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Western Distributor Economic Assessment Report

Department of Treasury and Finance

November 2015

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This report is a confidential document that has been prepared by PricewaterhouseCoopers Australia (PwC) at the request of the Department of Treasury and Finance (DTF) in connection with our contract to provide commercial and financial advice in relation to the development of a Business Case for the proposed Western Distributor Project (the Project).

The analysis contained in this report has been prepared by PwC from, inter alia, material provided by, and discussions with, DTF and third parties including:

- Advisian
- Axess Collaborative ITS Consulting Australia (CICA)
- Axess Advisory (Axess)
- GHD
- VicRoads
- Veitch Lister Consulting Pty Ltd (VLC), and
- Department of Economic Development, Transport, Jobs and Resources (DEDTJR)

(together, the Information).

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Executive summary

Purpose of this document

The report presents an economic assessment of potential investment in Melbourne's transport network being considered by the Victorian Government in relation to problems identified along Victoria's M1 Corridor. This includes the Western Distributor Project, a potential new freeway connection between the West Gate Freeway and CityLink, together with enhanced capacity of the West Gate Freeway from the M80 Ring Road to Williamstown Road, upgraded access from the West Gate Freeway to the Port of Melbourne, and upgraded access to Webb Dock. In addition, it includes the Monash Freeway Upgrade, involving additional lane in each direction along the Monash Freeway from EastLink to Clyde Road and expanded freeway ramp metering at key points between Warrigal Road and Koo Wee Rup Road. Together this scope is referred to as 'the Project' throughout the remainder of this report.

PricewaterhouseCoopers Australia (PwC) has been commissioned by the Department of Treasury and Finance (DTF) to work with the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) to undertake economic assessment of the Project. This document sets out the methodology and findings of that economic assessment. This report should be read in conjunction with the Victorian Government's business case for the Western Distributor.

Rapid cost benefit analysis of strategic options

A rapid cost benefit analysis (CBA) was undertaken to assist in strategic options assessment for the western section of the M1 Corridor. Strategic options assessment for the south-east section of the M1 Corridor was separately undertaken by VicRoads.

The rapid economic assessment was used in considering the sequencing of investment in two western Melbourne road corridors: a northern route connecting CityLink and the M80 under Footscray, and a southern route connecting CityLink and the West Gate Freeway in the vicinity of Williamstown Road. Figure 1 shows the two investment pathways assessed.

Figure 1: Western road corridor pathways

Source: diagram developed by GHD (2015), based on investment pathways developed by Advisian (2015) Western Road Corridor Options Assessment Technical Note.

Methodology

The rapid appraisal methodology was based on a cost benefit analysis framework largely aligned with the approach to the detailed economic assessment for the Project outlined below.

In terms of benefit estimation for the appraisal, investment in the western road corridor was considered to generate a number of direct benefits for road users and the Melbourne community. Key direct benefits identified and estimated included improved network efficiency, reduced congestion, enhanced freight efficiency and environmental cost savings. Benefit estimates were developed drawing on Veitch Lister Consulting (VLC) demand forecasts and applying economic parameters. The VLC Zenith modelling accounted for route and mode change as a result of the investment pathway.

Benefits were compared against cost estimates in a CBA framework. The cost estimates were developed by Advisian to P50 equivalent.

All investment pathways have been assessed over the period 2015/16 – 2095/96, reflecting 50 years of operation following completion of the final scope element of the investment pathways in 2045/46.

Results

Rapid CBA results for the investment pathways are presented in Table 1. The analysis suggests that Pathway 1 results in higher net economic benefits. This supports the southern corridor in Pathway 1 as the initial priority.

Table 1: Rapid CBA results of potential investment pathways as part of western road corridor strategic options assessment ($ June 2015 millions, real, discounted present values)

	Pathway 1	Pathway 2
Rapid Benefit Cost Ratio excluding wider economic benefits (WEBs)	**1.7**	**1.3**
Net Present Value excluding WEBs	**$3,700**	**$1,300**
Rapid Benefit Cost Ratio including WEBs	2.3	1.7
Net Present Value including WEBs	$6,900	$3,400

Note: Estimated incremental to the status quo base case, discounted based on a 7% real discount rate over the period 2015/16-2095/96 (50 years after the last construction year in 2045/46), demand modelling accounts for route and mode change only, P50 capital costs, may not total due to rounding.
Source: PwC, 2015

Economic assessment of the Project

Methodology

Based on strategic options assessment, the Western Distributor and Monash Freeway Upgrade Project were identified as part of the State Government's business case process. Together this scope is referred to as 'the Project'.

The Project will generate a number of direct benefits for road users and the Melbourne community. The Project will also create macroeconomic benefits for Victoria and Australia.

The direct benefits of the Project include improved network efficiency, reduced congestion, enhanced freight efficiency and improved accessibility to the Port of Melbourne. The Project will also increase the resilience of Melbourne's road network, particularly crossing the Maribyrnong River, and improve liveability and amenity through reduced crashes and improved air quality. These benefits will create new jobs and increase gross state product (GSP).

A CBA framework has been applied to estimate net economic benefits based on directly attributable benefits. Macroeconomic benefits have been modelled based on economic impact assessment (EIA) using computable general equilibrium (CGE) modelling.

The CBA results have been developed based on current Victorian practice, taking into account Victorian Government guidelines[1] and the Victorian Auditor-General's Office recommendations for traffic modelling[2]. The CBA results have also been developed based on Infrastructure Australia's December 2013 published economic guidelines[3] as these have been recently applied for consideration of other nationally significant infrastructure projects. There are four main areas of differentiation relating to the BCR calculation and the approach to estimating two benefits.

An overarching requirement of most economic appraisal guidelines and fundamental principal of CBA is to measure the impact on the community as a whole. This involves identifying and, where possible, quantifying all costs and benefits directly attributable to an initiative.[4] As a result, where considered to reflect the nature of this Project, and supported by economic theory and guidelines, along with appropriate parameters for quantification, project-specific benefits have been included in the appraisal.

Results of the detailed economic assessment

Key findings of the economic assessment are:

- The Project will deliver direct benefits to the Victorian economy.
- The benefits for road users and freight flow from reduced travel times, lower vehicle operating costs, and higher load capacities.
- The broader community will also benefit from improved transport network resilience and redundancy, improved liveability, as well as agglomeration benefits and improved accessibility to jobs.
- The Project is expected to boost economy-wide activity, both in Victoria and nationally, induced by improvements to transport productivity and greater infrastructure expenditure in Melbourne. This includes additional jobs and increased GSP.

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[1] DTF (2013) Economic Evaluation for Business Cases Technical Guidelines, August 2013

[2] Victorian Auditor General, 2011, Management of Major Road Projects

[3] Infrastructure Australia, December 2013, Reform and Investment Framework, Templates for Stage 7 Solution evaluation (Transport Infrastructure) available at: http://infrastructureaustralia.gov.au/projects/files/Infrastructure_Priority_List_Submission_Template_Stage_7_Transport.pdf; Economic analysis using current Victorian practice takes into account DTF's (2013) Economic Evaluation for Business Cases Technical Guidelines (State Government of Victoria) and the Victorian Auditor-General's Office recommendations for traffic modelling (Victorian Auditor General's Report (June 2011), Management of Major Road Projects

[4] Infrastructure Australia, 2014, Better Infrastructure Decision-Making, available at: http://infrastructureaustralia.gov.au/projects/files/Reform_and_Investment_Framework_Guidance.pdf; Victorian Department of Treasury and Finance, 2013, Investment Lifecycle and High Value/ High Risk Guidelines (Stage 2 – Prove - Economics evaluation technical guide), updated August 2013, p 6.

Table 2: Cost benefit analysis results for the Project ($ June 2015 millions, real, discounted present values)

Costs and Benefits (Present Value $M)	Current Victorian Practice[1]	Infrastructure Australia Dec 2013[2]
Costs	3,570	3,541
Benefits excluding wider economic benefits (WEBs)	4,642	6,615
Benefit Cost Ratio (BCR)	**1.3**	**1.9**
Net Present Value (NPV)	**1,072**	**3,074**
BCR including WEBs	1.6	2.2
NPV including WEBs	2,285	4,149

Note: (1) Current Victorian practice results estimated incremental to the status quo base case, discounted based on a 7 per cent real discount rate over the period 2015/16-2071/72, P50 capital and operating costs, applying Victorian Government economic guidelines and Victorian Auditor-General's Office recommendations for traffic modelling; (2) IA December 2013 results estimated incremental to the base case, discounted based on a 7 per cent real discount rate over the period 2015/16-2051/52, P50 capital and operating costs, applying Infrastructure Australia December 2013 published economic guidelines
Source: PwC, 2015

Table 3: Macroeconomic impact assessment results for the Project ($ June 2015 millions, real, discounted present values)

Economic impact (direct and indirect)		Construction period 2017/18-2021/22	Operating period 2022/23 – 2071/72	Total period 2017/18 - 2071/72
Increase in Gross State Product ($m)		1,126	9,681	10,807
Jobs created (FTE)	Maximum	5,600	2,700	5,600
	Average	2,400	700	900

Note: estimated incremental to the base case, analysed over the period 2015/16 to 2071/72, GSP discounted based on a 7% real discount rate and provided in $ June 2015, jobs estimated on Full Time Equivalent basis.
Source: PwC, 2015

Sensitivity testing

Sensitivity testing of key economic appraisal inputs and assumptions is provided in Table 4. Key findings of the sensitivity testing are:

- Under the majority of scenarios tested, benefits exceed costs (the exception when a 10% discount rate and Victorian practice is applied).
- Net benefits are still estimated assuming a 20% increase or P90 capital costs .
- On a standalone basis both the Western Distributor Project and Monash Freeway Upgrade Project result in net benefits. A higher relative BCR for the Monash works is largely attributable to lower cost upgrades of existing infrastructure that, for example, do not require tunnelling that is part of the Western Distributor scope.
- The core results may understate the potential range of attributable benefits, in particular:
  - Sensitivity results demonstrate that the Project generates benefits not only from the physical infrastructure (the focus of the core BCR results) but also from implementing a tolling solution relative to the base case. The proposed

tolling and associated justification to continue tolls on the CityLink as a result of investment in the network (relative to a base case where tolls on CityLink are assumed to lapse rather than continue after the current concession ends from 2036) significantly increases the scale of economic benefits.

– Sensitivity analysis has been undertaken to estimate impacts associated with land use change occurring as a result of the Project. This analysis is based on the SGS Economics and Planning assessment that employment and households will be attracted to Melbourne’s western subregion from the inner city and south-east suburbs.

The results suggest that the Project facilitates improved accessibility and therefore utility for those attracted to move household or job location. This is measured indicatively in the sensitivity test in the form of amenity associated with larger land area, improved natural space and quality of the environment based on European values. These benefits are partly offset by a net increase in travel costs on the road network due to greater densification in some areas of Melbourne. However, the land use benefits are likely to be understated, as they do not incorporate utility derived from changing job location. There are also challenges associated with isolating traffic impacts from land use benefits

Table 4: Sensitivity testing of cost benefit analysis results

	A. Consistent with Victorian guidelines and practice	B. Consistent with December 2013 IA guidelines for national comparison
Sensitivity test	**BCR**	**BCR**
Core results (from Table 2)	1.3	1.9
Discount rate		
4% discount rate	2.3	3.1
10% discount rate	0.8	1.2
Project cost		
P90 Costs	1.2	1.8
+ 20% Costs	1.1	1.6
- 20% Costs	[illegible] 2.3	2.3
Technical scope		
Western Distributor Project only *West Gate Freeway widening, Western Distributor tunnel and improved access to Port of Melbourne/Webb Dock*	1.1	1.3

Sensitivity test	A. Consistent with Victorian guidelines and practice BCR	B. Consistent with December 2013 IA guidelines for national comparison BCR
Monash Freeway Upgrade Project only *Monash Freeway widening and improved ramp metering between Warrigal and Koo Wee Rup Road*	4.2	8.4
Western Distributor tunnel *Constructed as a surface road instead of a tunnel*[5]	1.8	2.6
Tolling scope		
Western Distributor tunnel tolls +20% *A 20% increase in tolls on the Western Distributor including the West Gate Distributor ramp and City Access (Footscray/Dynon Road ramps)*	1.3	1.9
No extension of CityLink tolls in the base case *In the base case tolls on CityLink are assumed to lapse rather than continue after the current concession ends (assumed from 2036)*	2.1	2.4
Change in land use		
Indicative land use change *Assumes land use change expected as a result of the Project (with the appraisal accounting for traffic impacts as well as amenity improvement from attracting households and employment to preferred locations)*[6]	1.3	1.9
Change in demand drivers		
Port Commercial Vehicles - 20% *A 20% reduction in assumed number of commercial vehicle trips to/from the Port of Melbourne in the VLC Zenith Model*	1.2	1.7
Fuel price +10% *A 10% increase in fuel price assumed in the VLC Zenith Model*	1.3	1.9
CBD parking changes +10% *A 10% increase in CBD parking charges assumed in the VLC Zenith Model*	1.3	1.9

Note: estimated incremental to the base case, discounted based on a 7% real discount rate, based on P50 capital and operating costs; (A) Consistent with Victorian Government economic guidelines therefore analysed over the period 2015/16 – 2071/72, and applying Victorian Auditor-General's Office recommendations for traffic modelling; (B) Consistent with Infrastructure Australia December 2013 published economic guidelines therefore analysed over the period 2015/16 – 2051/52 and not applying VAGO recommendations for traffic modelling.
Source: PwC, 2015

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5 Tunnel component of Project capital costs assumed to reduce by around 65% (a 25% reduction in total Project capital costs) if it could be constructed as a surface road based on benchmarks from similar Melbourne road project

6 Based on SGS Economics forecasts of the change in population and employment as a result of the improved accessibility (population) due to the Project. While the BCRs are the same as the core to one decimal place, the NPV's are higher both based on Victorian guidelines and practice and Infrastructure Australian 2013 guidelines ($1,086M and $3,083M respectively in real $ June 2015, discounted, net presented values).

1 Introduction

1.1 Background

The report presents an economic assessment of potential investment in Melbourne's transport network being considered by the Victorian Government in relation to problems identified along Victoria's M1 Corridor. This includes the Western Distributor Project, a potential new freeway connection between the West Gate Freeway and CityLink, together with enhanced capacity of the West Gate Freeway from the M80 Ring Road to Williamstown Road, upgraded access from the West Gate Freeway to the Port of Melbourne, and upgraded access to Webb Dock.

The genesis of the Western Distributor was the market-led proposal from Transurban to the State Government in March 2015 to build a $5 billion Western Distributor Project, funded by new tolls and an extension to CityLink tolls. Transurban's preliminary design has since been updated in response to technical, safety and community feedback.

Reflecting that the Transurban Western Distributor project was put forward to Government as a market-led proposal, the State has undertaken a broader assessment of Melbourne's transport needs in the M1 Corridor and its adjoining economic precincts. Victoria's M1 Corridor stretches from Geelong through to the Latrobe Valley and provides transport connectivity (both road and public transport) critical to the functioning of key economic assets for Melbourne, including significant employment and education clusters and major and emerging freight terminals.

This broader network assessment found that transport performance and capacity is a key problem on the corridor, particularly on the following two sections:

- the West Gate Freeway between the M80 Ring Road and the West Gate Bridge
- the Monash Freeway between Warrigal Road and Clyde Road.

As a result, the Western Distributor business case also identified the Monash Freeway Upgrade, involving an additional lane in each direction along the Monash Freeway from EastLink to Clyde Road and expanded freeway ramp metering at key points between Warrigal Road and Koo Wee Rup Road. Together with the Western Distributor, this scope is referred to as 'the Project' throughout the remainder of this report.

PricewaterhouseCoopers Australia (PwC) has been commissioned by the Department of Treasury and Finance (DTF) to work with the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) to undertake economic assessment of the Project. This document sets out the methodology and findings of that economic assessment.

1.2 Purpose of this document

This report sets out the economic analysis undertaken by PwC on behalf of the State to evaluate the project scope independently developed by the State Government. The purpose of this report is to document the methodology and results of the economic assessment. This report should be read in conjunction with the Victorian Government's business case for the Western Distributor.

The remainder of this report is structured as follows:

- Rapid cost benefit analysis of investment pathways – this chapter presents a rapid cost benefit analysis (CBA) undertaken to assist in strategic options assessment for the western section of the M1 Corridor
- Nature of the economic assessment – this chapter presents the overarching methodology and key assumptions for the economic assessment
- Scenarios assessed – this chapter defines the project scope and options evaluated in the economic assessment
- Demand forecasts – this chapter outlines methodology and key assumptions of the demand forecasting model in terms of its application to estimate economic benefits
- Costs – this chapter outlines the capital costs, operating and maintenance costs of the project, and discusses the approach to estimating the avoided costs and the residual value of assets
- Benefits – this chapter presents detailed methodology of the direct benefits estimation
- Results – this chapter presents the results of the economic assessment.

2 Rapid cost benefit analysis of investment pathways

A rapid cost benefit analysis (CBA) was undertaken to assist in strategic options assessment for the western section of the M1 Corridor. The strategic options assessment for the south-east section of the M1 Corridor was separately undertaken by VicRoads.

The rapid economic assessment was used to assist in determining the sequencing of investment in two western Melbourne road corridors: a northern route connecting CityLink and the M80 under Footscray, and a southern route connecting CityLink and the West Gate Freeway in the vicinity of Williamstown Road. Figure 2 shows the two investment pathways assessed.

Figure 2: Western road corridor pathways

Source: diagram developed by GHD (2015), based on investment pathways developed by Advisian (2015) Western Road Corridor Options Assessment Technical Note.

The rapid CBA undertaken is consistent with a number of current Victorian and national economic appraisal guidelines. These guidelines suggest that rapid CBA may be used to assess and rank strategic options for more detailed assessment but note that a lower level of detail is required relative to a full CBA (ie focus on key benefits and use of strategic rather than probabilistic costs). For example:

- The Victorian Department of Treasury and Finance 2013 *Investment Lifecycle High Value High Risk Guidelines* (Stage 1) requires identification and assessment of alternative strategic options to address the problems identified, including defining the method and criteria used to assess and rank the strategic responses for more detailed assessment.[7] Importantly, 'agencies would not be expected to provide the level of detail about the project options, or the recommended project solution that is required for a proposal to be endorsed for funding (i.e. at full business case stage).'[8] In addition, 'cost estimates should be sufficiently reliable to provide an 'order of magnitude' for the final cost.'[9]

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[7] Victorian Department of Treasury and Finance, 2012, Investment Lifecycle and High Value/ High Risk Guidelines (Stage 1 - Conceptualise), updated August 2013, p. 16-19.

[8] Ibid, p. 24.

[9] Ibid, p. 25.

- The IA 2014 Guidelines state, in the options assessment stage of the Reform and Investment Framework, that a rapid CBA can be developed for a short list of options to determine the lead options for a thorough and detailed CBA.[10]
- The ATC 2006 NGTSM suggests that a rapid CBA is a cost-effective way of gauging whether an initiative is likely to pass a detailed appraisal. It can be undertaken on selected options to establish whether an initiative is worth developing further.[11] The guidelines suggest that estimates for a rapid CBA are less precise and the benefits and costs that are small or difficult to estimate can be omitted.[12]

Reflecting the rapid nature of assessment, the key measures of the results, such as BCR, should not be compared against the detailed CBA which comprises a comprehensive analysis of the impacts and overall merit of a proposed initiative. They should instead be used to understand the relative merits and prioritise strategic options for more detailed economic assessment.

2.1 Rapid cost benefit analysis approach

The rapid CBA methodology is aligned with the detailed CBA framework presented in section 3.1, but with the following key differences relative to the detailed economic analysis:

- **Appraisal period** – All investment pathways have been assessed over the period 2015/16 – 2095/96, reflecting 50 years of operation following completion of the final scope element of the investment pathways in 2045/46
- **Demand** – Traffic modelling has been undertaken using VLC's Zenith model and accounting for route and mode change as a result of the investment pathway, but not changes in destination. Other demand modelling assumptions and approaches, including the annualisation factor and interpolation/ extrapolation, are aligned with the approach in the more detailed project economic assessment presented in Chapter 5.
- **Benefits** – Reflecting the strategic nature of the assessment, the rapid CBA has focused on quantifying the most significant costs and benefits, including travel time savings, reliability, vehicle operating cost savings, environmental, other externality cost savings and wider economic benefits. The approach is aligned with the approach to estimating the economic benefits in the more detailed project economic assessment, as presented in Chapter 7.
- **Costs** – strategic capital costs (P50 equivalent) for the investment pathways have been estimated by Advisian.[13]

Table 5 presents the assumed scope for each of the elements of the investment pathways included in the rapid CBA. The core investment pathways include southern (Pathway 1) and northern corridor elements (both Pathway 1 and 2).

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[10] Infrastructure Australia, 2014, Better Infrastructure Decision-Making, p.23

[11] Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, Volume 3, p. 18.

[12] Ibid, p. 18.

[13] Advisian (2015), Western Road Corridor Options Assessment Technical Note, Attachment A, November 2015

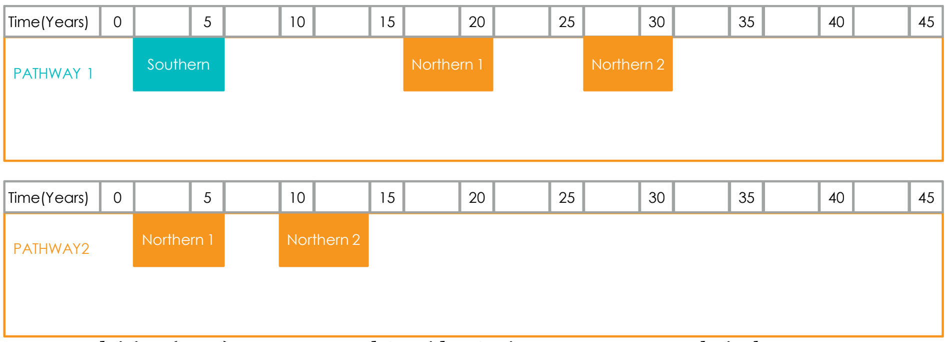
Table 5: Investment pathway assumed scope

Element	Scope
Core investment pathways	
Southern corridor (Pathway 1)	• West Gate Freeway to CityLink via the Port • West Gate Freeway Widening
Northern corridor (both Pathways 1 and 2)	• Stage 1 (Northern 1) – CityLink to Paramount Road • Stage 2 (Northern 2) – Paramount Road to M80 (including bifurcated connection to the M80 in the north and south)

Source: Advisian (2015), Western Road Corridor Options Assessment Technical Note.

Figure 3 illustrates the proposed pathways and the assumed indicative timing of each major investment stage. These pathways are designed to inform the current investment decision in the context of possible future investments rather than determining those future investments.

Figure 3: Investment pathways: potential construction timing



Source: Advisian (2015), Western Road Corridor Options Assessment Technical Note

2.2 Rapid CBA results

Rapid CBA results for the investment pathways are presented in Table 6. This analysis suggests that Pathway 1 results in higher net economic benefits and therefore supports making the southern corridor in Pathway 1 the initial priority.

Table 6: Rapid CBA results for western road corridor strategic options assessment ($ June 2015 millions, real, discounted present values)

	Pathway 1	Pathway 2
Present Value of Costs*	$5,300	$5,000
Present Value of Benefits excluding WEBs	$8,900	$6,300
Rapid BCR excluding WEBs	**1.7**	**1.3**
NPV excluding WEBs	**$3,700**	**$1,300**
Rapid BCR including WEBs	2.3	1.7
NPV including WEBs	$6,900	$3,400

*Note: Estimated incremental to the status quo base case, $ June 2015 millions (rounded to nearest hundred million), discounted based on a 7% real discount rate over the period 2015/16-2095/96 (50 years after the last construction year in 2045/46), demand modelling accounts for route and mode change only, P50 capital costs, may not total due to rounding. *Costs differ from out-turn capital cost estimates as they have been adjusted for inclusion in the economic appraisal to represent real, discounted (present value) costs over the lifecycle.*

2.3 Investment Pathway sensitivity tests

Sensitivity testing has been undertaken to understand the impact of changes in pathway timing and scope on the rapid economic appraisal results. As with the analysis of Pathways 1 and 2 above, this sensitivity testing has been designed to inform the current investment decision rather than determining future investments.

The timing of each 'block' or stage of investment within the pathways determines the present value of the cost as well as the timing of benefits. Potential variations in the timing of the pathways are:

- Earlier delivery of the northern corridor (entire northern corridor or only Northern 2) to achieve a network solution sooner
- Later delivery of the northern corridor (entire northern corridor or only Northern 2) to defer expenditure and reduce the present value of cost.

The scope sensitivities assume a number of scope changes within Pathway 2. The scope variations are summarised in Table 7.

Table 7: Scope sensitives

Element	Scope
Scope sensitivities	
West Gate Distributor (in addition to Northern Corridor investments)	• An additional lane each way on the West Gate Freeway from M80 to Williamstown Rd (no collector-distributor arrangement) • New ramps at Hyde St (tolled) • Whitehall St / Francis St / Hyde St upgraded to 2 lanes in each direction from Hyde St ramps to Footscray Rd.
Market Road / Boundary / Ashley /Paramount upgrades (with Northern Corridor Stage 1)	• Market Road extension (from Somerville Road to Geelong Road) • Boundary Road extension (from Little Boundary Road to Market Road) • Ashley Street and Paramount Road extension (to Geelong Road) and widening (two lanes, Geelong Road to South Road).
No bifurcated connection from Northern 2	• Northern 2 connects to the Princes Freeway West only (no direct connection to the M80 in the north-west)[14]

Source: Advisian (2015), Western Road Corridor Options Assessment Technical Note.

Table 8 shows the results of sensitivity testing. The conclusions of the investment pathways analysis are insensitive to changes in assumed timing or scope of investments as demonstrated by the results of sensitivity testing.

In general, delaying the assumed timing of a major pathway investment tends to improve the rapid BCR results. This is because the reduction in present value costs from delaying investment (that is more discounting of costs) exceeds the impact of delaying the achievement of benefits (that is higher benefits from demand growth offset by more discounting of future benefits).

Conversely, early delivery of investment pathways tends to reduce the rapid BCR results. However, this does not change the ranking of Pathways 1 and 2, implying

[14] The core Northern 2 scope includes bifurcated connection to the M80 in the north and the Princes Freeway via Old Geelong Road in the south-west.

that the pathway analysis is relatively insensitive to the assumed timing of each stage of investment.

Table 8 also shows the results of sensitivity testing the assumed scope for the pathways. Key findings include:

- There would be cost savings under Pathway 2 from avoiding investment in Northern 2 following interim upgrades to Market Road and Boundary Road to improve north-south connectivity. However, these would be more than offset by the foregone benefits of a freeway network connection (Northern 2) (that is higher net benefits are estimated for the core Pathway 2 scenario).
- There would be cost savings under Pathway 2 from avoiding investment in the northern branch of the proposed bifurcation from Northern 2 to the M80 (that is a southern connection to the Princes Freeway via Old Geelong Road only). However, this would be more than offset by the reduction in benefits from the northern branch of the bifurcation.

In conclusion, the southern corridor is identified as the preferred corridor for short-term investment. The remaining sections of this report present an economic assessment of proposed investments in the southern corridor.

Table 8: Rapid CBA results of investment pathway sensitivities

Pathway	Description	BCR
Pathway 1 (core)	• Southern Corridor constructed 2016/17–2020/21 • Northern 1 constructed 2031/32–2035/36 • Northern 2 constructed 2041/42–2045/46.	1.7
Pathway 2 (core)	• Northern 1 constructed 2016/17–2020/21 • Northern 2 constructed 2026/27–2030/31	1.3
Timing sensitivities		
Pathway 1 *Early delivery of northern corridor*	• Southern Corridor constructed 2016/17–2020/21 • Northern 1 brought forward 5 years to 2026/27–2030/31 • Northern 2 brought forward 5 years to 2036/37–2040/41	1.6
Pathway 1 *Delayed delivery of northern corridor*	• Southern Corridor constructed 2016/17–2020/21 • Northern 1 delayed 5 years to 2036/37–2040/41 • Northern 2 delayed 5 years to 2046/47–2050/51	1.8
Pathway 2 *Early delivery of northern corridor*	• Northern 1 constructed 2016/17–2020/21 • Northern 2 brought forward 5 years to 2021/22–2025/26	1.1
Pathway 2 *Delayed delivery of northern corridor*	• Northern 1 constructed 2016/17–2020/21 • Northern 2 delayed 5 years to 2030/31-2035/36	1.4
Scope sensitivities		
Pathway 2 *Including West Gate Distributor*	• Northern 1 constructed 2016/17–2020/21 • Northern 2 constructed 2026/27–2030/31 • West Gate Distributor constructed concurrently with Northern 1 (2016/17–2020/21)	1.1
Pathway 2 *Market/Boundary/ Ashley/Paramount*	• Northern 1 constructed 2016/17–2020/21 • Market Road, Boundary Road, Ashley Street, Paramount Road Upgrades (2016/17–2020/21)	1.1

Pathway 2 *No bifurcation*	• Northern 1 constructed 2016/17–2020/21 • Northern 2 constructed 2026/27–2030/31 and connects to the Princes Freeway West only (no direct connection to the M80 in the north-west)	1.1

Notes: Estimated incremental to the status quo base case, $June 2015 millions (rounded to nearest hundred million), discounted based on a 7% real discount rate over the period 2015/16-2095/96 (50 years after the last construction year in 2045/46), demand modelling accounts for route and mode change only, P50 capital costs, may not total due to rounding. Costs differ from out-turn capital cost estimates as they have been adjusted for inclusion in the economic appraisal to represent real, discounted (present value) costs over the lifecycle.

3 Nature of the economic assessment

The strategic options assessment in Chapter 2 identified the southern corridor as the initial investment priority. Investments in the southern corridor, which form the scope of the Project, will generate a number of direct benefits for road users and the Melbourne community. The Project will also create macroeconomic benefits for Victoria and Australia.

A cost benefit analysis (CBA) has estimated net economic benefits based on directly attributable benefits. Macroeconomic benefits have been modelled based on economic impact assessment (EIA) using computable general equilibrium (CGE) modelling.

Two sets of CBA results have been developed and presented for the Project, one representing current Victorian practice, and one reflecting Infrastructure Australia's December 2013 published economic guidelines as these have been recently applied for consideration of other nationally significant infrastructure.[15] There are four main areas of difference, relating to the BCR calculation and the approach to estimating two benefits.

An overarching requirement of these (indeed most) economic appraisal guidelines is that a cost benefit analysis framework be applied in order measure the impact on welfare considering the change in consumer surplus and producer surplus attributable to a transportation/other improvement. To measure the impact on the community as a whole, a fundamental principal of CBA is that all costs and benefits directly attributable to the project should be identified and quantified where possible.[16][17]

Most economic appraisal guidelines do not specify which costs and benefits should be included in an economic appraisal - though there are some exceptions to this, for example, wider economic benefits are recommended to be reported separately from core results by both Infrastructure Australia and Victorian guidelines.

Economists are principally constrained by the advancement of methodologies, and development of parameters for measurement and monetisation, in order to fully capture the full range of benefits and costs of an initiative. The nature of economic assessment underpinning government investment and policy decisions is an evolving field, as economists, planners, traffic modellers, governments and other researchers continually seek to more accurately measure the specific impacts of a project and to develop methodologies, estimation approaches and parameters.

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15 Infrastructure Australia, December 2013, Reform and Investment Framework, Templates for Stage 7 Solution evaluation (Transport Infrastructure); Economic analysis using current Victorian practice takes into account DTF's (2013) Economic Evaluation for Business Cases Technical Guidelines (State Government of Victoria) and the Victorian Auditor-General's Office recommendations for traffic modelling (Victorian Auditor General's Report (June 2011), Management of Major Road Projects

16 Infrastructure Australia, 2014, Better Infrastructure Decision-Making, available at: http://infrastructureaustralia.gov.au/projects/files/Reform_and_Investment_Framework_Guidance.pdf

17 Victorian Department of Treasury and Finance, 2013, Investment Lifecycle and High Value/ High Risk Guidelines (Stage 2 – Prove - Economics evaluation technical guide), updated August 2013, p 6.

As a result, where considered to reflect the nature of this project, and supported by economic theory and guidelines, project-specific benefits have been included in the appraisal in this business case.

This chapter provides a summary of each form of assessment and sets out the key assumptions and parameters applied.

3.1 Cost benefit analysis

3.1.1 CBA framework applied

CBA is an appraisal framework that allows costs and benefits of an initiative that fall across different members of the community – potentially at different points in time – to be compared in a consistent fashion.

The main steps of a CBA, outlined in Figure 4, represent the CBA methodology applied to the Project.

Figure 4: Stages in CBA

Source: PwC

3.1.2 Alignment with State and National Guidelines

The economic appraisal has been developed based on Australian guidelines and current Victorian practice, and draws upon Australian and international research papers.

The CBA methodology has been developed in consideration with the following Australian guidelines:

- Victorian Department of Treasury and Finance (DTF), *Investment Lifecycle and High Value/ High Risk Guidelines (*Stage 2 Prove economics evaluation technical guide), updated August 2013 ('Vic DTF 2013 HVHR')
- Infrastructure Australia, Better Infrastructure Decision-Making Guidelines, 2014[18] ('IA 2014 Guidelines')
- Infrastructure Australia, Reform and Investment Framework Template, Templates for Stage 7 Solution Evaluation (transport infrastructure), December 2013[19] ('IA December 2013 RIF')
- Australian Transport Council *National Guidelines for Transport System Management in Australia*, 2006, 5 volumes[20] ('ATC 2006 NGTSM')
- Austroads, *Guide to Project Evaluation*, 2012, "Part 4: Project evaluation data" ('Austroads 2012').

To consider specific methodologies required to estimate benefits (e.g. estimating wider economic benefits, or WEBs), other benefit guidance has been considered from international literature and guidelines, such as:

- Victorian Auditor General's Office (VAGO) recommendations regarding accounting for induced demand when forecasting traffic and estimating economic benefits.[21]
- United Kingdom Department for Transport (DfT), *Transport Analysis Guidance – WebTAG* ('UK DfT TAG')
- NZ Transport Agency (NZTA), Economic evaluation manual, 2013 ('NZTA 2013 EEM').

BCR results have been developed in two formats, reflecting that the economic assessment will be incorporated in a business case for consideration by both the Commonwealth and Victorian Governments and there are significant variations in current economic guidelines/practice:

- Consistent with Infrastructure Australia December 2013 published economic guidelines[22], noting these have been recently applied for consideration of other nationally significant infrastructure
- Based on current Victorian practice taking into account Victorian Government guidelines[23] and considering the Victorian Auditor-General's Office recommendations for traffic modelling.[24]

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[18] Infrastructure Australia, 2014, Better Infrastructure Decision-Making, available at: http://infrastructureaustralia.gov.au/projects/files/Reform_and_Investment_Framework_Guidance.pdf

[19] Infrastructure Australia, 2013, Reform and Investment Framework templates (transport Infrastructure), available at: http://infrastructureaustralia.gov.au/projects/files/Infrastructure_Priority_List_Submission_Template_Stage_7_Transport.pdf, accessed 1 July 2015.

[20] A draft update to the ATC 2006 National Guidelines for Transport System Management in Australia has been released for stakeholder comment, but final guidelines have not been released as at September, 2015, and so the updated guidelines have not been applied.

[21] Victorian Auditor General, 2011, Management of Major Road Projects

[22] Infrastructure Australia, December 2013, Reform and Investment Framework, Templates for Stage 7 Solution evaluation (Transport Infrastructure) available at: http://infrastructureaustralia.gov.au/projects/files/Infrastructure_Priority_List_Submission_Template_Stage_7_Transport.pdf

[23] DTF (2013) Economic Evaluation for Business Cases Technical Guidelines, August 2013

[24] Victorian Auditor General's Report (June 2011), Management of Major Road Projects.

There are elements of Victorian current practice that are more conservative than the Infrastructure Australia guidance, including:

- The Victorian Auditor-General's Office ('VAGO 2011')[25] recommended approach to considering induced demand is more conservative than the approach set out in Infrastructure Australia's Guidelines which does not specify this requirement.
- The residual value calculation approach is more conservative based on Victorian Government guidance which requires residual value to be calculated on the lower of either a straight-line depreciation or future benefits approach, whereas Infrastructure Australia supports either approach.
- The appraisal period approach is less conservative based on Victorian Government guidance, which supports an assessment period equivalent to asset life (50 years in the case of a long-life asset such as a tunnel or road pavement), whereas Infrastructure Australia supports a 30 year period for comparative purposes across initiatives.
- Both the Victorian and Infrastructure Australia guidelines suggest that wider economic benefits are reported separately to the core BCR.
- The differences between the two approaches in terms of the appraisal period and residual value largely impact the reporting of costs and benefits rather than the underlying CBA framework. Consistent with Infrastructure Australia guidelines, net lifecycle benefits after 30 years of operation would be reported in the residual value, while current Victorian practice would report these net benefits within each of the cost and benefit lines.

3.1.3 Key assumptions and parameters

The key appraisal assumptions and parameters presented in Table 9 have been assumed for economic assessment of the Project considering the guidelines outlined above.

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[25] Victorian Auditor-General, 2011, 'Management of Major Road Projects', June 2011, available at: http://www.audit.vic.gov.au/publications/2010-11/20110601-Major-Roads.pdf

Table 9: General CBA assumptions

Assumption	Infrastructure Australia Dec 2013	Current Victorian Practice	Source and Comments
Real discount rate	• 7.0% (real) • Standard 4% & 10% (real) sensitivity tests	• 7.0% (real) • Standard 4% & 10% (real) sensitivity tests	Consistent assumptions
Base price year	• June 2015	• June 2015	Consistent assumptions • At the time of undertaking this rapid CBA, the latest financial year for which ABS price index data is available is June 2015. • Parameters designated in prices prior to the base price year (e.g. 2006 dollars) are inflated to June 2015 dollars based on the Melbourne Consumer Price Index (CPI)[26], Victorian Wage Price Index (WPI)[27], and Melbourne Producer Price Index (PPI).[28]
Construction period	• FY2015/16-2021/22: • Western Distributor: 2017/18 – 2021/22 (operations commence July 2022) • Webb Dock Access Improvements: 2015/16 – 2016/17 • Monash Freeway Upgrade: 2015/16 – 2018/19.	• FY2015/16-2021/22: • Western Distributor: 2017/18 – 2021/22 (operations commence July 2022) • Webb Dock Access Improvements: 2015/16 – 2016/17 • Monash Freeway Upgrade: 2015/16 – 2018/19.	Consistent assumptions
Appraisal period	• Commences in 2015/16 and extends **30 years** from the operation start date of 2022/23 to 2051/52 based on IA December 2013 RIF.	• Commences in 2015/16 and extends **50 years** from the operation start date of 2022/23 to 2071/72 based on Vic DTF 2013 HVHR. This reflects the weighted average design life / useful	• IA December 2013 RIF suggests appraisals of significant infrastructure should typically be conducted using a 30 year timeframe. This timeframe is measured from the first year in which

26 ABS, 2015, 6401.0 - Consumer Price Index, Australia, Jun 2015

27 ABS, 2015, Wage Price Index, Australia, March 2015

28 ABS, 2015, 6427.0 - Producer Price Indexes, Australia, Jun 2015

Assumption	Infrastructure Australia Dec 2013	Current Victorian Practice	Source and Comments
		life of the project asset	the benefits of the initiative accrue. • Vic DTF (2013) HVHR suggests that projects should be evaluated over their full lifecycle.[29] • ATC (2006) NGTSM suggest an assumed economic life of 50 years for road pavement and 100 years for tunnels and viaducts.
Residual value	• Estimated based on a **future stream of future net benefits** based on IA December 2013 RIF.	• When applying current Victorian practice, **straight-line depreciation** is used.	• IA December 2013 RIF suggests that either the straight line or the future stream of net benefits approach can be adopted. • Vic DTF 2013 HVHR suggests that when the economic life of an asset exceeds the evaluation period of the project, the residual value can be counted as an inflow of benefits in the last year. The residual value should be the lower of: – The depreciated replacement cost – The future stream of net benefits at the arbitrary end of the project (discounted back to the present value along with the other costs and benefits).
Wider economic benefits (WEBs)	• Agglomeration[30], imperfect competition[31] and labour supply[32] reported separately to the core BCR	• Agglomeration, imperfect competition and labour supply reported separately to the core BCR	Consistent assumptions • IA December 2013 RIF acknowledges certain initiatives will generate WEBs, but recommends presenting the WEB inclusive results separate to traditional CBA results • Vic DTF 2013 HVHR suggest that WEB inclusive results should be presented separately from the

[29] Victorian Department of Treasury and Finance, 2013, Investment Lifecycle and High Value/ High Risk Guidelines *(*Stage 2 – Prove - Economics evaluation technical guide), updated August 2013.

[30] Agglomeration benefits relate to the positive externality (benefit) that firms experience when locating their commercial activities close together.

[31] Additional output from the recognition of imperfect competition. Many markets are not perfect: firms can charge more for a good or service than it costs to produce. Labour costs in such imperfect markets therefore underestimate

[32] Labour supply impacts, primarily from additional output from workers who are encouraged to increase their labour supply due to a reduction of commuting costs and the extra output from existing workers who work longer hours.

Assumption	Infrastructure Australia Dec 2013	Current Victorian Practice	Source and Comments
			standard Net Present Value or Benefit-Cost ratio results • UK DfT TAG (Unit A2.1) suggests that WEBs should be considered in the appraisal if a transport scheme increases accessibility in an area in close proximity to an economic centre or large employment centre.
Induced demand	• IA December 2013 guidelines do **not specify induced demand requirements**, so they have not been considered for the core results.	• For BCR results based on Victorian requirements, induced demand outputs have been used to capture **changes in route, mode and destinations**[33] as modelled by VLC.[34] • Variable matrix outputs that account for changes in destination are 'blended' using a linear profile, with the opening year being represented entirely (100 per cent) by the fixed matrix outputs (and zero per cent by the variable matrix outputs). By the ninth year of operation, demand outcomes are represented mostly (90 per cent) by the variable matrix outputs. Beyond the tenth year of operation, only the variable matrix outputs are used (100 per cent).	• VAGO[35] recommended VicRoads assess the significance of induced traffic for all major road projects and take account of this when forecasting traffic and estimating the economic benefits • Of the six types of induced demand suggested by VAGO (2011), The Veitch Lister Consulting (VLC)'s Zenith model accounts for three types of behavioural change (mode, route and destination)[36]

Source: PwC 2015; based on IA December 2013 RIF, ATC 2006 NGTSM, Vic DTF 2013 HVHR and VAGO 2011.

33 In the Veitch Lister model, each destination has a different utility or benefit attached to it. The traffic demand model measures the number of users who change their trip destination when the Project makes it easier to reach a destination of higher gross utility (that is, where it improves accessibility).

34 The ability to forecast time of travel and reallocated trips remains under development nationally and internationally as part of strategic traffic modelling. The variable approach applied in this business case is considered more conservative than fixed matrix approaches. The approach may understate economic benefits relating to outstanding areas of behaviour change. This is because the traffic model measures benefits in the form of lower/higher travel time as opposed to, for example, disutility from being unable to travel at the desired time of day or the utility possible from being able to relocate work/residence to superior locations due to improved accessibility and lower costs of travel. Even if modelling was able to estimate these changes economic parameter values are not readily available to enable quantification of this change.

35 Victorian Auditor General, 2011, Management of Major Road Projects

36 Victorian Auditor General, 2011, Management of Major Road Projects, page 8

3.1.4 Cost benefit analysis measures

Future costs and benefits are converted to a common time dimension: the present value (PV). Present values are calculated by discounting future values using a recommended discount rate of 7 per cent per annum (which reflects the time value of money). The discounted costs and benefits are then combined using specific equations to produce conventional measures of economic performance.

The CBA model produces the following key measures of economic performance:

- ***Net Present Value (NPV)*** – the difference between the PV of total incremental benefits and the PV of the total incremental costs, which allows the project options to be compared on the same basis to allow determination of the greatest net benefit to the community or the most efficient use of resources. The project case option that yields a positive NPV indicates that the (discounted) incremental benefits of a scenario exceed the incremental costs over the evaluation period.
- ***Benefit Cost Ratio (BCR)*** – ratio of the PV of total incremental benefits to the PV of total incremental costs. A BCR greater than 1.0 indicates that quantified project benefits exceed project costs. However, projects with BCRs less than 1.0 may still be considered to have net benefits if some of the benefits cannot be fully captured within a CBA framework, and such projects may still be considered reflecting that CBA is one of a number of considerations for decision makers.

3.2 Economic impact assessment

3.2.1 EIA framework applied

In addition to the CBA, PwC has analysed the macroeconomic impacts of the Project using computable general equilibrium (CGE) modelling. In contrast to CBA, which measures direct costs and benefits, CGE analysis estimates the indirect or flow-on impacts. In the context of the Project, these indirect, macroeconomic impacts are a result of:

- construction expenditure which affects the construction services sector and supplying industries
- productivity improvements that directly benefit road users and, indirectly benefit consumers of services that require road transport.

These impacts flow throughout the Victorian (and national) economy resulting in additional economic activity, jobs and Gross State Product (and Gross Domestic Product in the national economy).

This section sets out the framework of analysing the macroeconomic impacts, how it aligns with relevant economic appraisal guidelines and the assumptions applied in the modelling.

3.2.2 Appraisal Framework

CGE modelling is useful when a direct impact, at either the specific industry or regional level, is expected to have macroeconomic implications or significant ‘flow-on’ effects. These flow-on effects are different from the direct benefits estimated in the CBA (described in Section 3.1), given they represent both the direct and resulting indirect impacts.

The modelling PwC has undertaken, which considers national, state and regional impacts, is based on the Victoria University Regional Model (VURM, previously known as the Monash Multi Regional Forecasting Model or MMRF). The modelling considers the annual construction and operations impacts of the Project by drawing on capital, operating and maintenance costs and estimates of productivity improvements experienced by the road transport industry, which are provided from the CBA.

Using the results of the CBA as inputs into the CGE model ensures consistency and enables use of detailed traffic network productivity benefits as 'shocks' (ie changes to the status quo) to the State and national economies. This includes capital costs and productivity improvements (e.g. travel time savings, vehicle operating cost savings and reduced crashes).

3.2.1 Alignment with State and National Guidelines

PwC has considered the following statements from the relevant state and national guidelines in analysing the macroeconomic impacts of the Project:

- A requirement of the Victorian market-led proposals interim guideline is that proponents demonstrate that the proposal contributes to land use and development outcomes (eg jobs) and provides economic benefits to the state.[37]
- The ATC 2006 NGTSM (volume 3, p 37) states that secondary economic impacts, eg economic activity flow-on expenditure effects in the rest of the economy, are generally presented separately from the standard net present value or benefit-cost ratio results to avoid double counting.[38]
- The VIC DTF 2013 HVHR suggests CGE models only include market-based goods and services, not non-market goods (eg the environment). Due to their complexity and limitations, such models should only be used to complement a cost-benefit analysis, and only for significantly large investment projects that are likely to have economy-wide impacts.[39]
- The Victorian Auditor General states that it prefers CGE modelling over input output analysis to measure economic impacts where expenditure exceeds $10 million.[40]

PwC has designed the EIA approach to address these points by:

- demonstrating the impact on jobs and GSP to Victoria
- presenting the macroeconomic impacts separately from the CBA results
- considering which elements of the costs and benefits are market based ie productivity improvements that affect businesses are included and environmental benefits such as amenity are excluded. These inclusions and exclusions are described in detail in section 3.2.3.
- applying a CGE model given the expenditure greatly exceeds $10 million.

3.2.2 Approach to computable general equilibrium modelling

A CGE model is a mathematical model of an economy that is capable of capturing economy-wide impacts and inter-sectoral reallocation of resources that may result

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[37] Victorian Department of Treasury and Finance, 2015, Market-led Proposals Interim Guideline.

[38] Australian Transport Council, 2006, *National Guidelines for Transport System Management in Australia*, 2006, volume 3, page 37

[39] Victorian Department of Treasury and Finance (DTF), 2013, *Investment Lifecycle and High Value/ High Risk Guidelines (*Stage 2 Prove economics evaluation technical guide), updated August 2013, page 3-4

[40] Victorian Auditor General, 2007, 'State Investment in Major Events'

from a ‘shock’ to the economy. CGE models are generally designed for quantitative analysis of:

- Resource allocation and technical efficiency issues
- Government tax or expenditure policy related issues
- External events that can be represented as price or activity shocks.

The core data of a CGE model is an input-output table, which is provided by the ABS. An input-output table is a system of accounts which shows, in value terms, the supply and disposal of goods and services within the economy in a particular year. An input-output table captures sales of products to other industries for further processing (intermediate usage) or to the various categories of final demand. It also captures the inputs used in an industry’s production, whether they are intermediate or primary inputs (such as labour and capital). The table is balanced such that total inputs to each industry are equal to total outputs from each industry. Essentially, an input-output table is a snapshot of an economy (whether it is a region, state or country) in a particular year.

A CGE model attempts to ‘push forward’ the base input-output table through time by utilising a set of equations that capture neoclassical microeconomic theory to determine behaviour of economic agents (such as households, governments, industries) when they are faced with changes in key economic variables, especially relative prices. The equations are solved simultaneously, where some variables are determined by the model (endogenous variables) and some are determined outside the model (exogenous variables). The classification of endogenous and exogenous variables is determined by the user, based on the set of assumptions derived for the specific modelling exercise. The assumptions made in this model are set out below in section 3.2.3.

As noted above, the CGE model that has been used by PwC in this analysis is the Victoria University Regional Model (VURM, also known as MMRF) developed by the Centre of Policy Studies at Victoria University. VURM is a regional CGE model that provides a highly disaggregated representation of the Australian economy. It distinguishes up to eight Australian regions (six States and two Territories) and, depending on the application, up to 144 commodities/industries. The model recognises:

- Domestic producers classified by industry and domestic region
- Investors similarly classified
- Up to eight region-specific household sectors
- An aggregate foreign purchaser of the domestic economy's exports
- Up to eight State and Territory Governments and the Federal government.[41]

3.2.3 Key assumptions and parameters

The following general appraisal assumptions (see Table 10) have been applied to the economic impact assessment of the Project considering the guidelines outlined above and the settings of the VURM CGE model.

3.2.4 Economic impact assessment measures

The results of the CGE analysis are reported in terms of changes to:

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41 Centre of Policy Studies, Knowledgebase, available at: http://www.copsmodels.com/mmrf.htm Accessed 3 September 2015, Victoria University

- **Gross State Product –** The value of production is measured by summing the net value of goods and services across all industries in Victoria (Gross State Product, GSP)
- **Employment (FTEs) –** Employment measures the number of additional full-time equivalent (FTE) jobs in the economy. Differences in the hours worked between industries and employee types (i.e. casual, part time and full time) are standardised by calculating the total hours worked across all employees and dividing this by the average hours worked per full time employee.

Table 10: General economic impact assessment assumptions

Assumption	Value	Source and comments
Time dimension **(dynamic or comparative static)**	• Recursive dynamic • Modelled to 2071/72	• CGE models can be set up as either 'comparative static' or 'recursive dynamic', depending on the treatment of time in the modelling exercise, the presence of annual shocks and the degree to which it is desirable to represent underlying changes in the economy over time. This modelling exercise has been run as recursive dynamic. • Recursive dynamic modelling accounts for how the economy changes over time to move from one equilibrium position to another. This allows for: – underlying changes in the economy over time, including accumulation relationships such as for investment, capital and debt – how the shock might be disaggregated over a number of time periods and how it might play out through the directly affected industry, interrelated industries and the wider economy over time – a lagged adjustment process in the labour market. • The recursive dynamic model was run over a period to 2049/50, with an out of model extrapolation thereafter to 2071/72 assuming constant rates of economic growth. This out of model extrapolation is deemed reasonable as, by 2049/50, the assumptions for economic growth in the VURM are relatively stable and so extrapolating out further is only a continuation of the trend assumed in the baseline of CoPS model. The extrapolation also reflects an assumed return to long run employment post-2049/50 as, while productivity benefits are forecast in the CBA to continue into the future, at some point these will form part of the normal path of productivity growth and employment will return to base levels. Therefore, the economic analysis conservatively assumes a linear return towards zero incremental employment from 2050/51 to 2071/72.
Baseline projection of the economy (Australian Gross Domestic Product)	• 2.25% p.a.	• In the base line, Australia's Gross Domestic Product is projected to grow at a rate of about 2.25% over the long term. This compares to a current, annualised rate in the June quarter of about 2.0%[42] and a historical average growth rate of 3.25 - 3.5%.

[42] Australian Bureau of Statistics, 5206.0 – Australian National Accounts: National Income, Expenditure and Product, Jun 2015, http://www.abs.gov.au/ausstats/abs@.nsf/mf/5206.0/, accessed 3 September 2015.

Assumption	Value	Source and comments
Financing	• Net foreign investment	• The additional capital expenditure required for this project has to be financed. Whether the project is privately or publicly financed, the required resources may come from greater national investment or from reductions in investment elsewhere in the economy. In turn, higher national investment may occur either through higher national savings or greater capital inflow. In this scenario, it is assumed that national investment increases and that the additional funds come from foreign investment. This does not mean that this particular project is assumed to be financed by foreign debt, just that for a given level of domestic saving, additions to total investment at the Australian economy level must come from additional net foreign investment. The capital is paid for by payment of factor returns to foreigners. This is implemented by assuming that the ratio of foreign liabilities to Gross Domestic Product returns to base case levels in the long term.
Long term employment	• Full employment (returning to base case levels)	• The labour market is assumed to be driven by underlying population growth and institutional factors, meaning while the labour market can temporarily expand or contract around full employment, in the long run it must transition to a demographically driven full employment position. In effect this means that at a national level, employment returns to the level in the base case and that any gains to labour in a simulation accrue in the form of increased wages. Changes in economic conditions within a state and changes in the composition of employment may result in relatively small long term changes in state employment.
Construction phase shocks	• Construction costs prepared by Advisian representing the P50 estimate are used in the modelling of the construction phase impacts	• **Input:** The shock applied in the CGE modelling assumes the total construction cost of the Western Distributor is $4.3 billion in 2015, undiscounted terms. Construction takes place over six years, staring in 2016/17 and ending in 2021/22. The relatively small capital costs beyond the construction phase for maintenance are not included in the analysis. • **Shock:** The construction phase shock is an increase in output in the construction sector in Victoria.

Assumption	Value	Source and comments
Operational phase shocks	• Operational costs from Advisian and benefits as estimated by PwC in the CBA are used in the modelling of operational phase impacts	• **Input:** The operational phase includes a number of elements from the CBA. These are listed below. The operational impacts begin in 2021 and build over the period analysed. For each of the following benefits, only those attributable to business travellers, LCVs or HCV are included. This is consistent with other such analyses of infrastructure projects. – Project operating costs (note these are costs and therefore offset the below benefits) – Base travel time benefits from improved flow – car business, light commercial vehicles (LCV) and heavy commercial vehicles (HCV) - including travel time benefits from improved West Gate Bridge effective capacity and Monash Freeway ramp metering) – Travel time benefit from improved trip reliability – car business, LCV and HCV – HPFV user benefits – Vehicle operating cost savings – car business, LCV and HCV – Redundancy and resilience to incidents on the West Gate Bridge – Crash cost savings • **Shock:** The above listed components are summed together as a combined productivity gain. This gain is treated as an improved labour productivity for a number of industries that would use the Project. Industries that are shocked are listed below. Road freight is attributed 60% of the productivity gain with the remaining 40% split proportionally across the other industries. This is consistent with the approach taken in other such analyses of infrastructure projects. – Road freight – Trade – Road passenger – Community services – Financial services – Business services – Public services – Other services.

Source: PwC

4 Scenarios assessed

The economic assessment has been developed to compare future outcomes associated with the provision of the Project incrementally to a base case where the projects are not implemented. Scenarios are specified for the purpose of economic assessment in order to calculate benefits incremental to a base case or a continuation of the status quo.

Section 4.1 and section 4.2 define the base case (without project scenario) and project scenarios respectively for the detailed assessment, including land use and infrastructure assumptions by forecast year (ie 2020/21, 2030/31 and 2045/46).

4.1 Base case (without project scenario)

The base case was developed as part of the traffic modelling undertaken by Veitch Lister Consulting (VLC), based on the State's forecast land use, population and employment for Melbourne and a reference transport network developed by the State for consistency across Victorian initiatives.

The Reference Case defined by DEDJTR is considered by the State to represent the most realistic future path of infrastructure development, transport outcomes, and population and employment locations expected to occur in Victoria.[43]

Base case land use assumptions have been sourced by VLC from the Victorian Government's Victoria in Future (VIF) 2014 population and employment projections.

The reference network includes key planned initiatives for Melbourne including Melbourne Metro, CityLink-Tulla Widening, and expansion of Swanson Dock at the Port of Melbourne. Table 11 shows key projects included in the base case in each of the demand forecast years based on the Western Distributor Transport Modelling and Evaluation Framework.[44]

The base case excludes step changes in future technologies (eg driverless cars) and changes to current transport policies or service quality that would change the relative attractiveness of different transport modes for passengers and/or freight.

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43 DEDJTR, 2015, Western Distributor Transport Modelling and Evaluation Framework

44 DEDJTR, 2015, Western Distributor Transport Modelling and Evaluation Framework

Table 11: Projects included in the base case

2020/21	2030/31	2045/46
• Extension/escalation of CityLink tolls • CityLink Tullamarine Widening • M80 Upgrades • 50 Level Crossing Removals • Port of Melbourne Capacity Upgrade Project • West Gate Distributor (Northern Sections Only).	• Other arterial road upgrades • Melbourne Metro Rail • Port of Melbourne Capacity Enhancements (Swanson and Webb Dock).	• Freeway connection from CityLink to outer-east • Western Intermodal Freight Terminal • Outer ring transport corridor.

Source: DEDJTR, 2015

4.2 Project scenario

The project scenario considered in the economic assessment is the same as the base case except that investment in the Project is assumed over the period 2015/16 to 2071/72 with 2022/23 the first year of benefits.

The 'work packages' associated with the Project are outlined in Table 12.With-project land use assumptions are the same as the base case, based on the Victorian Government's VIF 2014 population and employment projections.

Table 12: Key elements of Project scope

Component	Description
West Gate Freeway - Widening	• Widening of the West Gate Freeway by two lanes in each direction to provide overall capacity of 6 lanes each direction between Williamstown Road and M80 (3 lanes on each of the separated carriageways) • Separated carriageways (collector-distributors) with braided connections at: Inbound – standard gauge freight railway overpass (west of Williamstown Road); outbound – east of Grieve Parade. The State concept separates movements bound for M80 from movements bound for Princess Freeway West • Strengthening of bridges along the West Gate Freeway to 75% SM1600 to accommodate HPFV Hat higher mass limits • Separation of carriageways – New Jersey Barrier • A new Eastbound connection from the Princes Freeway West to the collector-distributor with a braided ramp linking the collector-distributor to the West Gate Bridge prior to Williamstown Road • Freeway Management System (FMS) including ramp metering and LUMS covering the Project area, Princes Freeway West, M80 interface and West Gate Freeway / Western Link connections near Bolte Bridge • Replace two existing pedestrian bridges spanning over the West Gate Freeway at Wembley Avenue and Rosala Avenue
Western Distributor – Yarraville alignment (including tunnel)	• 3 lane bored, 1.6km tunnel • New west-facing ramps for vehicles to access Hyde Street • Southern portal between WGF and Hyde Street • Northern portal east of Whitehall Street, north of Somerville Road, west of the Maribyrnong River
Western Distributor – Elevated road and port access	• Single span bridge across the Maribyrnong River • Direct access to the Port of Melbourne at Mackenzie Road (to/from West Swanson Dock) • Three-lane viaducts above Footscray Road • Appleton Dock (to/from East Swanson Dock, Victoria Dock, Appleton Dock) • Grade separated shared user facility at Appleton Dock Road, Footscray Road and Mackenzie Road intersections
Webb Dock Access	• Widening of Cook Street from Todd Road (Eastbound) to the West Gate Freeway ramp terminal intersection • Dedicated new connection to CityLink (northbound) and an upgrade to Ramp M (the West Gate Freeway-to-Bolte Bridge ramp) including ramp metering, realignment and regrading along Ramp M
Western Distributor – Eastern interchange and city access	• Inbound and outbound connections to CityLink via the existing Dynon Road ramps • Access to Docklands, West Melbourne and the central / inner City via ramps onto Footscray Road with additional connections to Dynon Road and Wurundjeri Way through the construction of a new CBD Bypass road extending between Wurundjeri Way and Dynon Road
Monash Freeway Works	• Additional lanes on the Monash Freeway between the EastLink interchange and Clyde Road in the south-east • New ramp metering installations on M1 from Koo Wee Rup Road to Clyde Road inbound, Along Hallam Bypass outbound and on the EastLink connections to the Monash Freeway • Increased storage capacity on existing entry ramps along the Monash Freeway between Warrigal Road and Clyde Road

Source: DEDJTR, Project Scope Summary, provided 15 September

5 Demand forecasts

The economic assessment draws on estimation of the level, composition and location of traffic with the Project and the base case to understand the impact on traveller behaviour and thus quantify related economic benefits. Estimation and forecasting was undertaken by Veitch Lister Consulting (VLC) on behalf of the State using their city-wide transport demand model, Zenith.

This chapter provides an overview of the approach to incorporating demand forecasts in to the economic assessment, including annualisation, interpolation/extrapolation, benefit ramp-up and blending' fixed and variable matrix results.

5.1 Role of demand forecasts in the economic assessment

5.1.1 Key elements of traffic modelling for economic assessment

The most relevant aspects of VLC's demand modelling for estimating economic benefits are:

- Forecasts of total travel demand (across all transport modes) are estimated by VLC for 2020/21, 2030/31 and 2045/46 based upon relationships between demand and the location of activities. Forecasts of the transport network as well as employment and population numbers/locations are key inputs into the Zenith model that drive underlying demand for trips. The CBA draws on the traffic outputs in these years with extrapolation/interpolation between and following those years in order to develop forecasts of economic benefits.
- Demand is modelled across four time periods within a representative weekday (AM peak 7-9AM, interpeak 9AM-4PM, PM peak 4-6PM and off-peak 6PM-7AM periods) with trip choices constraining choices within a day (e.g. if a user takes public transport to work, they cannot drive home later that night). This is relevant as the CBA should reflect variances across the day and not only during peak periods. The mix of vehicles, trip purposes and levels of congestion will also change throughout the day, impacting both demand outputs and unit cost parameters used to estimate economic benefits.
- Vehicle type is modelled per trip – LCV, HCV and public transport costs are weighed up by travellers. The CBA is therefore able to measure benefits by vehicle type, reflecting that values of time and vehicle operating costs vary by type of vehicle
- The transport network's characteristics determine the extent to which demand feeds back into and alters transport costs, e.g. high demand for a road will result in slower travel times (congestion), which will tend to dampen demand for the road (prompting users to switch routes or travel modes).
- The model seeks to find the equilibrium between routes, modes and destinations such that future travel demand is distributed across the transport network in a realistic fashion.
- The model is able to capture multiple sources of induced demand/traveller behaviour. Traffic model outputs used in economic appraisals in Australia have traditionally only analysed route and/or mode changes by travellers, with the implication that economic appraisals applying such modelling are only able to estimate the value of outcomes for travellers based on a partial view of the level

of behaviour change that may occur as a result of network investment. VAGO 2011 recommends accounting for other potential sources of behaviour change such as changing mode, making additional journeys, changing destination, changing time of travel, and reallocating trips.[45] The IA December 2013 guidelines do not specify these induced demand requirements, so they have not been considered for the core results. For BCR results based on Victorian requirements, induced demand outputs have been used to capture changes in route, mode and destinations as modelled by VLC. The VLC modelling of travel behaviours includes the following, each of which PwC and VLC have developed an approach to quantify the economic benefits/disbenefits to estimate CBA outcomes:

- Fixed total trip matrix – modelling assuming users can change modes, routes (including the use of tolled and untolled roads), but not destinations, when new infrastructure is introduced to the transport network. Total trip numbers between a given origin and destination are the same in the option and base cases. The following behaviour changes are captured:
    - Route choice (e.g. for light, heavy and commercial vehicles - the choice of roads including tolled/untolled; for public transport - the choice of routes and services)
    - Mode choice (driver, passenger, public transport, etc.)
- Variable trip matrix – modelling assuming users can change modes, routes and destinations in response to changes in the transport network. Total trip numbers between a given origin and destination are not necessarily the same in the project and base case. The following behaviour change is captured in addition to those outlined for fixed matrix outputs:
    - Trip destination (some people may choose to travel further or to alternative destinations as a result of the Project traffic outcomes).[46][47]

Table 13: Types of induced demand available in VLC's Zenith model in response to road improvement

Type	Description	Incorporated in the Zenith model
Changing route	Drivers make the same journeys but use the improved route	Yes
Changing destination	Drivers decide to travel to more distant destinations because the improvement makes the journey time acceptable	Yes

45 Victorian Auditor-General's Report (June 2011), Management of Major Road Projects

46 In the Veitch Lister model, each destination has a different utility or benefit attached to it. The traffic demand model measures the number of users who change their trip destination when the Project makes it easier to reach a destination of higher gross utility (that is, where it improves accessibility).

47 The ability to forecast time of travel and reallocated trips remains under development nationally and internationally as part of strategic traffic modelling. The variable approach applied in this business case is considered more conservative than fixed matrix approaches. The approach may understate economic benefits relating to outstanding areas of behaviour change. This is because the traffic model measures benefits in the form of lower/higher travel time as opposed to, for example, disutility from being unable to travel at the desired time of day or the utility possible from being able to relocate work/residence to superior locations due to improved accessibility and lower costs of travel. Even if modelling was able to estimate these changes economic parameter values are not readily available to enable quantification of this change.

Type	Description	Incorporated in the Zenith model
Changing mode	Public transport passengers switch to car because the improvement makes road travel more attractive than rail	Yes
Changing time of travel	Drivers decide to travel in the commuting peak period because the improvement reduces journey times to an acceptable level	No
Making additional journeys	People are willing to make additional car journeys because of the improvement	No
Relocated trips	People and businesses relocate to take advantage of the improvement and so make journeys that are new to the area	No

Source: Victorian Auditor General, 2011, Management of Major Road Projects, page 8

5.1.2 Raw demand forecasts

To outline key raw demand outputs utilised in the CBA, Table 14 shows some of the 2030/31 summary demand forecasts for car travellers only (i.e. excluding freight vehicles and public transport users) during an average weekday across Melbourne under the base case, as well as the project case.

By comparison, there are currently (2013/14) approximately 305,000 to 330,000 trips per day crossing the Maribyrnong River, of which 59% to 63% use the West Gate Freeway (West Gate Bridge). By 2030/31, in the absence of the Project, there are forecast to be 240,000 to 250,000 vehicles per day on the West Gate Freeway alone (West Gate Bridge), accommodating 58% to 61% of vehicles trying to cross the Maribyrnong River.

The Western Distributor is forecast to carry approximately 50,000 to 70,000 vehicles per day (11% to 13% of all trips) across the Maribyrnong River by 2030/31, reducing volumes on the West Gate Bridge by approximately 16,000 to 22,000.[48]

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[48] GHD analysis of VLC Zenith demand forecasts, 2015.

Table 14: Project demand forecasts, 2030/31 average weekday – car users only[1]

Measure	Base case	Project case Fixed trip matrix	Project case Variable trip matrix
Trips – car users	13,020,511	13,020,511	13,021,584
Vehicle kilometres – car users	188,471,836	188,489,026	188,986,539
Vehicle hours – car users	3,984,035	3,952,518	3,981,025
Car user average travel time benefit hours – existing users[2]	N/A	37,512	18,600
Car user average travel time benefit hours – new users[2]	N/A	0	588
Car user average travel time benefit hours – lost users[2]	N/A	0	75

Notes:

1. Demand forecasts presented for a single year (2030/31) and vehicle type (car driver and passenger).
2. Car user average travel time benefit hours include vehicle hour savings and utility benefits measured in average hours resource corrections as discussed in section 7.3

Source: PwC based on VLC 2030/31 demand forecasts.

5.2 *Incorporating demand forecasts*

Four adjustments are required to be made to 2020/21, 2030/31 and 2045/46 transport demand outputs to deliver a complete and realistic profile of impacts (and hence benefits) over the economic appraisal period. These adjustments fill in gaps between the available forecast years as well as scale the modelled ('steady state') impacts according to how long real-world travellers will take to change their behaviours.[49] They include:

- annualisation
- interpolation/extrapolation
- benefit ramp-up
- blending' fixed and variable matrix results.

5.2.1 *Annualisation*

Factors are needed to derive annual benefits from average weekday outputs from Zenith. There is guidance on annualisation factors for public transport, including the ATC 2006 NGTSM (volume 4, section 6.9), Transport for NSW 2013[50]

[49] Experience has shown that it takes time for transport users to adjust to the changed transport conditions on the network, especially the improved travel times offered by the new infrastructure. In contrast, transport demand models are based on all information about the network being incorporated instantly by transport users.

[50] Transport for NSW, 2013, Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, page 281

guidelines and CityRail 2010 Compendium of City Rail Travel Statistics for public transport.

There is guidance on road user (car and commercial vehicle) annualisation factors in the TfNSW (2013) guidelines. However, there is no specific guidance on road annualisation factors in the IA December 2013 RIF or Vic DTF 2013 HVHR guidelines. As such, it is necessary to examine traffic statistics for weekdays versus weekends of the Melbourne road network for this analysis.

Annualisation factor – cars and commercial vehicles

A key driver of relative benefits between an average weekday and weekday is relative demand (i.e. trips) as well as the relative distance, location and timing trips, which will impact the level of congestion and therefore travel speeds and externalities.

Road demand on the Melbourne network is relatively balanced between weekdays and weekends. The VicRoads Traffic Monitor Report[51]estimates that an average weekend accommodates more than 80 per cent of the traffic of an average weekday, resulting in an implied weekday-to-year annualisation factor of 343 across all vehicles (Table 15 and Table 16).

The Victorian Integrated Survey of Travel and Activity (VISTA) provides total car trips on an average weekday and weekend day across Greater Melbourne, Geelong and selected regional centres between 2007 and 2010. It shows that the ratio of weekend day to weekday car trips is around 0.88, resulting in an implied annualisation factor of 351 for car trips (Table 16).

Table 15: Metropolitan Melbourne monitored network traffic volumes (trips) by day of the week

Day of week	Traffic volume (% of average weekday)
Monday	95%
Tuesday	98%
Wednesday	100%
Thursday	102%
Friday	105%
Saturday	86%
Sunday	75%

Note: traffic volume includes all vehicle types
Source: VicRoads, 2015, Traffic Monitor 2012-2013

Although there are fewer trips on an average weekday, the total distance travelled is around the same as an average weekday (Table 16). Longer average trips which would be expected to offset the impacts of reduced weekend trips on congestion. Similarly, the average time travelled per weekend trip is longer than an average weekday.

51 VicRoads , 2014, Traffic Monitor 2012-13, September 2014, page 23

VISTA[52] provides total car travel distance and hours for a typical weekend day and weekday. The relative weekend to weekday car trip distance and hours imply an annualisation factor of 362 and 348, respectively (Table 16).

Table 16: Calculation of vehicle average weekday to year expansion factors

	Weekday (A)	Weekend (B)	Weekend: Weekday ratio (C)	Implied annualisation factor[1]
Average traffic volume[2] (%)	100%	81%	0.80	343
Total car trips[3] (million)	27.74	24.38	0.88	351
Total car trip distance[4] (million km)	247.18	242.63	0.98	362
Total car trip hours[4] (million)	10.82	9.23	0.85	348
No. of days	251	114	-	-

Note:
[1] Implied annualisation factor = Column (A) + Column (B) Column (C)*
[2] Represents all traffic in the metropolitan Melbourne monitor network (VicRoads, 2013)
[3] Represents car trips across Greater Melbourne, Geelong and selected regional centres between 2007 and 2010 (sourced from VISTA online)
[4] PwC estimates based on VISTA online

The annualisation factor based on observed CityLink traffic volumes across all vehicle types (cars, LCVs and HCVs) has grown from an estimated 320 between 2003 and 2006 to 330 in 2014 (Table 17).[53]

Table 17: Observed CityLink annualisation factors

Year	2003 - 2006	2007-2011	2012	2013	2014
Annualisation Factor	320	323	326	329	330

Source: DEDJTR (2015), based on observed traffic volume on CityLink between 2003 and 2014

The annualisation factor based on observed CityLink traffic volumes in 2014 on the West Gate Freeway between Williamstown Rd and M80 in 2014 is estimated to be 343 (Table 18).[54]

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52 Retrieved from VISTA online, available at: http://www5.transport.vic.gov.au/webapi/jsf/login.xhtml

53 DEDJTR, 2015, Western Distributor Annualisation & Ramp-Up Factors, Ver 1, 14 July 2015

54 DEDJTR, 2015, Western Distributor Annualisation & Ramp-Up Factors, Ver 1, 14 July 2015

Table 18: Annualisation factors of West Gate Freeway between Williamstown Rd and M80

Vehicle Class	Inbound	Outbound
Car	343	343
LCV	281	280
HCV	277	276
All vehicles	334	334

Source: DEDJTR (2015), based on observed traffic volume in 2014

Transport for NSW 2013 guidelines suggest an annualisation factor of 345 for Sydney urban roads based on actual traffic data from a mix of freeway, arterial and local roads.[55]

The annualisation factors presented in Table 19 are recommended for the Project based on observed traffic volume on CityLink and Western Gate Freeway between 2003 and 2014, supported by network wide annualisation factors based on VicRoads Traffic Monitor Report (343), VISTA (348-362) and TfNSW guidelines (345). They reflect that:

- A large proportion of beneficiaries of the Western Distributor and M0nash Freeway Upgrade are freeway users and divert from freeways such as the West Gate Freeway and Princes Highway in the base case (Figure 5):
  - The Western Distributor and Monash are freeways, so user benefits (e.g. travel time) will be concentrated around freeways.
  - The Western Distributor will draw traffic off other freeways such as the West Gate Freeway, and Princes Highway benefiting continuing users of those freeways (e.g. in terms of travel time savings and vehicle operating cost savings from improved travel speeds).
  - Arterial road users that switch to the Western Distributor and Monash Freeway will likely have trip characteristics that are similar to freeway users (i.e. they would have travelled on a freeway in the base case if one serviced their desired location).
- A larger proportion of business travel occurs during weekdays, which impacts the annualisation factor for commercial vehicles more than cars (noting that business purpose trips account for around 3% of car trips on the West Gate Freeway).
- Observed annualisation factors on CityLink have been increasing over time.

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55 Transport for NSW, 2013, Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, page 281

Table 19: Annualisation factor assumptions

Vehicle type	Annualisation factor
Car – private	340
Car - business	340
LCV	285
HCV	275
All traffic	330

Source: PwC based on observed annualisation factors on CityLink (2003 to 2014) and West Gate Freeway (2014)

Figure 5: Change in total daily traffic volumes (2030/31 project case vs 2030/31 base case, 24 hour average weekday)

Note: For simplicity, increases in traffic volume on the West Gate Freeway (between M80 and Williamstown Road) and the Western Distributor tunnel and viaduct are not shown.
Source: Veitch Lister Consulting, 2015.

Annualisation factor - public transport

The ATC 2006 NGTSM (volume 4, section 6.9) provides an estimate of the distribution of public transport demand. While weekdays account for 69 per cent of annual days (251 in total), they account for 89 per cent of annual trips (i.e. reflecting fewer commute/business PT trips on the weekend) and 86 per cent of VKTs/vehicle hours respectively.

Table 20: Distribution of annual public transport demand and service supply

Time period	Days	Share of trips	Share of VKTs	Share of vehicle hours
Average working weekday	251	89%	85.5%	85.5%
Saturday	52	6.2%	8.5%	8.5%
Sunday	52	3.5%	5.0%	5.0%
Public holiday	10	0.5%	1.0%	1.0%
Total	365	100%	100%	100%

Source: ATC 2006 NGTSM (volume 4, section 6.9)

Each average weekend/public holiday is estimated to accommodate 25 per cent of the trips and 37 per cent of the VKTS/hours of an average weekday. This implies a PT annualisation factor of around 300 based on relative VKTs/hours which are key drivers of PT benefits.

Table 21: Calculation of PT average weekday to year expansion factors

Basis	Days		Average day	Calculation	Expansion factor
	Weekday	Weekend	Weekend: weekday		
Trips	251	114	25%	=251+114*25%	280
VKTs	251	114	37%	=251+114*37%	294
Hours	251	114	37%	=251+114*37%	294
			Assumption		**300**

Source: ATC 2006 NGTSM (volume 4, section 6.9)

This assumption is also supported by the CityRail (2010) Compendium of CityRail Travel Statistics[56], which also suggests a factor of 300 to convert average weekday patronage into an estimate of annual patronage.

5.2.2 Interpolation/extrapolation

The VLC demand model provides 2010/11 (base case validation), 2020/21, 2030/31 and 2045/46 model runs. As such, interpolation is required between modelled periods (e.g. 2020/21 to 2030/31 and 2030/31 to 2045/46) and extrapolation beyond 2045/46 is required after the final modelled period.

The ATC 2006 NGTSM note that it is usual for benefits to be estimated for several future years, reflecting the availability of forecast data on demographic and

[56] CityRail, 2010, *A Compendium of CityRail Travel Statistics*, Seventh edition, page 72

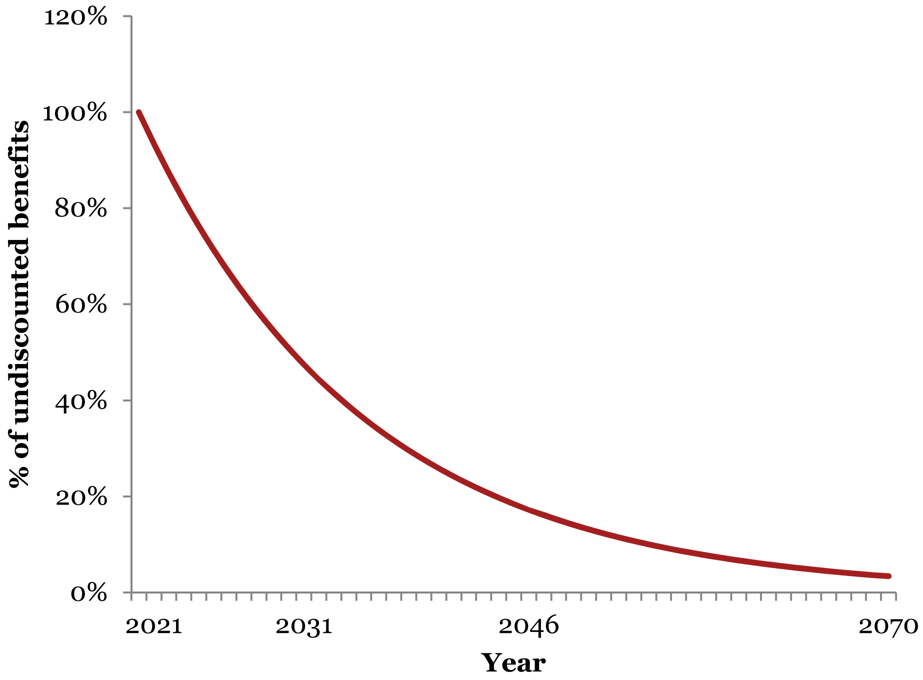
transport matters. Benefits for other years in the appraisal period can then be determined by interpolation or extrapolation. Benefits for other years should be based on historic trends, or related factors that may affect the growth in benefits such as population and traffic growth.

The UK Department for Transport's cost benefit analysis guidance module in the UK DfT TAG (Unit A1.1) suggests that, beyond the last modelled year, benefits should be estimated by extrapolation. They state that results from modelled years, particularly where intermediate years have been modelled, will be useful in determining what it is appropriate to assume. They note that it will be reasonable to assume that growth after the last modelled year is not greater than that implied by modelling results up to the last modelled year.[57]

The CBA assumes growth beyond the last modelled year in 2045/46 continues at the same rate as the last modelled period between 2030/31 and 2045/46. This is equivalent to a compound annual growth rate in trips and vehicle kilometres travelled of 1.15 per cent and 1.38 per cent per annum respectively, reflecting the expectation of ongoing growth in underlying demand drivers such as population and Gross State Product.

Even so, the approach to extrapolation should not have a substantial impact on the economic assessment results given the impact of discounting. For example, by 2045/46 application of a 7% discount rate means that benefits are discounted by 83%, increasing to 97% by 2071/72.

Figure 6: Stylised example of the impact of discounting on future benefits (at 7% discount rate)



Source: PwC

57 The UK DfT guidance should be distinguished from their appraisal software, which includes a default assumption of no growth in the magnitude of impacts which can be overridden by practitioners where continued growth in benefits is expected.

5.2.3 *Benefit ramp up*

When a new road project is completed, it is expected that the demand will take time to adjust in response to the new infrastructure. Hence, the benefits will need to be ramped-up to reflect the lagged demand adjustment.

Based on observed monthly ramp-up profiles for existing toll roads in Melbourne – CityLink and EastLink (Table 22),[58] the assumptions of the demand ramp-up are presented in Table 23.

Table 22: Toll road ramp-up behaviour in Melbourne

Month after opening	1	3	5	7	9	11	13	15	17	19	21	23
% of steady state volume	74%	85%	90%	93%	95%	96%	97%	98%	99%	99%	100%	100%
Median	Year 1 : 92%						Year 2: 99%					

Source: DETJTR based on observed traffic data on CityLink and East Link

Table 23: Demand ramp-up assumptions

Year	Ramp up assumption
• Year 1:	92%
• Year 2:	99%
• Year 3:	100%

Source: DETJTR based on observed traffic data on CityLink and East Link

5.2.4 *Blending fixed and variable matrix results*

In response to improvements in accessibility offered by major transport projects such as the Project, some transport users will make fundamental changes to their travel behaviour, including switching schools, shopping centres or even places of employment. To ignore this destination-switching behaviour (through the use of fixed matrix outputs in the CBA) may overstate congestion relief offered by new roads over the longer term.[59] In contrast, using only variable matrix outputs would ignore that fundamental changes to traveller behaviour are likely to happen gradually. The economic assessment assumes that such adjustments will take place gradually over a 10 year period commencing from the first year after the Project opens.[60]

[58] DEDJTR (2015), based on observed traffic data on CityLink and East Link.

[59] Victorian Auditor General, 2011, *Management of Major Road Projects*

[60] VLC advice for the East West Link Stage 1 Economic Analysis, September 2013.

A new transport investment is likely to change people's employment and household location as a result of change in accessibility. SGS analysis of timeframes for behavioural change resulting from major road project case studies in Melbourne suggests that:

- Land use change and wider economic benefits with CityLink took around 7-8 years to be realised. This appears to reflect that:
  - Behavioural change is an inherently slow process. It takes time for people to realise the benefits they might enjoy by changing location. This holds true for both households and businesses.
  - The development industry takes time to seek approvals, acquire sites and build. In sum, this process of realisation that new corridors have potential, and development lags take between 3 and 4 years after the construction of a project.
  - Only when a sufficient scale of activity gathered pace in these initial 3 – 4 years, did other businesses and households start to realise the true potential of relocating to the CityLink corridor. In this second phase, it took up to 4 years for more intensive activities start to take place in the corridor.
- In the case of the Western Ring Road, land use change, and the resulting wider economic impacts, appears to have taken between 4 and 6 years to be realised. However, the first stage development lag and behaviour change on the part of businesses and households took roughly the same time as with the CityLink project (i.e. 3 – 4 years). However, the second stage was shorter than CityLink due to smaller agglomeration benefits to transport and freight oriented industries rather than knowledge industries.

The case studies above are expected to reflect land use change resulting from further impacts than the direct transport investment itself. Reflecting this, along with the similarity to CityLink resulting in improved accessibility to employment in and around central Melbourne, and VLC advice for similar analysis of the East West Link East in 2013,[61] the timeframe for behavioural change resulting from the Western Distributor has been to be gradually over 10 years; commencing from year the first year of operation.

The gradual allowance for destination-shifting behaviour is implemented in the CBA by progressively shifting from fixed matrix results to variable matrix outputs when building the final time profile of transport impacts. Outputs are thus 'blended' using a linear profile, with the first full year of opening being represented mostly (90 per cent) by the fixed matrix outputs (and 10 per cent by the variable matrix outputs). By the ninth year of operation, demand outcomes are represented mostly (90 per cent) by the variable matrix outputs. Beyond the tenth year of operation, only the variable matrix outputs are used (100 per cent).

The final time profile of each transport impact is developed by applying each adjustment to the fixed and variable matrix outputs for 2020/21, 2030/31 and 2045/46 and described in Figure 7.

The blended demand matrix is adopted in the CBA for the scenario based on current Victorian practice, whereas the scenario of IA December 2013 RIF uses the fixed demand matrix.

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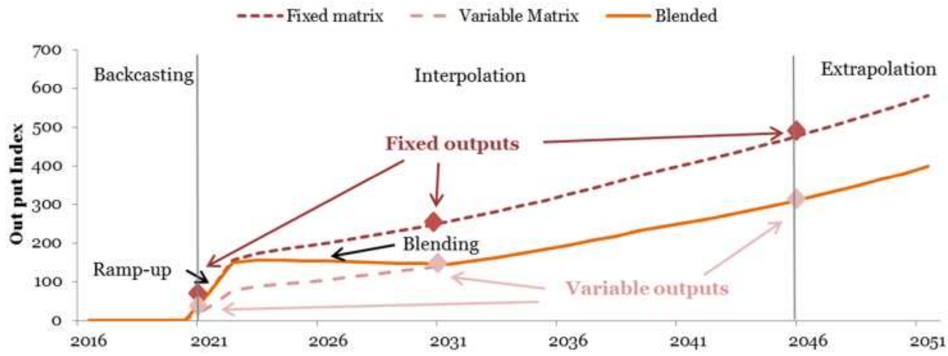
[61] VLC advice for the East West Link Stage 1 Economic Analysis, September 2013.

Figure 7: Illustrative final time profile of transport impacts from demand outputs



Note: Years presented in Figure 7 represent financial years. For example, 2013 represents 2012/13. Benefits post-2045/46 are assumed to grow at the same rate as the results assuming mode/destination switching between 2030/31 and 2045/46. The relatively 'flat' growth rate between 2020/21 and 2030/31 reflects the transition from results with no mode/destination switching to results including mode/destination switching.
Source: PwC calculations based on PwC and VLC assumptions.

6 Costs

Capital costs associated with construction, ongoing operations and maintenance of the Project projects are incorporated in the economic assessment as a comparative point to the economic benefits in the CBA and as a shock to economy in the EIA.

Capital costs are included in the economic assessments during construction of the project (2017/18-2021/22). Ongoing operating and maintenance costs have been included from the first full year of operations (2022/23) to the end of the appraisal period (2071/72).

Capital and ongoing operating and maintenance costs are expressed in real June 2015 dollars (i.e. excluding financial transfers such as price escalation that do not have an incremental impact on resources such as land, labour and capital).

6.1 Capital cost estimates

Costs were estimated by:

- **Advisian (2015)** – construction, contingency and land acquisition[62]
- **DTF (2015) -** state management costs (including statutory planning)
- **Collaborative ITS Consulting Australia (CICA)** – tolling capital costs [63]
- **Axess Advisory (Axess)** – insurance premium estimates for construction phase. [64]

Table 24 and Table 25 present the annual profiles of capital costs. The major component of the construction work will occur between 2018/19 and 2020/21. The majority (60 per cent) of land will be acquired in 2018/19.

Table 24: Annual profiles of the construction cost

Year	% of total capital cost
2017/18	10%
2018/19	15%
2019/20	30%
2020/21	30%
2021/22	15%

Source: VicRoads, 2015.

Table 25: Annual profiles of the land acquisition cost

Year	% of total capital cost
2017/18	0%
2018/19	60%
2019/20	5%

62 Advisian, 2015, 'Western Distributor: Risk adjusted Cost Estimate Report'.

63 Collaborative ITS Consulting Australia, 2015, 'Tolling Operations Cost Model for Western Distributor'.

64 Axess Advisory, 2015, 'Insurance Report: Western Distributor'.

Year	% of total capital cost
2020/21	20%
2021/22	15%

Source: DEDJTR, 2015.

The following adjustments were made to capital cost estimates for the purposes of the economic analysis:

- Given costs were estimated in June 2016 dollars, escalation was excluded to convert cost estimates to June 2015 dollars
- Inherent and contingent risks were allocated to the Monash Freeway Upgrade Project based on its proportion of total direct and indirect construction costs
- Business case and state planning costs which will be incurred prior to a decision being made about whether to proceed with the project were excluded from state agency costs
- State agency costs were allocated to the Monash Freeway Upgrade based on its proportion of total direct and indirect construction costs.

6.2 Operating and maintenance cost estimates

Operating and maintenance costs for the Project were estimated by:

- **Advisian (2015) –** Operating, maintenance and risk
- **CICA (2015)** – Tolling operating and maintenance
- **Axess (2015)** – Insurance payments during operating term.

Payments to Transurban and ConnectEast were excluded from tolling operating costs because they were considered to be financial transfers that redistribute cash within the economy and not real resource (land, labour and capital) costs.

6.3 Avoided costs

The provision of the Project will generate cost savings relative to the base case. The major components of the avoided costs in the context of this project are the resource cost savings and externality cost savings. The resource cost savings include vehicle operating costs, and the externality cost savings include emission and other environmental and social costs. Avoided costs are captured as benefits in the economic appraisal.

7 Benefits

The Project will generate a number of benefits for road users, the Melbourne community and the economy more broadly. The benefits quantified and monetised in the CBA and EIA include direct economic benefits as well as macroeconomic benefits for Victoria and Australia. This chapter identifies each benefit assessed and outlines the methodology applied to estimate each.

7.1 Benefits of the Project

The Project will provide a number of benefits for Melbourne transport users and for Melbourne's economy more broadly as a result of improvements in transport network efficiency and congestion for road users, improved efficiency of freight movement, greater resilience and redundancy in the transport network, a more liveable Melbourne, and improved connectivity and economic development in the west. The key benefits identified and incorporated into the CBA and EIA are outlined in Table 26.

Table 26: Economic benefits of the Project

Overarching benefits	Benefit category captured in economic assessment
Productivity and growth for Melbourne	Base travel time savings from improved traffic flow – cars[1]
	Travel time savings from reduced traffic congestion – cars
	Travel time savings from improved reliability – cars
	Vehicle operating cost savings – cars[2]
More competitive port and freight sector	Base travel time savings from improved traffic flow – LCV and HCV[3]
	Vehicle operating cost savings – LCV and HCV
	Travel time savings from improved reliability – LCV and HCV
	HPFV user benefits[4]
Reduced reliance on the West Gate Bridge	Resilience to lane closures on the West Gate Bridge[5]
A more liveable Melbourne	Base travel time savings from improved traffic flow – public transport users[6]
	Crash cost savings
	Reduced air emissions and improved amenity
Economy-wide benefits	Agglomeration
	Imperfect competition
	Macroeconomic development in the State and nationwide

Notes: (1) Includes car fuel and toll resource corrections for cars, travel time savings for Monash Freeway ramp metering and travel time savings from increased West Gate Bridge effective capacity; (2) includes 'switcher VOC' resource correction; (3) includes LCV and HCV travel time savings for reduced congestion, fuel and toll resource corrections for cars, travel time savings for Monash Freeway ramp metering and travel time savings from increased West Gate Bridge effective capacity; (4) includes reduction in HCV driver wages and vehicle operating costs as a result of improvement in efficiency for HPFVs; (5) probability weighted direct benefits across all other categories reflecting the likelihood and duration of lane closures on the West Gate Bridge; and (5) includes fare resource correction.
Source: PwC

The approach to estimating each of the identified economic benefit categories has been based on welfare economic theory, whereby the change in economic value measured is defined by changes in travel conditions in terms of the theoretical concepts listed below:

- **User benefits** – the change in value that is perceived by users of the affected transport services. The change in 'consumer surplus'[65] is comprised of effects on:

  a. Existing transport users – change in perceived costs of existing road and public transport users ('transport users') who do not change behaviour with the project, and

  b. New and lost transport users – change in perceived cost of transport users who change their behaviour (different mode or destination compared to the base case).

- **Resource corrections** – the opportunity costs of resources expended by undertaking and/or supplying a transport trip, measured from a societal perspective (since the perceived cost of travel does not always reflect the associated change in resource costs). Examples include the cost of tyres, depreciation, insurance and public transport fares.[66] Differences between perceived and resource costs arise due to gaps in information, misperceptions, taxes, subsidies and financial transfers.
- **Externalities** – effects on other transport system users and non-users. Externalities are measured as the difference between social resource costs and private resource costs. Examples of such externality effects include congestion, road crashes, amenity and environmental effects.
- **Network resilience benefit** – Melbourne's west is heavily reliant on the West Gate Freeway to access the city and CityLink. This poor connectivity is placing the city's transport network under increasing pressure. Incidents on the West Gate Bridge can significantly impair the ability for freight and passenger vehicles to traverse the city. By providing an alternative to the West Gate Bridge, the Project will deliver benefits when and if such events occur.
- **Wider economic benefits** – improvements in national output that are not already reflected in user travel costs elsewhere in the appraisal. Agglomeration benefits are one example, as these reflect the benefits collectively experienced by clusters of businesses being brought closer together (in terms of shorter travel times).

The remainder of this chapter documents the detailed methodology applied to quantify each of the benefits above for the Project.

7.2 User benefits

Users of the Melbourne transport network will be key beneficiaries of the Project. The Project will **improve transport network efficiency and congestion for road users** by providing better connectivity between the west and the Melbourne CBD. The inclusion of the Monash Freeway Upgrade will also provide a better level of service for the south-east corridor. Through the Webb Dock Access Project and the expansion of the West Gate Freeway, the Project will also **improve the efficiency of freight movements**.

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65 This appraisal approximates the change in consumer surplus as changes in generalised trip cost (GTC), the measure of the perceived cost of travel.

66 ATC, 2006, *National Guidelines for Transport System Management in Australia*, Volume 3, p 58.

The user benefits estimated are related primarily to savings in transport user costs due to a reduction in travel times and distances compared with the base case:

- Travel time benefits:
  - Base travel time benefits from improved flow
  - Travel time benefits from reduced traffic congestion
  - Travel time benefits from improved trip reliability[67]
- Savings in vehicle operating costs
- HPFV user benefits.

The following sub-sections describe the methodologies for estimating each of these benefits in a given forecast year.

7.2.1 Base travel time benefits from improved flow

Improvements in travel times across the Melbourne transport network are expected due to the Project. As shown in Figure 8 and Figure 9, travel time benefits will be experienced by travellers whose journey originates in the inner west, north-west and south-west, accessing central, eastern and northern Melbourne due to decongestion.

For example, it is estimated that by 2030/31, travel time savings by car in the morning peaks will be up to 12 minutes faster for trips from the west compared to the base case. Average speeds will be up to 15 km/h hour faster in the morning and 20 km/h faster in the afternoon peak from the west.[68] It is also estimated that there will be approximately 5 minute time savings for a peak trip on the Monash Freeway between Warrigal to Clyde Road.[69]

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[67] Based on the three categories of travel time benefits defined in: New Zealand Transport Agency (NZTA) 2013 Economic Evaluation Manual (EEM). See Appendix A.

[68] GHD and Veitch Lister Consulting, 2015.

[69] PwC, GHD and Veitch Lister Consulting, 2015.

Figure 8: Travel Time Benefits by Origin – Car, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)

Source: Veitch Lister Consulting, 2015.

Figure 9: Travel Time Benefits by Destination – Car, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)

Source: Veitch Lister Consulting, 2015.

The construction of a new high productivity freight vehicle compliant freeway link to the Port of Melbourne will bring significant time (and operating cost savings) to the freight industry. More than a third of the national containerised trade in Australia will have direct freeway access to the Port precinct by 2022/23.

Figure 10 and Figure 11 illustrate that for freight and commercial travellers, travel time benefits will be experienced by those accessing the Port of Melbourne precinct, inner western suburbs and Brooklyn/ Laverton North. It also shows the freight travelling to Tullamarine and Craigieburn will benefit from decongestion.

For example, it is estimated that by 2030/31:

- Freight using the Western Distributor to access the port precinct from Melbourne's west will enjoy time savings, some up to 50%.[70] Freight sector savings are expected to flow through to consumer prices and bring wide community and economic benefits.
- Superior freight links, with unimpeded access for 110 tonne mass limit trucks to the Port, will deliver $15 to $20 per trip efficiency savings for HPFVs.[71]

Figure 10: Travel Time Benefits by Origin – Commercial vehicles, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)

Source: Veitch Lister Consulting, 2015.

70 GHD and Veitch Lister Consulting, 2015.

71 PwC and Veitch Lister Consulting, 2015.

Figure 11: Travel Time Benefits by Destination – Commercial Vehicles, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)

Source: Veitch Lister Consulting, 2015.

For the purpose of economic quantification, improvements in base travel times are assumed to accrue in the form of consumer surplus to:

- existing road users who divert to the Project or take advantage of reduced congestion
- travellers switching modes of transport due to the improved travel times offered by the Project
- travellers switching their origins and/or destinations to access more desirable destinations (which may involve taking longer trips)
- public transport users who will experience reduced travel times as a result of reduced congestion enabled by the Project.

Calculation approach based on VLC demand model outputs

Savings in base travel times for the project case have been estimated relative to the base case for existing users and switchers, with the latter estimated based on new and lost user calculations.

The demand model has been specified to estimate generalised trip cost (GTC) savings in terms of person hours for car users (by applying estimates of vehicle occupancies across journey purposes) and public transport users, and in terms of vehicle hours for commercial vehicles.

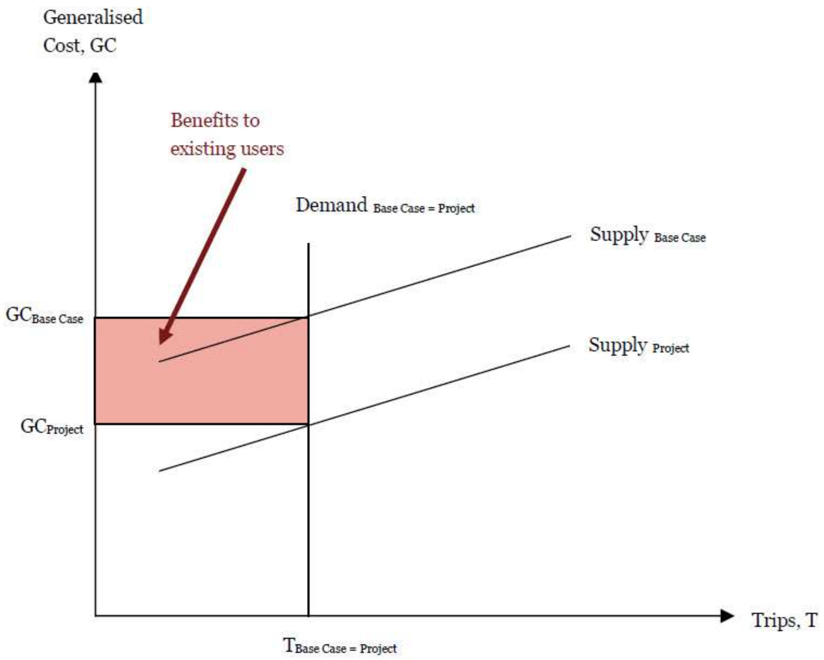
The structure of the traffic demand forecasting model determines how the change in consumer surplus is estimated for the purposes of economic analysis. Traffic demand modelling approaches are broadly differentiated by whether fixed or variable trip matrices are used.

Fixed matrix

Fixed *mode trip* matrix methods assume that a project will not lead to a change in the number of trips undertaken by each mode between a particular origin-destination (OD) pair as a result of mode shift, trip redistribution or trip generation. This approach also implies that the project will not change traveller behaviour to the extent to which the traveller's wellbeing or utility is left unchanged, except for the change in travel cost which affects net utility. Therefore, the benefits of the project are measured by the change in perceived and resource costs between the do-minimum network and the option.

This situation is shown in a simplified representation below where the demand for travel for OD pair *ij* using mode *m* is fixed and the benefit is simply given by the change in generalised trip cost (GTC) of this trip. GTC captures all user-perceived costs of the journey, such as time, tolls and fuel. Figure 12 shows that a project that improves journey times reduces the GTC from $GC_{Base\ Case}$ to $GC_{Project}$. The change in consumer surplus or net benefit for T trips is simply T trips multiplied by the change in GTC, defined by the pink area.

Figure 12: Change in consumer surplus with fixed trip matrices



Source: PwC

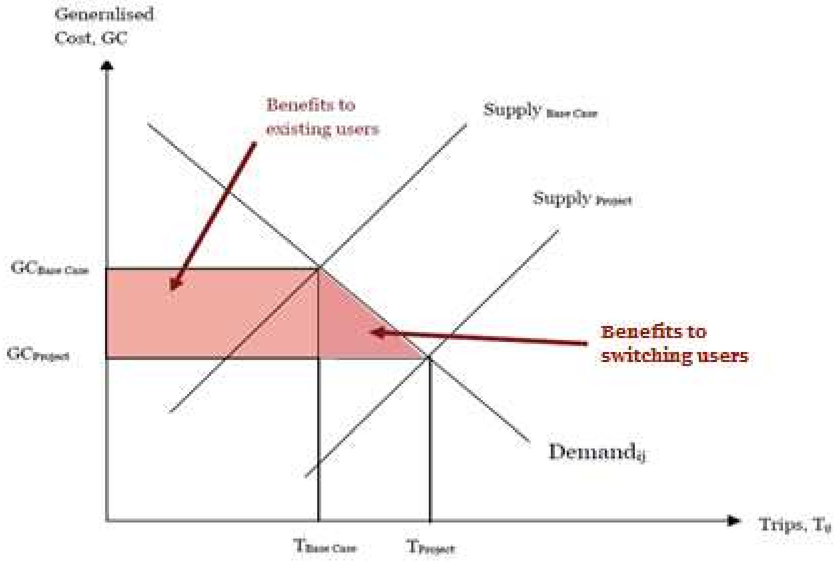
Variable trip matrices

A more realistic representation of the market for trips features a demand curve for travel which is inversely related to trip cost. Therefore, a reduction in GTC will *induce* travel by mode *m* between the *ij* as traveller behaviour changes compared to the base case. There are two common alternatives of this type: fixed *total trip* matrix methods assume that a project can lead to a change in transport modes, but will not lead to a change in the number of trips between a particular OD (by all modes) as a result trip redistribution or generation.

Alternatively, traffic and transport models can be based on *variable trip matrix* methods that recognise that transport is an intermediate service used to access activities which generate value. Travellers will seek to maximise the net benefit of travel, rather than simply minimise cost and therefore may choose to access more distant destinations if the costs of reaching them decline. In short, there may be any number of behavioural (induced) changes which occur as a result of the project, including travellers changing their mode or their destinations by travelling further.

The simple supply/demand representation above is generalised below to identify the change in consumer surplus when these demand changes are captured. The key aspect of this figure is that the number of trips by mode *m* (e.g. private vehicle) between *ij* increase to $T_{Project}$ with the Project. Accordingly, the consumer surplus increases from those confined to existing users to include the 'triangle' associated with the net benefit enjoyed by the switching users (Figure 13).

Figure 13: Change in consumer surplus with variable trip matrices



Source: PwC

The total net benefit in the figure above can be explained in terms of the two segments of demand following the introduction of the Project for a particular *ij*:

- Each existing user was willing to pay $GC_{Base\ Case}$ given by the intersection of the trip supply and demand curve in the base case but pays only $GC_{Project}$ with the Project. This results in an increase in net benefit of $GC_{Base\ Case}$ - $GC_{Project}$ for each existing user.
- The net benefit enjoyed by switching users (mode or destination switchers) is given by the pink triangle. By definition, switchers were not willing to pay GC_{BC} to travel between *ij* by mode *m* (otherwise they would have travelled with the base case and comprise an existing user); however, they are prepared to pay at least $GC_{Project.}$ The first new user who switched to *ij* by mode *m* would have been willing to pay a price which is slightly less than $GC_{BC.}$ Therefore, the net benefit for the user would be slightly below the benefits enjoyed by existing users, i.e. $GC_{Base\ Case}$ - $GC_{Project.}$ The last few people who decide to switch to *ij* by mode *m* would only be willing to pay slightly less than the new trip cost, i.e. $GC_{Project}$ and hence, their net benefit from switching is effectively zero. Therefore, the average increase in net benefit for the switchers is between slightly above zero and slightly less than $GC_{Base\ Case}$ - $GC_{Project.}$ Therefore, on average, the net benefit to a switcher is 0.5*($GC_{Base\ Case}$ - $GC_{Project}$), i.e. the benefit enjoyed by each switcher is on average half the benefit attained by existing users on that *ij*. This is commonly known as the **'rule of half'**.

Those who change trip behaviour (mode or destination switchers) are **new** with respect to their newly chosen alternative and **lost** with respect to previously chosen alternative. The calculation of the net benefit enjoyed by existing users remains unchanged. However, by introducing the ability for travellers to choose across a range of trip elements means that the method used to calculate net benefit of induced users must be generalised. This is done by first defining new, lost and existing trips as follows:

- continuing users of a mode/destination$_{ij}$ =min ($T_{Base\ Case}$, $T_{Project}$)
- new trips$_{ij}$ = max($T_{Project}$ - $T_{Base\ Case}$, 0)
- lost trips$_{ij}$ = max($T_{Base\ Case}$ - $T_{Project\ Case}$, 0)

The second step to estimating consumer surplus is to apply the incremental GTC between the base case and the project case, i.e.

- continuing user benefits = ($GC_{Base\ Case}$ - $GC_{Project}$) * min ($T_{Base\ Case}$, $T_{Project}$)
- new user benefits = ($GC_{Base\ Case}$ - $GC_{Project}$) * max ($T_{Project}$ - $T_{Base\ Case}$,0) * 0.5
- lost user benefits = ($GC_{Base\ Case}$ - $GC_{Project}$) * max($T_{Base\ Case}$ - $T_{Project\ Case}$, 0) * 0.5

These formulas are applied by VLC for each time period, travel mode and vehicle class, and then aggregated across each *ij* pair before being reported to PwC.

Approach to monetise

Following the estimation of generalised trip cost (GTC) savings by vehicle type for the base case and project case, monetisation of this benefit involves applying the relevant value of travel time for each of the following four broad user types:

- Car (business) – for business purposes, time spent on trips made for business purpose (work travel from, or returning to, the workplace, but excluding commuting) is directly valued by employers at the direct resource cost, i.e. the average wage rate. Time spent driving in congested conditions is also perceived as a cost valued at travellers' average willingness to pay to avoid congested conditions.
- Car (non-business) – for non-business journey purposes, time is valued according to travellers' average willingness to pay for additional leisure time and to avoid travelling in congested conditions.
- Commercial vehicles (light and heavy) – these business purpose journeys are also valued at the average wage rates (which can vary by the specific vehicle class). In addition, the freight carried by the vehicles also has an opportunity cost from sitting in traffic. Vehicle classes with greater average freight loads are estimated to have greater values of freight time, e.g. a heavy rigid truck is assumed to have a freight value of time of $14.97 per vehicle hour, compared with a B-double at $68.41 per vehicle hour (both in June 2015 dollars).[72]
- Public transport– passenger journeys are valued according to travellers' average willingness to pay for additional leisure time while driver time is valued at the average wage rate.
- Car (business) and car (non-business) base travel time savings can be valued directly by applying the Transport and Infrastructure Council's parameters from the 2015 NGTSM to the VLC demand modelling outputs (travel time saving hours). For LCVs and HCVs a weighted average value of time is required. The DEDJTR supplied PwC with VicRoads estimates of 2015 West Gate Freeway traffic counts across 20 Austroads vehicle categories. These proportions were applied to the Transport and Infrastructure Council's 2015 NGTSM estimates of driver and freight values of time for each class to derive the weighted values of travel time.

The data and parameters used in the valuation of time saving benefits are shown in Table 27.

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[72] Transport and Infrastructure Council, 2015, National Guidelines for Transport System Management in Australia – Road Parameter Values, p.15

Table 27: Estimation of base travel time savings for improved traffic flow

Element	Input
Data	**Travel time saving hours** (project case versus base case) from the demand model, broken down into: • User types – heavy vehicles, light commercial vehicles, car (business), car (non-business) and public transport • Time periods – AM Peak, PM Peak, Inter-Peak and Off-Peak.
Parameters	Unit **value of travel time savings** (VOTT) (values below are in June 2015 dollars, using ABS's Victorian Wage Price Index). Transport and Infrastructure Council 2015 NGTSM urban values are broken down into user types, with LCV HCV values weighted to reflect Melbourne 2015 vehicle composition on the West Gate Freeway. • car (business) = **$51.26/hr** (resource cost of employee time) • car (non-business) = **$15.65/hr** (willingness to pay for leisure time) • light commercial vehicles = **$35.96/hr** (wage + freight) • heavy commercial vehicles = **$76.59/hr** (wage + freight) • Public transport value of travel time = **$16.34/hr** (willingness to pay for leisure time).
Calculation (simplified[73])	$Time\ saving\ benefit = \sum_{user\ type} Time\ saving_{user\ type} * VOTT_{user\ type}$ These time saving benefits are calculated for each of the modelled time periods and are then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.

Source: PwC

Travel time benefits from improved West Gate Bridge effective capacity

Reduction in truck volumes on the West Gate Bridge increases the effective capacity of the bridge, given trucks take up more space than other vehicle types (expressed in passenger-car equivalence units).

Travel time benefit hours from improved West Gate Bridge effective capacity have been forecast by VLC by adjusting the effective capacity of the West Gate Bridge between the base case and project case, based on the forecast change in vehicle composition and trips assuming passenger car equivalence ratios of 1.5 for LCVs and 4.5 for HCVs. These benefit hours are included in estimates of base travel time savings in section 7.2.1.

73 Two major extensions were applied in practice: (1) the use of the rule of half for time savings for new and lost users; (2) for public transport users, 'time savings' are actually 'generalised travel cost' (GTC) savings. GTC measures the perceived cost of travel, including higher perceived costs of a minute of travel time spent waiting at bus or tram stops compared with a minute spent in vehicle.

Travel time benefits from Monash Freeway ramp metering

The VLC Zenith model captures the impact of additional lanes with the Monash Freeway Upgrade, but the strategic model was unable to isolate the impact of ramp metering and storage capacity improvements as it models people rather than interactions between vehicles.

VicRoads has advised that there are currently 19 ramps with metering in place on the Monash Freeway between Springvale Road to Clyde Road. Of these, 15 are proposed to be upgraded and 8 new ramps are proposed, which will provide ramp metering coverage across the entire corridor (ie 'full control' instead of the current 'partial control'). This is expected to result in additional travel time savings along the entire Monash Freeway corridor over and above those based on Zenith outputs.

Base travel time savings on the Monash Freeway between Springvale Road to east of Clyde Road forecast by VLC in Zenith on a link basis have been adjusted for inclusion in the CBA to reflect an assumed 7.5% uplift in travel speeds with the Monash Freeway Upgrade. This is more conservative than US simulation modelling of partial versus full control of ramp metering, which estimated that travel time savings would be around 10% lower with full control relative to partial control of ramp metering.[74]

7.2.2 Travel time benefits from reduced traffic congestion

Base travel times benefits capture changes in the opportunity cost of time spent travelling, measured as either willingness to pay for additional leisure time or the resource costs of labour as described above. However, this does not capture the full benefits to road users who also perceive a reduction in dis-utility as a result of the discomfort and lack of amenity from travelling in congested conditions.

As indicated in Figure 14 below, in the absence of investment in the Project, the M1 corridor is expected to experience significant levels of congestion with multiple locations forecast to experience levels of demand that exceed road capacity available. For example, at volume capacity ratios greater than 0.85 travellers will face significant restrictions selecting desired speed and manoeuvring, with minor disturbances causing traffic flows to break down. At volume to capacity ratios greater than 1.0, traffic flows will break down resulting in queuing and delays.[75]

As shown in Figure 15 (AM peak) and Figure 16 (interpeak), the project is expected to generate benefits (as measured in the VLC model by calculating whether weighted travel time hours experiencing volume to capacity ratios of 0.7 and 1.0[76] reduce relative to the base case) in the outer west, the inner west and the north. Travellers accessing central, inner suburbs and outer northern and inner western suburb will also benefit.

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[74] Utah Department of Transportation (2015), Interstate 15 – Managed Motorways Study, Project No. S-R299(199), PIN No. 13271, August 2015, Utah, the USA, page 57.

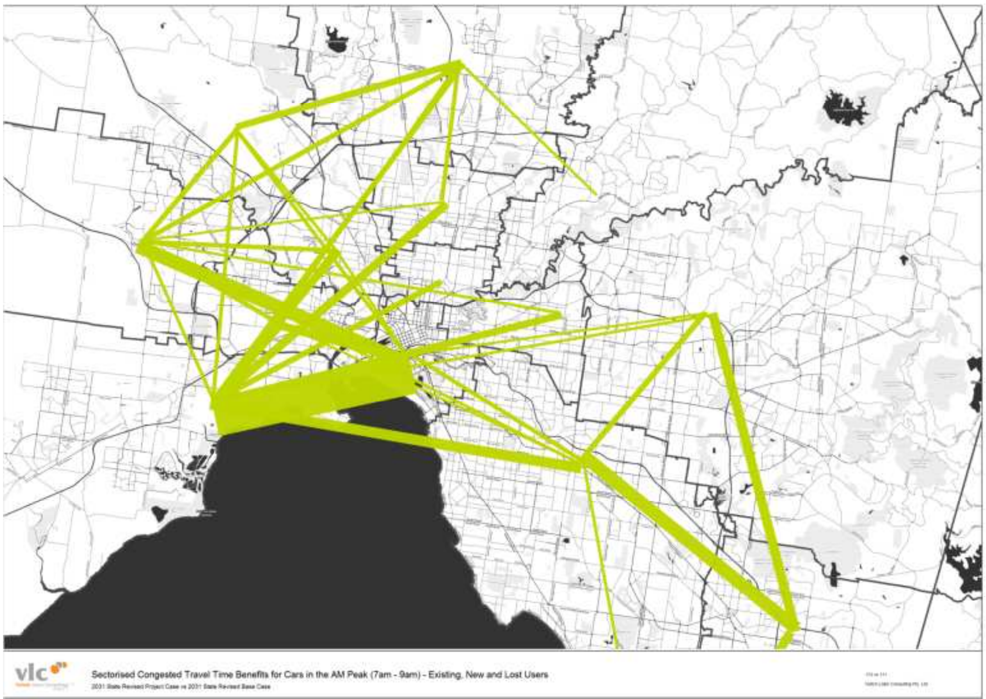
[75] NSW Government, Draft Newell Highway Corridor Strategy, May 2015.

[76] Based on approach suggested in New Zealand Transport Agency, 2013, 'Economic Evaluation Manual', discussed in more detail below.

Figure 14: Base case volume capacity ratios – AM peak (7am – 9am), 2030/31

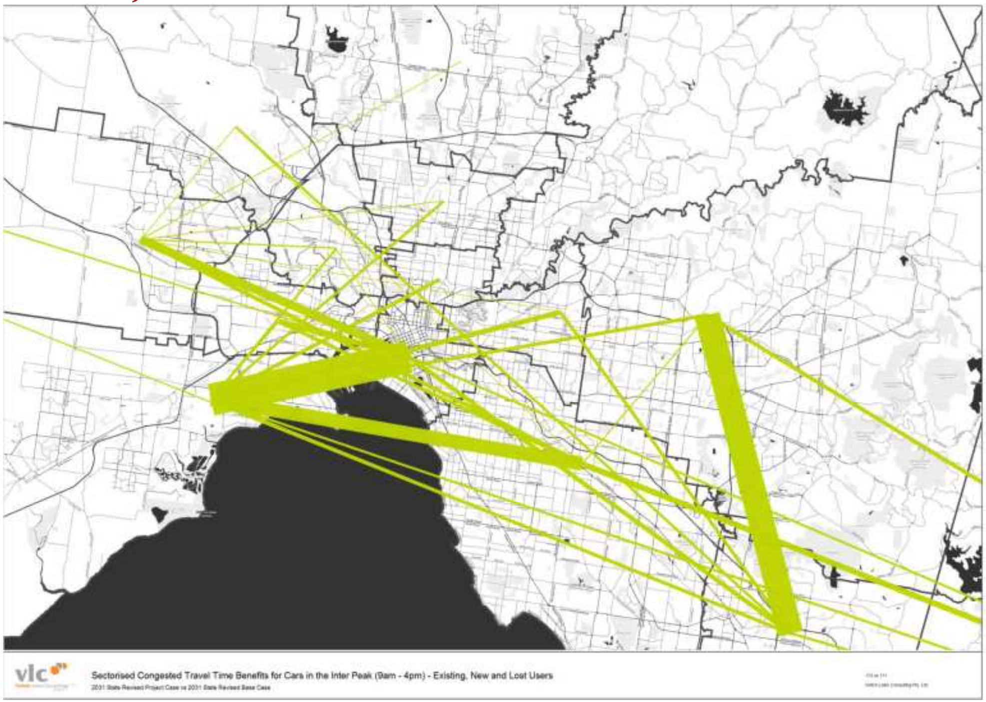
Source: Veitch Lister Consulting, 2015.

Figure 15: Sectorised travel time benefit hours from reduced traffic congestion, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)



Note: Trips are shown to/from the centroid of each sector.
Source: Veitch Lister Consulting, 2015.

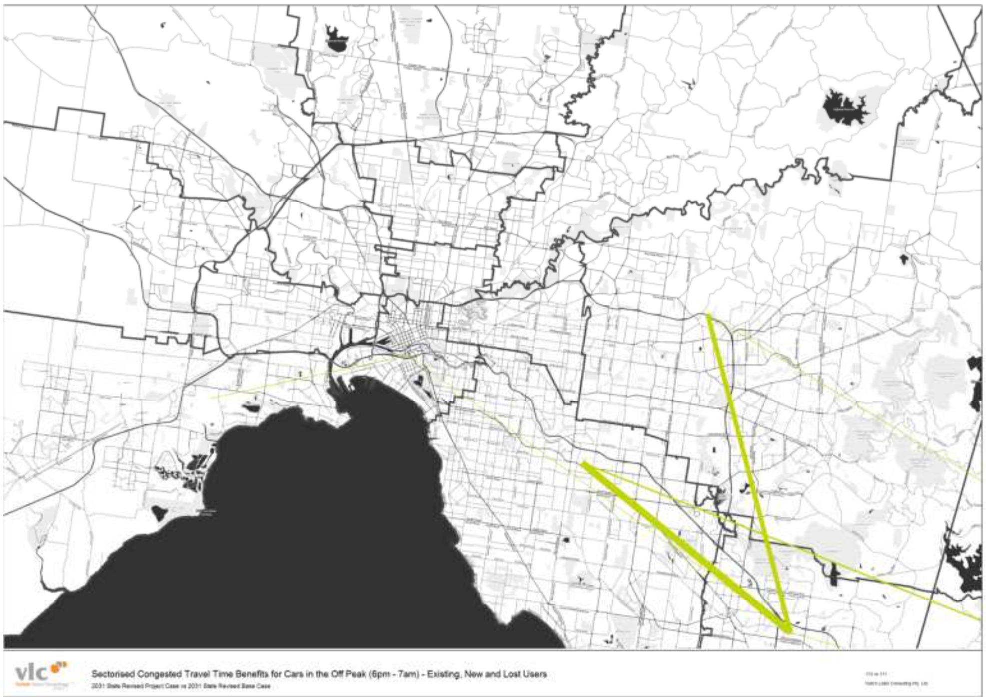
Figure 16: Sectorised travel time benefit hours from reduced traffic congestion, interpeak (9am – 4pm), (2030/31 project case vs 2030/31 base case)



Note: Trips are shown to/from the centroid of each region/sector
Source: Veitch Lister Consulting, 2015.

Figure 17 shows that no significant benefits are expected in the evening off peak, reflecting lower levels of congestion.

Figure 17: Sectorised travel time benefit hours from reduced traffic congestion, evening off peak (6pm – 7am), (2030/31 project case vs 2030/31 base case)



Note: Trips are shown to/from the centroid of each region/sector
Source: Veitch Lister Consulting, 2015.

Travel time benefits from improved traffic congestion: Australian and international studies and evidence

The evidence supporting estimation of travel time benefits from improved traffic congestion has been identified in a number of guidelines and international research:

- The ATC 2006 NGTSM states that the general principle for the valuation of benefits should be based on the revealed willingness of users to pay to gain the benefits[77]
- The NZTA 2013 EEM states that road users value improvements in traffic congestion over and above the benefits gained from travel time saving (Appendix)[78]
- The TfNSW economic appraisal guidelines state that travel time costs are the costs of time spent travelling, which vary with the amount of time spend on travelling as well as with the disutility (the discomfort and lack of amenity) of the travel mode[79]
- The UK DfT TAG suggests that journey quality should be considered where specific revealed preference data is available[80]
- The Victorian Transport Policy Institute (Canada) note that travel time costs vary depending on travel conditions and traveller preferences, with time spent in discomfort carrying higher unit costs[81]
- The 2015 NGTSM[82] identifies further research in this area, stating that:

  'research on travel time reliability has been focused…on issues of variability of travel time and unpredicted variation in trip times arising from incidents as opposed to expected delays (non-recurrent versus recurrent congestion). Evidence also points to the potential of willingness to pay (stated preference) techniques as a means of valuing travel time and value of variability… Further research in his area has been identified as a priority by Austroads in the future and it is recommended that results of this work be incorporated in to future updates of NGTSM parameter values as they become available'.

Research dating back to 1978 has categorically found stress and aggression levels are higher in highly congested conditions. This has been attributed to the high level of sustained attention required to drive without bumping into other cars and the frustrating nature of start-stop driving.[83]

Various studies have found travel time costs tend to be significantly higher under congested and unpredictable travel conditions and when comfort and convenience

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77 Australian Transport Council, 2006, National Guidelines for Transport. System Management in Australia, Part 4, Section 3.2.3, p. 21

78 NZ Transport Agency, 2013, Economic Evaluation Manual, p. 4-66

79 Transport for NSW, 2013, Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, Appendix 4, p. 230.

80 The UK Department for Transport, 2014, Transport Analysis Guidance – TAG Unit A1.1 Cost Benefit Analysis, p. 2

81 VTPI, Transportation Cost and Benefit Analysis II – Travel Time Costs, available at: http://www.vtpi.org/tca/tca0502.pdf

82 Transport and Infrastructure Council, 2015, National Guidelines for Transport System Management in Australia – Road Parameter Values, p.16

83 University of Minnesota (2003), 10th International Conference on travel behaviour research: Evaluating the perception of in-vehicle travel time under moving and stopped conditions.

are included. A US study (Small, et al, 1999)[84] suggests that travel time costs under congested conditions be calculated at 2.5 times higher than that of overall travel time savings.

Furthermore, Abrantes and Wardman (2011) conducted a comprehensive review of travel time valuation methods in the UK. This study concluded that car time spent in congested traffic conditions is, on average, valued 34 per cent more highly than time spent in free flow traffic.[85]

The NZTA 2013 EEM suggests that road users value relief from congested traffic conditions over and above their value of travel time savings. The additional value for congestion should apply to vehicle occupants by road category and time period. For example, Table 28 provides an example of the comparison of the base value of time and the maximum increments for congestion.[86] New Zealand has included congested premiums in their transport guidelines since 1998.[87]

Table 28: Base and congested values travel time (NZ $July 2002)

	Work travel purpose	Commuting to/from work	Other non-work travel purposes
Base values of time for uncongested traffic			
Car, motorcycle driver	23.85	7.8	6.9
Car, motorcycle passenger	21.7	5.85	5.2
LCV driver	23.45	7.8	6.9
LCV passenger	21.7	5.85	5.2
Medium/heavy driver	20.1	7.8	6.9
Medium/heavy passenger	20.1	5.85	5.2
Maximum increment for congestion			
Car, motorcycle driver	3.15	3.15	2.75
Car, motorcycle passenger	2.35	2.35	2.05
Commercial vehicle driver	3.15	3.15	2.75
Commercial vehicle passenger	2.35	2.35	2.05

Source: NZ Transport Agency 2013 EEM (see Appendix A)

A number of Australian studies undertaken by Hensher and Rose between 2004 and 2008 for confidential toll road projects have identified that travellers' value of travel time savings is higher in stop-start traffic than in free-flow traffic as summarised in Table 29. This evidence implies that travellers would be willing to pay a higher value for travel time savings under congested traffic conditions than the average traffic condition.

84 Small, K. et al, 1999, Valuation of Travel-Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation, NCHRP 431, Transportation Research Board (www.trb.org).

85 Abrantes,P.A.L. and Wardman, ,M.R., 2011, Meta-analysis of UK values of travel time: An update, Transportation Research Part A, vol. 45, p. 1–17.

86 NZ Transport Agency, 2013, Economic Evaluation Manual, Appendix 4, p. 5-206

87 TransFund (1998), Project Evaluation Manual, TransFund New Zealand

Table 29: Australian evidence on value of time under difference traffic conditions ($June 2015)

Source	Traffic	Commuter Car	Non-Commuter Car	HCV
Hensher and Rose #1	Free Flow	$35.18	$26.49	$115.12
	Slowed down	$36.92	$31.76	$118.44
	Stop start	N/A	N/A	N/A
	Total time	$36.03	$28.79	$ 116.68
Hensher and Rose #2	Free Flow	$26.08	$17.39	N/A
	Slowed down	$27.97	$21.53	N/A
	Stop start	$35.42	$28.66	N/A
	Total time	N/A	N/A	N/A
Hensher and Rose #3	Free Flow	$27.55	$16.89	N/A
	Slowed down	$29.01	$20.34	N/A
	Stop start	$35.50	$26.54	N/A
	Total time	N/A	N/A	N/A
Hensher and Rose #4	Free Flow	$12.52	$8.59	N/A
	Slowed down	$19.05	$12.94	N/A
	Stop start	$24.40	$14.70	N/A
	Total time	N/A	N/A	N/A

Note: Based on Hensher and Rose studies between 2004 and 2008 for confidential road projects. Prices inflated to June 2015 using the ABS Victorian WPI. Peak and non-peak values converted to a weighted average based on 2010/11 VLC Zenith outputs for car trips in the peak versus average weekday.
Source: David Hensher, personal communication, September 2015.

Application of perceived values for improved trip quality: public transport

The application of factors to average travel time savings to account for the perceived value of improvements in public transport journey quality is well established in Australia. The 2015 NGTSM publish factors (equivalent in-vehicle time) to value improvements in public transport journey quality, including crowding. For example:

- The 2015 NGTSM recommends that seated time for rail and bus should be based on load factors relative to seats. When all seats are occupied, seated time is valued at 110 per cent of in-vehicle-time, increasing linearly to 130 per cent at crush capacity, which is typically 6 passengers per square meter.
- The crowding factor has been formally adopted in TfNSW 2013 economic guidelines, which recommends applying a multiplier of 1.17 for crowded seating time relative to standard in-vehicle-time for rail travel.

Calculation approach based on VLC demand model outputs

Within the VLC Zenith model, equivalent base travel times for the base case and project case reflecting the perceived cost of congestion have been quantified according to the methodology laid out in the NZTA 2013 EEM (Appendix A), which defines the perceived change in travel time caused by congestion on urban roads, multi-lane rural highways and motorways as:

$$\Delta T_1^C = \min(0.0, \max(1.0, \frac{V_l - 0.7C_l}{0.3C_l}))T_l$$

where:

ΔT_1^C – perceived incremental travel time caused by congestion

T_l – congested travel time on link l

V_l – traffic volume on link l

C_l – capacity on link l

The Zenith model calculates the perceived cost of congestion in units of hours for each individual link in the network. This link based metric is then converted to an OD based metric as follows such that it can be combined with demand matrices to generate the overall benefits:

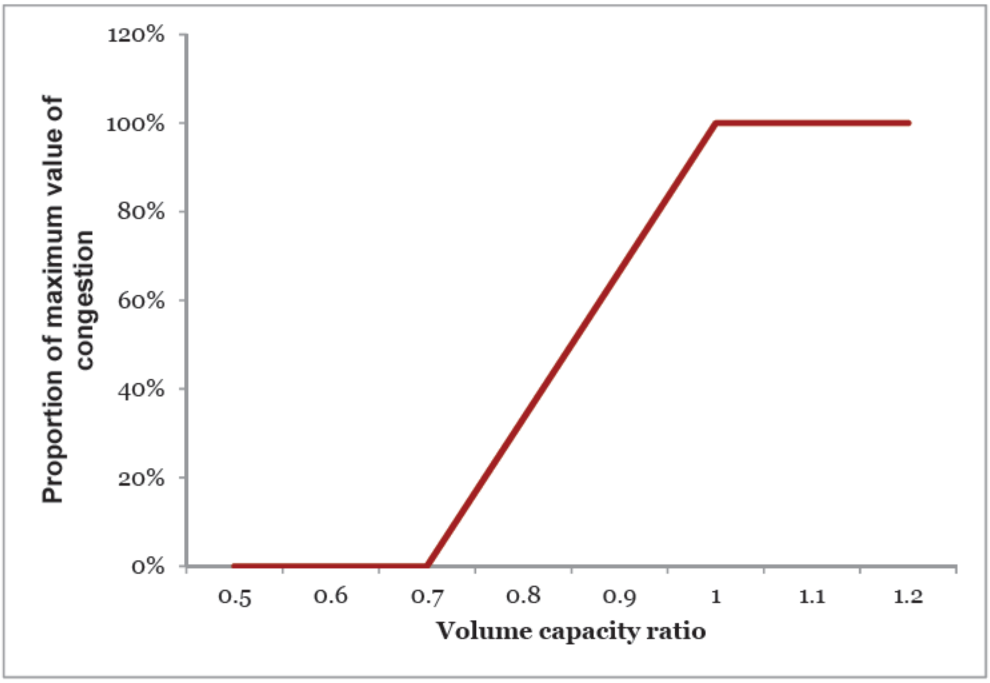
1. Determine the volume capacity ratio for each link in the network, disaggregated by modelled time period
2. For each OD zone pair within each modelled time period:
    a. Select the path through the network which minimises the route choice cost function (typically this is chosen as the shortest cumulative travel time)
    b. Calculate the summation of the weighted travel time across this path (corresponding to the volume to capacity ratio and travel time for a link) and store this in the appropriate cell within the output matrix.

In other words, perceived congested time is calculated by converting the volume capacity ratio to a cost (expressed in minutes) using a piece-wise linear conversion function. As a first step the volume capacity ratio on each link is calculated, and then converted to units of time (which can be additively aggregated). The above process is then applied to calculate the overall perceived congested time for each OD pair.

Weighting of travel times for the base case and project case are required because the value of time in congested conditions (Table 32) represents a maximum value corresponding to a volume capacity ratio of 1.0. This value reduces in line with the volume to capacity ratio, with the New Zealand EEM suggesting a lower bound of 0.7.

Travel time on a link is weighted according to the function below, which applies a weighting of 0% where volume capacity ratio is less than 0.7 and 100% where the volume capacity ratio is greater than 1.0. The weighting factor increases linearly between volume capacity ratios of 0.7 and 1.0. For example, travel times would be weighted by 50% with a volume capacity ratio of 0.85.

Figure 18: Weighting function applied to base travel times



Source: PwC based on NZ 2013 EEM.

The table below presents a number of stylised volume-capacity ratio scenarios, the weighting that would be applied to travel times and the implication for travel time benefits from reduced traffic congestion. For example:

- If both the base and project case volume capacity ratios are both less than 0.7, then there would be no benefit as both base and project case travel times would be weighted by zero.
- If the base case volume capacity ratio is greater than 0.7 there would be a benefit from reduced traffic congestion if there is a reduction in the volume capacity ratio.
- Where both base and project case volume to capacity ratios are greater than 1.0 base travel times for the base and project case would be weighted by 100%. There would be a benefit as a result of the reduction in base travel times – which also reduces the amount of time spent travelling in congested conditions and is therefore additional to the travel time savings from improved traffic flow.

Table 30: Stylised volume capacity ratio scenarios and weighting applied to base travel times

Volume capacity ratio			Weighting		
Scenario	Base Case	Project Case	Base Case	Project Case	Impact on travel time benefits from reduced traffic congestion
Both base and project case below 0.7	0.7	0.6	0%	0%	No benefit
Base case between 0.7 and 1.0, project case less than 0.7	0.85	0.6	50%	0%	Benefit from avoiding travel in congestion (ie base case travel time multiplied by 50%)
Both base and project case between 0.7 and 1.0	0.9	0.8	67%	33%	Benefit from reduced travel in congestion (67% of base case travel time less 33% of project case travel time)

Volume capacity ratio			Weighting		Impact on travel time benefits from reduced
Base case greater than 1.0 and project case between 0.7 and 1.0	1.1	0.9	100%	67%	Benefit from reduced travel in congestion (100% of base case travel time less 67% of project case travel time)
Base and project case greater than 1.0	1.2	1.1	100%	100%	Benefit from reduced travel in congestion (100% of base case travel time less 100% of project case travel time – with project case travel time reducing relative to base case Travel time)

Source: PwC based on NZ EEM

Approach to monetise

Travel time benefits from improved congestion have been valued by applying Australian stated preference estimates of the value of time in congested compared to uncongested conditions (Table 31) to the VLC demand modelling outputs (congested time saving hours, linearly weighted by link-based volume capacity ratio between 0.7 (0%) and 1.0 (100%)).

Table 31 sets out the estimated incremental value of time in congested conditions based on Australia specific research outcomes presented in Table 29.

The value of perceived congestion cost is represented by the difference in the value of time in stop-start traffic ($VOT_{stop\text{-}start}$) and the value of overall travel time ($VOT_{overall}$). The average value of perceived congestion cost was weighted by the number of commuting trips and non-commuting trips in 2011 (from Zenith model). All values were escalated to June 2015 values. The resultant average value of perceived congestion cost for car travel is around $5.30.

To measure the value of perceived congestion cost for LCVs and HCVs, this analysis uses the value of total time estimated by Hensher and Rose as a basis, with the stop-start value of time estimated based on the relativity between stop-start and free flow values of time across the other Hensher and Rose studies. The maximum value of congested time has been calculated as the difference between the stop-start and total value of time, with LCV values assumed to be the same as HCVs.

It is important to note that the estimation of the travel time savings in congested conditions is incremental to the base travel time saving benefits, as it is calculated as the difference between the value of stop-start travel time and the average value of travel time. It does not double count reliability benefits as the stated preference surveys were undertaken based on single trips rather than repeated trips (for which the reliability benefits are valued).

When comparing the value of time in congested conditions as set out in Table 31 to the NZTA 2013 EEM in Table 28, on average the values in the NZTA 2013 EEM comprise a higher proportion of base values than the Australian values estimated by Hensher and Rose studies. For example, the estimates are 13% and 10% of base values in the NZTA 2013 EEM and Hensher and Rose's studies respectively for car work travel, and 39% and 33% respectively for car non-work travel.

Table 31: Calculation of the value of time in congested conditions ($June 2015)

Vehicle type	$VOT_{stop-start} - VOT_{overall}$
Car	$5.30
LCV	$4.04
HCV	$4.04

Source: PwC based on Hensher and Rose (2004, 2005, 2006 and 2008)

The data and parameters used in the valuation of time saving benefits are shown in Table 32.

Table 32: Estimation of travel time benefits from reduced traffic congestion

Element	Input
Data	**Travel time saving hours** (project case versus base case) from the demand model, broken down into: • User types – car, light commercial vehicles and heavy commercial periods
Parameters	Unit **value of congested travel time (VoCT)** (values below are in June 2015 dollars, using ABS's Victorian Wage Price Index): • car = **$5.30/hr** • light commercial vehicles = **$4.04/hr** • heavy commercial vehicles = **$4.04/hr**
Calculation (simplified[88])	$Congested\ time\ saving\ benefit = \sum_{user\ type} Congested\ time\ saving_{user\ type} * VoCT_{user\ type}$ These congested travel time savings are calculated for each of the vehicle types and then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.

Source: PwC

7.2.3 Travel time benefits from improved trip reliability

Reliability can be defined as *unpredictable* or random variation in journey times. This covers variability in the degree of congestion during the same period each day (e.g. random variability) and incidents. This definition excludes predictable variation associated with regular peaks in demand during particular the times of day, days of week, and seasons (e.g. school holidays) which travellers are assumed to be able to predict.[89]

The Project is expected to result in reliability benefits particularly in the outer western and inner western suburbs for project users (see Figure 19). For example, instead of the same morning commute taking 14 minutes one morning and 25 the next, the Project will reduce the allowance for travel time variability from 26

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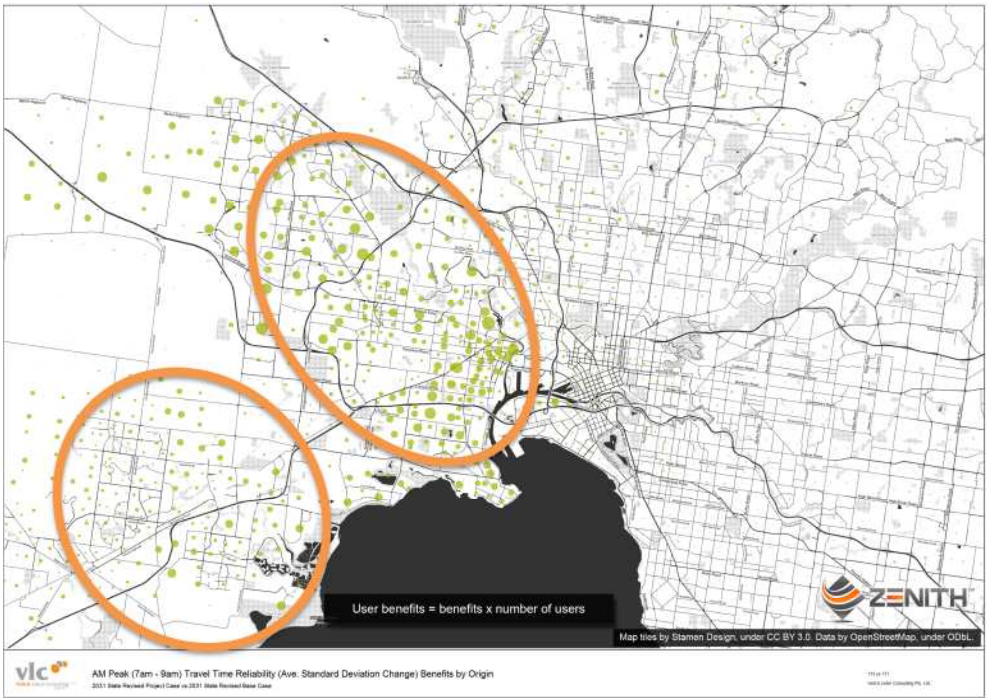
[88] Two major extensions were applied in practice: (1) the use of the rule of half for time savings for new and lost users; (2) for public transport users, 'time savings' are actually 'generalised travel cost' (GTC) savings. GTC measures the perceived cost of travel, including higher perceived costs of a minute of travel time spent waiting at bus or tram stops compared with a minute spent in vehicle.

[89] UK Department for Transport, *The Reliability Sub-Objective*, TAG Unit 3.5.7, April 2009

minutes to 15 minutes – an 11 minute saving from improved travel time reliability.[90]

Figure 19: Reliability Benefit Hours – Car, AM Peak (7am - 9am), (2030/31 project case vs 2030/31 base case)



Source: VLC

The UK DfT TAG[91] suggests that calculation of changes in travel time reliability be net of the effects that are attributable to prediction variation. It is reasonable to expect travellers to be aware of the average journey time, including variations caused by factors such as traffic conditions. Hence, the reliability benefits should be estimated in addition to the average travel time savings.

The two components required to estimate reliability benefits of a transport intervention are:

- Impacts (relationship between project and reliability outcome for travellers)
- Valuations (monetary valuations of incremental improvements to reliability).

Calculation approach

The approach to measuring reliability impacts on highways in urban areas as suggested by the UK Department for Transport (DfT) has been applied to estimating reliability benefits for Project within the VLC Zenith model. The UK approach links reliability to a ‘congestion index’ (CI): the ratio between modelled average (or equilibrium) travel time and free flow travel time.

$$CI_{ij} = \frac{t_{ij}}{T_{ij}}$$

[90] GHD and Veitch Lister Consulting, 2015.

[91] UK Department for Transport, *The Reliability Sub-Objective*, TAG Unit 3.5.7, April 2009

where t_{ij} is the actual forecast travel time between areas i and j, and T_{ij} is the free flow travel time between areas i and j. The transport model produces estimates of equilibrium travel time and free flow travel time for both the base case and project case between each of the travel zones.

Reliability is then measured by the coefficient of variation (CV): the standard deviation of travel time to the average travel time. The relationship links the CV as a function of distance and the CI:

$$CV_{ij} = \propto \ CI_{ij}^{\beta} \, d_{ij}^{\delta}$$

where d_{ij} is the distance between areas i and j, α is a scaling factor (estimated at 0.16), β is a coefficient (estimated at 1.02) and δ is another coefficient (estimated at -0.39).[92]

Multiplying CV by the average travel time between the relevant zones gives an estimate of the standard deviation of travel time (reliability) with both the base case and project case. Lower travel times with the project are associated with reductions in the standard deviation of average journey times.

$$Average\ standard\ deviation\ change\ (hrs) \quad = \sum_{i,j} Trips_{ij} * \Delta(\, t_{ij} * \ CV_{ij})$$

$$= \sum_{i,j} Trips_{ij} * \Delta(\, t_{ij} * \ 0.16 \left(\frac{t_{ij}}{T_{ij}}\right)^{1.02} \ d_{ij}^{-0.39})$$

where $Trips_{ij}$ is the number of trips between areas i and j.

Approach to monetise

Valuation of the change in reliability is via the 'reliability ratio', i.e. the value of a saved hour of *standard deviation* of travel time relative to the value of a saved hour of *average* travel time. Hyder suggests a value of 0.8 for light vehicles and 1.2 for heavy vehicles.[93] The data and parameters used in the calculation of reliability benefits are shown Table 33 .

[92] Hyder Consulting, Black, I. and Fearon, J. 2008, "Forecasting Travel Time Variability in Urban Areas," Deliverable 2: Model Application cited in AECOM *WestLink Planning and Consultation Study Economic Assessment Technical Report*, 2011, Appendix A

[93] Cited in AECOM *WestLink Planning and Consultation Study Economic Assessment Technical Report*, 2011, Appendix A

Table 33: Estimation of savings in travel time variability costs (reliability benefits)

Element	Input
Data	Average **standard deviation reduction** (project versus base case) from the demand model and subsequent calculations, broken down into: • Time periods – AM Peak, PM Peak, Inter-Peak and Off-Peak • Origins and destinations – all modelled O-D pairs **Trip numbers** from the demand model, broken down into: • User types – heavy vehicles, light commercial vehicles, car (business) and car (non-business) • Origins and destinations – all modelled O-D pairs
Parameters	Unit **value of travel time savings** (VOTT) (values below are in June 2015 dollars, using ABS's Victorian Wage Price Index). Transport and Infrastructure Council 2015 NGTSM urban values are broken down into user types, with LCV HCV values weighted to reflect Melbourne 2015 vehicle composition on the West Gate Freeway. • car (business) = **$51.26/hr** (resource cost of employee time) • car (non-business) = **$15.65/hr** (willingness to pay for leisure time) • light commercial vehicles = **$35.96/hr** (wage + freight) • heavy commercial vehicles = **$76.59/hr** (wage + freight) • Public transport value of travel time = **$16.34/hr** (willingness to pay for leisure time). Reliability ratio by: • User types – heavy commercial vehicles = **1.2** – light commercial vehicles = **1.2** – car (business) = **1.2** – car (non-business) = **0.8**
Calculation	$Reliability\ benefit = Avg.st.deviation\ reduction\ (hours)_u x\ Reliability\ ratio_u x\ VOTT_u$ This calculation applies the rule of half to new users and was performed across all vehicle and user types (u) and all travel zones in the transport model. These reliability benefits are calculated for each of the modelled time periods and are then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.

Source: PwC

7.2.4 Vehicle operating cost savings

In urban conditions such as in inner Melbourne, an improvement in average road travel speeds will be associated with lower vehicle operating costs (VOC) per kilometre for users. In addition, a change in road type or kilometres travelled may also influence the total VOC associated with the Project relative to the base case.

Total VOCs are comprised of:

- Basic running costs (fixed and operational) of the vehicle, such as depreciation, fuel, repairs and maintenance;
- Additional running costs due to road surface and gradient;
- Additional running costs due to any significant speed fluctuations from free flow speed; and

- Additional fuel costs due to stopping, such as queuing at traffic signals.[94]
- It is estimated that by 2030/31 commercial vehicles across Melbourne would save $35 million per year ($June 2015, undiscounted) as a result of vehicle operating cost savings.

Calculation approach

The 2015 NGTSM provide VOC equations to estimate the resource costs associated with travel for 20 vehicle classes (consistent with Austroads vehicle classifications) and for road types (freeway (>60 km/hr) and urban/suburban arterial roads (<60 km/hr).[95] The equations are based on stop-start and free-flow models and relate average cost per kilometre travelled by a vehicle to the average all day speed on the road.

Stop-start model (for urban arterial): $c=A + B/V$

Free-flow model (for freeways): $c=C_0+C_1V+C_2V^2$

where, c= vehicle operating cost (cents/km), A,B ,C_0,C_1, C_2 = model coefficients, and V= average speed in km/hr.

The stop-start and freeway model parameters applied by VLC are shown in Table 34 (noting that 2015 traffic counts on the West Gate Freeway were used to aggregate 20 vehicle classes to car, light and heavy commercial vehicles).

Table 34: VOC parameters (cents/km, June 2015 dollars)

	Stop – Start Model		Free Flow Model		
Vehicle Type	A	B	Co	C1	C2
Car	12.786	903.155	27.228	-0.132	0.001
LCV	46.169	2,234.570	69.951	-0.413	0.004
HCV	103.119	3,746.294	127.668	-0.710	0.007

Note: Escalated from June 2013 to June 2015 dollars based on ABS Melbourne Consumer Price Index (cars) and Victorian Producer Price Index – Road Freight (commercial vehicles)
Source: Transport and Infrastructure Council, 2015 NGTSM.

The transport model provides estimates of the average speed on different road types in the study area for four vehicle classes (car, light commercial vehicle, heavy commercial vehicle and bus) with and without the project.

Results from the VLC traffic model (road speeds and vehicle kilometres by vehicle type) are combined with the VOC equations with the VLC Zenith model to estimate the VOC in the option and base cases.[96] The change in VOC between the base case and option scenarios determines VOC savings associated with the option.

Approach to monetise

The underlying calculations were undertaken in the demand model across all vehicle and all road types. Estimated VOC values were inflated to June 2015 dollars using ABS Melbourne Consumer Price Index (cars) and Victorian Producer Price Index - Road Freight (commercial vehicles). The benefits were calculated for each

94 RTA, *Economic Appraisal Manual, Version 2, Appendix B – Economic Parameters for 2007*, pp 4-8.

95 Transport and Infrastructure Council, *2015 National Guidelines for Transport System Management in Australia*, p 31-32.

96 These equations are represented directly within VLC's model.

of the modelled time periods and then scaled to annual values using the annualisation factor to reach an annual value for the forecast year. Table 35 outlines the data, parameters and calculations to estimate the VOC savings.

Table 35: Estimation of vehicle operating cost savings

Element	Input
Data	**Average road speeds** from the demand model, broken down into: • Time periods – AM Peak, PM Peak, Inter-Peak and Off-Peak • Road links – all modelled links • The project case and base case
Parameters	**Vehicle operating cost equations**: • Stop-start model (for urban arterial): c=A + B/V • Free-flow model (for freeways): $c=C_0+C_1V+C_2V^2$ • where, c= vehicle operating cost (cents/km), A,B ,C_0,C_1, C_2 = model coefficients, and V= average speed in km/hr. broken down by: • User types – Car, light commercial vehicle and heavy vehicles • Model – stop-start and free-flow.
Calculation	$Vehicle\ operating\ benefit = Network\ VOC_{without\ project} - Network\ VOC_{project\ case}$ The underlying calculations were undertaken in the demand model across all vehicle and all road types. Estimated VOC values were inflated to June 2015 dollars using ABS Melbourne Consumer Price Index (cars) and Victorian Producer Price Index - Road Freight (commercial vehicles). The benefits were calculated for each of the modelled time periods and then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.

Source: PwC

7.2.5 High productivity freight vehicle user benefits

The Project will improve freight efficiency, particularly through the construction of a new, high productivity freight vehicle (HPFV) compliant freeway link to the Port of Melbourne following planned Victorian Government investment to strengthen bridges under the Australian Government's Bridges Renewal Programme (BRP) and National Highway Upgrade Program (NHUP).[97]

Figure 20 shows that, following these proposed bridge strengthening projects, there would be a 'HPFV compliant' network that will allow HPFVs to be utilised across key freight routes around the state. However, the upgrades planned under the NHUP do not include the final connection to the port. To fully utilise the enhanced road network and maximise the adoption of the HPFVs, a HPFV compliant link to the Port of Melbourne is essential.

For the purposes of economic appraisal, benefits from the conversion of articulated trucks and B-Doubles to HPFVs (e.g. A B Combination, A-Triple and D-Double) have been estimated, reflecting that HPFVs have higher load capacity and can therefore service the same freight task with fewer trips (resulting in avoided vehicle operating costs, accidents and environmental externalities).

[97] Department of Economic Development, Jobs, Transport and Resources (VicRoads), 2015, Strong Bridges, a Strong Economy, version 1.4, 27th January 2015

Figure 20: Proposed bridge strengthening for high productivity freight vehicles

Source: VicRoads, 2015.

Advisian estimates that between 2,000 and 3,100 HPFVs could be using the West Gate Freeway per day in 2045/46 and the median of 2,550 has been adopted in the CBA.[98]

Avoided Articulated 6 axle and B Double trips have been estimated based on vehicle composition and load factor assumptions provided by VicRoads. The change in vehicle kilometres travelled has been estimated based on an Advisian estimate of a 29 km weighted average distance to freight generating precincts. Base travel times have been estimated based on an assumed average of 80km/hour for travel on freeways.

The change in base travel times by vehicle type between the base case and project case are applied to the driver wage component of the base value of travel time (see section 7.2.1) to estimate cost savings from avoided trips. No change in speed has been assumed between the Base and project case to avoid double counting of base travel time benefits estimated within the VLC Zenith model. The change in VKTs by vehicle type between the base case and project case are also applied to unit cost parameters to estimate vehicle operating cost savings (see section 7.2.4), crash cost savings (7.4.1) and environmental externality cost savings (see section 7.4) over and above those based on Zenith outputs.

7.3 Resource cost corrections

The perspective of CBA requires that careful account must be made for actual resources expended and produced. In many cases, private perceptions and valuations of resource flows are the most appropriate method for achieving this accounting and valuation. However, there are several cases where private participants do not adequately perceive actual resource flows with and without the project. A range of resource corrections are therefore required to adjust standard measures of resource savings due to a misalignment of *user perceptions* versus *actual resource* use.

In a fixed matrix road-only CBA, benefits are well represented by changes in resource costs and perceived user costs. Social welfare changes to the extent that with the project (compared to the base case) there is a change in user perceived costs (time and vehicle operating costs) and unperceived costs on the community (unperceived vehicle operating costs and 'external' impacts such as air pollution). Any changes to financial outlays net out between parties (e.g. increased toll revenues are perceived by users spending and equally by toll road operators receiving). No resource corrections are required.

In multi-modal situations, mode or destination switchers create some challenges for appraisal that require treatment through resource corrections. In a multi-modal transport demand model, travel choices are modelled based on users' generalised travel costs. Generalised travel costs capture perceived monetary costs (road tolls and public transport fares) and other perceived costs (travel time, dislike of transfers between public transport services, etc.) in the same measure.

A number of corrections are applied in this CBA to avoid double counting (or under counting) of resource costs and costs perceived by users. These improve the estimates of benefits to switchers than simply benchmarking to the time savings of existing users.

98 Advisian, HPFVs on West Gate Freeway and Average Travel Distance, September 2015.

7.3.1 Transport user benefit corrections

People who switch destination or mode do so because they perceive they will receive higher satisfaction from doing so. In estimating the benefits to the user from making this decision, the analyst does not have full information about how much extra satisfaction is achieved. This is overcome by estimating time savings achieved by 'existing' users and the application of the rule of a half to each switcher. However, this understates the information available to estimate the welfare gain by users when they switch; other components of their generalised costs should also be incorporated. A resource correction is therefore applied by estimating the change in *perceived* tolls paid plus the change in *perceived* vehicle operating costs for a given trip with and without the project.

Calculation approach

For each new car trip travelling between origin A and origin C, there is an additional benefit of:

$$Extra\ user\ benefit\ per\ new\ trip\ (AC) = \frac{\Delta perceived\ toll_{AC} + \Delta perceived\ VOC_{AC}}{2}$$

Where Δ *perceived* $toll_{AC}$ is the decrease in the perceived toll faced by continuing users travelling between A and C in the Project compared with the base case; Δ *perceived* VOC_{AC} is the decrease in VOCs. This adjustment applies only to switchers and only to the perceived components of these new users' trips, the rule of a half also applies.[99] In the tolled option case, the first component is a dis-benefit as people switching destination to take advantage of the improved accessibility of destinations served by the Project would likely compare this case with the base case which would have accessed that destination without paying a toll; conversely the VOC adjustment is a positive as the improved road grade lowers VOCs of accessing a given destination.

Approach to monetise

Transport user benefit corrections are calculated within the VLC Zenith model for an average weekday for each of the forecast years and monetised in the CBA by applying an annualisation factor and inflating to $ June 2015 using ABS Melbourne CPI.

7.3.2 Revenue transfer payment corrections

Two further corrections are required in the CBA to account for the actual flow of resources relative to user perceptions already represented elsewhere: operator revenue and vehicle operating costs.

The increase in transport operator revenues stemming from users is ordinarily considered a monetary transfer payment between users and the operator to reflect the resources required to provide the transport services, and hence excluded from CBA. However, from the user's perspective, tolls and fares are perceived in generalised travel costs when choosing between modes and destinations.[100] As the

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[99] A corresponding 'lost' user correction also applies which has the analogous extra benefit for each user who no longer travels between A and B because they now travel between A and C.

[100] For example, a project that lowers bus travel times yields direct benefits in generalised travel costs for existing bus users. Importantly, when the project encourages people to choose to catch a bus instead of driving as previously (i.e. new bus users), it is because in the project case their generalised travel cost is lower by bus than car, even accounting for the travel time and fares. The rule of a half relies on being able to measure the net change in generalised cost from existing bus users as an upper bound estimate of the generalised cost improvement experienced by new bus users. Although the measurement of these existing user benefits is usually based on travel time savings and may not explicitly look at fare component, when new bus user benefits are estimated, the

perceived resources are already accounted for (through perceived journey costs in section 7.2.1), there is a need to reflect this additional revenue as a resource correction for the mode and destination switchers.

Calculation approach

The *perceived* component of forecast toll revenue attributable to new users is included as a transfer payment correction as a 'benefit' line item in the CBA. This is because the resources required to provide the road are also captured in the capital and operating costs and these costs are perceived by users in choosing between tolled/untolled roads.[101] Likewise, forecast changes in public transport fare revenue attributable to switching users will be included in CBA as a transfer payment correction.[102]

Approach to monetise

Revenue payment transfer corrections are calculated within the VLC Zenith model for an average weekday for each of the forecast years, and monetised in the CBA by applying an annualisation factor and inflating to $ June 2015 using ABS Melbourne CPI.

7.3.3 Switcher VOC correction

The increase in resources expended by all travellers is captured in estimates of network VOC benefits in section 7.2.4. However, for mode and destination switchers on the road network, the perceived resources required for their trip are already indirectly accounted for as part of the estimation of user benefits in section 7.2. An adjustment is therefore required to the network VOC line item to reverse out the extra VOCs added to the network by these switchers.

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calculated change in generalised trip costs embodies the fare component as the total generalised cost is what is weighed up in the mode choice.

[101] Godinho, P and Dias J, 2011, "Fuel taxes and tolls in cost-benefit analysis," *Economics Bulletin*, Vol. 31, no. 2, pp. 1372-1378. In practice, not all toll costs are perceived by users (especially under e-tag charging). Only the perceived component can be considered to already be captured in the existing measure of consumer surplus in section 7.2.

[102] This is supported by guidelines in Australia; while fares are perceived by transport users, the premise behind their inclusion is that '[a]ll additional public transport users have to pay a fare, which is part of their perceived costs in making their mode choice decision. However, as the resource cost of providing public transport (both capital and operating) is included elsewhere in an economic appraisal…, fares are a transfer payment. Accordingly, it is necessary to add fares back in, as a component of the benefits, to derive the net resource benefit' (ATC, National Guidelines for Transport System Management in Australia, 2006, pp 22, 31).

7.4 Externalities

Improving connectivity between the west and the rest of the city will translate into an improved quality of life for those living in the west, through improved amenity (e.g. reduced noise, crashes and pollution). It will provide the foundation for a more equitable Melbourne, not only in relation to economic opportunities but also in greater liveability across all parts of the city.

A substantial reduction in the number of heavy vehicles moving through residential areas will make communities safer and healthier, as well making it easier to travel along local streets and around local neighbourhoods. Environmental benefits, such as reduced noise pollution, will increase community wellbeing and make the inner west a more appealing prospect for urban renewal and residential development.

For example, by 2030/31, it is estimated that as a result of the Project:

- up to 55 serious crashes per year would be avoided
- air pollution would be reduced by 2.3 million tonnes a year
- trucks along Francis Street and Somerville Road in Yarraville will reduce 50-75%, with a 28% reduction in trucks more broadly across inner west roads.
- cycling will be further encouraged with the completion of the main cycling route, the Federation Trail, which is already used by more than 6,000 cyclists in the west, along with greater connectivity of other shared pathways.[103]

7.4.1 Crash cost savings

Crash costs for the base case and the project case are forecast in the VLC Zenith model using crash rates and vehicle trip numbers. The model estimates the number of casualty crashes on each road type (freeway, other divided roads, undivided major roads, other roads). Estimates of the number of crashes are applied to average crash costs by road type in three severity categories: fatal, serious injury and other injury.

An improvement in the road network through the project is likely to have two partially offsetting effects on crash numbers and severity:

- improvements for all existing transport users due to improved speeds and road quality.
- worsening due to additional road travel associated with mode and destination switchers.

Calculation approach

The valuation of crash cost reductions was undertaken by applying VLC forecast VKTs by road type (freeway, other divided, undivided and local) to VicRoads crash rates by speed limit and Victorian crash cost estimates from the Transport and Infrastructure Council 2015 NGTSM[104] that value a single fatal, serious injury other injury crash.

Crash cost assumptions use the 'inclusive willingness to pay' approach which reflects that the cost of an injury or fatality is greater than simply the foregone

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[103] PwC, GHD and Veitch Lister Consulting, 2015.

[104] Transport and Infrastructure Council, 2015, "National Guidelines for Transport System Management in Australia – Road Parameter Values", p.24, p. 28-89.

productivity of individuals involved in road crashes and associated the property damage and response costs. Costs by crash severity have been weighted by the distribution of casualty crashes by severity at different speed limits across Metropolitan Melbourne over the period 2006 to 2012 to develop estimates of crash costs by road type.

Approach to monetise

Crash cost savings are calculated within the VLC Zenith model for an average weekday for each of the forecast years, and monetised in the CBA by applying an annualisation factor and inflating to $ June 2015 using ABS Victorian WPI. The data and parameters used in the calculation of crash cost savings are shown in Table 36.

Table 36: Estimation of crash cost savings

<table>
<tr><th>Element</th><th>Input</th></tr>
<tr><td>Data</td><td>Estimated crash costs from the demand model, broken down by:
Time periods – AM Peak, PM Peak, Inter-Peak and Off-Peak
Road types – all modelled links
Option and base cases</td></tr>
<tr><td>Parameters</td><td>VLC have applied Victorian crash values within the model that relate:
link road types to crash frequencies per 100 million kilometres travelled
<table>
<tr><th>Road Type</th><th>Casualty crash rate (accidents/10^8 VKT)</th><th>Casualty crash costs ($June 2015/crash)</th></tr>
<tr><td>Freeway</td><td>6.9</td><td>617,816</td></tr>
<tr><td>Other divided</td><td>21.3</td><td>439,088</td></tr>
<tr><td>Undivided major</td><td>27.4</td><td>389,957</td></tr>
<tr><td>Local</td><td>30.8</td><td>347,632</td></tr>
</table>
Source: VicRoads crash rates, updated in 2010 based on VicRoads (1996), "Accident Analysis by Road Profile Study, Operational Report", January 1996 Table 3.1; VicRoads 2013 Road Crash Information System, Metropolitan Melbourne Casualty Crashes by Speed Limit, All Road Types, 2006 to 2012; Transport and Infrastructure Council 2015 National Guidelines for Transport System Management in Australia, Table 4.8: Estimation of Crash Costs by Injury Severity, Inclusive Willingness to Pay Values; prices escalated to June 2015 dollars based on Victorian Wage Price Index.</td></tr>
<tr><td>Calculation</td><td>$$Crash\ cost\ saving = \sum_{severity} unit\ cost_{severity} * (crashes_{severity}^{base} - crashes_{severity}^{option})$$
The savings in crash costs will be aggregated against the available crash severity categories across all travel zones in the transport model. Unit crash costs are inflated to June 2015 dollars using ABS Victorian WPI. The benefits are calculated for each of the modelled time periods and are then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.</td></tr>
</table>

Source: VLC and PwC

7.4.2 Environmental and other externality cost savings

The Project is expected to improve urban amenity by diverting heavy traffic to the freeway. Urban amenity impacts are measured between the base case and project case as improvements in:

- Urban separation costs
- Nature and landscape costs
- Noise costs.

A change in vehicle kilometres travelled (VKT) between the base case and options will also have a range of non-amenity-related environmental impacts on the community. These include:

- Greenhouse/climate change
- Air pollution (carbon monoxide, oxides of nitrogen, particulate matter and hydrocarbons)
- Water pollution.

Calculation approach

The demand model is able to directly estimate the magnitude of some of these environmental externalities directly from traffic flow characteristics. For example, greenhouse gas emissions are proportional to the amount of fuel burnt. If traffic speeds increase in the project case, then the amount of fuel burnt to undertake a given trip is likely to decline, reducing the amount of carbon dioxide released.

To capture urban amenity and other environmental externality impacts, this CBA distinguishes between trips undertaken on a surface arterial road (where urban impacts will be prevalent) and those undertaken on a tunnel freeway (where urban impacts are negligible). For instance, local residents will experience noise pollution from car trips on nearby surface arterial roads, but not on similarly proximate tunnel freeways. Vehicle travel in tunnels is consequently allocated zero cost in terms of amenity impacts, while impacts on surface roads are valued at the relevant Austroads unit rate (Table 37).

The local amenity costs of vehicle traffic used in this CBA are based on the default parameters presented in the Austroads 2012 Guide to Project Evaluation.[105] However, the ATC notes that such parameters are default average national valuations of impacts.[106] In an area with high population density, such as inner Melbourne, it is likely that valuations of impacts such as noise impacts would be greater than estimated under the default parameters. However, the relatively small change in traffic associated with the Project mean that the cost of estimating location-specific valuations is unlikely to be warranted.

Approach to monetise

The value of benefits or dis-benefits is therefore estimated based on monetary unit values – either per unit of impact (e.g. tonne of carbon dioxide) or per VKT. In the case of impacts where values are applied to changes in VKTs, these are estimated by vehicle type.

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105 Austroads, *Guide to Project Evaluation: Part 4 Project Evaluation Data*, 2012, p. 27-35

106 Australian Transport Council (ATC), *National Guidelines for Transport System Management in Australia*, 2006, vol. 3, p. 73

Emission cost savings (carbon monoxide, oxides of nitrogen, particulate matter and hydrocarbons) are calculated within the VLC Zenith model for an average weekday for each of the forecast years, and monetised in the CBA by applying an annualisation factor and inflating to $June 2015 using ABS Melbourne CPI.

Other environmental externality (water pollution) and amenity cost savings (noise, nature and landscape and urban separation) are monetised by applying Austroads 2012 Guide to Project Evaluation externality parameters ($/VKT) by vehicle type to VLC forecast changes in tunnel and surface VKTs between the base and project case.

The data and parameters used in the calculation of environmental and other externality benefits are shown in Table 37.

Table 37: Estimation of environmental and other externality cost savings

Element	Input
Data	**Vehicle kilometres travelled** (VKT) from the VLC demand model, broken down by: • Time periods – AM Peak, PM Peak, Inter-Peak and Off-Peak • Road types – surface and tunnel • Vehicle type – car, light commercial vehicle and heavy vehicle • Option case and base case In-model estimates of **emissions and their valuation** in dollars, broken down by: • Road types – surface and tunnel • Option case and base case
Parameters	Unit **valuation of environmental cost** per VKT ($/km), the 2011/12 dollar values from Austroads (2012) were inflated to June 2015 values using the ABS Consumer Price Index: (see table below)

Model Inputs ($June 2015)	Car ($/km)		LCV ($/kn
	Surface	Tunnel	Surface
Noise	0.01	0.00	0.01
Water	0.005	0.005	0.01
Nature and landscape	0.001	0.00	0.01
Urban separation	0.01	0.01	0.01
Total	**0.02**	**0.0005**	**0.04**

Note: Totals may not sum due to rounding
Source: 2012 Austroads 2012 Guide to Project Evaluation

For those impacts measured in **physical quantities**, valuations were undertaken in the transport model using the unit values in Table 5.4 of Austroads (2012). The June 2010 values in Austroads (2012) were inflated to June 2015 dollars based on Melbourne CPI as presented below:

- air pollution (surface roads) = carbon monoxide (**$3.87/tonne**), oxides of nitrogen (**$2,448/tonne**), particulate matter (**$389,575/tonne**), hydrocarbons (**$1,097/tonne**)
- air pollution (tunnels) = carbon monoxide (**$0/tonne**), oxides of nitrogen (**$0/tonne**), particulate matter (**$0/tonne**), hydrocarbons (**$0/tonne**)
- greenhouse (surface and tunnels) = carbon dioxide equivalent (**$61.38/tonne**)

Element	Input
Calculation	$Environmental\ saving = \sum_{r,v,I}^{all\ types} \$/km_{r,v,I} * (VKT_{r,v}^{base} - VKT_{r,v}^{option}) + \sum_{r,v,I}^{all\ types} \$/tonne_{r,v,I} * (tonne_{r,v,I}^{base} - tonne_{r,v,I}^{option})$ The environmental cost saving is calculated by aggregating benefits across road types (r), vehicle types (v) and impacts (I). The benefits are calculated for each of the modelled time periods and are then scaled to annual values using the annualisation factor to reach an annual value for the forecast year.

Source: PwC

7.5 Greater resilience and redundancy

The M1 (Princes Freeway–West Gate–CityLink–Monash) freeway corridor, the M2 (CityLink-Tullamarine) freeway corridor and the equivalent rail corridors are Melbourne's most important transport connections, underpinning Melbourne's economy.

Building the Western Distributor will create an alternative river crossing and improve the resilience of the city's transport network.

On the West Gate Bridge in 2014 there were more than 750 vehicle breakdowns/incidents, 70 property damage collisions and 14 casualty crashes. Even minor incidents can take around 10 minutes to respond to and 15 minutes to clear while casualty crashes could result in two or more lanes being closed for between 2 to 6 hours.[107]

Incidents on the West Gate Bridge can significantly impair the ability for freight and passenger vehicles to traverse the city. By providing an alternative to the West Gate Bridge, the Project will deliver benefits when and if such events occur. It is estimated that by 2030/31, the Project will:

- Free up capacity on the West Gate Bridge by taking up to 22,000 vehicles off it (including 4,000-6,000 trucks a day)
- Enable 50,000-70,000 trips per day to bypass congestion and incidents on the West Gate Bridge
- Result in up to 50 fewer incidents per year.[108]

These benefits are estimated in a probabilistic framework similar to that applied in the 2009 Westlink appraisal.[109] This methodology draws from the 2009 study and extends it by applying a more realistic demand response to long term inoperability of parts of the corridor.

[107] VicRoads 2014 Road Crash Information System Data for the West Gate Bridge.

[108] PwC, GHD and Veitch Lister Consulting, 2015.

[109] Ernst & Young, '*Supporting economic analysis to Victoria's submission to Infrastructure Australia,*' October 2009

Calculation approach

Benefits are realised probabilistically under two types of inoperability: short term lane closures and longer term full closures of the West Gate Bridge:

- For short term partial unavailability of the corridor, e.g. from a casualty, breakdown or debris resulting in lane closures, travellers are assumed to travel to their usual destinations, by their usual modes. Motorists would experience delays for the extent of the incident owing to the reduced capacity of the bridge.
- For longer term unavailability events, e.g. structural problems with the bridge, motorists would face significantly greater inconvenience but would have more scope to alter their travel patterns than in the short-term case. In this analysis it is assumed that travellers will be able to change their modes, but not their origins, destinations or number of daily trips (though it is acknowledged that these responses will occur to some extent).

The framework for analysis is:

- **Outcome – what are the traffic and welfare impacts from the unavailability of a bridge?** These will be estimated using runs of the demand models with two or all lanes on the West Gate Bridge removed in one direction, both from the base case (no Western Distributor project) and with the project in place. Longer travel times and associated environmental effects are expected in the base case.
- **Probability – what is the likelihood in a given year of having a two lane or full bridge closure?** For short term lane closures, the likelihood was informed by Victorian Road Crash Information System (RCIS) data on casualty crashes on the West Gate Bridge in 2014 (3 serious injury and 11 injury crashes per year) and VicRoads 2014/15 data on the number of collisions (73), breakdowns (513), debris (186) and other incidents (171). Injury crashes and vehicle collisions/breakdowns have been included, while more transitory incidents such as debris have been excluded (average VicRoads response and clearing time of nearly 30 minutes). Every 5 years there is assumed to be a full closure of the West Gate Bridge for half a day for more serious incidents such as chemical or fuel spills.[110] For the long-term closures, a single annual probability of 0.1% is applied based on previous studies.[111] The probability functions are assumed to act independently.
- **Duration – if the bridge is closed in a given year (or on a given day), how long is it closed?** For the short term closures, the average duration of closure is assumed to range from 1 hour/1 lane for minor incidents to 6 hours/2 lanes for a serious injury crash (Table 38); full closures of the West Gate Bridge are assumed to occur for half a day; for the long term closures, the average closure is assumed to be 2 years.
- **Economic benefit** – on average, what is the value of the improved outcomes when the Project is in place? The benefits are calculated in terms of outcomes (with and without the Project) under the state of the world where closures occur. Other benefits in the economic appraisal are similarly weighted to reflect the probability of the West Gate Bridge being open to avoid double counting of benefits.

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[110] See, for example, The Australian, '*West Gate Bridge re-opens after acid spill this morning*', July 31 2015.

[111] Ernst & Young, '*Supporting economic analysis to Victoria's submission to Infrastructure Australia,*' October 2009

Approach to monetise

All benefits are monetised as per the methodologies outlined above (ie for travel time savings, travel time benefits for improved congestion, vehicle operating cost savings, resource cost correction crash cost savings and environmental externalities) based on VLC Zenith outputs assuming either a two lane closure or full closure of the West Gate Bridge.

The data and parameters used in the calculation of such 'redundancy' benefits are shown in Table 38, noting that redundancy benefits have been estimated for the Western Distributor Road Link only (i.e. excluding the impacts of the Monash Freeway Upgrade) and are likely to be understated.

Table 38: Estimation of 'redundancy' benefits for the Project

<table>
<tr><th>Element</th><th>Input</th></tr>
<tr><td>Data</td><td>Outcomes are the conventional benefits with a closure of a component of the West Gate Freeway, with and without the Western Distributor Road Link:

savings in average travel time costs, savings in travel time variability costs, savings in vehicle operating costs, savings in crash costs, savings in environmental costs, and avoided loss of agglomeration economies
for short term closures, benefits will be estimated based only on route choice reassignment, with a daily benefit estimated
for long term closures, benefits will be estimated based on route choice and mode choice reassignment, with a daily benefit estimated
</td></tr>
<tr><td>Parameters</td><td>Probability of closure:

West Gate Bridge lane closure probability of 6 per cent per year (2 lanes) – this is based on VicRoads Road Crash Information System, West Gate Bridge 2014; VicRoads Incident Rate, West Gate Bridge 2014/15; and VicRoads advice on average response and clearing times for freeway incidents. Short term closures are assumed to happen independent of one another.
<table>
<tr><th>Incident type</th><th>Frequency/year</th><th>Avg. lane closure</th><th>Average duration</th></tr>
<tr><td>Fatality</td><td>0</td><td>Full bridge closure (5 lanes)</td><td>6 hours</td></tr>
<tr><td>Serious injury</td><td>3</td><td>2 lanes</td><td>6 hours</td></tr>
<tr><td>Other injury</td><td>11</td><td>2 lanes</td><td>2 hours</td></tr>
<tr><td>Property damage collisions</td><td>73</td><td>2 lane</td><td>2 hours</td></tr>
<tr><td>Break downs – cars, trucks and buses</td><td>513</td><td>1 lane</td><td>1 hour</td></tr>
</table>
Source: VicRoads Road Crash Information System, West Gate Bridge 2014; VicRoads Incident Rate, West Gate Bridge 2014/15; VicRoads advice on average response and clearing times for freeway incidents.
West Gate Bridge full closure probability of 0.2 per cent per year (5 lanes) assuming a half day closure every 5 years and a 0.1% probability of a long term (2 year) closure.
</td></tr>
</table>

Element	Input
Calculation	The Road Link benefits in the 'closure' states of the world are combined with the core benefits (obtained in the state of the world where the West Gate Freeway operates without closures) using an adjustment to the annualisation factor. For example, for a West Gate Freeway closure from property damage collisions that occurs for 2 hours 73 times a year, the closure states of the world occur, on average, for a total of 6 days of the year. As such, under just short term closures, with an annualisation factor of 330, the daily core benefits are multiplied by 324 (= 330 – 6), while the daily benefits of the Western Distributor during a two lane closure apply for 6 days per year.

Source: PwC

7.6 Residual value of assets

Residual values are recognised in the last year of the evaluation period to represent the unused portion of assets that have lives greater than the evaluation period.

Calculation approach

When applying current Victorian practice, straight-line depreciation is used. Current Victorian Government guidance requires residual value to be calculated on the lower of either a straight-line depreciation or future benefits approach. Infrastructure Australia supports either approach, and the residual value has been estimated based on the future stream of net benefits approach.

Monetisation approach

The ATC 2006 NGTSM[112] provide some indicative asset lives that are used to estimate the residual value based on the straight line depreciation approach. For example, road pavement has an assumed economic life of 50 years, while tunnels and viaducts have an assumed 100 year life. These have been applied to capital cost estimates by asset type from Advisian.

The future stream of net benefits approach consistent with IA December 2013 RIF extrapolates costs and benefits from 2051/52 to 2071/72 reflecting the weighted average design life / useful life of the project assets.

7.7 Wider economic benefits

Wider economic benefits (WEBs) help in measuring the impacts on Melbourne's economic growth that are not captured elsewhere in the CBA. The four specific WEBs are:

- **Agglomeration** benefits, which relate to the positive externality (benefit) that firms experience when locating their commercial activities close together. Firms and workers often cluster: hence the existence of cities, financial districts, business parks and technology corridors. This clustering occurs despite the higher land rents and labour costs in these areas. This clustering is driven by the improved knowledge sharing and access to suppliers and labour markets that come with higher densities of activity.[113] The level of agglomeration is influenced by a transport initiative because improved transport links effectively brings firms closer together and by increasing overall employment accessibility, further increasing the density of the cluster.

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[112] Australian Transport Council (ATC), *National Guidelines for Transport System Management in Australia*, 2006, vol. 4, p. 44

[113] Department for Transport, *Transport, Wider Economic Benefits and Impacts on GDP*, 2006, pp 19-20.

- **Labour supply** impacts, primarily from additional output from workers who are encouraged to increase their labour supply due to a reduction of commuting costs and the extra output from existing workers who work longer hours. Alternatively, workers may shift to more productive jobs due to a decrease in commuting time, though this latter effect is difficult to accurately forecast. The incremental tax revenue from any additional output is an additional benefit not captured elsewhere in a standard CBA.
- Additional output from the recognition of **imperfect competition**. A traditional CBA measures the reduction in labour costs to firms due to travel time savings as a proxy for the actual value to society of the time saving. This is because, in a perfectly competitive market, hourly labour costs equal hourly productivity. Perfect competition ensures the price a firm can charge for a good or service is the same as the cost of producing that good or service. In reality, many markets are not perfect: firms can charge more for a good or service than it costs to produce. Labour costs in such imperfect markets therefore underestimate productivity and, therefore, the value of business time savings.
- **Increased competition** benefits, whereby a transport project may open up a new area to competition where previously the lack of good transport links represented a barrier to new entrants to a market. This benefit is assumed to be zero in locations with well-developed transport networks, such as Melbourne.

The Project will better connect people to jobs shopping and other destinations. The Project will reduce noise, crashes and pollution, particularly on residential streets. Increased community wellbeing, safer and less-congested arterial roads, and lower truck volumes on local roads will make the inner west a more appealing prospect for urban renewal and residential development. Figure 21 demonstrates the connectivity benefits expected along the entire M1 corridor.

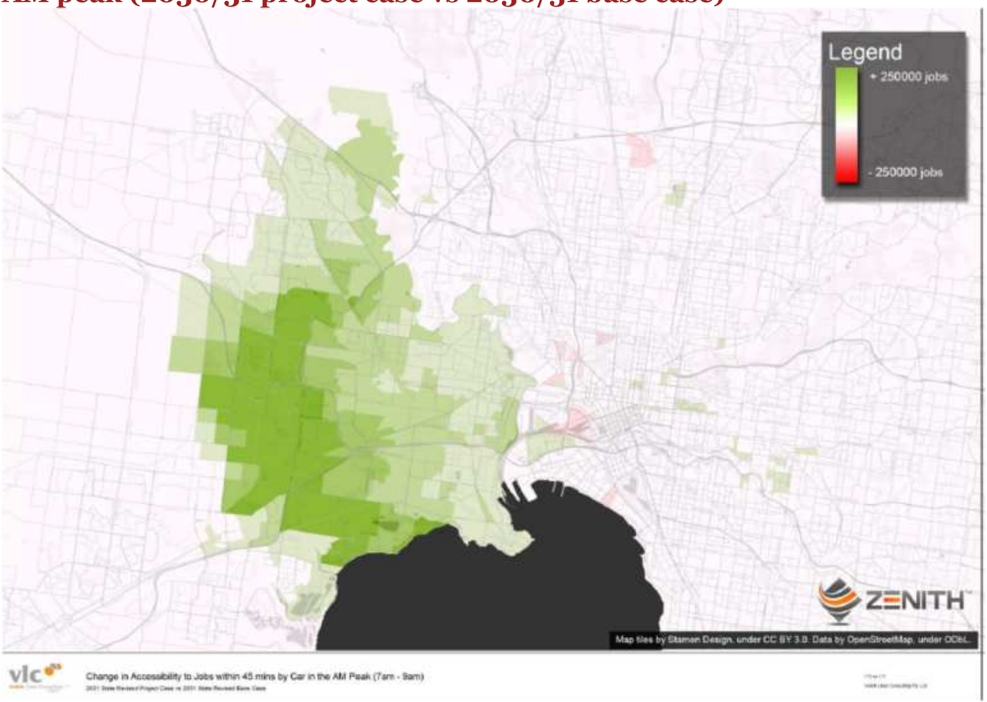
Figure 21: Travel time sectorised benefits – car, interpeak (9am – 4pm), (2030/31 project case vs 2030/31 base case)

Notes: The green lines connect origins and destinations for each defined sector, as marked by the black boundary lines. The thickness and concentration of line corresponds with the level of benefits. Trips are shown to/from the centroid of each region/sector
Source: Veitch Lister Consulting, 2015

Improved connectivity would give residents in the west better access to jobs across the city, as well as expanding the potential for new diverse job opportunities in the west and surrounding areas. Better road links between the west and the CBD may also increase investment in the west by making it a more viable option for business start-ups, expansions or relocations. Furthermore, as more firms move into an area, they create a clustering effect, increasing the competitiveness of the area and potentially leading to higher levels of investment and employment growth. For example, by 2030/31, it is estimated that an additional 2,200 jobs will be attracted to the west, and residents will be in range of 7% more job opportunities as a result of the Project.[114]

Figure 22 shows the scale of the accessibility created by the development of the Project. The figure plots the changes in accessibility to employment within 45 minutes as a result of the project. The green areas are those where the number of jobs within a 45 minute travel time in the AM peak has increased, while the red areas are those where the number of jobs within the 45 minute travel time has decreased. As shown in this diagram, there are large sections of Melbourne's west where accessibility to employment will increase, while there are only a small number of pockets where it will decrease due to traffic redistribution around the network.

Figure 22: Change in accessibility to jobs within 45 minutes by car in AM peak (2030/31 project case vs 2030/31 base case)



Source: VLC (2015)

The Project will boost interpeak connectivity between businesses, making business more productive. Figure 23 maps these agglomeration benefits. It shows the increase in economic output in each statistical local area.

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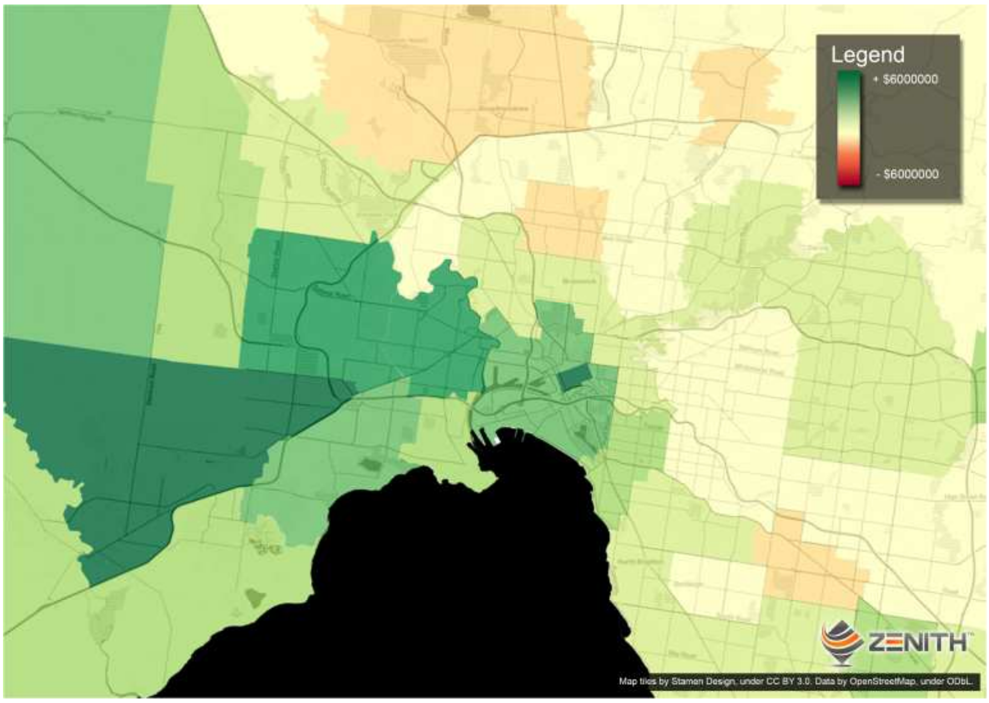
[114] SGS, GHD and Veitch Lister Consulting, 2015.

Figure 23: Distribution of additional output from agglomeration economies – by Statistical Local Area (2030/31 project case vs 2030/31 base case)



Notes: The shading indicates the change in economic output (ie gross regional product) resulting from the agglomeration benefits of Project (eg the dark green coloured areas experience the largest boost in economic output)
Source: Veitch Lister Consulting, 2015

PwC has estimated three of the four WEBs (agglomeration, labour supply and imperfect competition), which is in line with current practice and guidance from the UK and Infrastructure Australia. This proposed coverage is compared with other relevant CBAs in Table 39.

Table 39: Comparison of proposed WEBs coverage with other CBAs

Wider Impact	Western Distributor	East-West Link (2013)	WestLink (2009)	WestLink (2011)
Agglomeration economies (WEB 1)	✓	✓	✓	✓
Labour supply (WEB 2)	Increased labour supply	Increased labour supply	Increased labour supply Move to more productive jobs	Increased labour supply
Imperfect competition (WEB 3)	✓	✓	✓	✓
Increased competition (WEB 4)	Assumed zero	Assumed zero	Assumed zero	Assumed zero

Sources: Department of Transport, Supporting economic analysis to Victoria's submission to IA, 2009, prepared by Ernst & Young; Linking Melbourne Authority, Westlink Planning and Consultation Study: Economic Assessment Technical Report, 2011, prepared by AGA; PwC, 2013, East West Link – Stage 1 Economic Analysis Report

7.7.1 Agglomeration

Calculation approach

The additional output attributable to an improvement in transport accessibility of linked employment areas relies on the concept of 'effective job density'. The effective job density, *EJD*, of a given employment area, *i*, is the sum of all of the employment within all other areas, but where this employment is weighted according to how easily its location is reached from *i*. That is, the effective density of area *i* in industry *k* is estimated as:

$$EJD_i^k = \sum_{j,m} \frac{E_j^k}{g_j^m}$$

where E_j^k is the employment in an area linked to *i*, and g_j^m is the generalised travel cost between *i* and *j* by mode *m*.

The calculation of the additional output from an improvement in effective density due to a transport project is not straightforward due to the different industry responses to increased effective density, the number of transport modes and the spatial diversity of employment location and accessibility changes. In simple terms, the calculation of agglomeration benefits can be broken down into five general steps:

Step 1: Define spatial and industry dimensions

The various data sources (e.g. ABS, transport model, parameter estimates) provide input values using potentially different spatial and industry disaggregations/definitions. This step involves defining, then harmonising data to, a single set of spatial and industry disaggregations. For example, aligning industry classifications for: the ABS's output per worker; the employment forecasts; and productivity elasticities. The harmonising process involves the averaging or aggregation of subcategories (or sub-zones) into the defined level of detail required for the overall calculation.

Step 2: Calculate effective job densities

The effective job density is calculated for each destination by taking the employment in each destination and dividing it by the average (trip-purpose-weighted) generalised cost with an exponential decay factor to take account of the decreasing significance of the agglomeration effect as the distance from the central area increases.

Step 3: Calculation of the increase in productivity per worker

This step takes the change in effective densities and converts this into a productivity factor per worker. This is achieved by dividing the effective densities in the option by the effective densities in the base case and then applying the industry elasticity of productivity.

VLC's industry categories have been mapped to the ANZSIC 2006 categories and the estimated elasticities (ρ^k) by KPMG (2015)[115] as set out in Table 40.

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[115] KPMG,2015, Estimating WEBs of Transport Projects, 27 July 2015, page 48

Table 40: Elasticity of productivity parameters

VLC Industry	ANZSIC 2006 categories	Elasticity of productivity: Core* (ρ)
Agriculture	A	0.09
Mining	B	0.09
Manufacturing	C	0.07
Electricity, gas & water	D	0.00
Construction	E	0.08
Wholesale	F	0.04
Retail	G	0.10
Accommodation and Food Services	H	0.05
Transport & storage	I	0.02
Communications	J	0.07
Financial and Insurance Services	K	0.05
Rental Hiring and Real Estate Services	L	0.06
Professional Scientific and Technical Services	M	0.06
Administrative and Support Services	N	0.08
Public Administration and Safety	O	0.04
Education and Training	P	0.06
Health Care and Social Assistance	Q	0.10
Arts and Recreation Services	R	0.04
Other Services	S	0.12
Total (all industries)		0.09

Source: KPMG,2015, Estimating WEBs of Transport Projects, 27 July 2015, page 48

Step 4: Calculation of the agglomeration impacts per worker

The total agglomeration impacts are then calculated by taking one away from the number in the last step to get the change in the productivity per worker per industry. For every geographic area, this is then multiplied by the industry specific GDP per worker and the number of people employed in each industry in that geographic area. This produces the total agglomeration benefit in monetary terms for each industry and geographic areas.

Victorian GSP per worker in Table 41 by industry is based on VLC's industry classifications which have been mapped from the ANZSIC 2006 industries and are assumed to apply in 2020/21, 2030/31 and 2045/46.

Table 41: Output per worker by industry

VLC Industry	ANZSIC 2006 categories	Output per worker (*GSPW*)
Agriculture	A	95,115
Mining	B	445,243
Manufacturing	C	92,539
Electricity, gas & water	D	247,053
Construction	E	90,572
Wholesale	F	135,888
Retail	G	59,920
Recreation and personal services	H, R, S	49,790
Transport & storage	I	104,607
Communications	J	221,362
Finance & business	K, L, M, N	180,075
Public administration	O	102,155
Community service	P, Q	72,179

Source: ABS June 2014 Victorian GSP per capita; Victorian May 2014 total employment by industry, ABS Catalogue No. 6291.0.55.003 Labour Force, Australia, Detailed, Quarterly, Table 05. Employed Persons by State and Industry, Victoria.

Step 5: Aggregation of the agglomerations impacts

The agglomeration impacts are then aggregated in the final step to give a total impact of agglomeration across all industries and geographic areas.

Approach to monetisation

The data and parameters used in the calculation of agglomeration benefits are shown in Table 42. Intermediate calculations are performed at the matrix level by VLC using parameters supplied by PwC. Average weekday estimates of agglomeration benefits by Statistical Local Area from Zenith are converted to annual estimates by applying an annualisation factor of 330 (Table 19).

Table 42: Estimation of agglomeration benefits

Element	Input to monetise
Data	**Employment** (*E*) forecasts from ABS embedded in the demand model by: • Travel zone • Industry – using the Australian and New Zealand Standard Industrial Classification (ANZSIC) • Option and base cases – these are assumed to be the same **Output per worker** (*GSPW*) using ABS State Accounts and Census of Population and Housing (Table 41), broken down by: • Travel zone • Industry – using ANZSIC **Generalised travel costs** (*g*), reflecting the full perceived costs of travel estimated in the demand model in the inter-peak only, by: • Travel zone – full matrices of origins and destinations • Mode – car and public transport (weighted by number of trips for each purpose & each mode)

Element	Input to monetise
Parameters	**Elasticity of productivity (ρ)**, linking output and effective density of the employment location (Table 40), by • Industry – using ANZSIC – sourced from recent work for the Melbourne Metro business case.[116] **Distance decay parameter (k)**, by Industry – using ANZSIC – in the first instance, this is assumed to be 1 for each industry[117]
Calculation	The simplified calculation for a given industry in a single location is given by: • New output = [(% ch. in effective job density)^(unit response in output per worker)] x (output per worker) x (number of workers) More formally, for a single location (*i*) in a single forecast year (*f*), the equation is: $$WEB1_i^f = \sum_k \left[\left(\frac{\sum_j \frac{E_j^f}{g_{i,j}^{A,f}}}{\sum_j \frac{E_j^f}{g_{i,j}^{B,f}}} \right)^{\rho^k} - 1 \right] GDPW^{B,k,f} E_i^{B,k,f}$$ • Here, *i* is the travel zone under consideration and *j* is every other travel zone and modes are represented by *m*. Total agglomeration benefits are calculated by aggregating benefits across industries and zones (*i*). The benefits are calculated for each forecast year.

Source: VLC and PwC

7.7.2 Labour supply

The UK DfT considers that major transport projects that reduce commuting time costs can have two potentially significant labour market impacts that are not adequately captured in conventional benefit calculations. The first is the increase in labour supply for a given set of employment and resident locations; the second is the potential for people in their existing residential locations to move to more productive jobs (typically further away).

Labour supply impacts are primarily from additional output from workers who are encouraged to increase their labour supply due to a reduction of commuting costs and the extra output from existing workers who work longer hours. Alternatively, workers may shift to more productive jobs due to a decrease in commuting time, though this latter effect is difficult to accurately forecast. The incremental tax revenue from any additional output is an additional benefit not captured elsewhere in a standard CBA.

Individuals are expected to increase their supply of labour if their net wage increases for a given amount of work. Perceived commuting costs are considered part of this net (post-tax) wage. An improvement in commuting costs can therefore result in an expansion of output. Part of this will be reflected as improved welfare in the conventional benefits (travel time savings). However, the private travel time savings are valued based on post-tax wages (i.e. the private returns to labour supply). There is an additional benefit to society of the extra labour supply, which

[116] KPMG,2015, Estimating WEBs of Transport Projects, 27 July 2015, page 48

[117] This simplifies the calculation and is justified because there is no direct available Australian evidence on this parameter.

is the difference between pre-tax and post-tax wages, which is not reflected elsewhere in the CBA.[118]

Calculation approach

The calculation of change in labour supply benefit is broken down into five steps:

Step 1: Calculate the change in generalised costs

For each travel zone, the mode-weighted average annual generalised cost of business commuting (home-based commute purpose) to all other zones in the base case is compared to the average generalised cost of business commuting in the option.

Step 2: Calculate the perceived change in net after tax earnings

This step involves taking the change in average generalised business commuting cost and multiplying by the number of workers commuting from a given zone to get the total change in cost across all workers. This is perceived by workers as an increase in effective wages. This change in annual commuting costs can be considered as a change from the perceived annual return from working. It is divided by the average gross wage of workers working in the destination zone to give perceived relative change in net earnings.

Step 3: Calculate the change in labour force participation and wages

The change in labour force participation is then calculated from the change in the perceived net after tax earnings – the gross wage divided by one minus the average tax 'wedge' – using the 'elasticity of labour supply with respect to effective wages'. This converts the change in effective wages to the change in employment and actual wages. E.g. With an elasticity of 0.1, an increase in effective take home wages due to the change in average generalised cost of commuting of 50 per cent will have an impact of increasing labour supply by 5 per cent (0.1 x 0.5).

Step 4: Calculate the change in welfare

This step takes the change in the labour supply and converts it into a net benefit (not captured already in the conventional benefits). The change in labour supply is multiplied by a factor to account for the fact that workers at the margin of the workforce are on average less productive. The benefit in turn is multiplied by the average gross wage of workers working in the destination zone and the tax wedge to isolate increase in tax revenue within the additional output.

Given that step 2 divides by the average wage, and step 4 multiplies by the average wage, these elements cancel each other out.

Step 5: Summation of the labour supply impacts for the different travel zones

The labour supply impacts are then aggregated in the final step to give a total impact of labour supply across all travel zones.

Approach to monetisation

The data and parameters used in the calculation of agglomeration benefits are shown in Table 42. Intermediate calculations are performed at the matrix level by

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[118] Department for Transport, '*Wider Impacts and Regeneration, TAG Unit 2.8d,*' March 2011

VLC using parameters supplied by PwC. Average weekday estimates of agglomeration benefits by Statistical Local Area from Zenith are converted to annual estimates by applying an annualisation factor of 330 (Table 19).

Table 43: Estimation of labour supply benefits

Element	Input to monetise
Data	**Average travel time savings** in terms of average *return* generalised trip costs trip weighted across modes (*G*) by: • Commute trip purpose (i.e. home-based commute-purpose) • Travel zone **Number of workers** (*W*) by: • Travel zone (of residence) • Travel zone (of employment) Average workplace-based gross **wage** by: • Travel zone (of employment)
Parameters	**Elasticity of labour supply** with respect to effective wages (net of taxes and other transport costs) (ε^{LS}) of **0.1** has been found for the UK labour market.[119] Estimates as high as 0.7 have been used in previous Australian studies,[120] so 0.1 is considered a conservative value. **Lower productivity of workers on the margin of the labour force** (η) of **0.69**, which is based on available UK evidence that new workers entering the workforce are 31 per cent less productive than the average of the current workforce.[121] **Average tax rate on earnings** (τ) of **0.35** to convert the gross earnings into net earnings. This reflects the average effective tax rate facing new entrants to the labour force in Australia.[122] It is also the gap between perceived private earnings and public (tax) benefit from additional output.
Calculation	The additional output produced by new entrants to the labour force and existing workers supplying more labour is given as: New output = (%ch. in avg. net wage) x (unit labour supply response) x (no. workers) x (avg. wage) However, only the 35 per cent tax wedge of this new output is genuinely additional to the welfare gain made by the employees that is already captured in private travel time savings. The new output is therefore multiplied by 0.35 to estimate the benefit for each forecast year. Or, more formally for a given forecast year[123]: $LabourSupplyBenefit = -\varepsilon^{LS} \frac{\eta}{(1-\tau)} \sum_i \left(\sum_j W_{i,j} \left(G_{i,j}^{A,c} - G_{i,j}^{B,c} \right) \right) * \tau$

119 Gregg, P., Johnson, P. and Reed H. '*Entering work and the British tax and benefit system*', 1999

120 Linking Melbourne Authority, '*Westlink Planning and Consultation Study: Economic Assessment Technical Report*,' 2011, prepared by AGA

121 Gregg, P., Johnson, P. and Reed H. '*Entering work and the British tax and benefit system*', 1999

122 Meyrick & Associates, '*East West Needs Assessment Economic Benefits and Costs Analysis - Technical Report*,' March 2008 (p. 28) notes that 'evidence from the Australian Treasury finds the average UK and Australian tax wedges to be 33 per cent and 28 per cent, respectively. The effective tax wedge for individuals joining the labour market is higher than for those already working because new entrants would typically forego benefit payments. Since the relevant tax wage [sic] for increased labour supply in the UK has been found to be 40 per cent, we apply a tax wedge for our analysis of 35 per cent to reflect the lower average taxation level in Australia.'

123 Adapted from Department for Transport, '*The Wider Impact Sub-Objective, TAG Unit 3.5.14*', August 2012, p. 15 eq. 4.1a

Element	Input to monetise
	where i is the travel zone of residence, j is the travel zone of employment, c signifies commute journey purpose only, so $G_{i,j}^{A,c}$ is the generalised daily return commuting costs from i to j in the Stage 1 (A).

Source: VLC and PwC

7.7.3 Imperfect competition

Imperfections in product markets in and around Melbourne mean that firms can charge more for a good or service than it costs to produce. Labour costs in such markets therefore underestimate labour productivity and, therefore, the value of business time savings. The 'imperfect competition' benefit of the Project accounts for the gap between wages and labour productivity by scaling up the conventional 'perfect competition' estimate of business travel time savings.

Calculation approach

An up-rate factor is applied to the value of business time savings (both average and variability). [124] This up-rate factor is a combination of the cost-price margin (how imperfect is the market) and the elasticity of demand in the imperfect market (by how much does output rise following a reduction in time savings).

Ideally, the up-rate factor is calculated for each sector or industry within the model; however, in reality this is not plausible. In the UK, the Department for Transport reviewed a number of estimated of price-cost margins within the UK economy. Based on the best estimates available they suggest an imperfect competition 'up-rate' parameter of one tenth, or 10%, be applied to the traditional value of business travel times.[125] This is based on a price-cost margin of 0.2 and an elasticity of demand of 0.5.

In Australia, data suggests that the imperfect competition parameter may be higher due to a greater degree of market concentration. This concentration implies firms may be able to charge high mark-ups over their marginal costs (in this case the price of labour). However, the conservative UK estimate of 0.1 is applied.

Approach to monetise

The data and parameters used in the calculation of imperfect competition benefits are shown in Table 44. Direct benefits accruing to business purpose cars, LCVs and HCVs estimated elsewhere in the CBA are multiplied by a factor of 0.1 to quantify imperfect competition benefits.

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[124] Department for Transport, '*The Wider Impact Sub-Objective, TAG Unit 3.5.14*', May 2012

[125] Department for Transport, *Transport, Wider Economic Benefits and Impacts on GDP*, 2006, p 26.

Table 44: Estimation of imperfect competition benefits

Element	Input to monetise
Data	Average travel time savings benefit (conventional benefit) by: • Business trip purpose (i.e. work-based work-purpose, including freight) **Reliability benefit** (conventional benefit) by: Business trip purpose (i.e. work-based work-purpose, including freight)
Parameters	**Up rate factor** (τ) of **0.1**, reflecting the degree to which demand will respond to a change in input costs: $\iota = \frac{P-MC}{P} \times ED$, where $\frac{P-MC}{P}$ is the representative price-cost margin (with price (P) and marginal cost (MC)) assumed to be 0.2 ED is the representative elasticity of demand assumed to be 0.5
Calculation	Additional output = τ (average time savings benefit + reliability benefit) The benefits are calculated for business benefits for each forecast year.

Source: PwC

8 Economic analysis results

8.1 Summary of CBA results

Economic analysis indicates that the Project deliver substantial direct benefits.

The benefits for road users and freight are significant due to reduced travel times, lower vehicle operating costs, and higher load capacities. The broader community will also benefit from improved transport network resilience and redundancy, improved liveability, as well as agglomeration benefits and improved accessibility to jobs.

The direct benefit cost ratio (BCR) and macroeconomic benefits of the Project are set out below based on two sets of economic appraisal guidelines/practice: current Victorian practice and Infrastructure Australia December 2013.

Table 45: Cost benefit analysis results for the Project ($ June 2015 millions, real, discounted present values)

		A. Current Victorian Practice[1]		B. Infrastructure Australia Dec 2013[2]	
Costs and benefits		**PV $m**	**%**	**PV $m**	**%**
Costs	Capital costs	3,283	92%	3,283	93%
	Operating and maintenance costs	287	8%	258	7%
	Sub-total costs	**3,570**	**100%**	**3,541**	**100%**
Benefits	**Productivity and growth from Melbourne**	**2,931**	**50%**	**3,627**	**47%**
	Travel time savings – car	1,578	27%	1,880	24%
	Travel time benefits for improved congestion - car	579	10%	778	10%
	Reliability – car	145	2%	208	3%
	Vehicle operating cost savings – car	628	11%	761	10%
	More competitive port and freight sector	**910**	**16%**	**972**	**13%**
	Travel time savings – light and heavy commercial vehicles	388	7%	356	5%
	Vehicle operating cost savings – light and heavy commercial vehicles	237	4%	380	5%
	Reliability – light and heavy commercial vehicles	64	1%	65	1%
	High Productivity Vehicle Freight User Benefit	221	4%	171	2%
	Greater resilience in the transport network	**440**	**8%**	**341**	**4%**
	Resilience to lane closures on the West Gate Bridge	440	8%	341	4%
	A more liveable Melbourne	**325**	**6%**	**416**	**5%**
	Travel time savings – public transport	34	1%	11	0%
	Crash cost savings	210	4%	270	4%
	Reduced air emissions and other environmental externalities	53	1%	98	1%
	Improved amenity	28	1%	37	1%
	Residual value	**36**	**1%**	**1,260**	**16%**
	Sub-total benefits excluding WEBs	**4,642**	**79%**	**6,615**	**84%**
Results	**Benefit Cost Ratio**	**1.3**		**1.9**	
	Net Present Value	**$1,072**		**$3,074**	
Wider Economic Benefits	**Economic development in Melbourne and the west**	**1,213**	**21%**	**1076**	**14%**
	Agglomeration	1,139	19%	993	13%

Costs and benefits		A. Current Victorian Practice[1]		B. Infrastructure Australia Dec 2013[2]	
	Labour supply	13	0%	23	0%
	Imperfect competition	60	1%	60	1%
Results including WEBs	Benefit Cost Ratio including WEBs	1.6		2.2	
	Net Present Value including WEBs	2,285		4,129	

Note: the costs differ from out-turn capital cost estimates as they have been adjusted for inclusion in the economic appraisal to represent real, discounted (present value) costs over the lifecycle
Note: estimated incremental to the base case, discounted based on a 7% real discount rate, based on P50 capital and operating costs; (A) Consistent with Victorian Government economic guidelines therefore analysed over the period 2015/16 – 2071/72, and applying Victorian Auditor-General's Office recommendations for traffic modelling; (B) Consistent with Infrastructure Australia December 2013 published economic guidelines therefore analysed over the period 2015/16 – 2051/52 and not applying VAGO recommendations for traffic modelling;
Source: PwC, 2015

8.2 Sensitivity analysis of CBA results

Sensitivity testing of key economic appraisal inputs and assumptions is provided in Table 46. These include:

- Changes to CBA model assumptions (discount rates and costs)
- Technical scope and tolling scope sensitivities (based on revised VLC Zenith model forecast and Advisian cost estimates), noting that:
  - Tunnel component of Project capital costs assumed to reduce by around 65% (a 25% reduction in total Project capital costs) if it could be constructed as a surface road based on benchmarks from similar Melbourne road project.
- Allowing land use to change as a result of the Project, including:
  - Isolating the traffic impacts of the land use change: project infrastructure is held constant in the base case and project case, and land use is allowed to change[126] in the VLC Zenith model forecasts.[127] All CBA benefits are re-estimated and added to the core results.
  - Estimating indicative amenity benefits for households that relocate as a result of the Project: This is based on estimated willingness to pay as a proportion of household income (approximately 1.6%) for a range of factors affecting relocation decisions including quality of environment, land size, access to public spaces and natural open spaces).[128]
- Changing assumptions for key demand drivers in the VLC Zenith model: Port of Melbourne commercial vehicle trips, fuel price and CBD parking charges.

Key findings of the sensitivity testing are:

- Under the majority of scenarios tested, benefits exceed costs (the exception when a 10% discount rate and Victorian practice is applied)

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[126] Based on SGS Economics forecasts of the change in population and employment as a result of the improved accessibility (population) due to the Project (see attachment M – Land Use Report).

[127] VLC assume that each household that relocates as a result of the Project would take at least one trip per day on the Western Distributor.

[128] Piotr Litynski (2015), Suburban vs. urban fringes entities' willingness to pay for amenities: Empirical research in Cracow City, Poland, Journal of Urban and Regional Analysis, vol. 7, p. 21-34.

- Net benefits are still estimated assuming a 20% increase or P90 capital costs
- On a standalone basis both the Western Distributor and Monash Freeway Upgrade result in net benefits. A higher relative BCR for the Monash works largely attributable to lower cost upgrades of existing infrastructure that for example does not require tunnelling that is part of the Western Distributor scope
- The core results may understate the potential range of attributable benefits, in particular:
  - Sensitivity analysis finds that the Project generates benefits not only from the physical infrastructure (the focus of the core BCR results) but also from implementing a tolling solution relative to the base case. The proposed tolling and associated justification to continue tolls on the CityLink as a result of investment in the network (relative to a base case where tolls on CityLink are assumed to lapse rather than continue after the current concession ends from 2036) has been found to significantly increase the scale of economic benefits.
  - Sensitivity results to estimate benefits associated with land use change occurring as a result of the Project reflect the SGS Economics and Planning assessment that employment and households will be attracted to Melbourne's western subregion from the inner city and south-east suburbs. This testing suggests that while increased travel costs are expected due to trips that are on average longer for households relocating from inner city to the west, these households would benefit from better amenity associated with larger land spaces, natural spaces and the quality of environment. The amenity benefits offset those impacts on travel costs result in increased net economic benefits.

Table 46: Sensitivity testing of cost benefit analysis results

Sensitivity test	A. Consistent with Victorian guidelines and practice	B. Consistent with December 2013 IA guidelines for national comparison
	BCR	BCR
Core results (from Table 45)	1.3	1.9
Discount rate		
4% discount rate	2.3	3.1
10% discount rate	0.8	1.2
Project cost		
P90 Costs	1.2	1.8
+ 20% Costs	1.1	1.6
- 20% Costs	1.6	2.3
Technical scope		
Western Distributor Project only *West Gate Freeway widening, Western Distributor tunnel and improved access to Port of Melbourne/Webb Dock*	1.1	1.3
Monash Freeway Upgrade Project only *Monash Freeway widening and improved ramp metering between Warrigal and Koo Wee Rup Road*	4.2	8.4
Western Distributor tunnel *Constructed as a surface road instead of a tunnel*	1.8	2.6
Tolling scope		
Western Distributor tunnel tolls +20% *A 20% increase in tolls on the Western Distributor including the West Gate Distributor ramp and City Access (Footscray/Dynon Road ramps)*	1.3	1.9
No extension of CityLink tolls in the base case *In the base case tolls on CityLink are assumed to lapse rather than continue after the current concession ends (assumed from 2036)*	2.1	2.4
Change in land use		
Land use change *Assumes land use change expected as a result of the Project (with the appraisal accounting for traffic impacts as well as amenity improvement from attracting households and employment to preferred locations)*[129]	1.3	1.9
Change in demand drivers		
Port Commercial Vehicles - 20% *A 20% reduction in assumed number of commercial vehicle trips to/from the Port of Melbourne in the VLC Zenith Model.*	1.2	1.7

129 Based on SGS Economics forecasts of the change in population and employment as a result of the improved accessibility (population) due to the Project (see attachment M – Land Use Report). See Attachment J – for further details on approach to estimating land use impacts. While the BCRs are the same as the core to one decimal place, the NPV's are higher both based on Victorian guidelines and practice and Infrastructure Australian 2013 guidelines ($1,086M and $3,083M respectively in real $ June 2015, discounted, net presented values).

Sensitivity test	A. Consistent with Victorian guidelines and practice	B. Consistent with December 2013 IA guidelines for national comparison
	BCR	BCR
Fuel price +10% *A 10% increase in fuel price assumed in the VLC Zenith Model*	1.3	1.9
CBD parking changes +10% *A 10% increase in CBD parking charges assumed in the VLC Zenith Model*	1.3	1.9

Note: estimated incremental to the base case, discounted based on a 7% real discount rate, based on P50 capital and operating costs; (A) Consistent with Victorian Government economic guidelines therefore analysed over the period 2015/16 – 2071/72, and applying Victorian Auditor-General's Office recommendations for traffic modelling; (B) Consistent with Infrastructure Australia December 2013 published economic guidelines therefore analysed over the period 2015/16 – 2051/52 and not applying VAGO recommendations for traffic modelling.
Source: PwC, 2015

8.3 Summary of macroeconomic impacts

The Project is expected to generate macroeconomic activity induced by improvements to transport productivity and increased expenditure throughout the economy. The CBA does not measure these benefits as they are indirect measures not easily attributed to a particular project. This section summarises the results for Victoria.

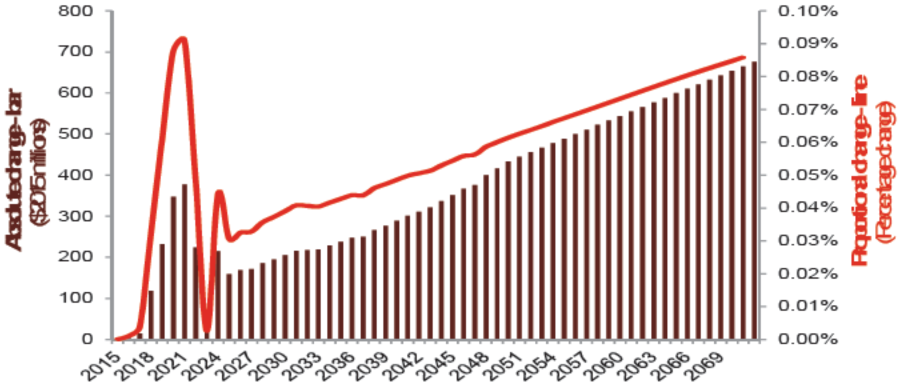
The Project will result in an increase in economic activity in Victoria – observed in the increase in Victoria's GSP as well as employment as indicated in Figure 24, Figure 25, and Table 47. There is an initial boost to the Victorian economy during the construction period from 2016/17 to 2022/23. This is driven by expenditure on the road, bridge and tunnel construction which expands the construction sector and increases demand from the various supporting industries.

During the transition from construction to operation, there is a slight decline in Victoria's GSP and employment as higher real wages from demand for construction labour take time to adjust to status quo levels.

However, the Project brings about productivity gains (for example, as a result of travel time savings for service industries such as transport, postal and warehousing) that boost the Victorian economy once the Project is operational. As a result, from 2023/24 onwards, the productivity improvements drive Victoria's economic growth higher. By 2071/72, Victoria's real GSP is $700 million (real $2015, undiscounted) per annum higher than in the base case reflecting the productivity improvements associated with the projects.

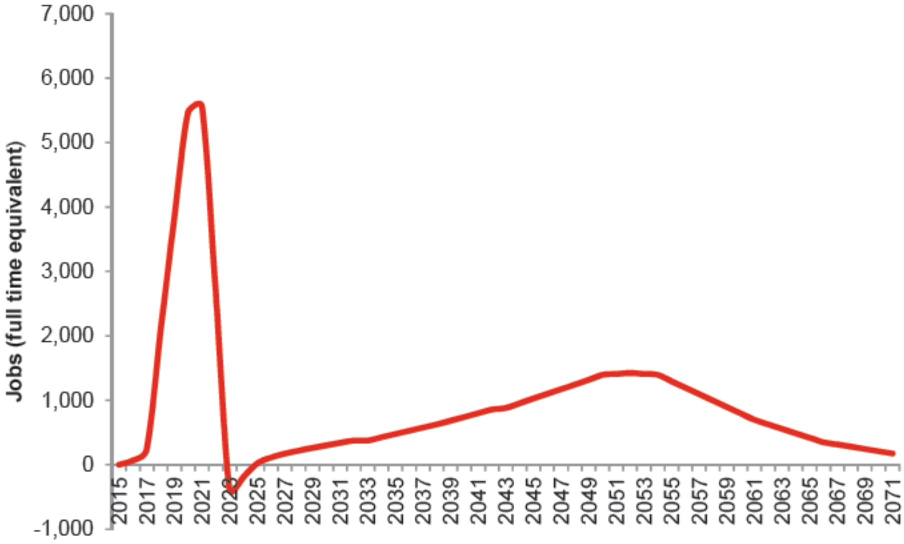
Employment remains above the long term average in Victoria for most of the period due to the productivity gains that are achieved from the Project. However, over time employment returns towards base case levels as the gains from the Project become part of the normal levels of productivity growth and are realised in higher real wages rather than increased employment levels.

Figure 24: Impact on Victoria’s Gross State Product



Note: Years represent financial years, for example, 2015 is 2014/15
Source: PwC

Figure 25: Impact on Victoria's employment



Note: Years represent financial years, for example, 2015 is 2014/15
Source: PwC

Table 47: Economic impact assessment results

Economic impact (direct and indirect)		Construction period 2017/18-2021/22	Operating period 2022/23 – 2071/72	Total period 2017/18 - 2071/72
Increase in Gross State Product ($m)		1,126	9,681	10,807
Jobs created(FTE)	Maximum	5,600	2,700	5,600
	Average	2,400	700	900

Note: estimated incremental to the base case, analysed over the period 2015/16 to 2071/72, GSP discounted based on a 7% real discount rate and provided in $ June 2015, jobs estimated on Full Time Equivalent basis.
Source: PwC, 2015

Although not presented here, household and government consumption expenditure is also increased as a result of the projects, and is a proxy measure of the effect on living standards, or welfare, of households. Household consumption is driven by wages and employment, as employment or wages increase household consumption increases. As wages and employment falls household consumption decreases. The Project result in both an increase in employment in Victoria and higher wages and follows a similar growth profile to Victorian GSP, with higher wages persisting in Victoria as a result of the Projects.

Appendices

Appendix A Guideline on travel time benefits from reduced congestion

This appendix provides extracts from the New Zealand Transport Agency 2013 Economic Evaluation Manual (4.2.5 - Road User Benefits and A.4 - Travel Times), applied in the estimation of travel time benefits from reduced traffic congestion (see Section 7.2.2, above).

Economic evaluation manual

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4.2.5 Benefits of road activities

Introduction

Typical benefits for a road activity are the reduction in road-user costs and the reduction in external impacts compared with the do-minimum. Road user benefits considered include:

- travel time cost savings (including those gained from reduced traffic congestion and improved trip reliability)
- vehicle operating cost (VOC) savings
- crash cost savings
- comfort and productivity benefits from sealing an unsealed road
- driver frustration reduction benefits from passing options
- benefits from reducing or eliminating the risks of damage
- carbon dioxide reduction benefits
- other external benefits
- national strategic factors.

Travel time cost savings (Appendix A4)

Travel time savings are a function of travel times and traffic volumes and vary by travel purpose and mode, vehicle occupancy, traffic composition and congestion.

Appendix A4 provides unit values for vehicle occupant, vehicle and freight time costs, along with values for travel in congested conditions and procedures for estimating the costs of improved trip reliability. Unit travel time values are given for standard traffic compositions on urban arterial, urban other, rural strategic and rural other roads by time period.

New trips generated or induced as a result of travel time savings for existing traffic (see Appendix 11) shall be assessed at half the benefits from travel time saving per vehicle for existing traffic. This assumes that the benefits to new trips will be uniformly distributed between zero and the max.

Reduced traffic congestion (Appendix A4)

Road users value improvements in traffic congestion over and above the benefits gained from travel time saving. The benefits from reduced traffic congestion apply to both work and non-work travel time, and are calculated using the procedures in Appendix A4.

The change in congestion calculated using the procedures in Appendix A4, may also help demonstrate how a particular activity contributes to the wider objectives considered under the NZ Transport Agency funding allocation process.

Improved trip reliability (Appendix A4)

Journey times tend to vary throughout the day, particularly between peak and off-peak periods, and between weekdays and weekends. This type of variation is well known to regular drivers and is taken into account in calculating the travel time values (including congestion values).

Trip reliability is a different type of variability, which is much less predictable to the driver. (For example, drivers that make a particular journey at the same time every day, and some days it takes as little as 20 minutes, and on other days as much as 40 minutes.) Hence, when drivers plan their trips, they have to consider not just the expected travel time but also its variability. Where an activity improves trip reliability, the benefits apply to both work and non-work trips, and can be calculated using the procedures in Appendix A4.

The change in trip reliability calculated using Appendix A4 may also help demonstrate how a particular activity contributes to the wider objectives considered under the NZ Transport Agency funding allocation process.

In addition to the normal day-to-day variation in travel times, there can be occasional large delays resulting from major incidents (eg crashes or breakdowns). Assessing this type of variability is best handled separately from normal day-to-day variability and is outside the scope of the procedures contained in Appendix A4.

Vehicle operating cost savings (Appendix A5)

Vehicle operating cost (VOC) savings for road sections are functions of the length of the section, traffic volume and composition on the section, and vary by road roughness condition, gradient and vehicle speed. Unit values for VOC are given in Appendix A5. The values are made up of the following components:

- basic running costs of the vehicle, such as fuel, and repairs and maintenance
- additional running costs due to the road surface
- additional running costs due to any significant speed fluctuations from the cruise speed
- additional running costs due to traffic congestion
- additional fuel costs due to being stopped, such as queuing at traffic signals.

Crash cost savings (Appendix A6)

Crash cost savings are a function of predicted numbers of crashes and unit crash costs. Unit crash costs vary by crash type and severity, and vehicle speed, while predicted crash numbers need to take account of the road environment, under-reporting and the exposure to the risk of having a crash.

Based on historical data of crashes at the site and other information (including typical crash rates) the following methods can be used for estimating future crash numbers and costs:

- Crash-by-crash analysis, when there are limited modifications to an existing site and a high number of crashes (ie five or more injury crashes at the site, or three or more injury crashes per kilometre).
- Crash rate analysis, when a new facility is being provided or an existing site is being modified to such an extent that the historic crash record can no longer be used as the basis for prediction.
- Weighted crash procedure, when there are limited numbers of crashes and information is used from both of the above procedures, drawing on both site history and predictive model information.

Formulae for determining typical crash rates are given in Appendix A6. Unit values of crash costs are provided in Appendix A6 for each crash type by movement category, speed limit, severity and vehicle involvement.

Driver frustration reduction benefits (Appendix A7)

Vehicle passing options may be provided through the construction of dedicated passing lanes, climbing lanes, slow vehicle bays, and improved alignments.

Providing passing options releases vehicles from platoons of slower moving vehicles, allowing them to travel along the road at their desired speed until they are once again constrained by platoons. Typically, the evaluation of passing options has been undertaken by micro-simulation programmes, which use various vehicle performance models together with terrain data to establish, in detail, the speeds of vehicles at each location along the road. These assessments can be excessively complex, particularly given the general magnitude of such activities.

An alternative method is based on multiple simulations and the Unified Passing Model described in Appendix A7. This method can be used to identify the most appropriate strategy for providing improved vehicle passing options over a route, and assess the benefits of individual vehicle passing options within those strategies.

Other external benefits (Appendix A8)	Where an indicative monetary value has been established in Appendix A8, the external impact should be quantified, and the total benefit calculated using FP Worksheet 16.1. Benefits and disbenefits that do not have monetary values shall be described and, where appropriate, quantified in their natural units. This information is taken into account in the funding allocation process. It is assumed that the benefit of improved consumer travel options is included in the various willingness to pay values used in transport service.
Seal extension benefits (SP 4)	Road user comfort benefits and productivity gains from sealing an unsealed road should also be taken into account. Simplified Procedure SP4 provides information on productivity gains. A value of 10 cents per vehicle per kilometre can be used for road user comfort, which takes account of the other benefits associated with avoiding unsealed roads.
Risk reduction benefits (Appendix 13)	Where there is a quantifiable risk of disruption to traffic, damage to vehicles, the roadway or structures, or injuries to road users from natural or human-made events, and the activity reduces or eliminates the impacts compared with the do-minimum, then the benefits of the reduced or eliminated impacts must be included in the activity evaluation. The benefits of risk reduction shall be included for each year of the analysis period over which they occur, both in the do-minimum and the activity options. These benefits shall be included either as expected values or as a probability distribution, depending on the size and nature of the activity as discussed in Appendix A13.
Vehicle emission impacts (Appendix A9)	Benefits to the environment and public health result from the reduction of vehicle emissions. Appendix A9 provides procedures for the estimation of vehicle emissions. Carbon dioxide has been given a standard value of $40 per tonne and therefore any reduction in carbon dioxide emissions is included in the calculation of the BCR. The reduction of particulate emissions has also been assigned a monetary value and is included in the calculation of the BCR.
National strategic factors (Appendix A10)	The NZ Transport Agency recognises the following as national strategic factors for road activities and transport services (particularly large activities): • agglomeration • benefits of increased labour supply • effects of imperfect competition • providing for security of access on busy inter-regional routes • providing for investment option values – including building-in extra capacity or flexibility today to enable easier future expansion. The criteria for assessing national strategic factors and the valuation of the above factors are discussed in more detail in Appendix A10.

A4 Travel time values

A4.1 Introduction

Introduction

This appendix contains travel time values for vehicle occupants, passenger transport users, pedestrians, cyclists, and freight vehicle travel time. The road user values are used to produce composite travel time values for the different road categories for uncongested and congested traffic conditions. Values and procedures are also provided to calculate the values for changes in road user journey time reliability.

The travel time benefits for a project option shall be calculated as the difference between the do minimum and option travel time costs as follows:

Total travel time savings	=	base travel time benefits for improved flow
	+	travel time benefits for reduced traffic congestion (if applicable)
	+	travel time benefits for improved trip reliability (if applicable).

In this appendix

	Topic
A4.1	Introduction
A4.2	Base values for travel time
A4.3	Composite values of travel time and congestion
A4.4	Traffic congestion values
A4.5	Benefits from improved trip time reliability
A4.6	Worked examples of trip reliability procedure

A4.2 Base values for travel time

Base values for travel time

For vehicle occupants, separate values are given for travel during the course of paid employment (work travel), commuting to and from work, and for other non-work travel purposes. Table A4.1(a) gives behavioural values of time for transport modelling purposes for vehicle drivers and vehicle passengers, for seated and standing bus passengers, pedestrians and cyclists. This table also gives the maximum values for congestion (denoted as CRV), which may be added to these values of time for transport users, as described in Appendix A4.4.

Table A4.1(b) gives base values of time by trip purpose for calculating travel times benefits.

Table A4.2 gives values of travel time for vehicles and freight.

Table A4.1(a) Behavioural values of time for vehicle occupants in $/h (all road categories; all time periods – July 2002)

Vehicle occupant	Work travel purpose	Commuting to/from work	Other non-work travel purposes
Base values of time for uncongested traffic ($/h)			
Car, motorcycle driver	23.85	7.80	6.90
Car, motorcycle passenger	21.70	5.85	5.20
Light commercial driver	23.45	7.80	6.90
Light commercial passenger	21.70	5.85	5.20
Medium/heavy commercial driver	20.10	7.80	6.90
Medium/heavy commercial passenger	20.10	5.85	5.20
Seated bus and train passenger	21.70	4.70	3.05
Standing bus and train passenger	21.70	6.60	4.25
Pedestrian and cyclist	21.70	6.60	4.25
Maximum increment for congestion (CRV, $/h)			
Car, motorcycle driver	3.15		2.75
Car, motorcycle passenger	2.35		2.05
Commercial vehicle driver	3.15		2.75
Commercial vehicle passenger	2.35		2.05

Table A4.1(b) Base values for vehicle and freight time in $/h (July 2002) by purpose for calculating travel time benefits

Trip Purpose	Base value of time ($/h)	Maximum increments for congestion (CRV $/h)
Work Travel Purpose	23.85	3.15
Commuting to/from work	7.80	3.15
Other non-work travel purpose	6.90	2.75

Table A4.2 Base values for vehicle and freight time in $/h (July 2002) for vehicles used for work purposes

Vehicle type	Vehicle and freight time ($/h)
Passenger car	0.50
Light commercial vehicle	1.70
Medium commercial vehicle	6.10
Heavy commercial vehicle I	17.10
Heavy commercial vehicle II	28.10
Bus	17.10

A4.3 Composite values of travel time and congestion

Composite values of travel time and congestion

Travel time values combining passenger and commercial (including freight) occupants, and vehicle types for standard traffic compositions are given in table A4.3. These include different time periods for the four road categories defined in Appendix A2.2. The right-hand column gives the maximum additional values for traffic congestion (CRV), to be applied as described in Appendix A4.4.

Table A4.3 Composite values of travel time in $/h (all occupants and vehicle types combined – July 2002)

Road category and time period	Base value of time ($/h)	Maximum increments for congestion (CRV $/h)
Urban arterial		
Morning commuter peak	15.13	3.88
Daytime inter-peak	17.95	3.60
Afternoon commuter peak	14.96	3.79
Evening/night-time	14.93	3.68
Weekday all periods	16.83	3.79
Weekend/holiday	14.09	4.26
All periods	16.27	3.95
Urban other		
Weekday	16.89	3.82
Weekend/holiday	14.10	4.32
All periods	16.23	3.98
Rural strategic		
Weekday	25.34	4.23
Weekend/holiday	19.21	5.22
All periods	23.25	4.39
Rural other		
Weekday	24.84	4.24
Weekend/holiday	18.59	5.23
All periods	22.72	4.40

A4.4 Traffic congestion values

Introduction

Road users value relief from congested traffic conditions over and above their value of travel time saving. The maximum increments for congestion values apply to vehicle occupants or road category and time periods as indicated in tables A4.1, A4.2 and A4.3. The actual additional value for congestion used in the evaluation is adjusted according to the requirements set out below.

Treatment of passing lane projects

An exception to the procedures below is made in the case of passing lane projects evaluated using the procedures in Appendix A7 of this manual. The procedures in Appendix A7 include a separate value for the reduction in driver frustration and the effect of reducing travel time variability. When evaluating passing lanes using the procedures in Appendix A7, no additional allowance shall be made for congestion or improvements in trip reliability. Similarly, if passing lanes are evaluated using the values for congestion and/or reliability outlined in this appendix, and then no allowance can be included for driver frustration.

Congested traffic conditions - rural two-lane highways

To allow for congestion, the following addition should be made on sections of rural two-lane highways. Section lengths for this analysis should normally be greater than two kilometres.

Peak traffic intensity and volume to capacity ratio (VC ratio) are first calculated in the normal manner (see Appendix A3.17). Using the VC ratio, terrain type and percentage no-passing for the road section, the percentage of time delayed (PTD) following slower vehicles is selected from figure A4.1 or table A4.4. Alternatively, the formulae shown in figure A4.1 can be used to calculate PTD, within a limiting range of PTD greater than or equal to 30%. For lower values of PTD the curves are linear.

Incremental value for congestion = CRV × PTD/90 ($/h)

where CRV is the value for congestion (in $/h) and is given in table A4.1 for drivers or passengers, and in table A4.3 for standard traffic compositions.

Percentage of time delayed has a maximum limit of 90%, for situations where PTD is ≥90%, the maximum increment for congestion (CRV) should be added to the base value of travel time.

Congested traffic conditions - urban roads, multi-lane rural highways and motorways

To allow for congestion, the following addition should be made to road section travel time values where the time period VC ratio exceeds 70%.

Incremental value for congestion =

CRV x (road section traffic volume - 70% of road section capacity volume) ($/h)30% of road section capacity volume

Bottleneck delay

For all bottleneck delay, the maximum increment for congestion from table A4.1 or table A4.3 should be added to the base value of travel time.

Worked examples

Four worked examples are given below of the calculations for the value of congestion. In each case, the example describes the calculation for a single time period and for the base year. For a full project evaluation, the calculations would be made for each flow period and for future year traffic forecasts as necessary.

Example 1 –

An activity involves the realignment of a busy two kilometre section of rural highway, which

Rural highway: realignment

improves sight distances, providing more overtaking opportunities for following traffic. The road is classified as rolling terrain.

From calculations in Appendix A2 and/or A3, the road section carries 12,500 veh/day, with a peak interval intensity of 1,000 veh/h, 60/40 directional split and 12% heavy truck component. In the do-minimum, the alignment offers no passing opportunities (0% overtaking sight distance), and after realignment there is no restriction on overtaking sight distance (100% overtaking sight distance). The hourly capacity of the road in the do-minimum is calculated as:

$2,800 \times f_t \times f_d = 2,800 \times 0.675 \times 0.94 = 1,775$ veh/h

where: 2,800 is the ideal capacity of the road section; f_t and f_d are adjustment factors for directional distribution and the proportion of trucks (see Appendix A3.11). The peak interval traffic intensity (1,000 veh/h) divided by capacity gives a VC ratio of 56%.

From figure A4.1(b), the PTD in the do-minimum is 79%, and 71.5% after realignment. The maximum increment for congestion (CRV) for rural strategic roads is $4.23 per veh/h (from table A4.3).

The incremental values for congestion for the do-minimum and project option are calculated as follows:

Do-minimum:	4.23 × 79/90	=	$3.71 per veh-hr
Activity option:	4.23 × 71.5/90	=	$3.36 per veh-hr

The time period total average travel time for the road section is calculated using the procedures in Appendix A3.22 (based on component values calculated in other sections of Appendix A3). For this example, the average travel times per vehicle have been calculated as 1.70 and 1.30 min/veh for the do-minimum and realignment option, respectively.

The congestion cost savings are calculated by multiplying the peak interval traffic intensity by the incremental value for congestion and the time period average travel time divided by 60. For example:

Do-minimum = 1,000 × 3.71 × 1.70/60 = $105.1/h

Project option = 1,000 × 3.36 × 1.30/60 = $72.8/h

Congestion cost saving = $105.1 - $72.8 = $32.3/h over the peak period.

Example two – Rural highway: four laning

A section of two lane rural strategic road is approaching capacity. One option is four lane. The road carries 20,000 veh/day in rolling terrain with 20% overtaking sight distance, peak interval traffic intensity of 2,050 veh/h, 70/30 directional split and 7$ heavy truck component. The ideal capacity for a two lane rural road is 2,800 vehicles/hour (total in both direction of travel).

For the do-minimum, the congestion cost is calculated in the same way as an example 1. The capacity is $2,800 \times f_d \times f_t = 2,800 \times 0.89 \times 0.92 = 2,290$. This compares with a traffic volume of 2,050, which gives a VC ratio of 0.90. The percentage of time delayed is 90% from table A4.4. The incremental value of congestion is therefore equal to is the maximum incremental value of $4.23 per veh-hr from table A4.3.

For the four lane option, assuming there are no restrictions requiring a reduction in the lane capacity, a capacity of 2,200 veh/h/lane is applicable (See Appendix A3.10). The VC ratio is 2,050/(4 × 2,200) = 0.23, which is below 70%, so congestion costs are not applicable.

The saving in congestion costs over the peak period is $4.23 per veh-hr multiplied by the section traffic volume and time period average travel time for the do-minimum.

Example 3 – Urban arterial road: additional traffic lanes

A project provides a four lane clearway in the peak direction for an urban arterial road and improves the capacity of a signalised intersection half-way along the project length.

The morning peak interval traffic intensity is 1,000 veh/h in the peak flow direction (from Appendix A3.16). Capacity has been established to be 1,250 veh/h for the do-minimum and 2,000 veh/h with the clearway project (based on the multilane road capacity procedure in Appendix A3). The road section VC ratio reduces from 80% to 50% as a result of the project.

Intersection stopped delay will be reduced from 15 s/veh in the do-minimum to 6 s/veh after widening for the 2,000 veh/h through the intersection.

The incremental value of congestion for the road section in the do-minimum for the peak direction of flow is given by:

$$\$3.88 \times \frac{(1{,}000 - 0.7 \times 1{,}250)}{0.3 \times 1{,}250} = \$1.29 \text{ per veh-hr}$$

where: $3.88 per veh-hr is the CRV value from table A4.3.

With the clearway, the VC ratio in the peak direction is below 70%, so no incremental value for congestion is applicable. The congestion cost saving for the road section travel time is therefore $1.29 per veh-hr multiplied by the traffic volume and average vehicle travel time for the section.

For the bottleneck delay, the incremental value for congestion is given by:

Do-minimum = $3.88 ×15/3600 = $0.0162/veh through the intersection

Intersection improvement = $3.88 ×6/3600 = $0.0065/veh through the intersection.

Congestion cost saving per vehicle = $0.0162 - $0.0065= $0.0097/veh through the intersection.

The congestion cost saving attributable to reduction in bottleneck delay is $0.0097/veh multiplied by 2000 veh/h using the intersection = $19.40/h over the peak period.

Example 4 – Urban intersection improvement

A project proposal will reduce delay and improve safety at a priority-controlled T-intersection through the installation of a roundabout. Traffic volumes on the three approaches to the intersection are evenly balanced, there is a high proportion of turning traffic and the configuration of the site is such that a roundabout can be constructed without additional land take.

Bottleneck delay to side road traffic during the peak interval of the morning peak period has been observed to average 35 s/veh for the 500 veh/h on the side road approach, and 5 s/veh for the 300 veh/h turning off the main road. With the roundabout, traffic volume and bottleneck delay for the three approaches has been modeled at: 500 veh/h and 7 s/veh; 700 veh/h and 5.5 s/veh; and 600 veh/h and 6 s/veh.

Total bottleneck delay is calculated as:

Do-minimum = (500 ×35 + 300 ×5) / 3600 = 5.28 veh-hr

Roundabout option = (500 ×7 + 700 ×5.5 + 600 ×6) / 3600 = 3.04 veh-hr

Reduction in bottleneck delay = 5.28 – 3.04 = 2.24 veh-hr

Congestion cost saving = 2.24 ×CRV = 2.24 ×$3.88 = $8.68/h over time period.

Appendix B High Productivity Freight Vehicles

This appendix attaches Advisian analysis of HPFV volumes on the West Gate Freeway and average vehicle kilometres travelled, applied in the estimation of travel time benefits from reduced traffic congestion (see Section 7.2.5, above).

Appendix C Sensitivity testing: base case tolling

This appendix provides additional justification for inclusion of a sensitivity test of base case tolling after the current concession (assumed from 2035/36) relative to the project case with network investment. In summary, the Melbourne CityLink) MCL legislation requires a positive decision from Government to extend the toll, and there is precedence for not continuing the toll after the concession (e.g. M4 Motorway in Sydney)

Melbourne CityLink legislation

The current MCL legislation results in tolls being discontinued on expiry or termination of the MCL concession unless Government enacts new legislation to continue tolls (ie Government has to make a positive decision and take action to do so.

Case Study: M4 Motorway in Sydney

The construction of the M4 began in the late 1960's, in 1985 the government had to halt the final stages of construction for four years due to a lack of available funds. In December 1989, the government agreed to a BOT financing agreement with a Macquarie Bank backed consortium. In return for funding the remainder of the construction ($246[131] million in 1992) the consortium was given permission to toll a section of the motorway (where traffic volumes were highest), commencing in 1992. The toll road provided an alternative to the heavily congested Parramatta Road and eliminated as many as 60 set of traffic signals. The consortium was also given permission to increase tolls in line with CPI.

At the end of the concession period the NSW government had a range of options including:

- Negotiating an extension of the toll concession
- Seek proposals for a new concession
- Continuing tolls under state management as on the Sydney Harbour Bridge
- Detolling.

Ultimately the decision was made to detoll the road.

Data on the impact of the removal of the toll on traffic volumes suggested a traffic increase of about 27% or roughly 6.5 minutes extra on the prior 26 minute morning commute.[132]

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[131] http://www.bpmmagazine.com/monitor_online_exclusive/02_print/RBC_BPMOct10.pdf

[132] http://www.bpmmagazine.com/monitor_online_exclusive/02_print/RBC_BPMOct10.pdf

www.pwc.com.au