A reduction in the average perceived value of in-vehicle time to reflect a transition towards a fleet with a higher proportion of AVs in use (which allows activities other than driving).
- The introduction of the concept of fleet AV vehicles, representing a shared pool of vehicles. This means essentially that everyone has access to private vehicle travel (rather than only those who own cars).

As this scenario tests technology changes which are still highly uncertain and somewhat speculative, the results should be interpreted with caution.

Existing policy and direction

The Victorian Government is already taking steps to encourage and adapt to EVs and prepare for AVs so that the changes produced by these technologies benefit the community. These include:

- Victoria's *ZEV roadmap* which outlines the Victorian Government's approach to boosting ZEV uptake.
- Commissioning Infrastructure Victoria's *Automated and Zero Emissions Vehicle Infrastructure Advice* (AZEVIA) which explored the implications of automated and electric vehicles on Victorian's wellbeing, emissions, travel behaviour, and urban form.
- Trials of zero emission buses on routes in different Victoria cities.

The recommendations of *Victoria's infrastructure strategy*, and the EAV scenario, build on and are informed by AZEVIA, our previous advice on this topic.

Victoria's infrastructure strategy 2021-2051

The coming technological change of ZEVs and AVs has implications for each of our overarching themes throughout *Victoria's infrastructure strategy*:

- Confront long-term challenges, including achieving a 2050 net zero emissions target: ZEVs will be key in achieving this target.
- Manage urban change, including better integrating land use and infrastructure planning: AVs and ZEVs have implications for urban form and connectivity.
- Harness infrastructure for productivity and growth, including major transport projects: AVs will allow for more efficient use of a given level of road infrastructure.
- Develop regional Victoria, including supporting the competitive strengths of the regions: AVs and EVs could improve connectivity and transport in regional Victoria.

Victoria's infrastructure strategy includes specific recommendations to encourage uptake of ZEVs and prepare Victoria for AVs. These are:

- Recommendations 1 and 2 call for the Victorian Government to:
  - commit to no longer registering new petrol and diesel vehicles in Victoria by 2035 at the latest
  - publish a statewide electric vehicle charging network strategy
  - produce charging infrastructure design standards and payment principles
  - monitor and review the effectiveness of financial incentives in encouraging early zero emission vehicle purchases
  - increase uptake of ZEVs in government and freight.
- Recommendation 21 calls for the Victorian Government to immediately begin updating transport regulations to allow AV operation on the road network. In the next 10 years, upgrade roads and communications infrastructure to help

facilitate increasingly connected and automated vehicles, particularly for corporate and government fleets. Develop policy, business case and land use planning guidance to maximise the benefits of automated vehicles.

Scenario Description and Modelling Approach

The EAV scenario modifies VITM to represent an alternative future. This modified version of VITM is then employed within the VLUTI model.

There is significant uncertainty around the overall timing and extent of impacts of this scenario, particularly around AVs. A wide range of possible future outcomes are possible with the rise of ZEVs and AVs, while this scenario only tests one particular outcome.

The AV component of this scenario considers both privately owned vehicles as well as for-hire vehicles which are analogous to existing taxi and rideshare services ('fleet AVs').

The key input changes, compared to the NDS, which the EAV scenario tests are:

- **Changes to Value of Time (VOT)**: Given the broader flexibility of how one spends their time when riding within an AV, the perceived in-vehicle cost of travel will be lowered compared to a conventionally driven vehicle (CDV).
- **Changes to Vehicle Operating Cost (VOC**): Past research by Infrastructure Victoria has indicated that the VOC of ZEVs is lower than that of a CDV due to several factors. Modifications to the VOC vary based on assumed fleet mix and region.
- **Network Operating Efficiency**: The lane capacity assumptions across the statewide network have been altered to reflect operating efficiency gains that could potentially accompany the introduction of AVs. AVs will adopt 50% of the capacity of ordinary vehicles on freeways. For arterials, this will increase to 67%, representing diminishing returns in a more complex environment. For local and secondary roads, it will be assumed that AVs will not perform any better than conventional vehicles.
- **Dead Running**: A portion of private AV use will involve empty vehicles returning to their origin after their owners reach their destination. This will be represented within the VITM by taking a proportion of trips within a time period, flipping their direction and applying that back to the highway assignment process in order to represent this extra demand. The VOC component of the dead running will be added to overall costs for the trip.
- **Increased Trip-Making due to Lower Perceived Travel Costs**: Related to the impacts of AVs set out above is an expected general reduction in the perceived cost of car travel, potentially leading to not only a shift in modal choices, but also an increase in overall trip making activity.

The trajectory of take up of electric and autonomous vehicles is shown in the following table. By 2036, 11.5% of vehicles are modelled as being autonomous, and this rises to 46.5% by 2051. Fleet AVs were assumed to have a higher take up in inner and middle areas where there is more intensive trip making that could support such a commercial service. Private vehicle trips are assumed to continue to dominate journeys in outer and regional areas, with the take up rate of electric or autonomous vehicles being stronger in Inner Melbourne and lowest in regional Victoria. This assumed future fleet mix is based on Infrastructure Victoria and Arup's research, including our *Automated and Zero Emissions Vehicle Infrastructure Advice,* and professional judgement regarding a plausible future uptake and share of different vehicle types in Victoria.

Table 46: Assumed Future Fleet Mix

Note: Total share proportions are indicative based on the number of trips originating from each FUA based on reference case results from the problem definition modelling report. As mode share shifts, these proportions are likely to shift in turn.

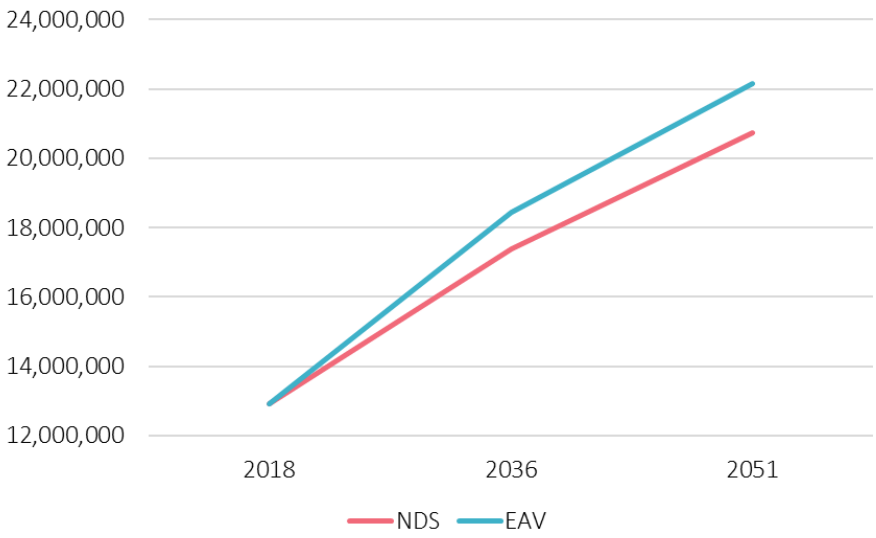
Year	Region	PV Trip Share	CDVs	Electric CDVs	Private AVs	Fleet AVs
2036	Inner	*69%*	48%	32%	10%	10%
	Middle	*91%*	55%	30%	7.5%	7.5%
	Outer	*96%*	65%	25%	5%	5%
	Regional	*99%*	68%	25%	4%	3%
	Total Share	-	*61.5%*	*27.0%*	*5.9%*	*5.6%*
2051	Inner	*68%*	0%	20%	30%	50%
	Middle	*90%*	5%	35%	35%	25%
	Outer	*95%*	10%	50%	25%	15%
	Regional	*98%*	20%	50%	20%	10%
	Total Share	-	*10.4%*	*43.2%*	*26.5%*	*20%*

Source: Arup 2021 Strategic Modelling Outcomes Report
Note: CDV stands for conventional drive vehicle, i.e. non-automated internal combustion engine vehicles. All AVs are also electric vehicles.

Transport outcomes

In general, this scenario sees an increase in the number of private vehicle (car) trips made. This is a result of both an increase in the total amount of trips and the increased mode share of private vehicles. This can be attributed to the lower perceived cost of travel time and lower vehicle operating costs (on the demand side) and an increase in network efficiency (on the supply side). Both factors make car travel, including by commercial fleet services, more attractive. In 2036, there are 18.5 million daily person car trips under the EAV scenario, compared to 17.4 million under the NDS. This represents an increase in car trips of around 6%. In 2051, the differential between EAV and the NDS increases to 7%, with 22.1 million daily person car trips under the EAV scenario.

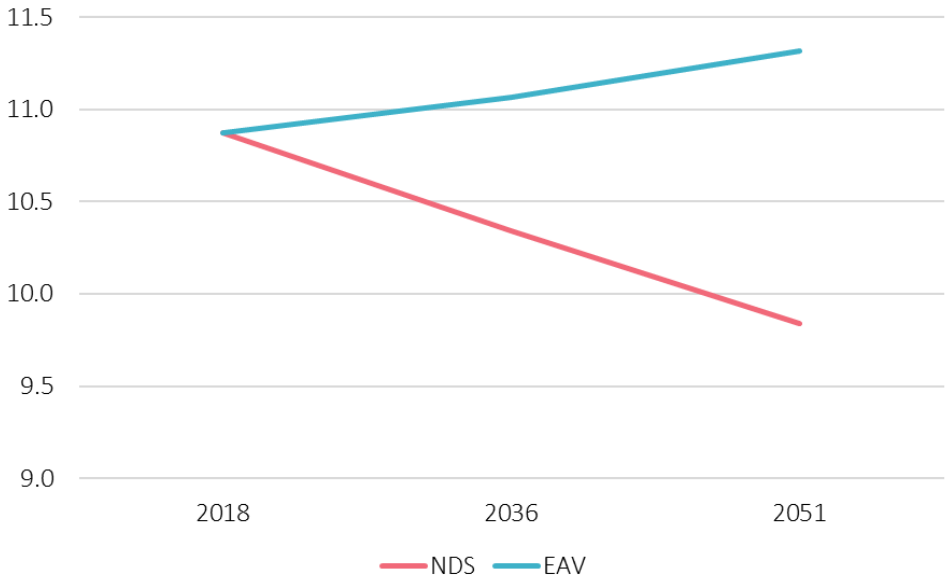
Figure 126: Daily person car trips (Greater Melbourne)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

In addition to the number of car trips increasing in the EAV scenario, people are also travelling further. At 2051, an average car trip is 11.3km in EAV compared to 9.8km in the NDS.

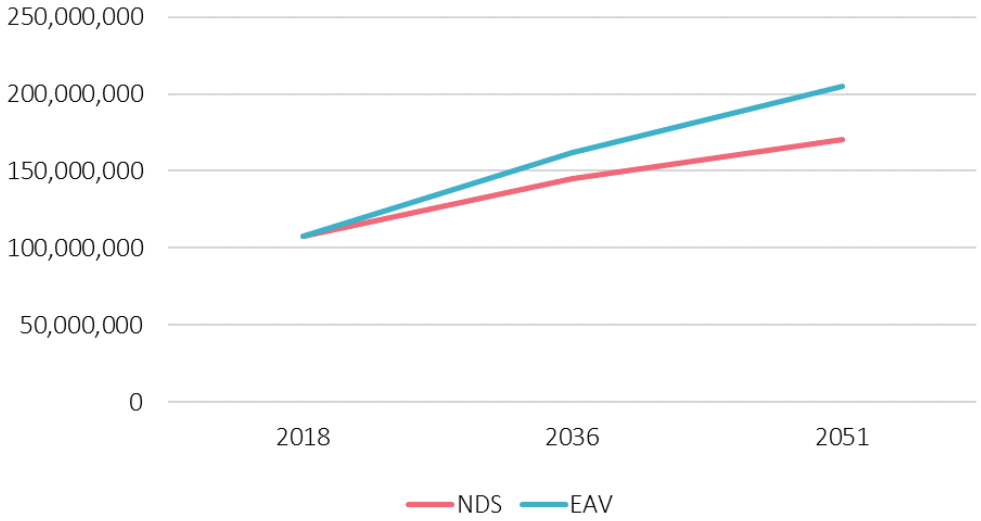
Figure 127: Average PV trip length (km, Greater Melbourne)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

With a greater number of car trips and increased average distance travelled, total VKT is around 20% higher in 2051 in the EAV scenario. This reflects the greater convenience and lower cost of car travel factored into EAV.

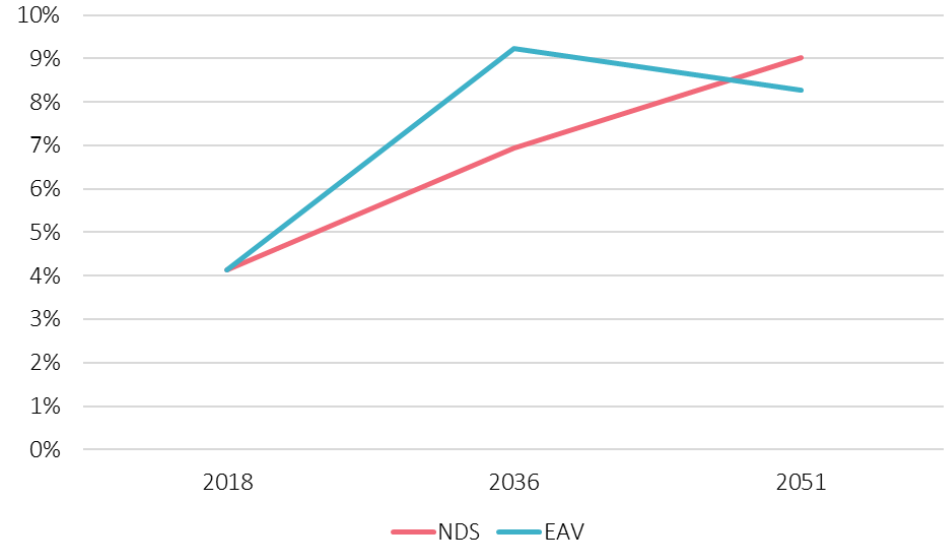
Figure 128: Daily total VKT (Greater Melbourne)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

In 2036 the increased demand for car travel, primarily due to the lower costs of EVs, means that road congestion is worse in EAV in 2036. However, by 2051 congestion improves compared to the NDS, despite a greater number of car trips and increase in average trip length. This improvement in congestion is due to the road network efficiency gains enabled by AVs becoming more widespread by 2051. This means the network efficiency gains, as modelled in this scenario, have outweighed the increase in demand for car travel in 2051.

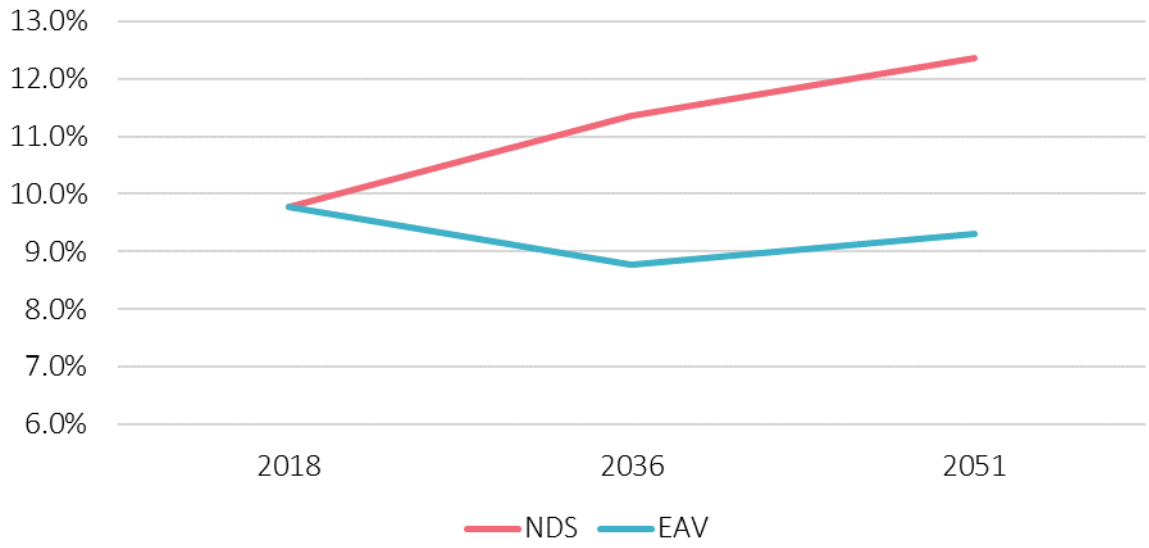
Figure 129: Proportion of VKT congested (AM peak, Greater Melbourne)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Public transport mode share under the EAV scenario decreases from current levels of 9.8% to 8.8% in 2036 before rising to 9.3% in 2051. This means that under the EAV scenario, public transport mode share is less in 2051 than current levels. In the NDS, public transport mode share increases in the future to 12% by 2051. This difference in outcomes is partly due to the lower value of time which travelling in an AV provides, as well as lower operating costs for EVs. A person travelling in an AV is not driving and can do other productive things, therefore the opportunity cost of travel time is lower, which is an important assumption to note. These factors make travelling by car, including rideshare and taxi vehicles, relatively more attractive than public transport.

Figure 130: Public transport mode share for Greater Melbourne

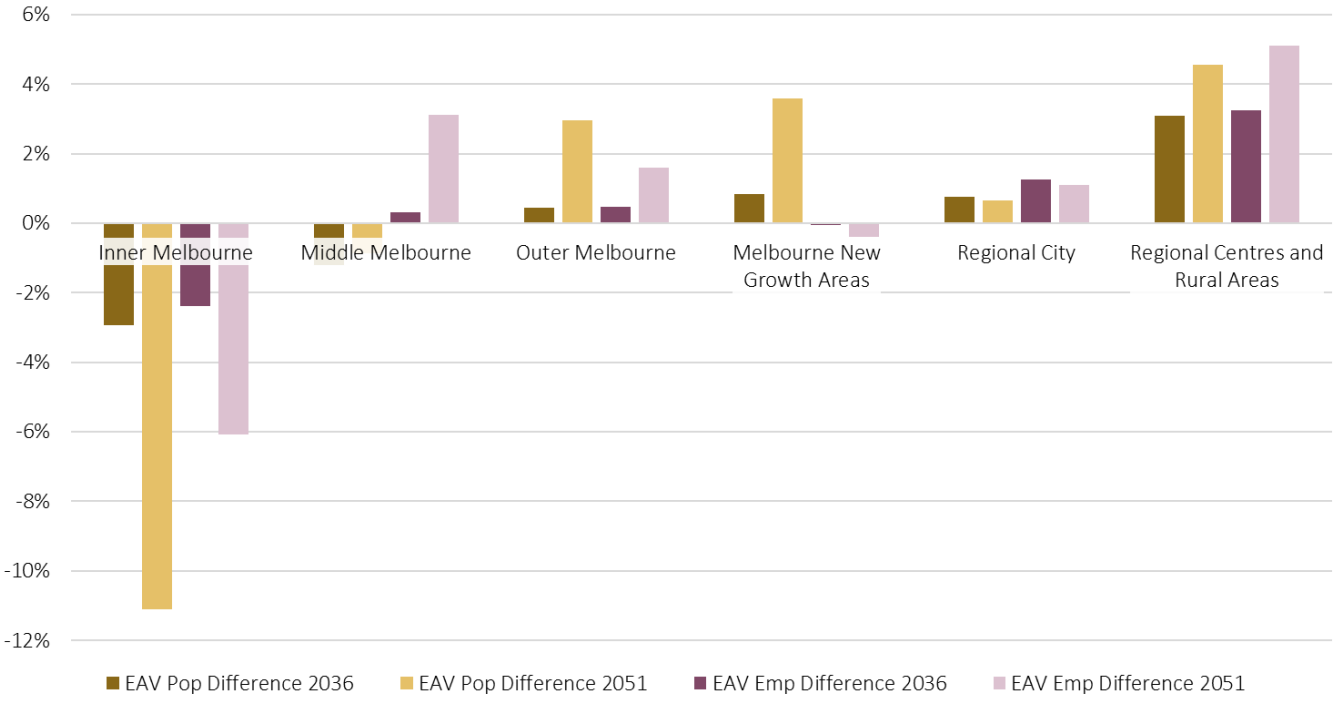


Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Land use outcomes

Total Victorian population and employment in the EAV scenario remains the same as the NDS into the future, however the spatial distribution of population and employment differs under the EAV scenario. There is a general pattern of dispersal out of Inner Melbourne under EAV for both population and employment.

Figure 131: Population and employment differences by FUA 2036 and 2051

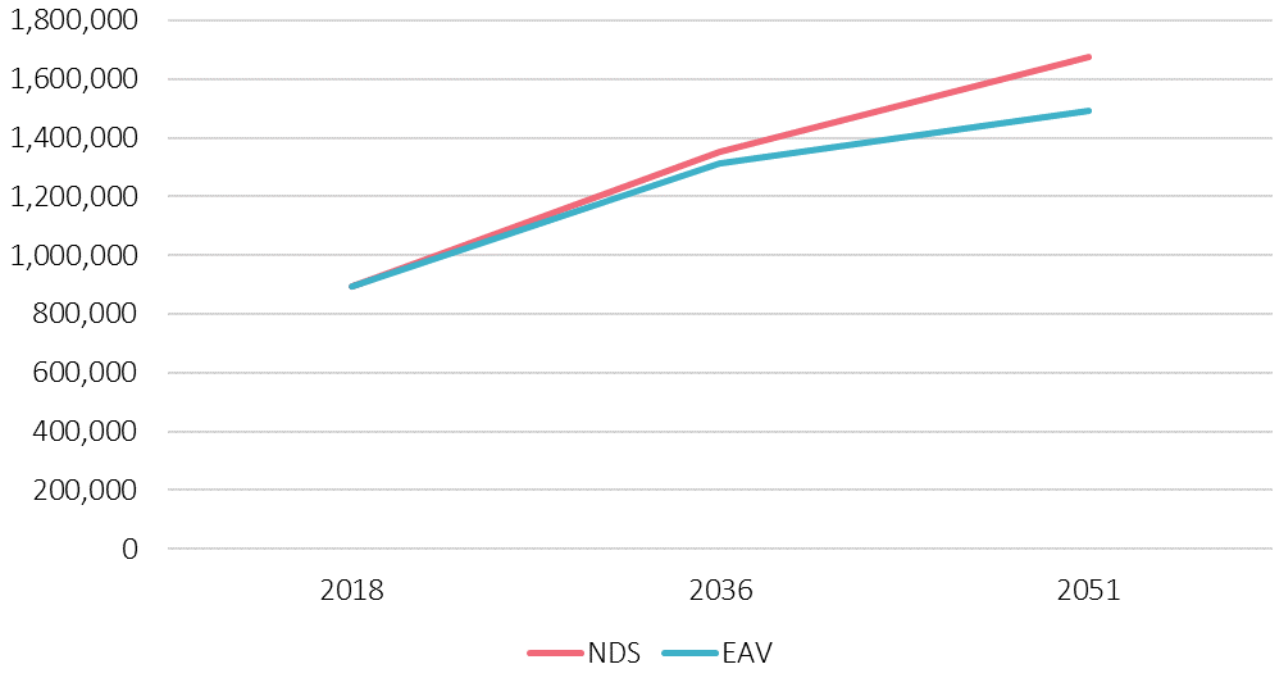


Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

In terms of population, Inner Melbourne FUA is modelled as experiencing the largest impact with an 11% smaller population in 2051 (186,000 fewer people) compared to the NDS. Middle Melbourne FUA is 1% smaller, compared to the NDS in 2051, with 22,000 less people. All other FUAs have larger populations under the EAV scenario. Outer Melbourne FUA is 3% larger, or 78,000 people and New Growth Areas FUA is around 4% larger, or 54,000 people, compared to the base case in 2051. There is also a larger number of people living outside of Melbourne in the EAV scenario with Regional Centres and Rural Areas FUA 5% larger, or 69,000 people in 2051 compared to the NDS.

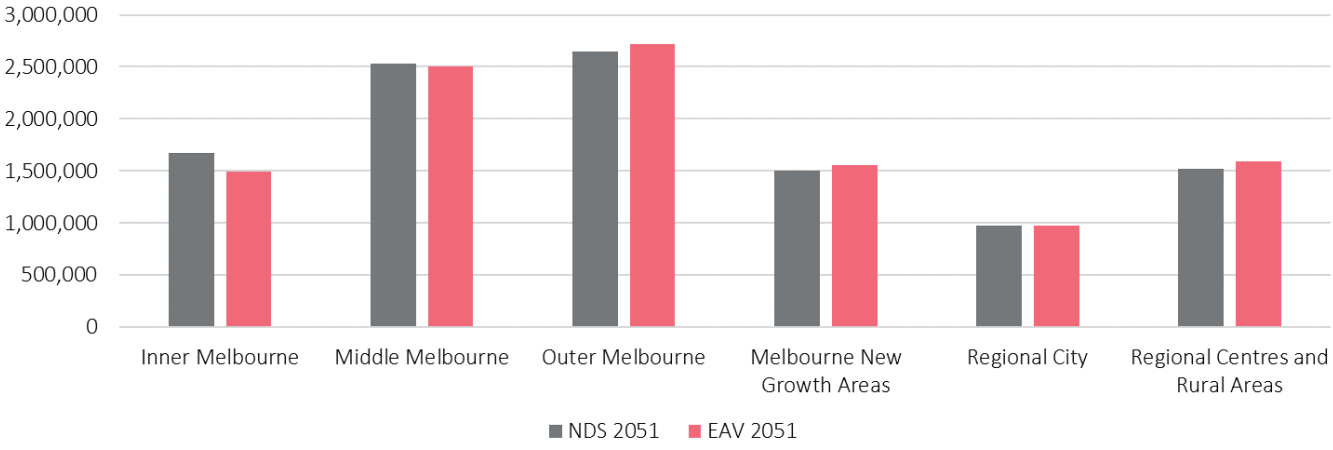
This pattern can be explained by the reduction in the value of travel time, reduction in vehicle operating costs, and increase in road efficiency. This means that longer trips are more readily tolerated by travellers, and areas more spatially dispersed from Inner Melbourne experience improved connectivity (from a low base) under the EAV scenario. Furthermore, with increased car and rideshare travel in general, inner areas are more congested and suffer from a relative reduction in accessibility. Whilst longer travel times in this scenario are tolerated by travellers, the acceptability of more congestion on the road for the communities that these roads pass through is not considered in the modelling of this scenario.

Figure 132: Inner Melbourne FUA population EAV vs NDS



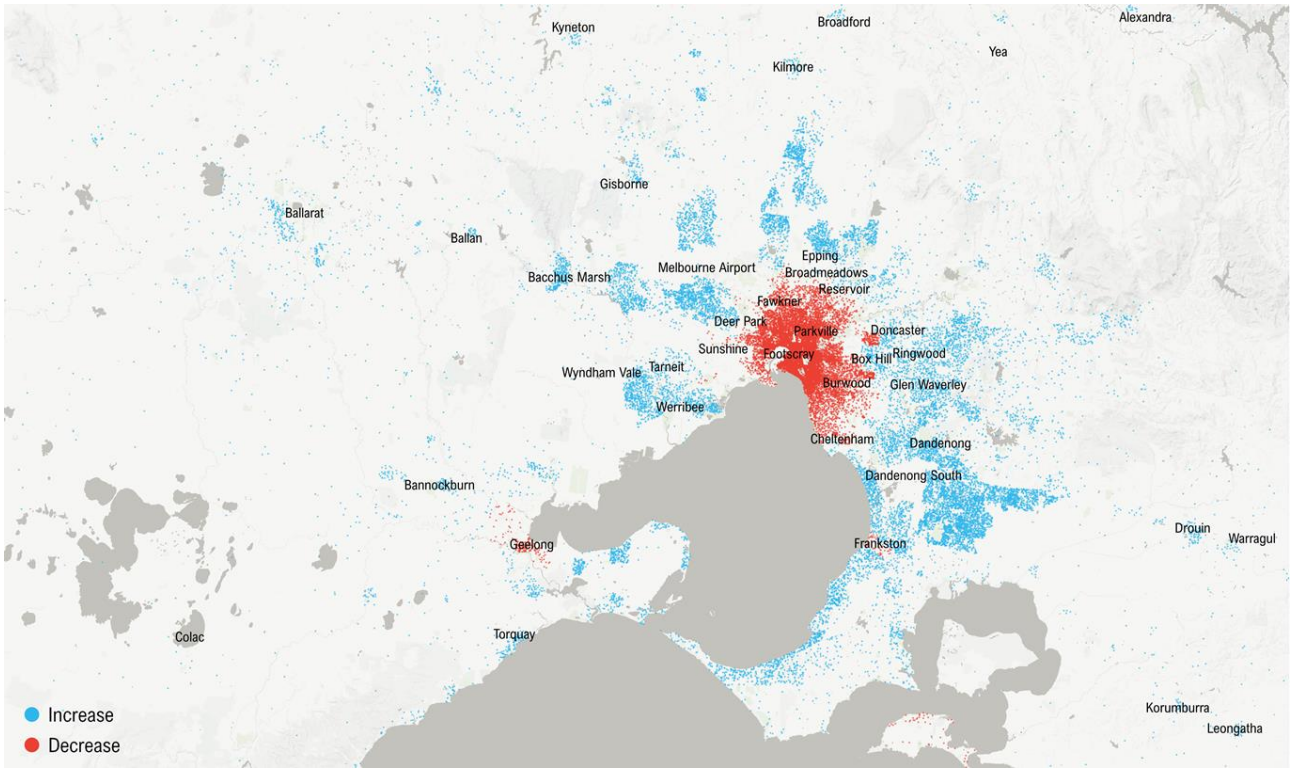
Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Figure 133: Population by FUA, EAV vs NDS 2051



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

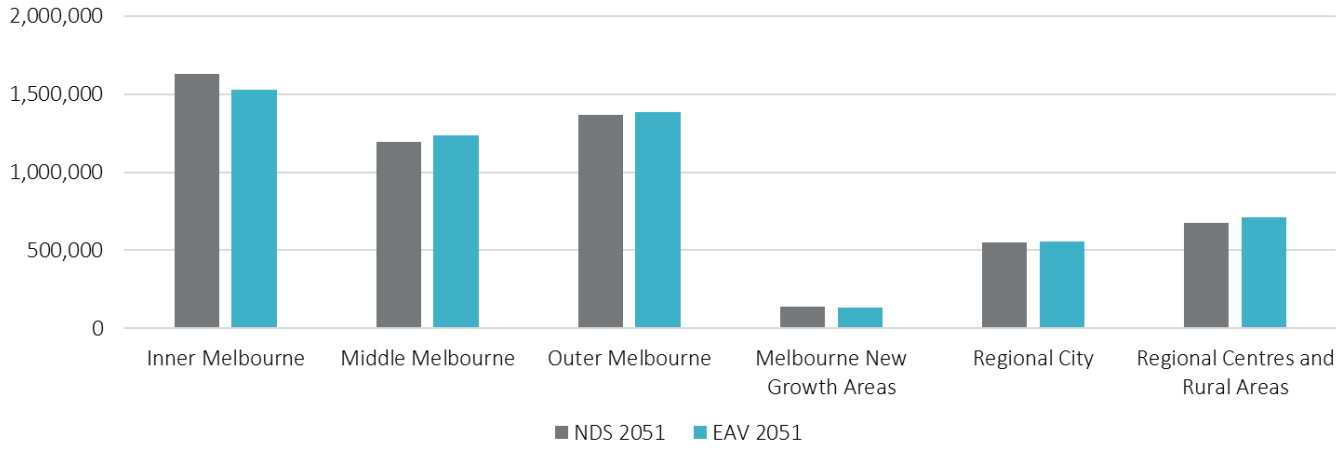
Figure 134: Change in population EAV vs NDS 2051



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

The impacts on employment are less pronounced than population impacts. Inner Melbourne FUA sees a drop in employment of around 6% or 99,000 jobs in 2051 compared to the NDS, while Melbourne's New Growth Areas FUA has a marginally lower employment (less than 0.5% smaller). All other areas experience an increase in employment in 2051, compared to the NDS, with Middle Melbourne FUA gaining 3% of employment or 37,000 jobs, and Outer Melbourne FUA gaining 2% or 22,000 jobs. Employment also disperses beyond Melbourne, with regional centres and rural areas FUA 5% larger, or 34,000 people in 2051.

Figure 135: Employment EAV vs NDS by FUA 2051



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Figure 136: Change in employment EAV vs base case 2051

Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Implications for Victoria's infrastructure strategy

ZEVs and AVs have significant implications for the environment, communities, and transport. ZEVs offer a chance to help decarbonise road transport, including car travel, which will be key in meeting the Victorian Government's goal of net zero emissions by 2050. AVs offer an opportunity to expand car transport access, make car, rideshare and taxi travel more convenient and safer, while also improving road network efficiency. Accordingly, recommendations 1 and 2 of *Victoria's infrastructure strategy* support the increased uptake of ZEVs in Victoria while recommendation 21 calls for greater planning and preparedness for AVs.

Similar to the rise and ubiquity of internal combustion engine (ICE) cars in the mid-20th Century shaping the layout and functioning of Victoria's cities, the new technologies of ZEVs and AVs also have the potential to shape and change urban areas. Furthermore, just as some aspects of 20th Century car-centric planning have been found to be undesirable in hindsight,[320] there are risks that a passive approach to these technologies could also result in undesirable outcomes.

As illustrated by the EAV scenario, there are possible transport and land use impacts of ZEV and AVs which are concerning and need to be considered and mitigated. These impacts include:

- increase in private vehicle mode share at the expense of public and active transport
- dispersion of population and employment
- increase in road congestion, especially for other road users in non-automated vehicles and the amenity impacts for communities that these roads pass through (in the medium term).

Active and public transport

It would be inaccurate to draw the conclusion that encouraging and investing in public and active transport is no longer necessary due to coming technology changes of AVs. In the past, public transport networks have been dismantled or neglected to prioritise the newer technology of cars. An example of this was in Sydney in the 1950s when the tram network, which was more extensive than Melbourne's, was ripped up.[321] In contrast, Melbourne's tram network remains

[320] Bruce McVean 2013, *A new movement for The New City,* Cambridge University's The New City lecture 2013 https://www.smartcitiesdive.com/ex/sustainablecitiescollective/new-movement-new-city-problem-cars/130786

[321] Laura Brierley Newton 2018, ABC News, *Sydney once had the biggest tram system in the southern hemisphere,* https://www.abc.net.au/news/2018-04-12/sydneys-original-tram-network-what-happened-curious-sydney/9610328

largely intact to the ongoing benefit of Melburnians. ZEVs and AVs could offer personal convenience, financial, environmental, and transport benefits. However, public and active transport should continue to have a central role and be an attractive option to transport Victorians within their cities in future.

Widespread use of active and public transport in a city, as opposed to car transport, has benefits to individuals as well as external benefits which accrue to society more broadly. Active transport improves personal health and wellbeing (both physical and mental), reduces health system costs, and reduces road congestion and damage to road infrastructure.[322] Public transport also has benefits in reducing road congestion and damage to infrastructure, as well as health benefits from the associated active transport undertaken in accessing public transport. Compared to car travel, it is less energy intensive per person and can transport a higher volume of people in any transport corridor.[323]

We note there is substantial uncertainty as to how exactly these technology changes will play out in coming decades. The EAV results are one possible outcome based on a particular set of assumptions. Infrastructure Victoria's AZEVIA work modelled seven scenarios including one, 'Fleet Street', where public transport mode share actually increases.[324] The Fleet Street AZEVIA scenario explores the situation of AVs being fleet based and not privately owned. This is analogous to current ride share services. As travellers perceive a higher cost of AV travel, modelling results found an increase in public transport mode share and decrease in total number of car trips.

Road congestion

The EAV scenario sees worse road congestion in 2036 due to the prevalence of ZEVs and their lower operating costs. The network efficiency benefits of AVs, as modelled in the EAV scenario in 2051, mean that generally road congestion reduces even with additional demand for car trips. The exception to this is in the Inner Melbourne FUA which experiences worse congestion at 2051 in EAV. Infrastructure Victoria's AZEVIA work found similar results in the Private Drive scenario which saw an overall improvement in road congestion but a worsening in the inner areas of Melbourne due to empty running AVs.

The shift in population to outer areas driven by increased car accessibility also reinforces the dependence on car transport, which further adds car trip demand. Similar results were found in the 'Private Drive' AZEVIA scenario. In this context, it was noted that there is a risk to eroding the 'capacity benefits for our freeways by flooding them with additional demand from the outlying areas'.[325] Accordingly, to ensure the network efficiency benefits of ZEVs and AVs are harnessed, there needs to be mitigation against the induced demand impacts.

Land use

The EAV scenario demonstrates the possible land use implications of ZEVs and AVs, with a general pattern of dispersal of population and employment in Melbourne, compared to the NDS. This implies a less dense city. Broadly similar results of dispersion of population and employment were found in the AZEVIA Fleet Street and Private Drive scenarios. However, there are some differences in the precise distribution and scale of impacts owing to the differences in modelling methods between AZEVIA and EAV.

Dense cities have some desirable characteristics including more efficient service and infrastructure provision, as well as being more effective for sustaining high public and active transport mode share.[326] Dense local areas with widespread use of active and public transport can also result in favourable local urban design outcomes.[327] Infrastructure Victoria's AZEVIA work noted that more dispersed cities, resulting from AVs, would "likely place strained infrastructure under greater pressure".[328]

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[322] Todd Litman 2021, *Evaluating Active Transport Benefits and Costs* https://www.vtpi.org/nmt-tdm.pdf and

Australian Transport Assessment and Planning Guidelines 2021, *Mode Specific Guidance, M4 Active travel, 5. Estimation of Benefits* https://www.atap.gov.au/mode-specific-guidance/active-travel/5-estimation-of-benefits

[323] Elliot Fishman 2018, *Transport and Climate Change*, https://www.linkedin.com/pulse/transport-climate-change-dr-elliot-fishman/ and Climate Council of Australia 2018, *Waiting for the Green Light: transport solutions to climate change,* https://www.climatecouncil.org.au/wp-content/uploads/2018/10/CC_MVSA0154-Report-Transport_V6-FA_Low-Res_Single-Pages.pdf

[324] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

[325] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

[326] SGS Economics and Planning 2016, *Comparative costs of urban development: a literature review,* https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SGS-Economics-and-Planning-Comparative-costs-of-infrastructure-across-different-development-settings.pdf

[327] Office of the Victorian Government Architect 2019, *The case for good design: Urban design*, https://www.ovga.vic.gov.au/case-good-design-urban-design-guide-government

[328] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

Higher density cities with concentrations of businesses, and subsequently employment, also enable knowledge spill overs, innovation and competition which drive agglomeration economies. This can lead to increased productivity, higher wages, greater employment and increased output.[329]

Harnessing benefits, mitigating costs

Therefore, the EAV scenario demonstrates that while there are benefits to be harnessed from the technology change of ZEV and AVs, there are also possible adverse outcomes which need to be planned for and mitigated against.

Victoria's infrastructure strategy is guided by the principle of 'manage urban change', including better integration of land use and infrastructure planning. *Victoria's infrastructure strategy* includes a suite of recommendations to improve the liveability and sustainability of our cities which will help mitigate the adverse impacts of ZEVs and AVs. This includes recommendations to manage demand on the road network (recommendations 51, 52, and 53), significant active and public transport investments (including recommendations 38, 39, 60, and 61), ensuring the integration of land use and transport planning (recommendation 33), and encouraging housing densification in well-serviced areas (recommendation 35).

As the EAV scenario demonstrates, the heightened convenience of car travel that ZEVs and AVs offer will mean greater demand for car trips and more cars on the road. Policies such as TNP (recommendations 51, 52, and 53), to manage demand on the transport network, including roads, will be vital to ensure that the benefits of ZEVs and AVs are not outweighed by a subsequent overwhelming increase in car travel.

The EAV scenario also shows how more convenient car travel can act as a force for population and employment dispersal in cities. The AZEVIA work noted "the increased congestion from empty trips in inner urban areas would most likely significantly reduce the amenity of these locations, making them a relatively less appealing place to live".[330] Strategic land use planning which encourages clustering of services, housing, and public transport in locations accessible to economic opportunity and quality open space will ensure that our cities remain liveable and not overly car reliant, while also enabling efficient infrastructure provision (recommendation 33 and 35). Again, the land use impacts particular to ZEVs and AVs will be influenced by government policy. AZEVIA's Fleet Street scenario, in which there was no private ownership of vehicles, found that along with increased public transport use, housing clustering increased around public transport nodes.[331]

Victoria's infrastructure strategy's recommendation on AVs (recommendation 21) also notes that in doing preparatory work to enable AVs, the Victorian Government should consider and prepare to mitigate possible adverse outcomes as well as look to how AVs could help improve conditions for active transport, such as freeing up road space from car use.

These recommendations will help ensure that our cities and regions continue to be places of high liveability and that the benefits of technology change can be enjoyed, while the adverse outcomes are mitigated.

Implications for Major Transport Projects

The EAV scenario has multiple and conflicting implications for the performance of individual transport projects. This section explores some of the broad implications for transport projects, generally, of greater ZEV and AV use in Victoria.

Again, we emphasise that the EAV scenario models a single outcome, when in reality there is a high degree of uncertainty around the specific transport and timing implications of AVs and, to some extent, ZEVs. It is also important to note that the EAV scenario is not a traditional transport project, which can be tested and appraised as desirable or not. Rather, the EAV scenario represents an alternative state of the world, enabled by an exogenous technology change. This scenario is an exercise to understand the possible implications of ZEVs and AVs and to help understand how the positives can be harnessed and the negatives mitigated.

Overall, the EAV scenario:

- increases the availability and attractiveness of car travel which increases overall car trips
- improves road network efficiency
- worsens road congestion in 2036 and improves it in 2051
- reduces public transport mode share and total trips
- disperses population out of Inner and Middle Melbourne
- disperses employment out of Inner Melbourne.

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[329] Infrastructure Victoria 2019, *Growing Victoria's potential,* https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Growing-Victorias-Potential-April-2019.pdf

[330] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles: evidence base report*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Infrastructure-Victoria-Vehicles-Infrastructure-Advice-Evidence-Base-Report-August-2018.pdf

[331] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles: evidence base report*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Infrastructure-Victoria-Vehicles-Infrastructure-Advice-Evidence-Base-Report-August-2018.pdf

These results would mean that, in general terms:

- road projects would gain additional effective capacity in 2051
- road projects in general will be more heavily patronised
- road projects would see high levels of congestion in 2036
- public transport projects would have less patronage due to cars being more attractive.

Infrastructure Victoria has explored some of the possible implications that the EAV scenario has on transport projects (in general) across various metrics, as outlined in section 4 for each project and summarised below. This is only a high-level discussion and not an exhaustive list.

Transport

With car travel more favoured in the EAV scenario, and more car trips across the road network, congestion is also at higher levels in 2036, while it generally improves due to AVs in 2051. With more people using the road, this could imply that there is a greater need for road projects which add road capacity. Conversely, instead of a new road project, a substantial level of decongestion benefits could be achieved through the technology of AVs. Infrastructure Victoria's AZEVIA work noted that the network efficiency gains of AVs could mean that government can delay or avoid some major road capital investments.[332]

Furthermore, there could also be lower consumer benefits to be gained from road projects as the cost of congestion is lower. That is, the value of in-vehicle time is lower, meaning that people are no longer as averse to spending time in congestion. This implies that the consumer benefits (as assessed in a CBA) of a new road project, which reduces congestion, could be lower.

With car travel more favoured under the EAV scenario, public transport has a lower mode share. Therefore, a new public transport project would benefit a smaller amount of people with a correspondingly lower level of consumer benefits. However, while EAV as modelled in this project has resulted in a lower public transport mode share, we note the substantial uncertainty as to how these technology changes will play out. For example, AZEVIA modelled a scenario, 'Fleet Street', under which public transport mode share actually increases compared to a base case. This is due to the prevalence and perceived costs of using fleet AVs and absence of private AVs.[333] This meant that while AVs were common, they are also perceived as costly to use, and this makes public transport relatively more attractive. The AZEVIA work noted that in this scenario there is "significant pressure on public transport capacity, particularly at peak times on key routes".

Emissions

With cars transitioning to ZEVs from ICEs, and assuming that energy sources for ZEVs do not create greenhouse gas emissions, car use will not create emissions in operation. Road project assessment would be penalised by an increase in electric vehicles because the avoided emissions from reductions in congestion would be less, making building a new road less attractive from an emissions perspective.

Similarly, for public transport projects, there would be no avoided emissions benefit from trips switching from car to public transport as is traditionally the case in economic appraisal. However, we note that there may be benefits of avoided emissions on a lifecycle basis, taking into account manufacture, operation, and disposal, when comparing public transport and car transport.[334] Infrastructure Victoria's AZEVIA work noted that given these lifecycle emissions, "it will be a major challenge for zero emissions vehicles to ever truly be 100% zero emissions" and that the environmental impact of battery production for AVs and ZEVs is greater with a larger vehicle fleet.[335]

The EAV scenario modelled around 40% of cars as ZEV in 2036 and 90% by 2051. This could imply that avoiding emissions is a stronger strategic justification of a transport project if it is delivered sooner. This is because car emissions would decrease substantially in any case with the advent of ZEVs.

Economic

The dispersion of employment under the EAV scenario would likely result in a decrease in the level of agglomeration economies on offer for firms locating in Inner Melbourne. Therefore, if a transport project results in greater dispersion of employment, the economic cost of avoided agglomeration benefits (as considered in WEBs) would not be as large.

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[332] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

[333] Infrastructure Victoria 2018, *Advice on Automated and Zero Emissions Vehicles*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/Advice-on-automated-and-zero-emissions-vehicles-October-2018.pdf

[334] Alexandre Milovanoff, the Conversation, 2020, *The myth of electric cars: Why we also need to focus on buses and trains,* https://theconversation.com/the-myth-of-electric-cars-why-we-also-need-to-focus-on-buses-and-trains-147827

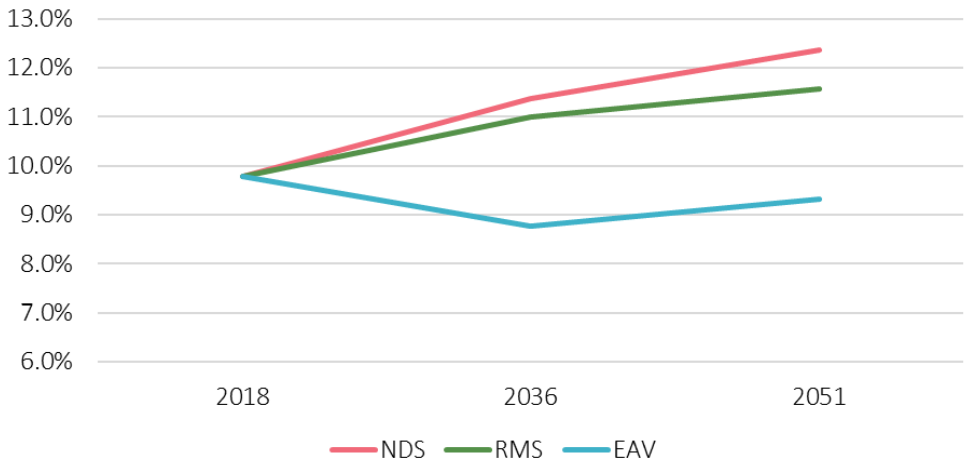
RMS and EAV

The RMS project and the EAV scenario have some commonalities in terms of transport outcomes. The RMS project results in an increased efficiency in the road network, similarly the AV component of EAV results in improved road efficiency. Furthermore, RMS also relates to EAV as the RMS project includes technology upgrades to the road management system which could also help enable the new technologies of electric and autonomous vehicles.

Therefore, we present some of the results of RMS alongside the results of the EAV scenario, as they could be viewed as a spectrum of road network efficiency upgrades enabled by technology. It is again important to note that while RMS can be conceptualised as a transport project, the EAV scenario is not a transport project, rather it is one possible outcome of an exogenous technology change.

In terms of transport outcomes, both RMS and the EAV scenario result in a lower share of public transport mode share and a higher level of daily car trips. Across Greater Melbourne both RMS and EAV result in more roads being congested in 2036; RMS due to the induced demand of network improvements (particularly in Inner Melbourne), and EAV due to the lower cost of travel. However, congestion improves in Outer Melbourne and the growth areas in both RMS and EAV, as shown in Figure 138.

Figure 137: Public transport mode share (Greater Melbourne)



Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

Figure 138: Change in proportion of congested road hours travelled in AM peak for EAV and RMS compared to base case by FUA (2036)

Source: Analysis of Arup 2021 Strategic Modelling Outcomes Report

6.7 Appendix B – *Victoria's infrastructure strategy 2021-2051* objectives

Infrastructure Victoria surveyed the Victorian community on the objectives of *Victoria's infrastructure strategy*. This confirmed substantial support for the existing objectives. These objectives also align with the directions in the United Nations' Sustainable Development Goals (SDGs). In response to the survey feedback, and in line with the SDGs, we have adjusted the language of the objectives to make them clearer.

The achievement of relevant objectives that are dependent on transport and land use are presented below.

Table 47: Objectives of *Victoria's infrastructure strategy*

Objective	Description
Prepare for population change	Victoria's infrastructure meets new and shifting demands from a growing and changing population. Change will vary and occur in different ways including changing demographics, family structures, and cultural diversity.
Drive Victoria's changing, globally integrated economy	Victoria remains prosperous by staying attractive for trade and investment nationally and internationally, adapting to change and capitalising on economic opportunities.
Lift productivity	Victorians can maintain a good standard of living from an economy boosted by enhanced skills, innovation, market access and efficient investment.
Enable workforce participation	Victorians develop the capabilities, and have the opportunities, to engage in enough secure and meaningful work.
Reduce disadvantage	All Victorians have the resources and capabilities for a good quality of life. They have equal access to opportunities regardless of their backgrounds, attributes or locations.
Foster healthy, safe and inclusive communities	Victorians achieve and maintain good physical and mental health. They feel safe in their homes and communities, free from harm. They maintain social connections and participate in civic, cultural and community life.
Protect and enhance natural environments	Victoria protects natural environmental systems to preserve and enhance healthy, resilient and biodiverse ecosystems for future generations.
Advance climate change mitigation and adaptation	Victoria's community and economy adapts to the impacts of climate change and achieves the legislated target of net zero greenhouse gas emissions by 2050.
Promote sustainable production and consumption	Victoria protects natural environmental systems to preserve and enhance healthy, resilient and biodiverse ecosystems for future generations.
Build resilience to shocks	Victoria can better prevent, respond to, and recover from shocks. Victoria is less vulnerable to economic, technological, biological, ecological, and geopolitical disruptions and emergencies.

Source: Victoria's infrastructure strategy 2021-2051

Table 48: Alignment of Recommendations of *Victoria's infrastructure strategy* to Objectives

	Pop Change	Inclusive	Reduce Disadvantage	Enable workforce participation	Lift productivity	Drive changing globally integrated economy	Sustainable production and consumption	Enhance Natural Enviro	Climate Change	Resilience to Shocks	Land use and Infra Align
Support more homes in priority established places	X	X		X	X			X			X
Transport network pricing Initiatives	X				X		X				
Introduce new on-road demand management technology		X			X						
Reallocate road space to priority transport modes	X			X	X		X		X		X
Prepare for increasingly automated vehicle fleets		X		X	X				X	X	
Construct an outer metropolitan road and rail corridor	X			X	X	X					X
Reconfigure the City Loop	X			X	X	X					
Prepare for Melbourne Metro 2 and Geelong rail	X			X	X	X					X
Protect a long-term option for a new cross city motorway	X			X	X	X					X
Extend rail services in Melbourne's western and northern growth areas	X	X	X	X	X	X					X

Source: Victoria's infrastructure strategy 2021-2051

6.8 Appendix C – Industry group classifications

This appendix provides the detailed industries that are included in the four industry group classifications (knowledge-intensive, industrial, health and education, population-serving).

INDUSTRY GROUP CLASSIFICATIONS (SGS 2019)

The following ANZSIC Divisions describe the classifications used in this report:

Knowledge-intensive: Information Media & Telecommunications; Financial & Insurance Services; Rental, Hiring & Real Estate Services; Professional, Scientific & Technical Services; Administrative & Support Services; Public Administration & Safety

Industrial: Agriculture, Forestry & Fishing; Mining; Manufacturing; Electricity, Gas, Water & Waste; Wholesale Trade; Transport, Postal & Warehousing

Health and education: Education & Training; Health Care & Social Assistance

Population-serving: Construction; Retail Trade; Accommodation & Food Services; Arts & Recreation Services; Other Services

ANZSIC 2006 Division Codes and Titles	
A	Agriculture, Forestry and Fishing
B	Mining
C	Manufacturing
D	Electricity, Gas, Water and Waste Services
E	Construction
F	Wholesale Trade
G	Retail Trade
H	Accommodation and Food Services
I	Transport, Postal and Warehousing
J	Information Media and Telecommunications
K	Financial and Insurance Services
L	Rental, Hiring and Real Estate Services
M	Professional, Scientific and Technical Services
N	Administrative and Support Services
O	Public Administration and Safety
P	Education and Training
Q	Health Care and Social Assistance
R	Arts and Recreation Services
S	Other Services

Source: Australian Bureau of Statistics
cat.no.1292.0.55.002 Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 - Codes and Titles
Table 1. ANZSIC 2006 Division Codes and Titles

6.9 Appendix D – Key modelling assumptions and definitions

Overview

This section provides a high-level overview of the key modelling assumptions and definitions used in the analysis within this report. Further detail on the modelling and assumptions is provided in Arup's Strategic Modelling Outcomes report, and Infrastructure Victoria's VLUTI Model Architecture report.

Network Development Scenario (Base Case)

The network development scenario (base case) assumes that the transport network will develop and expand as the state grows to meet day-to-day travel needs, which includes the assumption that a range of recommendations that are in *Victoria's infrastructure strategy* are implemented. This includes the development of the arterial road network and tram and bus services, including into Melbourne's outer growth areas. Projects committed by Government to be progressively delivered, such as North East Link, Metro Tunnel Project, Suburban Rail Loop and associated rail services are assumed to be part of this scenario. Arup's Strategic Modelling Outcomes report presents these assumptions in detail.

Time periods

The VLUTI model aims to represent travel demand and network performance for the average non-school holiday weekday. This representative day is split into four distinct periods to account for varying travel behaviours during these times. Assessment outcomes will often correspond to one of these specific time periods.

Table 49: VLUTI Time Periods

Time period	From	To
Morning peak (AM)	7am	9am
Inter-peak (IP)	9am	3pm
Evening peak (PM)	3pm	6pm
Off-peak (OP)	6pm	7am

Source: Arup Strategic Modelling Outcomes Report 2021

Region systems

A variety of region systems are referred to throughout this report and the supporting technical reports. Two key region systems include *Functional Urban Areas* (FUA) and *Functional Economic Regions* (FER). Maps of these regions are shown in Figure 139 and Figure 140.

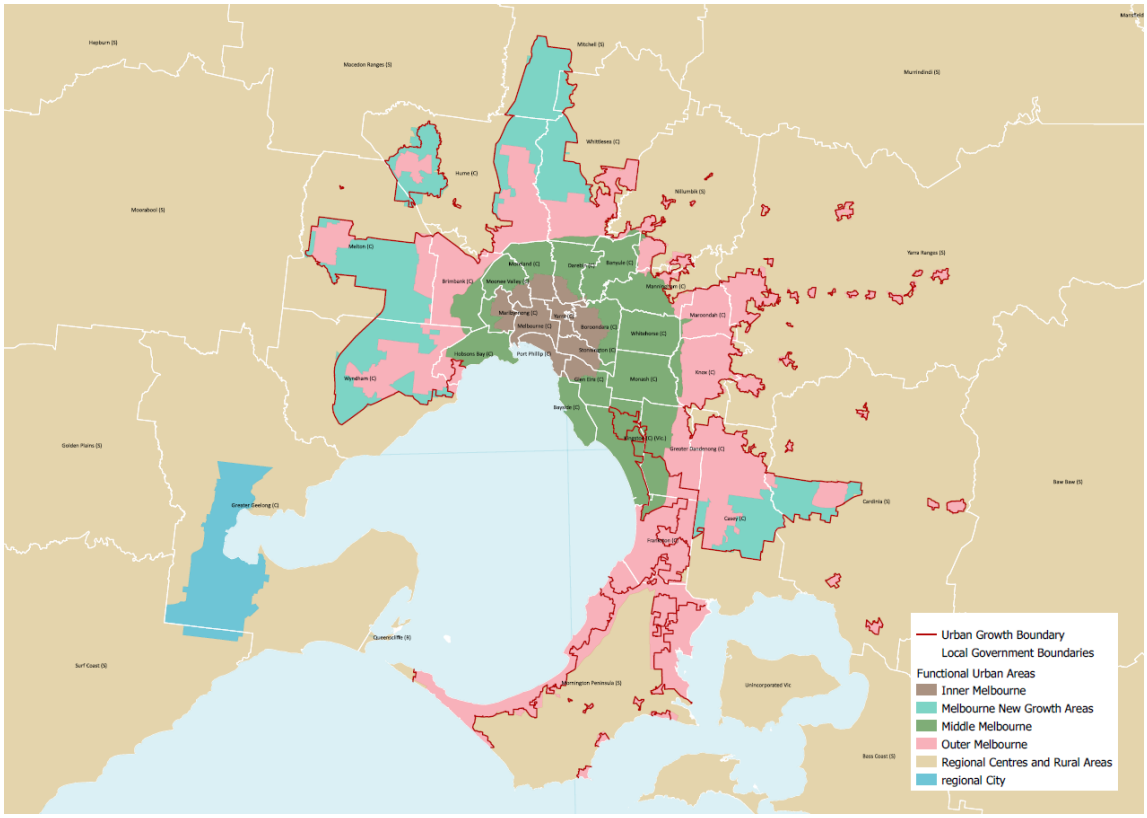
The FUA system splits Victoria into six regions, defined by their level of centrality to Melbourne's CBD. This also accounts for potential growth opportunities in the future.

The FER system defines distinct parts of Melbourne's geography that correspond to interconnected, regional economies within the city. In brief, trade, commerce, commuting and other activities occur more frequently between firms and residents within these regions than outside of them.

VLUTI model limitations

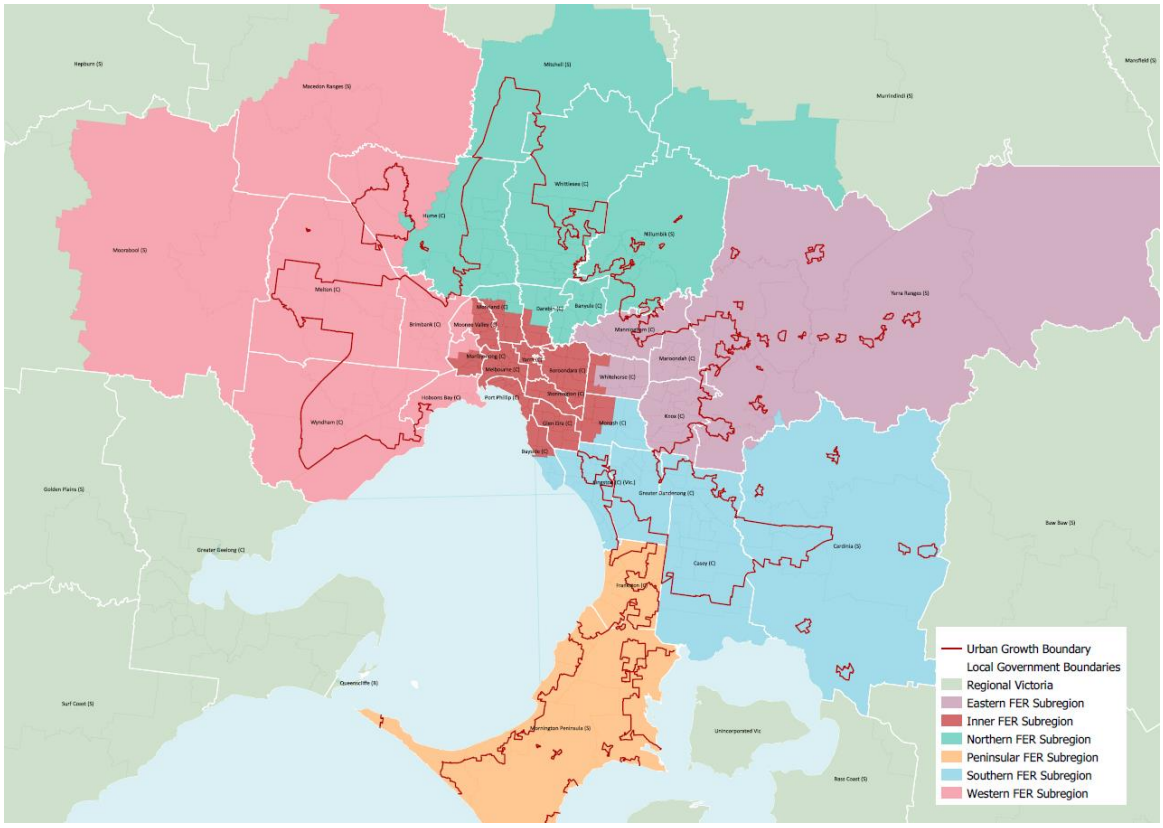
It is important to note that model outputs are always an approximation of what can be expected in the real / built environment. They are subject to technical limitations and the general uncertainty associated with projections. As such, it is important that results from the VLUTI model are treated with caution and interpreted with an understanding of the strengths and weaknesses of these modelling tools, as well as the basis of inputs adopted. Further detail on VLUTI model limitations are outlined in Infrastructure Victoria's *VLUTI Model Architecture Report*.

Figure 139: Functional Urban Areas



Source: Infrastructure Victoria

Figure 140: Functional Economic Regions



Source: Infrastructure Victoria

6.10 Appendix E – VLUTI model approach and working from home scenario

6.10.1 Modelling Approach and Methodology

We have used an integrated land use and transport demand (VLUTI) model to investigate the potential medium to long-term infrastructure and land use implications of increased working from home for some industries/professions in Victoria. The VLUTI model employed here is integrated, incorporating the most essential processes of spatial development in Victoria. This model has been developed to simulate interactions between land use and transport systems or the effect of spatial scenarios. The VLUTI model is a composite of two existing models: 1) an economic model that incorporates land use (a spatial computable general equilibrium (SCGE) model) developed by Victoria University; and 2) the Victorian Integrated Transport Model (VITM) model developed by Victorian Department of Transport.

Economic Model

The latest version of Victoria University's spatial economy model (land use model), called the Spatial Interactions within and between Regions and Cities in Victoria (SIRCV) model is used to make a preliminary assessment of the impacts of increased working from home in Victoria. The current spatial resolution of the SIRCV model is at Statistical Area Level 2 (SA2) of the Australian Bureau of Statistics' (ABS) Australian Statistical Geography Standard 2016 (ASGS) throughout Victoria. Each SA2 region represents a community that interacts together socially and economically. SIRCV simulates two core sets of economic agents (Households and Firms) and two additional agents (Government and Foreign Market) that interact with the core sets of economic agents.

The SIRCV model distinguishes two populations of households: working and non-working. Households are distinguished by skill type. Each household in the SIRCV framework is represented by a set of demand and supply functions that can be incorporated in the market equilibrium equations. Each household represents the population residing in each region ($Region_1$) and working in each region ($Region_2$) for each employer. Worker households must make trips to work (from $Region_1$ to $Region_2$) and incur travel costs such as private vehicle operating costs and public transport fares. Working households are modelled as choosing their occupation (38 occupational groups – ANZSCO 2-digit), locations to reside (458 SA2s) and to work (458 SA2s), and expenditures on goods and services that maximise their utility. There are also non-working households who choose where to reside and their expenditures on goods and services.

The SIRCV model distinguishes 100 industries: 10 produce primary products, 40 firms manufacture goods, five provide utilities, four undertake construction activities, 41 produce non-housing services and one produces housing services. Each of the 100 industries corresponds to one or several ABS Input-Output Industry Groups (IOIG). In each industry and locality, firms produce goods and services using Cobb-Douglas technologies combining using land (four categories), labour (ANZSCO two-digit level - 38 occupational groups), intermediate inputs (100 types), and capital.

As an input into the SIRCV model, land resources were classified into four broad classes (Residential, Commercial, Industrial and Rural) exogenously based on Victorian planning zones. Exogenously zoned land is endogenously allocated amongst competing uses (e.g. commercial and residential), with the allocation responding endogenously to relative land rents. In the SIRCV framework, total land in each region is allocated between Residential and Non-residential. Then, the total Non-residential land (Rural, Commercial, and Industrial) is allocated between specific industries. In any SA2 regions, each industry sector is identified with a single land category, but housing services provided by a single dwelling may use Residential and/or Commercial land.

Within the SIRCV model, people may travel to work or education or to purchase goods and services. Goods are also transported using freight networks. All travel has associated transport costs and these transport costs are an input to the model. Transport costs incurred while commuting is treated differently to those incurred with the purchase of goods and services. Each trip or freight shipment incurs a transport cost that is based on the fastest route by road between the origin and destination zones. The road network includes major car ferry services. In addition, bus, light or heavy rail or ferry services are used for a significant share of trips. For consumption and business travel and for long-distance commutes, the model allows for the use of an air leg within an otherwise road-based journey. By combining distances from multiple point origins and destinations within each SA2 region, it is possible both to estimate more representative travel times between SA2s, and travel times within each SA2 region.

Commuting costs, proxied for by estimated travel times, but reflecting time/inconvenience costs, directly enter the household indirect utility function. For working households, utility depends positively on local residential amenities, wage rates and their idiosyncratic preferences (that captures idiosyncratic reasons for a working household living in region r and working in region s). Utility depends negatively on the local level of prices, the rate of income tax and commuting costs. Commuting costs in the current version of the SIRCV model enter in a negative power law form. The model is calibrated using estimated commuting gravity coefficient $\zeta_o \varepsilon_L$ where ζ_o is the commuting cost coefficient and the epsilon ε_L is the logit parameter for detailed residence and workplace location choices. For the sake of simplicity, the model assumes that a single value of ζ_o applies in all occupations. This is because substantial heterogeneity was detected in estimating the value of commuting cost coefficient for individual occupations.

Activity in the SIRCV model is parameterised by trip costs between regions. This is used to accurately capture the preferences of individuals regarding where to live and work given network performance and other factors. The SIRCV

model is calibrated using a set of current year demographic inputs as well as modelled composite generalised travel costs (GTCs) produced by an iteration of the transport model (VITM). When testing future years (e.g. 2036 or 2051) the initial assumptions surrounding both demography and the economy must be manufactured from the current year starting point. The calibrated SIRCV model is run using the current year GTCs and SIRCV demographic and economic database but is also given the total change in resident workers and non-working households by SA2 in the future year. These total values are taken from external datasets such as the SALUP. The calibration runs through the VLUTI framework in much the same way as a policy simulation. The future year database produced by this calibration simulation then serves as an input for policy simulations in that year.

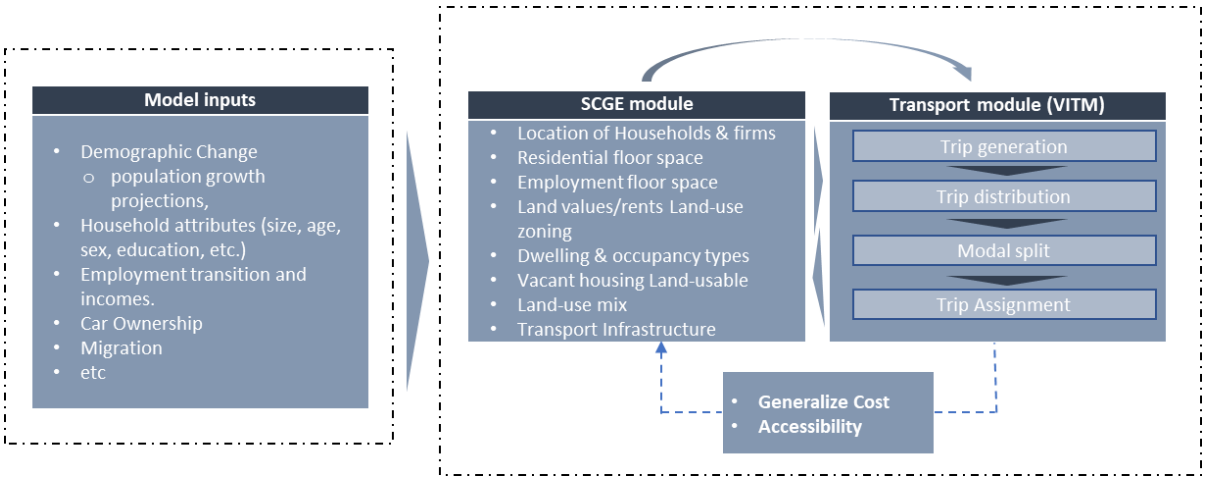
Transport Model

The Victorian Integrated Transport Model (VITM) is a multi-period, multi-purpose and multi-modal strategic level transport model which consists of car, public transport and active transport modes. VITM uses population and employment forecasts to examine future impacts of changes to the road and public transport networks in Victoria. The primary inputs to the VITM include model parameters, road and public transport networks, and zonal population and employment data. VITM is calibrated using the Victorian Integrated Survey of Travel and Activity (VISTA) data. VISTA is an ongoing cross-sectional household travel and activity survey conducted on behalf of the state government to understand the complex travel behaviour of individuals. In addition to VISTA data, the 2016 ABS Census data (population and employment levels and distribution) together with other demographic, economics, future land use change, and travel data (e.g. school enrolments; car ownership levels; household income; public transport usage; traffic counts) have been also used in the development of the VITM.

VITM contains four basic phases: trip generation, trip distribution, mode choice and trip assignment. VITM predicts the number of trips produced in each area of the network by trip purpose in the trip generation phase. The trip distribution, which takes the form of a gravity model, produces daily production to attraction matrices for motorised trips (combined car and public transport). The mode choice separates the total motorised trip demand into daily production to attraction matrices for car and public transport trips. The mode split utilises a logit choice model with inputs being the utility of travel for both car and public transport trips between zones. Time period factors are used to convert the daily production to attraction trips into trip defined from origin to destination for four time periods (AM peak (7AM – 9AM), interpeak (9AM – 3PM), PM peak (3PM – 6PM) and off-peak (6PM – 7AM)). The time period factors vary depending on the trip purpose, mode and on the location of the trips. Finally, trip assignment estimates the specific route for each trip.

Combining the land use (SIRCV) model and transport model (VITM) into a single, integrated process, and running both in sequence, provides a more realistic assessment outcome. The integrated model provides iterative modelling of land use and transport impacts to understand the feedback mechanisms between infrastructure provision and land use changes. Figure 1 shows the internal structure of the VLUTI model. Employment and consumption of goods in the SCGE module generate workers place of residence and work data sets which form inputs for the transport module. The transport module then determines mode split and assigns trips to the transport network, returning expected travel costs to the SCGE module.

Figure 141: The internal structure of the VLUTI model



6.10.2 Scenario specification

The changes in the technology supporting working from home are captured by changing the way distance affects utility in the land use model. We will discuss how distance is reflected in the land use model before focussing on how the increase in working from home is modelled.

Distance enters the SIRCV model at four points:

- Distance to the workplace reduces (working) household utility (via an indirect utility function). It has no effect on non-working households – therefore affects choices of where to work and in what occupation. The working from home scenario focuses on the frequency of commutes.
- Household utility also increases with the density of households nearby.
- Firm total factor productivity increases with the density of jobs nearby.
- The price of tradable goods (all goods and services except housing) increases with transport costs and decreases with firm productivity.

The way working from home is captured is a reduction in the disutility for a household, who work in a set of occupations, associated with distance from the workplace. The set of occupations is based on but narrower than those suggested by Dingell and Neiman (2020). In order to model medium to long-term COVID-19 behaviour change (working from home), we focus on occupations in which most tasks could be performed from home. There are few studies looking at the percentage of Australian workforce who could work from home based on their occupational characteristics.

Dingel and Neiman (2020) use the average responses to a set of two US surveys on occupational activities and the context within which they are conducted to classify six digit US Standard Occupational Classification occupations as to whether they can be conducted from home based or not. Occupations were classified as not able to be conducted at home if they involved physical activities, direct conduct with the public, specialised equipment or premises, were hazardous or involved a lot of walking/running or wearing specialised protective/safety equipment. All other occupations were assumed to be able to be conducted from home.

The occupational classification of Dingel and Neiman (2020) has been adapted for Australian data by three sets of authors: Coates et al. (2020), Stratton (2020) and Ulubasoglu and Onder (2020). Because the Australian standard occupational classification is different to the US occupational classification, each set of authors had to adapt Dingel and Neiman's classification to suit the Australian one. These estimates suggest about 40% of the workforce could work from home based on their occupational characteristics.

In order to calculate the percentage of workforce by occupation who could work from home, the occupational classification schemes used in each of the Australian adaptations of Dingel and Neiman (2020) were reviewed. Infrastructure Victoria adopted the classification by Coates et al (2020), at the ANZSCO four-digit level as it was the closest to what was needed to estimate the share of workers by ANZSCO two-digit level occupation who can work from home. Each four-digit occupation was assigned a 1 or a 0 as to whether it could be conducted from home. To construct a value that can be applied to two-digit ANZSCO occupations, as used in the land use model (SIRCV), the values for the four-digit occupations using Victorian occupational employment statistics from the 2016 census were aggregated. The estimated share of workers in each occupation who can work from home is outlined in the following table.

Table 50: Estimated share of workers in each occupation who can work from home

ANZSCO two-digit level Occupations	Share of workers who can work from home
Chief Executives, General Managers and Legislators	71.6%
Farmers and Farm Managers	0.0%
Specialist Managers	69.0%
Hospitality, Retail and Service Managers	0.0%
Arts and Media Professionals	81.3%
Business, Human Resource and Marketing Professionals	100.0%
Design, Engineering, Science and Transport Professionals	73.9%
Education Professionals	28.6%
Health Professionals	5.7%
ICT Professionals	100.0%
Legal, Social and Welfare Professionals	81.4%
Engineering, ICT and Science Technicians	65.6%
Automotive and Engineering Trades Workers	0.0%
Construction Trades Workers	0.0%
Electrotechnology and Telecommunications Trades Workers	0.0%
Food Trades Workers	0.0%
Skilled Animal and Horticultural Workers	5.3%
Other Technicians and Trades Workers	9.2%
Health and Welfare Support Workers	0.0%
Carers and Aides	0.0%
Hospitality Workers	0.0%
Protective Service Workers	0.0%
Sports and Personal Service Workers	0.0%
Office Managers and Program Administrators	100.0%
Personal Assistants and Secretaries	100.0%
General Clerical Workers	100.0%
Inquiry Clerks and Receptionists	14.5%
Numerical Clerks	83.8%
Clerical and Office Support Workers	37.2%
Other Clerical and Administrative Workers	83.6%
Sales Representatives and Agents	60.7%
Sales Assistants and Salespersons	0.0%
Sales Support Workers	16.0%
Machine and Stationary Plant Operators	0.0%
Mobile Plant Operators	0.0%
Road and Rail Drivers	0.0%
Storepersons	0.0%
Cleaners and Laundry Workers	0.0%
Construction and Mining Labourers	0.0%
Factory Process Workers	0.0%
Farm, Forestry and Garden Workers	0.0%
Food Preparation Assistants	0.0%
Other Labourers	0.0%

Source: Analysis of ABS Census data

The model does not permit fully endogenizing each individual's decision as to work from home. To model increased working from home, the frequency of working from home is endogenized by reducing coefficient zeta (ζ) – a commuting cost coefficient (commuting disutility). An increased propensity for working from home was modelled by lowering the value of commuting cost coefficient for relevant occupations.

As well as considering the direct effects of working from home, Infrastructure Victoria also modelled the following three indirect effects:

1. changes in household transport costs
2. changes in household internet costs
3. changes in firm internet costs.

Besides actually working from home, the next most obvious impact of shifting to working from home is the reduction in transport costs from no longer commuting to and from a workplace. This is reflected in a reduction in household expenditure on transport related industries. The size of the reduction will depend on how many days a week each worker works at home. The adjustment to the disutility parameters will result in, upon average, each worker working two days a week at home. We approximated the effect on the household expenditure share on transport by the change in the share

of work-related trips (not using active transport) for working age people as reported in VISTA if the individual worked at home two days a week. This was calculated to be about a 13% reduction.

The adoption of collaborative and video conferencing software was required in order to facilitate working from home. Hence, the household expenditure share on internet services will be affected from increased working from home. The primary assumption in generating the changes to the budget shares is that expenditure will vary directly with usage. Fixed broadband internet usage for a typical household as well as the internet usage associated with working from home two days a week were estimated. This is consistent with the assumption being made for transport.

Bureau of Communications and Arts Research (2020) reports estimates of usage of different applications for households and small businesses that form the basis of estimating the monthly per household member and per employee broadband internet usage. They also classify ANZSCO four-digit occupations as to whether they are low, medium, high or high+media users of broadband. A low user would do most of their work away from a computer screen whereas a high user spends most of their day in front of a screen. The high+media user spends all day in front of the screen but also has to transfer very large files (usually graphics). The estimates of the use of different applications are assumed to apply to medium occupations. Usage for low and high use occupations are scaled down or up as appropriate.

The Bureau of Communications and Arts Research (2020) estimates were compiled for pre-COVID-19 usage. The most striking example of this is that it is assumed businesses do only 0.6 minutes of video calls a day. This estimate was replaced with one based on survey data of businesses in lockdown by DeFilippis et al (2020). They found that on average employees were in video calls for 2.45 hours per day. To estimate the increase in household broadband usage we add the estimates for employee consumption to household consumption. Finally, the same source of estimates of internet usage as for estimating the change in the household expenditure share was used to calculate the change in internet cost share for businesses. To estimate the change in the cost share for businesses, the change in business internet usage pre-COVID-19 was compared with internet usage with employees working at home two days a week. The main difference in these estimates comes from the much greater use of video calls.

About us

Infrastructure Victoria is an independent advisory body, which began operating on 1 October 2015 under the *Infrastructure Victoria Act 2015*.

Infrastructure Victoria has three main functions:

- preparing a 30-year infrastructure strategy for Victoria, which is refreshed every three to five years
- providing written advice to government on specific infrastructure matters
- publishing original research on infrastructure-related issues.

Infrastructure Victoria also supports the development of sectoral infrastructure plans by government departments and agencies.

The aim of Infrastructure Victoria is to take a long-term, evidence-based view of infrastructure planning and raise the level of community debate about infrastructure provision.

Infrastructure Victoria does not directly oversee or fund infrastructure projects.

Aboriginal acknowledgment

Infrastructure Victoria acknowledges the traditional owners of country in Victoria and pays respect to their elders past and present, as well as elders of other Aboriginal communities. We recognise that the state's infrastructure is built on land that has been managed by Aboriginal people for millennia.

Published by Infrastructure Victoria

August 2021

This document is available in PDF at www.infrastructurevictoria.com.au

ISBN 978-1-925632-75-0 **(pdf/online/MS word)**