East West Needs Study

Engineering Design and Costing Report

Preface – East West Needs Study

This Working Paper presents findings from the East West Needs Study. The Study applied strategic analysis to the assessment of corridor types and feasible route options, to determine four alternative infrastructure options which address in different ways the Study objectives.

A number of specific routes and associated engineering details such as interchange layout, tunnel dimensions etc were developed and analysed during the course of the Study, for the purpose of determining feasibility and assessing the options. The specific routes and details described in this document should be seen in this context.

The overall project is being delivered as a collaborative approach between a range of specialist teams for DoI including:

- Environment and heritage analysis (Sinclair Knight Merz – Maunsell);
- Transport Planning and Costing (Sinclair Knight Merz – Maunsell – Evans & Peck);
- Economic Analysis (Meyrick and Associates);
- Demographics, social and land use effect analysis (SGS Economics and Planning);
- Commercial and Financial analysis (Ernst & Young);
- Legal (Clayton Utz) and
- Transport Modelling (Veitch Lister Consulting)

It may be necessary to read sections from the Main Report and specialist working papers to gain a more complete understanding of the information being reported in this paper.

Access to the Main Report is available via the study website at:

www.doi.vic.gov.au/eastwest

Details on how to gain access to the Working Papers can be found on the study website.

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Summary

The Victorian Government has requested Sir Rod Eddington to lead a study into the need for an East-West Link. The East-West Link Study Team supporting Sir Rod has commissioned Sinclair Knight Merz, Maunsell and Evans & Peck to undertake the Engineering Design and Costing Study for the East-West Link Needs Assessment (EWLNA). The purpose of the Engineering Design and Costing Study is to develop and cost a range of options for a possible additional east-west transport link. The findings will assist Sir Rod and the Study Team with providing an assessment of the need for, and feasibility of, an additional link.

The overall project is based on three Phases of Assessment as shown in Table 1-1 below:

Table 1-1: Phases of Assessment

Phase 1	Overview of strategic drivers, key issues and development of an assessment framework that will be used to assess the need for and performance of transport options resulting in a long list of modal options.
Phase 2	Generation of short list of initial options and assessment of those options against an assessment framework
Phase 3	Further development of options retained after the Phase 2 assessment.

The East West Needs -Transport Supply and Demand Paper details the work undertaken in Phase 1.This report presents the nine short-listed schemes which were assessed at Phase 2 and the four alternative modal options developed during Phase 3.

These four alternative modal options, Option A, B, C and D comprise major Public Transport infrastructure improvements and three different road solutions, incorporating road tunnels and new interchanges in order to provide the physical connection between the proposed East West Link and the existing arterial and freeway road network. The proposed tunnels would be separate unidirectional tunnels for eastbound and westbound traffic. Interchanges would be a cost effective combination of grade separated and at grade junction improvements.

Key Issues

This report addresses key issues in relation to the physical links including:

- design criteria
- interchange performance
- constructability
- associated works
- utilities and property
- construction costs

All of the above have a significant effect on the project complexity and its construction and operating costs. Each of the key considerations has been addressed at a strategic level of investigation to determine both feasibility and cost to acceptable confidence levels.

Design Criteria

The link is to be designed in accordance with the relevant VicRoads and Austroads publications and Australian Standards. In addition a number of additional criteria have been adopted, as follows:

- 80km/hr posted design speed in tunnels
- Freeway sections not in tunnel have been designed for 110km/hr, signed for 100km/hr
- Freeway ramp connections have generally been designed for 80km/hr design speed
- Local Road improvements have been designed to match current local conditions.
- Vertical headroom clearance 5.6 metres for surface traffic and 4.8m within tunnels
- Vertical grade on main alignment – absolute maximum 4% (general maximum 3%)
- Vertical grade on ramps – absolute maximum 6% (general maximum 4%)

Interchange Performance

After initial concepts were developed their future performance was modelled with predicted traffic flows. The designs were then adjusted as required to provide for anticipated traffic levels.

Constructability

Whilst this topic is largely about tunnelling for these options, there also is a significant challenge associated with building the Interchanges for any of the options. Traffic management and traffic control is perhaps the major issue – how to keep these existing roads functioning adequately whilst major civil engineering works are being undertaken.

Associated Works

Within each of the options, in addition to new construction, associated works, for example widening of existing freeways, will also be required to the existing infrastructure, to enable the options to operate effectively.

Impacts of Utilities and Properties

All of the options under consideration have significant impacts on major utilities. Each option will also directly impact a number of properties at the interchanges and indirectly a number of other properties, where they lie above the proposed alignments.

Construction Costs

The preliminary estimated project costs for the four modal options, including provisions for planning, design and contingency are as follows:

Table 1-2 - Cost Comparison of Options (in January 2008 prices)

	Description	Project Cost	Construction Cost	O&M Cost (30 Year figure)
		$billion	$billion	$billion
Public Transport (Options A, B, C &D)	• **Public transport* only**	**7.5 - 8.5**	**7.2 – 7.9**	**3.0**
Option A (Road component)	• **Eastern Fwy to West Gate Fwy link** • **Other road works**	**8.0 – 9.0**	**6.7 – 7.2**	**1.4**
Option B (Road Component)	• **Eastern Fwy to Deer Park Interchange link** • **Other road works**	**8.5 – 9.5**	**7.8 - 8.1**	**1.4**
Option C (Road Component)	• **Nicholson Street to Ballarat Road** • **Other road works**	**2.0 – 2.5**	**1.6 – 1.9**	**0.3**

* Public transport comprises: Bus rapid transit between the City to Doncaster
CBD rail between Footscray and Caulfield
Tarneit rail link between Werribee and Deer Park

The costs have been expressed in ranges to reflect the current level of detail used in developing unit rates and quantities, assumptions made with respect to construction methods employed and some allowance for refinements to the design scope during the preliminary design stage.

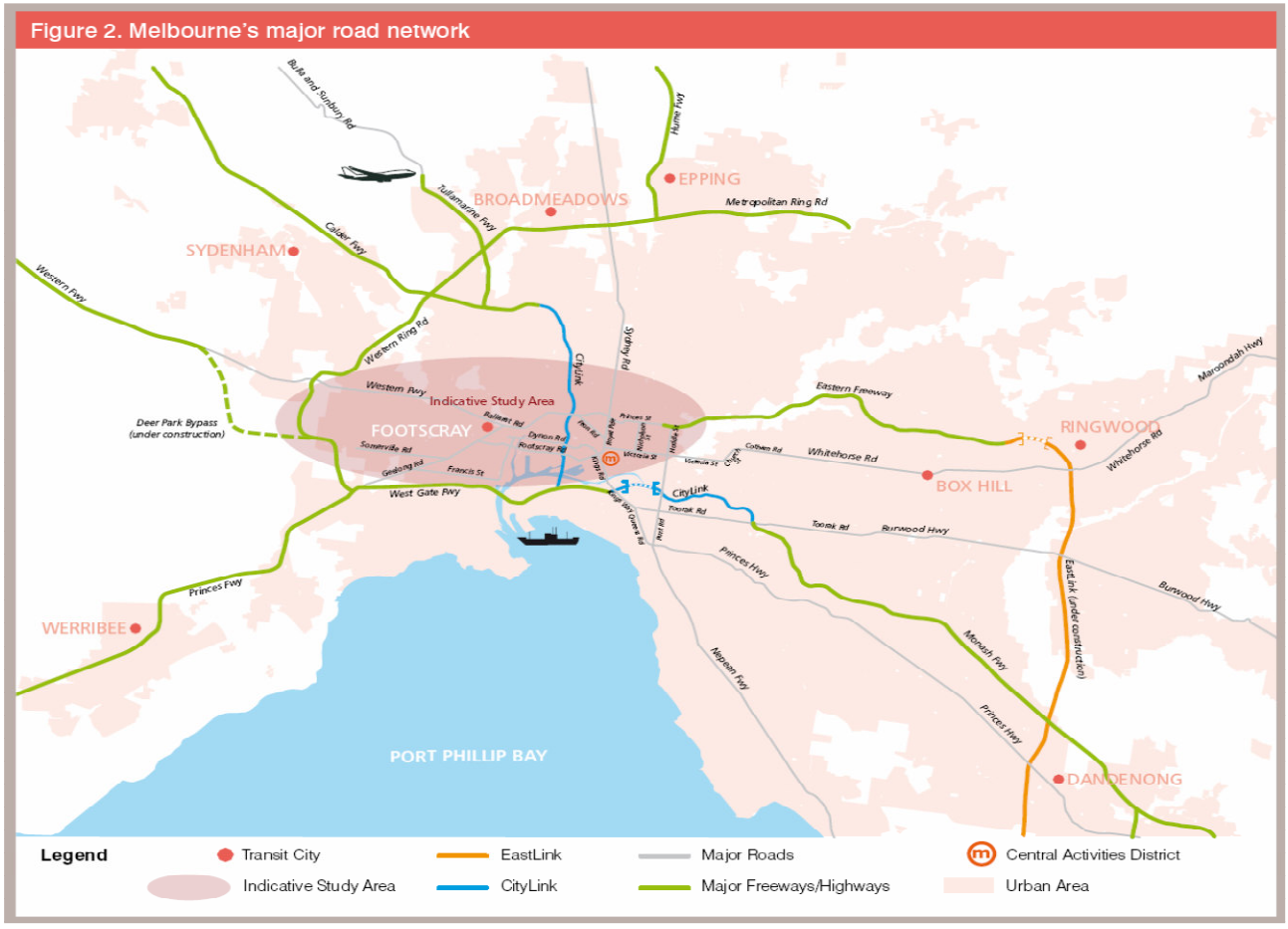
1

Introduction

The Victorian Government asked Sir Rod Eddington, with the support of the East-West Link Needs Assessment team to lead a study into an east-west transport link across Melbourne. A team comprising Sinclair Knight Merz, Maunsell and Partners Limited and Evans & Peck was commissioned to undertake the Transport Planning, Engineering and Costing components of this study.

The purpose of the study was to work out the next steps to take to address the growing demand for business, personal and freight travel across Melbourne, culminating in the identification of workable solutions in real time frames over the next 30 years. The indicative study area is shown in Figure 1.1.

Figure 1.1 Indicative Study Area



The National Guidelines for Transport System Management in Australia outline the following three step process for considering options:

- Strategic Merit Test, which is largely a qualitative assessment of "strategic fit", testing how well an option would play a part to achieve transport system objectives or need; whether there are any obvious 'fatal flaws' or key risks; and broadly, how an option is likely to measure up under a Triple Bottom Line (TBL) assessment.
- Rapid Appraisal, which is intended to be a cost effective way of gauging whether an initiative is likely to pass a detailed appraisal. The methodology used for rapid appraisal is similar to a detailed appraisal; however the estimates and detail for a rapid appraisal are less precise.
- The third phase is the Detailed Appraisal which, following further refinement and development of the options, provides a more comprehensive analysis of the impacts and merits of the options.

The investigation was carried out in three phases as described below, based on the process outlined above.

Phase 1 – Develop objectives, assessment framework and initial options.

Following an examination of the current situation within the Study Area, the Study Team identified Government and Societal Objectives and reviewed them against Transport System Objectives and East-West issues. During this period, a strategic analysis framework was also developed for use in the following phases of the study. An initial 'long list' of options was developed from public submissions and the work of the Study Team. A Strategic Merit Test was used to filter these options to provide a 'short list' for further examination.

Phase 2 – Initial Option assessment

Further examination of the transport network in the Melbourne and particularly in the Study Area was undertaken to identify existing and future drivers of transport demand. The gaps and problems in meeting this demand were investigated, both today and in the future. Public submissions and stakeholder consultation were a key part of this process.

At the same time, the short list of options was taken through concept engineering and costing processes, along with identification of environmental, social and economic issues within the study area that may impact on any infrastructure provision.

A high level options analysis was carried out, to identify those options to be further developed for final analysis.

Phase 3 – Final option assessment

Examination of the effects of the proposed options on the transport network in Melbourne was undertaken, along with a detailed review of the possible Social, Environmental and Economic effects. Possible changes in future conditions were also taken into account as a scenario analysis in order to understand the effects of changed conditions in the future on the demand for transport.

The previously identified options were combined to provide a multi-modal solution. Further detail was examined for engineering and costing of each of the options to ensure the feasibility and accuracy of the final options and identify any future challenges in development. The agreed analysis framework was then used to review the performance of each option and to identify the preferred transport options.

2

Option Evolution

2.1 Long List Options Investigations

2.1.1 Development of "Long List"

It was recognised that many of the nearly one hundred discrete options that had been identified could, not reasonably be differentiated at this stage due to the limited detail available at the time. For instance it was not yet possible to differentiate between a wide range of east-west road link options of differing lengths, construction and interchange configurations. Similarly, there are many possible ways to provide a transit link to Doncaster utilising the Eastern Freeway.

Where sensible, some individual options were therefore grouped into representative options. Taking the above examples, east-west road links were generically grouped, as were the Eastern Freeway transit links. The resultant amalgamated options were then considered in the initial assessment.

2.1.2 Option Short listing

The long list of options was assessed in order to identify those options with the greatest potential to address the transport needs in the study area. At the end of Phase 1, the short listed options to be taken forward for development and further consideration in Phase 2 were as shown in Table 2-1.

Table 2-1: Short listed Options

Basic Option	Included variations
a new East – West road	▪ with and without specific CBD access ▪ full tunnel vs. mixed tunnel / surface / elevated ▪ shorter tunnels from the east &/or west ▪ northern or southern alignments ▪ tolled vs. untolled
new Bayside east-west tunnel	▪ connection options ▪ tolled vs. untolled
upgrading of existing east-west roads	▪ addressing local issues vs. improving a whole EW route
a new east-west CBD rail tunnel	▪ alignment options ▪ station options ▪ operating/service options
a new transit link to Doncaster	▪ rail, light rail or bus rapid transit ▪ via existing links or new links ▪ stop/station locations
rail capacity upgrades from the West	▪ incremental capacity improvements ▪ electrifications to Melton, Sunbury & Geelong ▪ long underground Regional Rail in conjunction with road tunnel
new Caroline Springs rail line	▪ route options
amenity improvements in Yarraville	▪ Alternative freight routes around residential areas.
non-infrastructure policies	▪ pricing ▪ public transport priority/road space allocation ▪ travel demand management ▪ freight management

2.2 Short List Options Investigations

The option types considered during Phase 2 of the Study were as follows:

Option 1 – A new East-West Link Road

Option 2 – A new bayside road connection

Option 3 – Upgrading the existing road network

Option 4 - A new East-West Rail tunnel under the CBD

Option 5 – A new Transit link to Doncaster

Option 6 – Rail Improvements to the West

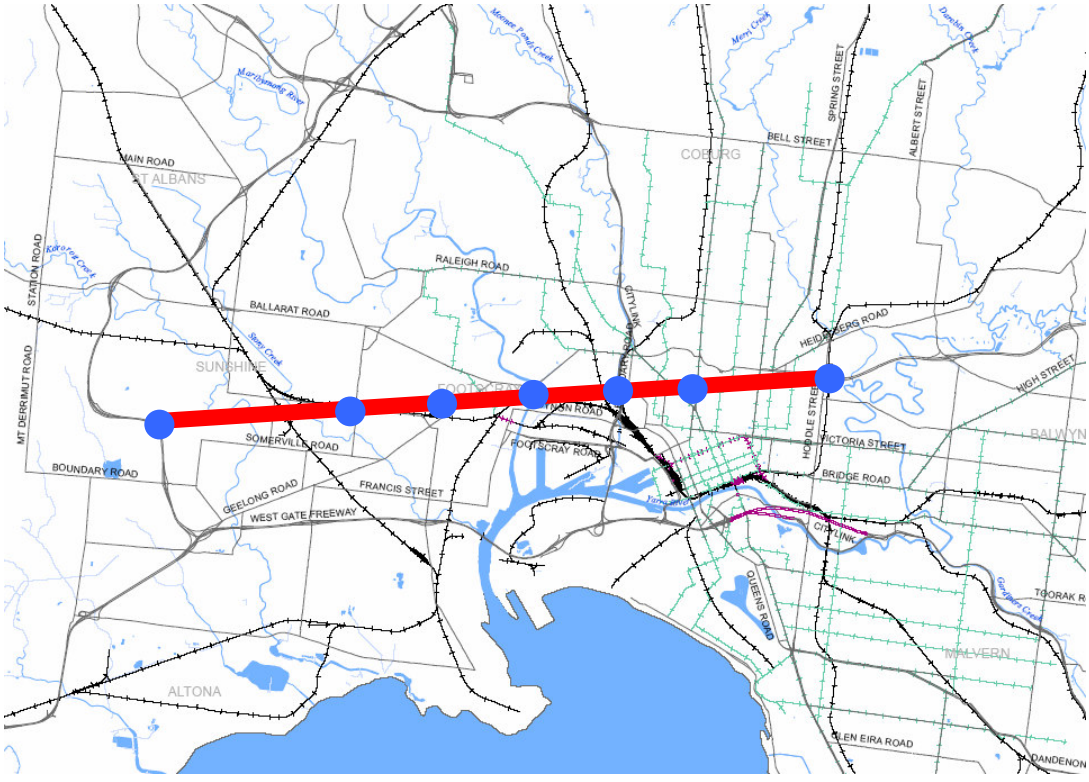
Option 7 – A new heavy rail line to Caroline Springs

Option 8 – Road improvements in the Yarraville area

Option 9 – Non Infrastructure Policy Options

Option 1 – A new East-West Link Road

This option was developed to provide a new link connecting the Western Ring Road in the west of Melbourne, with the end of the Eastern Freeway at Hoddle Street. The road would be in tunnel over much of its length to separate through traffic and local traffic which would continue to use the existing arterial road network. It was based on various concept sketches from Phase 1. An example is shown below.



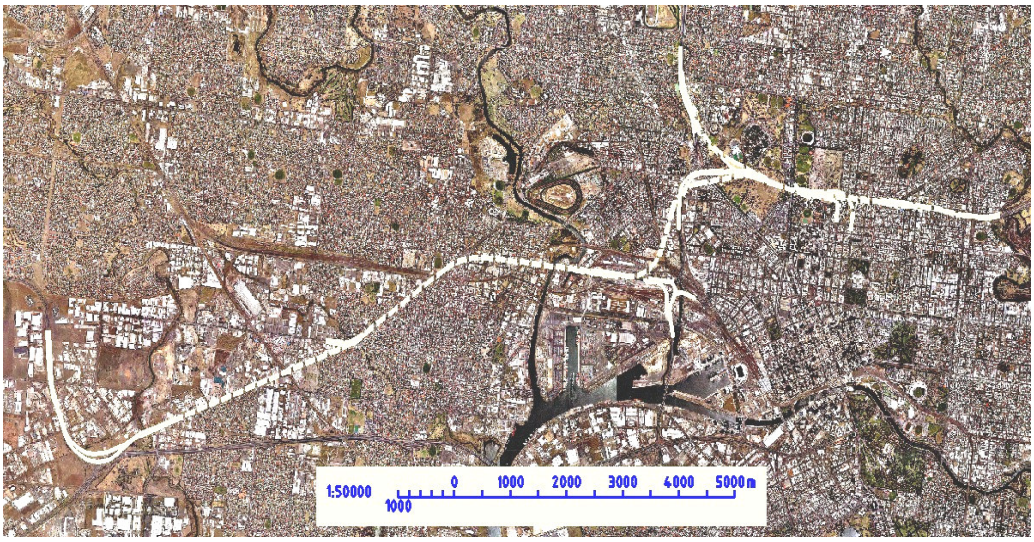
Route Description

The route commences in a tunnel at Eastern Freeway to the east of Hoddle Street and then follows the alignment of Alexandra Parade to Royal Parade, passing to the north of Elliott Avenue at Flemington Road and then heading south to Dynon Road. It then passes along Dynon Road to the west and then along Geelong Road / Princes Highway and finishes in Princes Highway in the vicinity of Old Geelong Road to the north east of the Western Ring Road interchange with West Gate Freeway. The road would consist of twin 2 lane tunnels with 2 lane entry / exits at each end.

For the concept design, the grade was generally set to provide approximately a nine metre clearance to the surface road along Alexandra Parade and elsewhere in order to mitigate surface disturbance during tunnelling, whilst the same time minimising access ramp lengths.

Following initial assessment of desire lines, the proposed connections were:

- 2 lane entry / exits at the Eastern Freeway portals
- single lane entry and exits within Alexandra Parade to the east of Queens Parade, to allow easterly movements to and from Nicholson St
- westerly orientated ramp connections to the south in Lygon Street (northbound) and Rathdowne Street (southbound) to complement easterly connections at Nicholson Street and Royal Parade
- Single lane entry and exit to the east of Royal Parade to allow easterly movements to and from Royal Parade.
- At City Link, extensive tunnels and structure are required to provide easterly connections to City Link.
- Westerly orientated connections are provided in Dynon Rd
- The existing CityLink / Dynon Rd interchange would be upgraded to provide full movements through the provision of additional southerly ramps.
- Easterly orientated ramps at Somerville Rd
- Tunnel portals located centrally within Princes Highway in the vicinity of Grieve Parade.
- At Western Ring Road Interchange, additional ramps are required to connect Princes Hwy to Western Ring Road.



Design Considerations:

In developing the concept designs, the following design parameters were adopted.

- Design speed in the tunnel 80 km/h
- Ramp terminal speeds adopted to match the environment ie
  - 60 km/h design speed adopted for Royal Parade and Somerville Rd
  - 70 km/h design speed adopted for Alexandra Parade, Princes Highway and Footscray Road
  - 100 km/h adopted for Eastern Freeway and City Link connections.

Staging

With the proposed alignment, there is the potential to stage construction of a complete link, or build only parts. Potential staging, in no particular order could be:

Stage 1, Eastern Freeway to CityLink
Stage 2, Dynon Road to Somerville Road
Stage 3, New interchange at Dynon Road
Stage 4, Western Ring Road Interchange upgrade
Stage 5, Somerville Rd to Western Ring Road.
Stage 6, Elliott Avenue to Dynon Road

Stage 1 - this option endeavours to ensure that all current movements are unhindered. The grading is critical at Hoddle Street due to level controls over Merri Creek, beneath the existing railway and Hoddle Street piers and above the main drain in Alexandra Parade. The exit at CityLink is to the north of Elliott Ave to allow for at grade staging. Some road widening is envisaged to allow for free flow movements at Flemington Rd intersection. This section of work will impact on the current road system in the vicinity of the 300m long portal slots at all locations and will concentrate traffic on the arterial road system at the ramp locations. A number of options were investigated for providing access to the tunnel for CBD traffic via Nicholson Street. However, this was difficult to achieve due to existing frontage properties, tram routes and the length of slot which would be required within Nicholson Street for any entry and exit ramps.

Stage 2 - Dynon Road to Somerville Road. The proposed westerly portals at Somerville Road could be located within Geelong Road as an alternative and the Northerly ramps at Dynon Road / CityLink provide direct connection to Stage 1. This section will provide Port connections to the west, but concentrates traffic at the portals which may require other road upgrades.

Stage 3 - Dynon Road Interchange Upgrade provides southerly ramps which allows movements to West Gate Freeway.

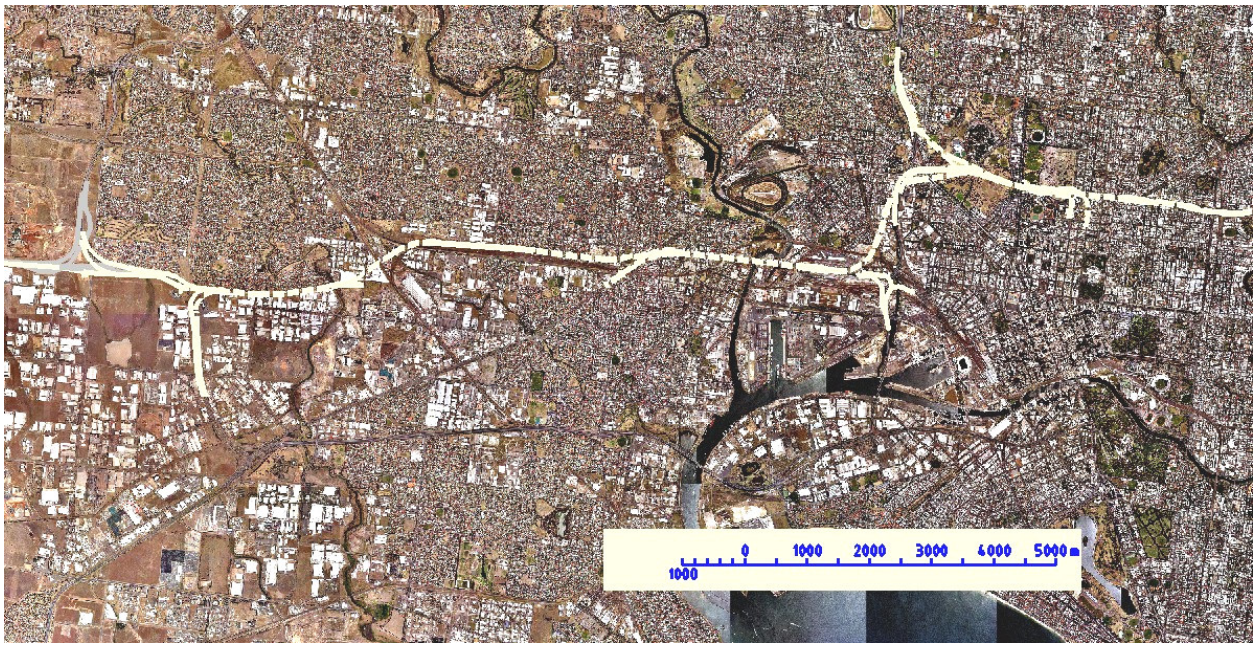
Stage 4 - Western Ring Road interchange upgrade, provides a direct connection between Geelong Road and the Western Ring Road

Stage 5 - Somerville Rd to Western Ring Road is a link that could be provided either as a tunnel or as an elevated roadway.

The final stage, Stage 6 linking Elliott Avenue to Dynon Road with freeway to freeway connections at the junction of CityLink and Flemington Road would complete the final direct connection of this scheme but would require extensive works. Further review will be required at Phase 3 of the study to optimise this solution, if this scheme is taken forward after the Rapid Appraisal.

With the tunnel operations generally there will need to be further refinement of the entries and exits to mitigate the issue of ramp merge and ramp diverge conflict with the potential for controlled lane discipline within tunnels.

After further consideration, a second alignment was developed as shown below, which connected into the Western Ring Road at the Deer Park Bypass.



However, the following issues will need further consideration at the next phase of development.

- Both options focus CBD turning movements at Nicholson Street.
- They require extensive Freeway to Freeway staging at CityLink.
- They do not provide for placard loads.
- New southbound city connections via CityLink were difficult to achieve.

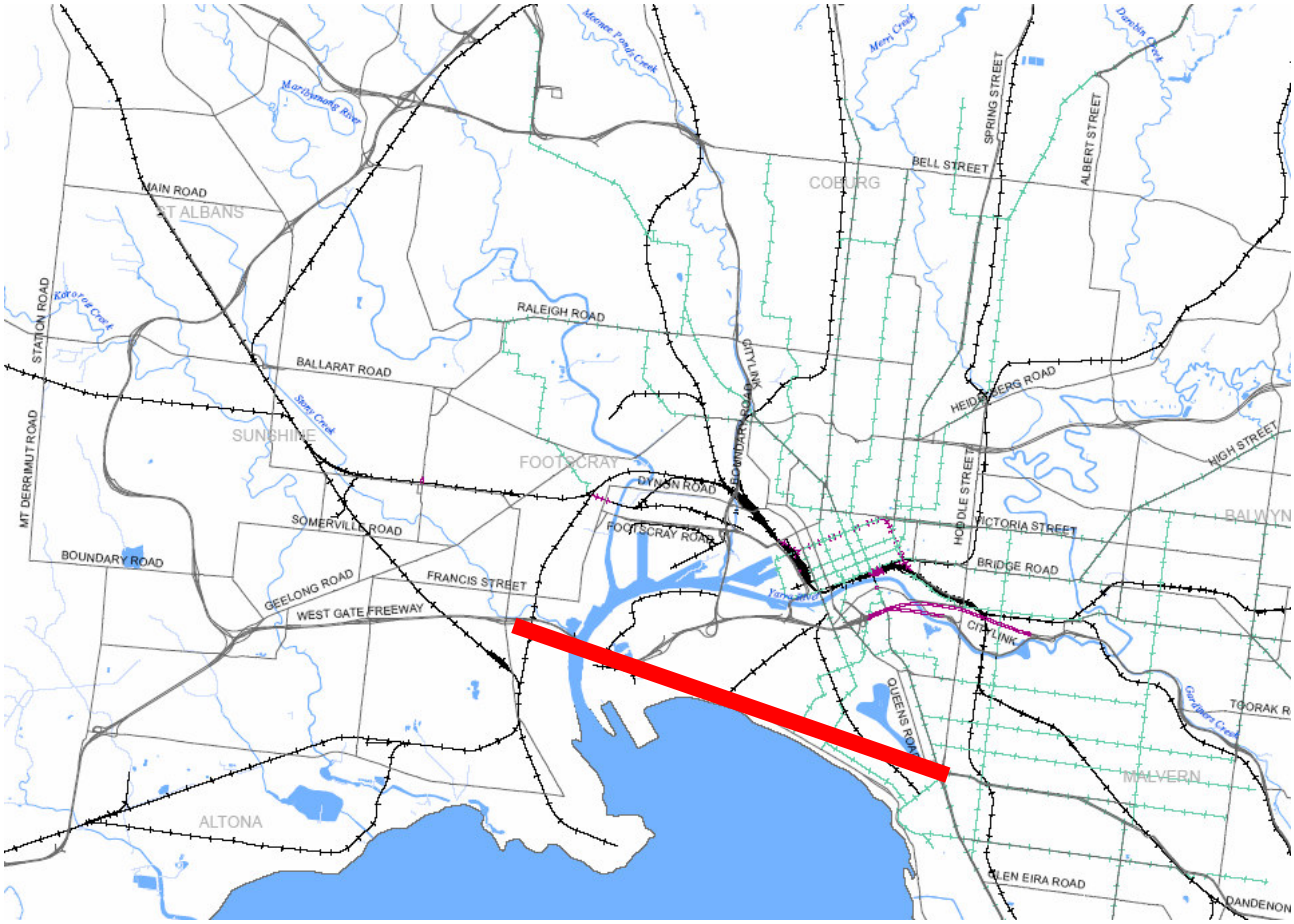
Geology

In terms of Geology, the table below shows the expected geology along the length of the route, based on historic borehole data.

Western Ring Road to Cypress ave tunnel portal (Western Portal).	Thin basaltic clays over Newer Volcanics basalt.	The basalt will provide sound foundations for road infrastructure. The road sub-base should be founded in soils at a depth below the influence of seasonal moisture fluctuation.
Western tunnel portal to West Footscray Station.	Newer Volcanics basalt	The basalt will provide very sound tunnelling conditions. The tunnel may be excavated by open face hard rock TBM or by basting and limited road header. Segmental lining, steel sets and rock bolts and shotcrete are possible support options.
West Footscray Station to Maribyrnong River (Dynon Road Bridge).	Newer Volcanics basalt thins to less than 20m thickness and terminates on the west bank of the river. Tunnel floor will enter Tertiary silts, sands and gravels.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered. Deep bridge foundations, and the North Yarra Sewer Main are present.
Maribyrnong River (Dynon Road Bridge) to Dynon Rd near South Kensington Station.	Complex Yarra Delta sediments, including Coode Island Silt and Older Volcanics Basalt, over Tertiary gravel, sand, silt and clay.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the basalts, gravels and sands, and severe settlement if groundwater is lowered (Issues as for CityLink).
Dynon Rd near South Kensington Station to Boundary Road.	Complex Yarra Delta sediments, including Coode Island Silt in deep valleys overlying Older Volcanics Basalt.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the basalts, gravels and sands, and severe settlement if groundwater is lowered (Issues as for CityLink).
Boundary Road to Royal Parade.	Older Volcanics Basalts and Tertiary sands and gravels over weathered Silurian siltstone.	EPB tunnelling methods would be needed. Hazards include aquifers in the basalts, gravels and sands, and settlement if groundwater is lowered. Optimise vertical alignment by lowering tunnel into the siltstone bedrock.
Royal Parade to Rathdown Street.	Residual silty clays over weathered Silurian siltstone.	The siltstone will provide sound tunnelling conditions. The tunnel may be excavated by open face hard rock TBM or excavator and road header. Segmental lining, steel sets and rock bolts and shotcrete are possible support options. The significant North Yarra Sewer Main tunnel and shafts are present.
Branches along Lygon and Rathdown Streets.	Residual silty clays over weathered Silurian siltstone.	The siltstone will provide sound tunnelling conditions. The tunnel may be excavated by open face hard rock TBM or excavator and road header. Segmental lining, steel sets and rock bolts and shotcrete are possible support options.
Rathdown Street to Hoddle Street.	Older Volcanics Basalts over thin Tertiary sands and gravels over weathered Silurian siltstone. The basalt thickens towards the east, so that the tunnel will be in basalt entirely near Hoddle Street.	Initially the mixed face conditions may require EPB tunnel boring, due to the sands and gravels. Thereafter the basalt will provide very sound tunnelling conditions. The tunnel may be excavated by open face hard rock TBM or by basting and limited road header. Segmental lining, steel sets and rock bolts and shotcrete are possible support options.

Option 2 – A new Bayside Link

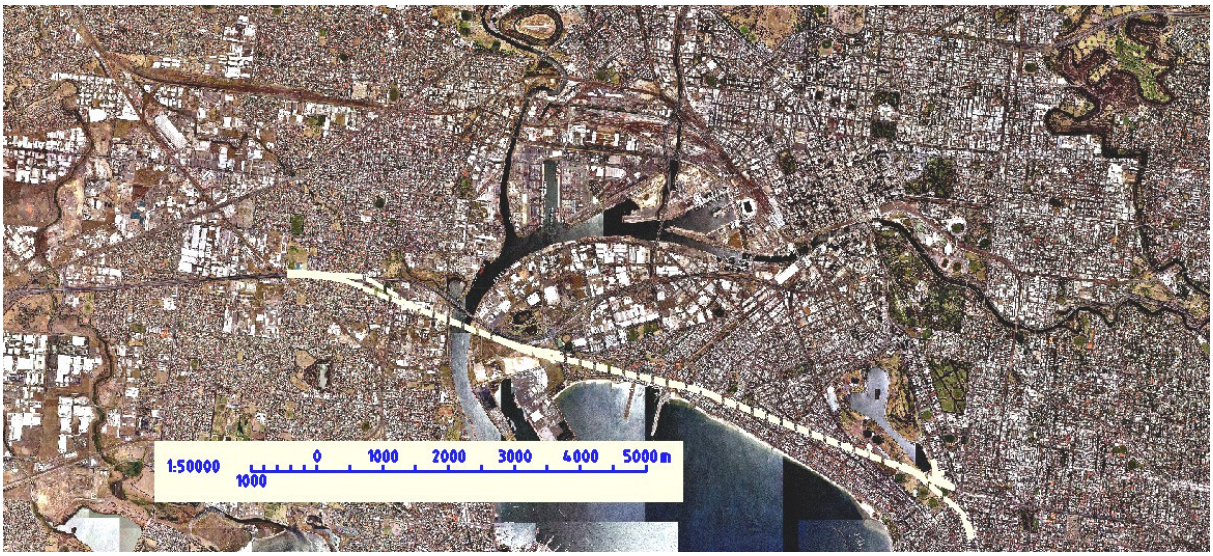
Again based on sketch designs from Phase 1 (example below), two options were developed for providing a link underneath Port Phillip bay. The first of these, referred to as the short bay option connected the West Gate Freeway at Williamstown Road Interchange to the St Kilda Road / Dandenong Road junction by a new 2 lane tunnel approximately 9.0km in length, together with an intermediate interchange servicing the Webb dock, providing an alternative route for East West traffic to the West Gate Bridge.



Design Considerations:

In developing the concept designs, the following design parameters were adopted.

- Design speed in the tunnel 80 km/h
- Ramp terminal speeds adopted to match the environment ie
  - 70 km/h design speed adopted for Princes Highway / Nepean Highway
  - 100 km/h design speed adopted for West Gate Freeway.



The following connections are provided in the design that has been developed.

- 2 lane entry and exit ramps at West Gate Freeway, westerly orientated at Williamstown Road interchange.
- Single lane entry and exit ramps, westerly orientated, to provide connection from the west into Webb Dock.
- Single lane entry and exit ramps, westerly orientated, both to Princes Highway to the east and Nepean Highway to the south.

Staging

- There is the potential to stage the construction in two stages, with stage 1 joining the West Gate freeway to the Webb dock and Stage 2 connecting the Webb Dock to St Kilda road.

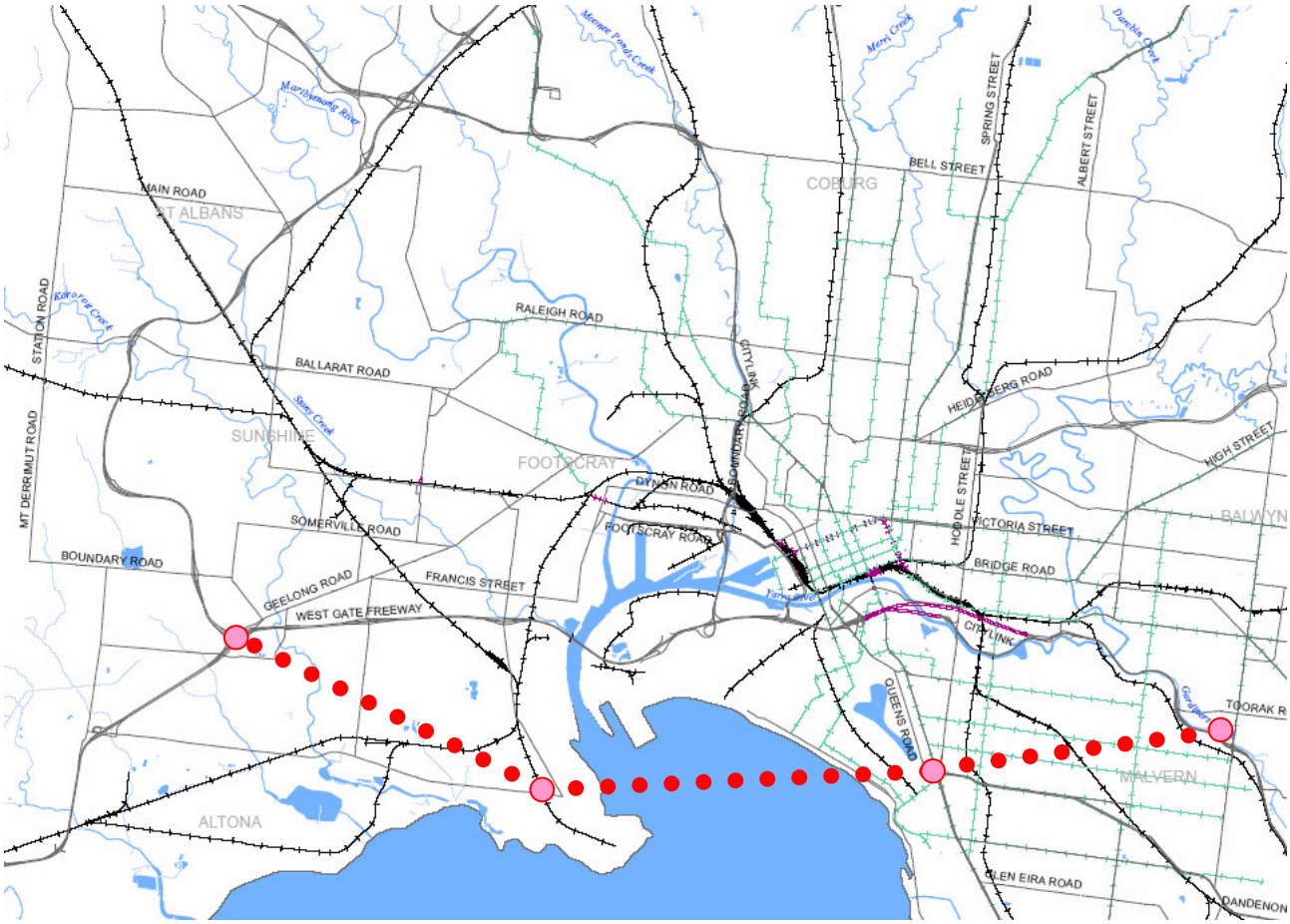
Operationally it would be difficult to construct the two end terminals, particularly the St. Kilda Road junction without significant disruption to the existing traffic.

Geology

In terms of Geology, the table below shows the expected geology along the length of the route, based on historic borehole data.

Williamstown Road to Princes Pier, beneath the Yarra River	Initially Newer Volcanics basalt near Williamstown Road. Then predominantly Quaternary / recent sands, gravels, silts and clays at tunnel level. These are low strength Yarra Delta sediments.	Very complex geology. EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered. Likely to be the most difficult tunneling conditions for a large diameter tunnel.
Princes Pier along the coast, and to St Kilda Junction.	Predominantly Tertiary Age sands, silts and clays at tunnel level overlain by Quaternary silts and sands. Some older volcanics basalt between westgate bridge and Princes Pier.	Relatively complex geology. EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered.

A second option beneath the bay was also developed based on connecting the Princes Freeway and Western Ring Road to the Toorak Road junction on the Monash Freeway, with intermediate connections at Williamstown and St Kilda Road / Dandenong Road based on the sketch design below. However, it would be difficult to provide a connection to the Monash Freeway at Toorak road without significant modifications to the existing layout which is currently being upgraded and could potentially have flow on effects to the effective capacity of the Monash Freeway.

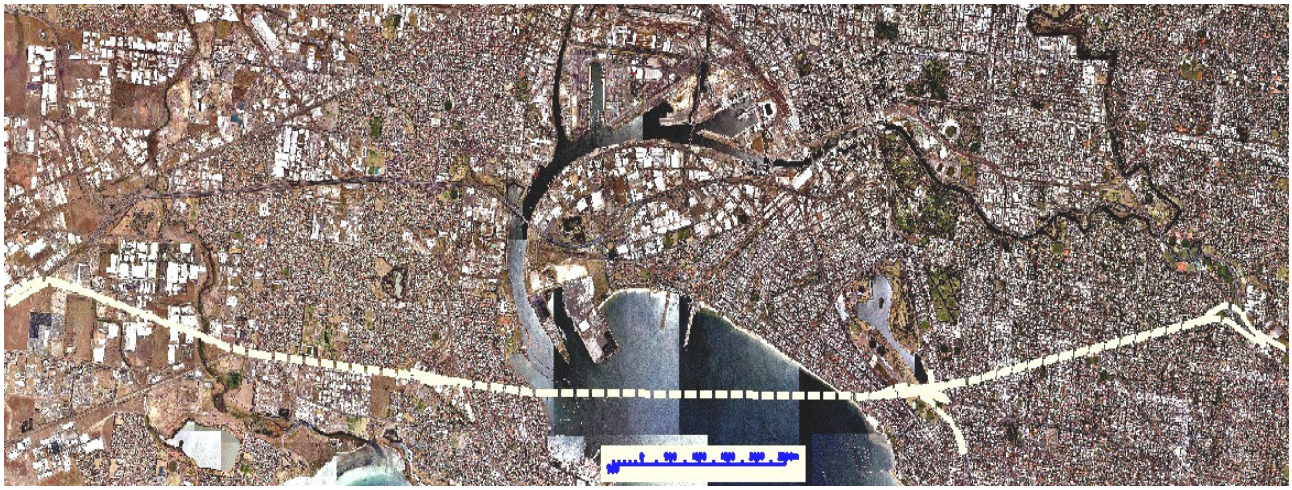


Description:

This option commences at the Western Ring Road / Princes Freeway Interchange with two lane entry and exit portals. A 7.5Km tunnel connects to easterly orientated entry and exit portals at Williamstown (access via Champion Rd) and a further 8.5 Km tunnel connects to St Kilda Rd junction with single lane connections to Princes Hwy to the east and Nepean Hwy to the south. Full movements are retained at St Kilda Rd junction. A further 5.5 Km of tunnel provides access to Monash Freeway, via westerly orientated connections involving extensive structures.

The following connections are provided in the concept design that has been developed.

- 2 lane entry and exit ramps at Geelong Road, easterly orientated.
- Single lane entry and exit ramps at Williamstown, easterly orientated
- Single lane entry and exit ramps, westerly orientated, both to Princes Highway to the east and Nepean Highway to the south.
- Single lane entry and exit ramps, westerly orientated, to Monash Freeway to the east.



Staging

As with the short bay link, there would be the option to stage the construction in three sections with stage 1 consisting of an 8.5 km tunnel between St Kilda Rd and Williamstown. This would provide relief to the West Gate Freeway but may generate traffic into Williamstown and into St Kilda Road junction. Stage 2 would involve an additional 7.5 Km tunnel between Geelong Road and Williamstown. This would provide further relief to the West Gate freeway. Stage 3 is a further 5.5 km tunnel joining St Kilda Road and Monash Freeway which provides relief to Princes Highway and provides full freeway to freeway connectivity.

Geology

In terms of Geology, the table below shows the expected geology along the length of the route, based on historic borehole data.

Geelong Road to Williamstown	Thin newer Volcanics Basalts over Tertiary sand, gravel, silt and clays.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered.
Williamstown to Albert Park	Recent marine silts and clays over Tertiary sands, silts and clays offshore in Port Phillip Bay. Then Tertiary sands and clays onshore beneath Albert Park.	These very soft conditions would best suit immersed tube tunnels. Depth to dense sands and clays is not known, and is likely to be too deep for conventional tunnelling.
Albert Park to Monash Freeway	Predominantly Tertiary sands, silts and clays at tunnel level overlain by Quaternary silts and sands. Then weathered Silurian siltstone near the Monash Freeway.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered.

Option 3 – Upgrading the existing road network

Option 3 involved investigating the impact of upgrading the existing road network as an alternative to providing a new east – west link road.

Option 3 East

Option 3 east is aimed at improving the capacity on the existing main east-west route, between the end of the Eastern Freeway and CityLink. The upgrade starts at Alexandra Parade and proceeds westwards along Princes Street, crossing Lygon Street and then along Cemetery Road east, College Crescent and Cemetery Road west. After crossing Royal Parade it continues west along Macarthur Road and Elliot Avenue before crossing Flemington Road, continuing along Racecourse Road to Citylink.

Details of the proposed connections and links are based on a review of the main constraints on the existing network.

Princes Street

- widen on the north side to create four lanes between Rathdowne Street and Nicholson Street
- Provide indented parking on south side between Lygon Street and Nicholson Street

Cemetery Road East

- widen on the north side to provide three through lanes in each direction, including around the roundabout

College Crescent

- widen on south side to provide three lanes in each direction

Cemetery Road West

- widen on north side to provide three lanes in each direction
- provide two right turn lanes to Royal Parade

Macarthur Road

- widen on the south side to create two lanes in each direction
- East bound, Royal Parade approach widen to three through lanes (for 100m) plus one right and one left.

Elliot Avenue

- Westbound, Flemington Road approach widen to one exclusive left lane (50m),two through lanes and two right turn lanes (100m)

Racecourse Road

- widen on the south side between Boundary Road and Flemington Road to create a left turn lane (50m) on the eastbound approach to Flemington Road, two through lanes full distance and two right turn lanes (120m and 80m)
- Westbound provide three lanes, widening out to include a right turn lane (50m) and a short left turn slip lane
- Relocate tram tracks and try to square up intersection with Flemington Road
- Reallocate westbound lanes on the approach to CityLink entry ramp as exclusive left, shared left and through and exclusive through.

There is the potential to stage the construction of this option. The following is one of the ways in which this option could be staged and would involve upgrading Princes Street between Nicholson Street and Lygon Street as Stage 1 followed by an upgrade to Cemetery Road and College Crescent, including an upgrade to the Royal Parade intersection as Stage 2. Stage 3 would involve upgrading the route across Royal Park along Macarthur Road and Elliot Avenue and the final stage would complete the route by constructing the racecourse road section.

The layout has been based on lane widths generally of 3.3m except where existing lane widths are narrower or where reduction is required to avoid land acquisition, with the minimum lane width being 3.0. The proposed widening has also been designed to match the existing levels and grades. Even adopting these design parameters some land acquisition is required along Alexandra Parade, Royal Park and Racecourse road and tree removal and footpath narrowing between Lygon Street and Royal Parade.

Option 3 West

Option 3 west starts on Ballarat Road to the east of the intersection with Geelong Road and then turns south onto Moore Street and continues to the intersection with Hopkins Street where it turns eastwards along Hopkins street before finishing in Whitehall Street to the south.

Details of the proposed connections and links are as follows:

Ballarat Road / Moore Street

- Convert right hand lane on Ballarat Road westbound to right turn lane into Moore Street to give three right turn lanes. Extend median side right turn lanes to provide increased storage.
- Widen Moore Street approach to Ballarat Road to three left lanes and one right turn lane (150m)
- Widen Moore Street (on east side) to three lanes in each direction
- Moore Street approach to Hopkins Street, three left turn lanes, one through lane (100m) and one right lane (50m)

Hopkins Street

- Widen Hopkins Street on the south side between Moore Street and Whitehall Street to three lanes in each direction (with centre median for protected right turn slot into Cowper Street)
- Hopkins Street westbound approach to Moore Street one left turn slip lane, one through lane and three right turn lanes.
- Hopkins Street eastbound approach to Whitehall Street two through lanes and two right turn lanes (one of which to be 100m)

Whitehall Street

- Whitehall Street southbound approach to Napier Street widen on east side to produce right turn lane (100m), through lane (150m) and two left turn lanes.

Staging

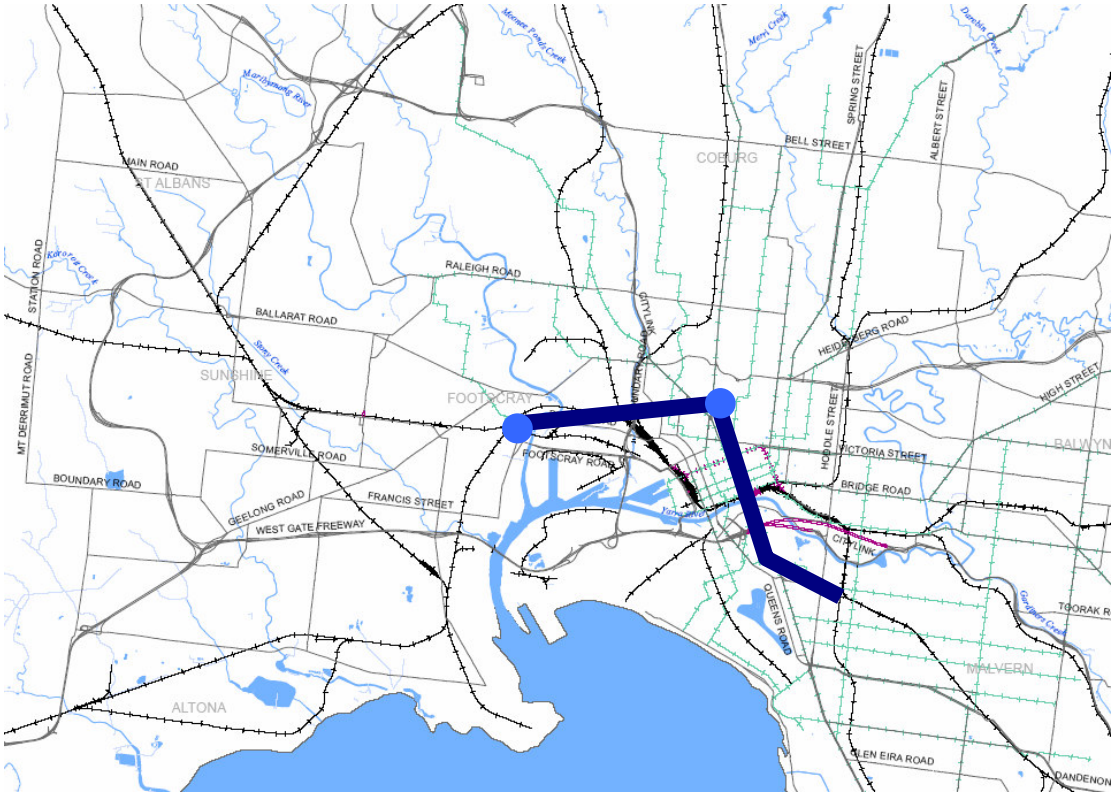
As with option 3 east, there is the potential to stage construction of this option. Below is one of the potential ways in which this option could be staged.

- Stage 1: Moore Street Widening – Demolish properties and clear site for widening. Construct new lanes on east side.
- Stage 2: Ballarat Road/Moore St Intersection – Widen Ballarat Rd and complete intersection upgrade works,
- Stage 3: Widen Hopkins Street to south side from Moore Street. to Whitehall Road
- Stage 4: Moore Street / Hopkins Street Intersection - Complete intersection tie-ins
- Stage 5: Upgrade Hopkins Street / Whitehall Street Intersection
- Stage 6: Widen Whitehall Street to east for additional left turn lanes

Consideration was given to linking Option 3 east and west together to provide a continuous surface option upgrade. However, due to the level of existing development in Kensington, no viable solution could be found.

Option 4 – A new East-West Rail tunnel under the CBD

Option 4 proposed a new east-west rail tunnel alignment passing beneath the CBD which would relieve the current congestion in the city loop and would provide direct access for commuters travelling between the eastern and western suburbs of Melbourne as indicated in the Transport Planning sketch below which came forward from Phase 1 of the Study.

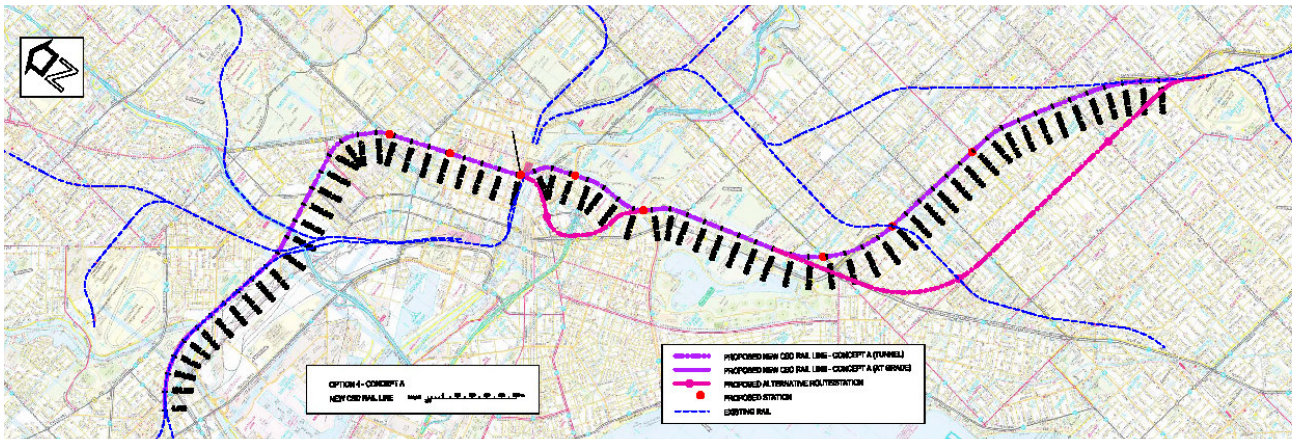


Within this main option, three sub options were investigated as follows:

- Option 4A – West Footscray to Caulfield via Dandenong Road
- Option 4B – West Footscray to Caulfield via Toorak Road
- Option 4C – West Footscray to Caulfield via Carlisle Street /Balaclava Road

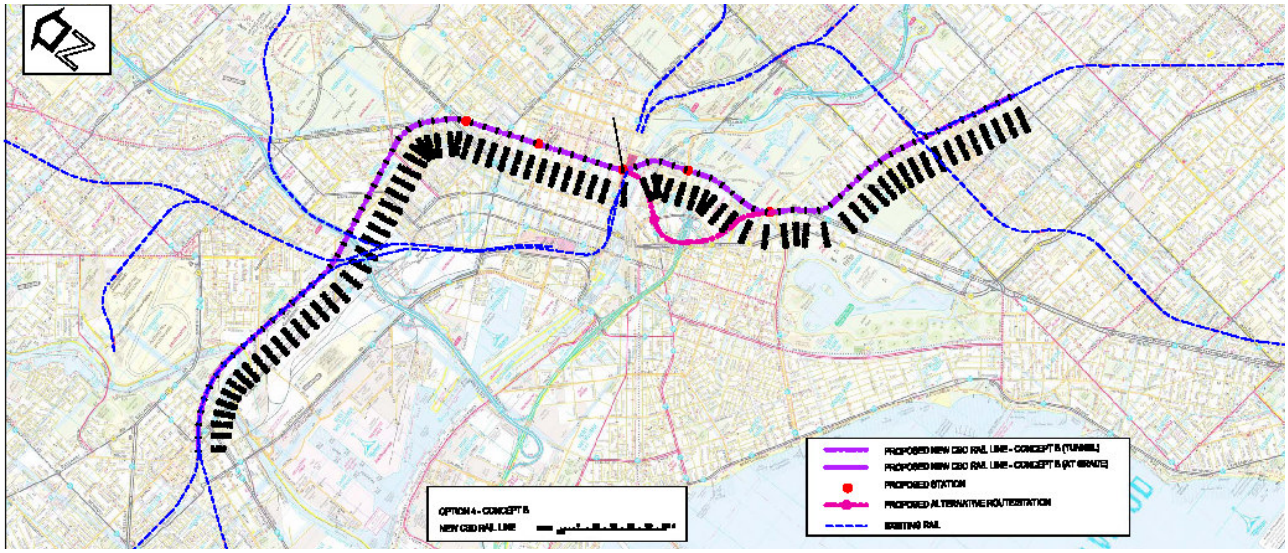
Option 4A

This option involves the construction of a new pair of tunnels, running from west of West Footscray station on the Sunbury corridor to the downside of Caulfield. Tunnelling would commence near West Footscray station and run under the existing rail reserve to Footscray station. After Footscray the tunnel would travel under various land uses to a new station near Melbourne University. From there, it would continue under Elizabeth Street to Melbourne Central and Flinders Street stations before running under St. Kilda Road. After this point the line would travel under Dandenong Road to Caulfield station.



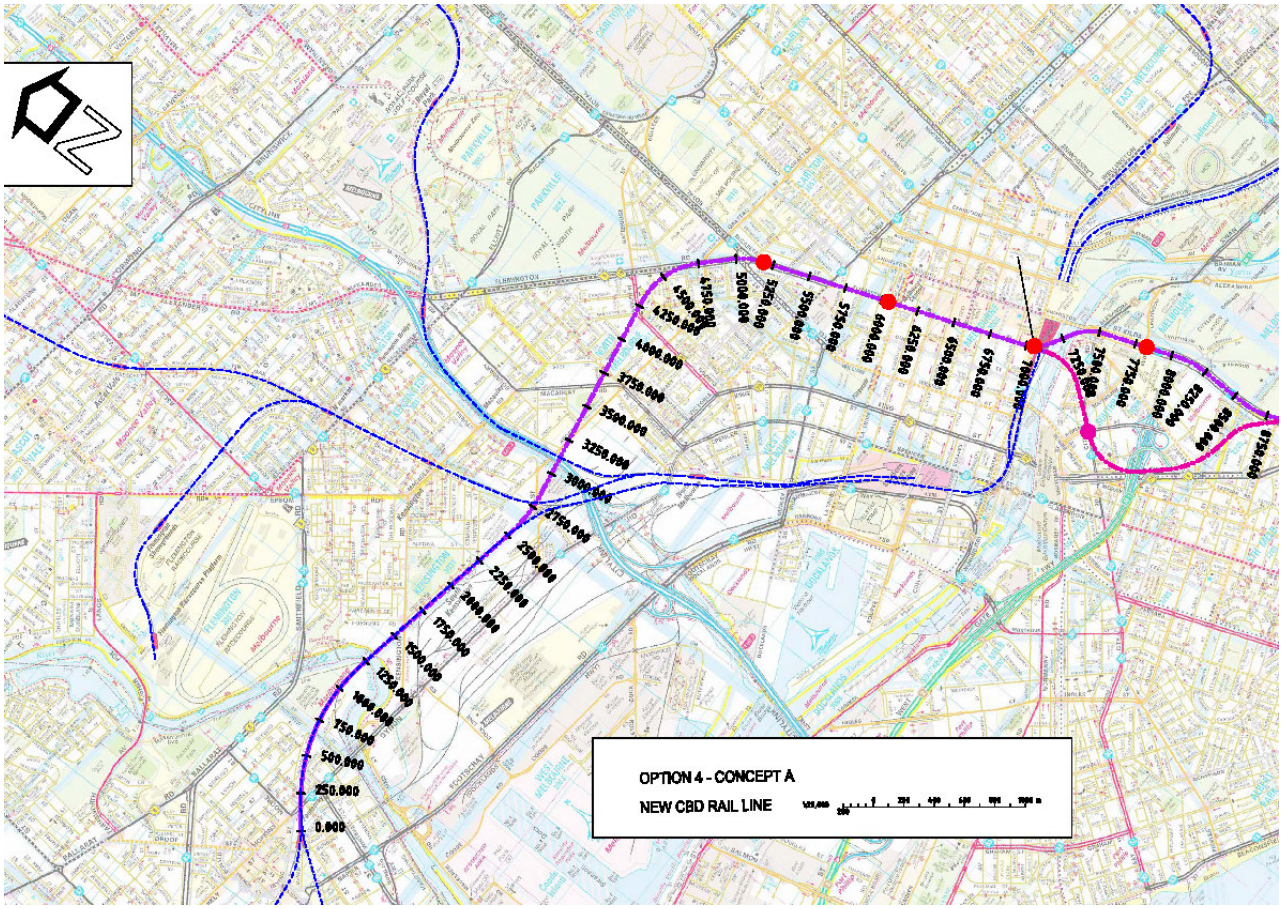
Option 4B

This option is similar to Option 4A between West Footscray and the Domain Interchange on St. Kilda Road. After this point the line would travel under Toorak Road to South Yarra station before running under the existing rail reserve to Caulfield Station.

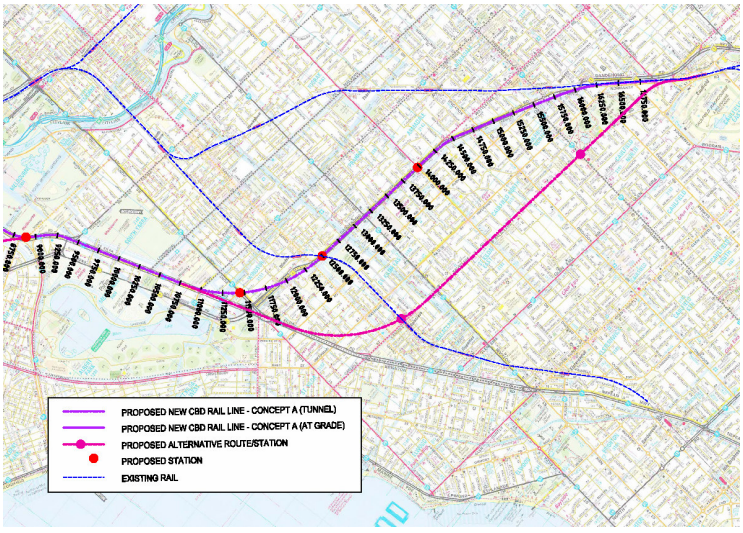


Option 4C

An alternative to Option 4A, shown in red in the plan below, between Flinders Street Station and the proposed Domain Station would be to realign the route under City Road to incorporate a possible station at Southbank, in the vicinity of Crown Casino and the Melbourne Exhibition Centre. Engineering issues including the soil profile through this area would need to be looked at in further detail.



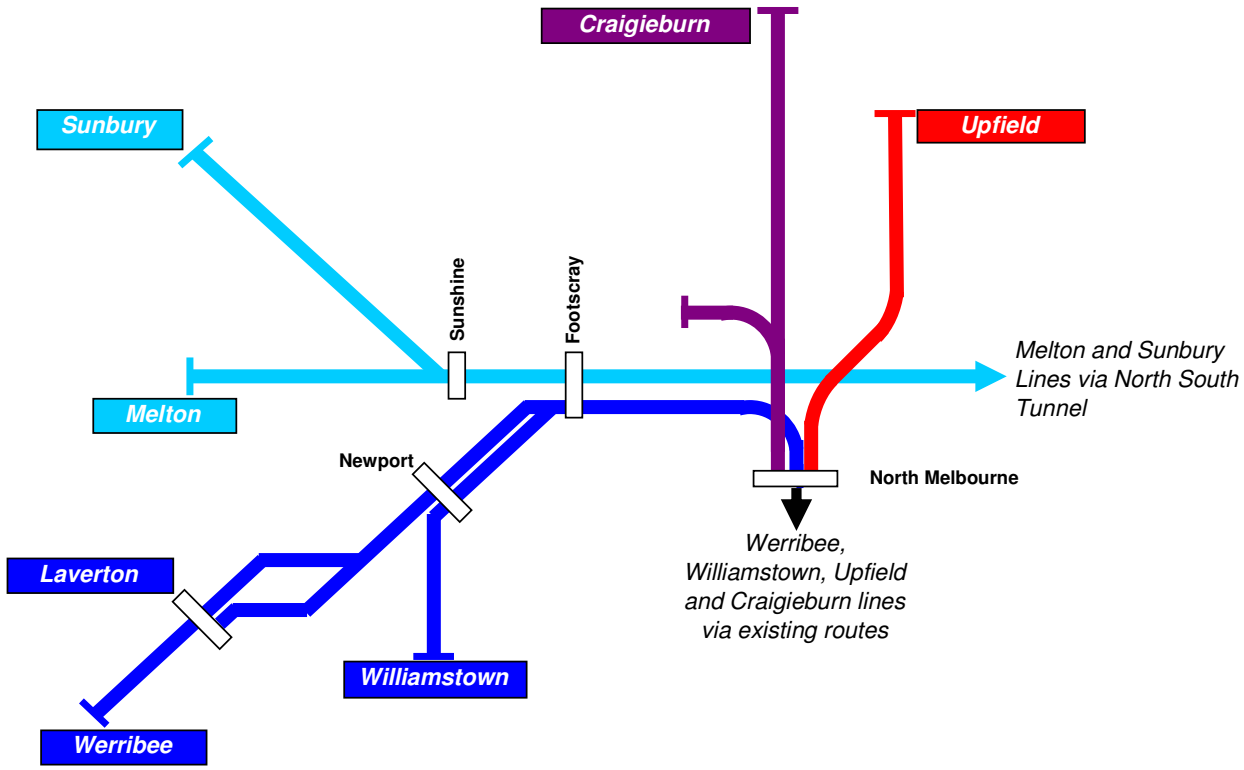
A further alternative, also shown in red on the adjacent plan, would be to continue the alignment along St.Kilda Road south of Dandenong Road, prior to deviating east and following the alignment of Carlisle Street /Balaclava Road where the proposed route would link into the existing rail network at Caulfield Station.



Operational Issues:

A north-south tunnel link running 24 trains per hour would provide the required capacity for the Melton and Sunbury lines (fully electrified). This would also enable enhanced Werribee / Williamstown services to run via the existing Northern Loop and Craigieburn trains to run via the North Melbourne fly-over into Southern Cross and Flinders Street (see diagram below).

- For train operations, studies will have to be conducted to determine whether track vibration isolation will be required. Having the tunnels at least 10m deep is a reasonable starting point in any pre-feasibility level studies of the route concepts;
- If the proposed rail line is connected to the Dandenong rail corridor, services will have to be coordinated with V-Line trains which would not be allowed to enter the tunnel. This would be averted if all Frankston line services were diverted into the new tunnel instead – providing a simpler and more self-contained service and improved reliability.



* New connection from light blue line above

Geology

The key geology along the route is indicated in the table below together with some comments related to the potential methods and complexity of tunnelling.

South Kensington Station to Flemington Road (Harker Street).	Complex Yarra Delta sediments, including Coode Island Silt and Older Volcanics Basalt, passing into Silurian Siltstone.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered.
Flemington Road under CBD to NGV.	Silurian Siltstone to Victoria Street, then into Tertiary sediments ? and Older Volcanics Basalt beneath the CBD. Recent (Coode Island) silts near the Yarra River. Siltstone near the NGV.	EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the basalts and sands, and severe settlement if groundwater is lowered (Issues as for CityLink).
NGV south along St Kilda Road, along Dandenong Road to Caulfield Station.	Predominantly Tertiary sands, silts and clays at tunnel level. Some weathered Silurian siltstone to the east of St Kilda Junction..	More uniform geological conditions. EPB or slurry tunnelling methods would be needed. Hazards include aquifers in the gravels and sands, and settlement if groundwater is lowered.

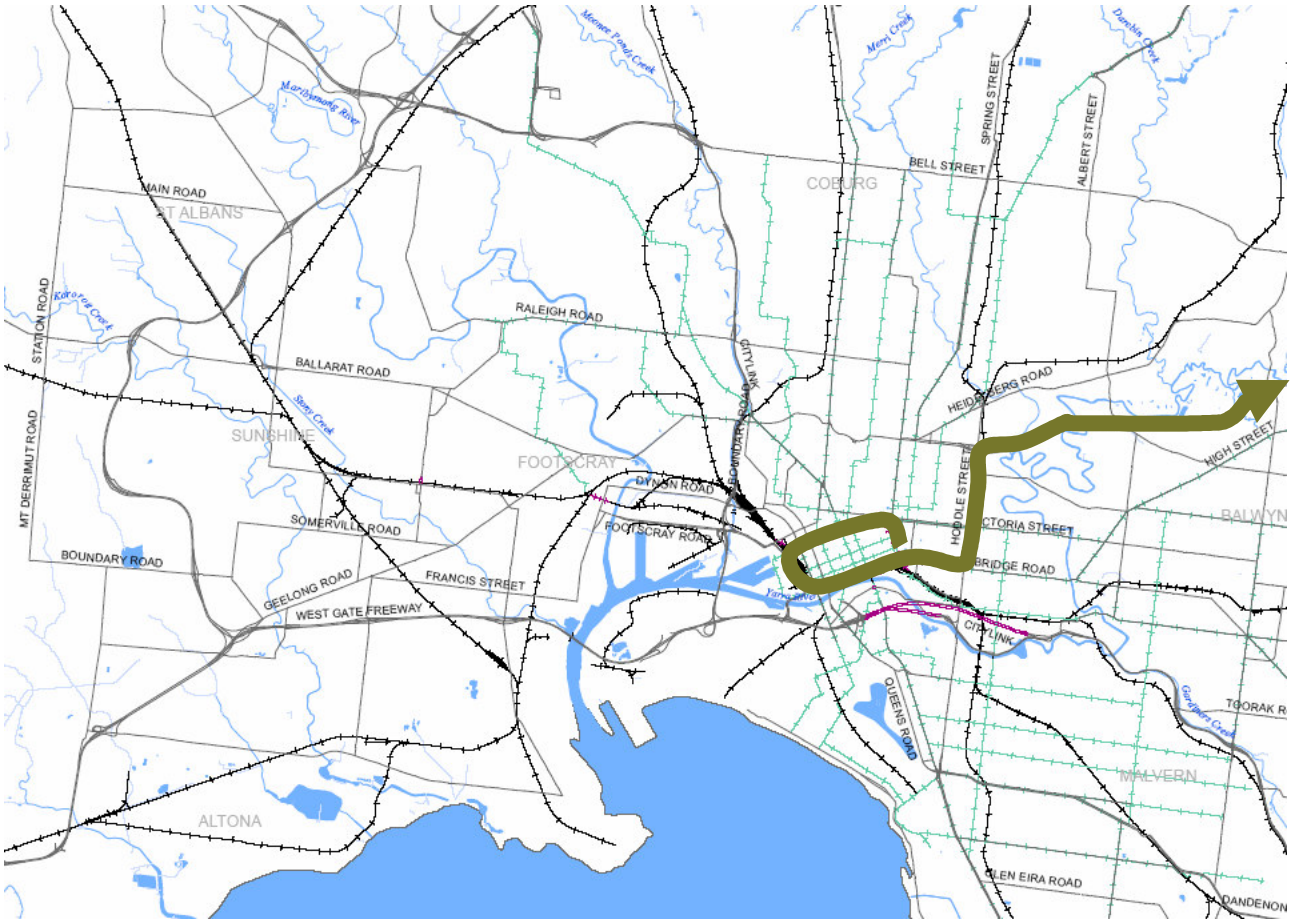
Option 5 – A new Transit link to Doncaster

Option 5 was aimed at improving public transport connections from the CBD to Doncaster. Three sub options were developed under this main heading to consider Public Transport provision between the CBD and Doncaster.

Option 5A – Heavy Rail

Description:

Option 5A encompasses the construction of a new heavy rail line along the Eastern freeway to Doncaster. This would connect into the existing network at Victoria Park Station onto the Clifton Hill group which currently serves the Epping and Hurstbridge lines. Commencing at Victoria Park, the proposed alignment would fly over the Eastern Freeway exit ramp at Hoddle Street and deviate to the east as it descends to follow an 'at grade' alignment along the Eastern Freeway. At Bulleen Road, the median strip ceases to exist along the Eastern Freeway. As a result, the alignment would gradually descend into a tunnel as it approaches the Bulleen Road overpass and continue to follow a direct path to Westfield Shopping Centre where the alignment would terminate. The total length of the link would be approx 12.6km including 5km of tunnel under the Eastern Freeway.



Due to the alignment following the path of the Eastern Freeway, the proposed alignment has been developed for a design speed of 80km/hr with maximum vertical grades of +/-2.5%, minimum horizontal radius of 550m and maximum cant of 80mm.

The main constraints associated with this option are as follows:

- The wide median strip along the Eastern Freeway concludes at Bulleen Road, which restricts the heavy rail alignment from travelling along the Eastern Freeway between Bulleen Road and Doncaster Road at-grade.

- The vertical distance between the Eastern Freeway to Victoria Park Station is in the region of 15 -20m. The recommended maximum vertical grade of 2.5% is insufficient to enable a tunnel alignment from Victoria Park and emerge along the Eastern Freeway without altering the height of the Eastern Freeway main carriageway and exit ramp at Hoddle Street. As a result, the proposed option incorporates a 'fly over' from Victoria Park Station prior to descending to follow the path of the median strip along the Eastern Freeway. If the Eastern Freeway was raised, it would need to be raised in the order of 1-2m to allow the rail tunnel to run beneath the pavement and this may cause subsequent problems for freight trucks exiting at Hoddle Street or continuing along Alexandra Parade with respect to the heights of the existing rail and road bridges.

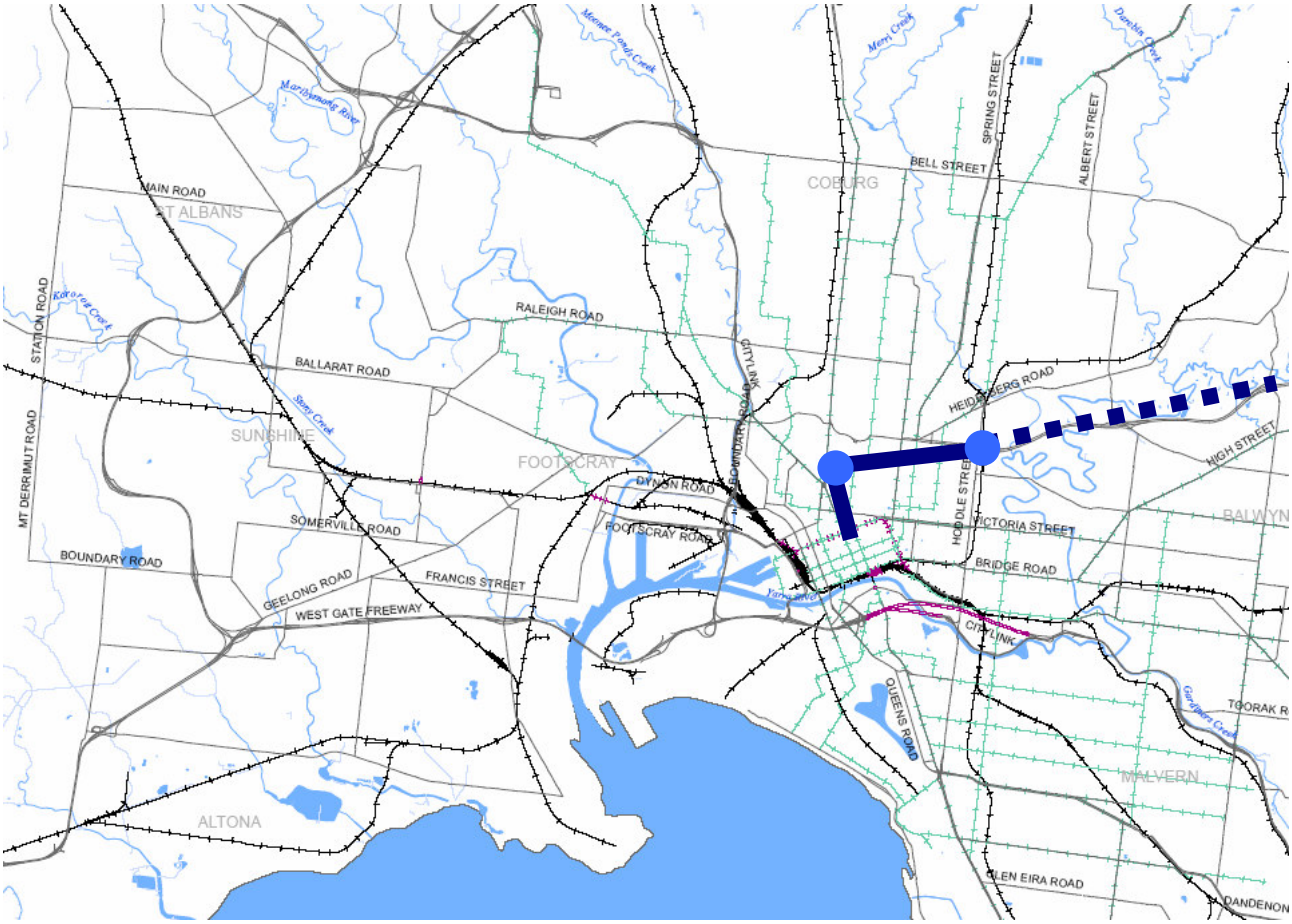
- The Clifton Hill Rail group may not be able to accommodate additional trains from Doncaster without major infrastructure works being brought forward many years.

Option 5B – Light Rail

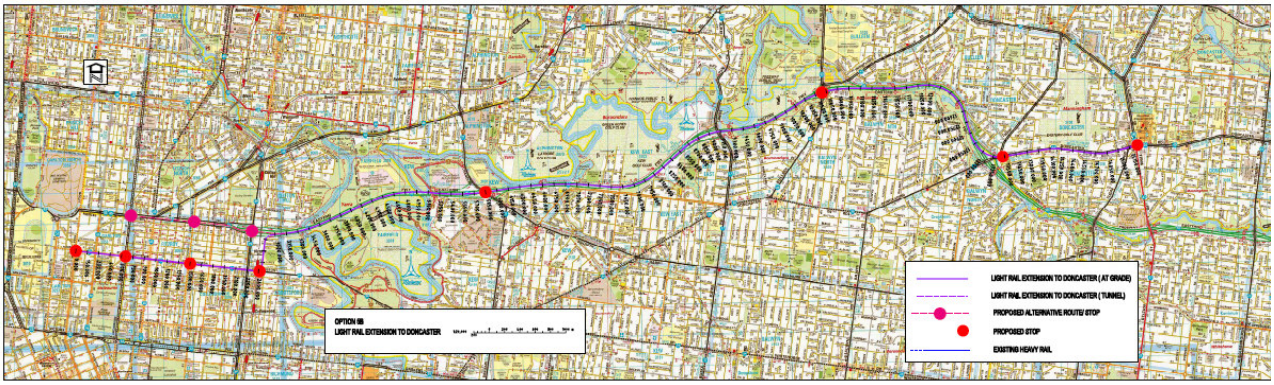
Description

Option 5B encompasses the construction of a new light rail line along the Eastern Freeway to Doncaster. The alignment would commence at Westfield Shopping Centre and follow the path of Doncaster Road 'at grade' towards the Eastern Freeway (Doncaster Road may require widening for this to be possible, or reallocation of 1 lane each way). Once the alignment reaches the Eastern Freeway underpass, the tram would deviate and descend from Doncaster Road onto the Eastern Freeway via a dedicated ramp. The Eastern Freeway would require widening between Doncaster and Bulleen Road to accommodate the tram to travel along the Eastern Freeway 'at grade'. The alignment would continue to follow the Eastern Freeway to

Hoddle Street within the boundary of the existing median strip. On the approach to Hoddle Street, the alignment would descend below the Eastern Freeway into tunnel, deviating south and emerging to the east of Victoria Park Station. From this point the alignment would follow the path of Johnston Street 'at grade', towards the University of Melbourne where the alignment would link into Swanston Street and the service could then terminate at the Domain Interchange, south of the Yarra River.



The engineering alignment is shown below. Due to the steeper vertical gradients which can be used in the design of a light rail compared to a heavy rail system, this option is able to climb up to reach Doncaster Road and then run on the surface along Doncaster Road. The option also proposes eight at grade tram stops as shown below.



The principal advantages of the light rail option compared to the heavy rail option are that it is significantly cheaper than the heavy rail option and easier to engineer due to the steeper vertical gradients and tighter horizontal radii permitted in the standards. Although it provides no direct link between western and eastern suburbs, it does link the Doncaster corridor with the inner north and the city and has the potential to integrate with the existing tram network. It would also help to relieve the existing arterial road network in the east, providing additional capacity for road freight. However, extensive tram priority measures would be required and there is the potential for excessive interchange at Victoria Park.

Option 5C - Bus

Description:

Option 5C is a bus-based transit option linking the Doncaster area with the CBD. Buses would travel along existing arterial roads in the Doncaster area before turning onto the Eastern Freeway, Hoddle Street, Victoria Parade, Gisborne Street, Albert Street and Lonsdale Street, terminating at a new turnaround facility at Spencer Street opposite Southern Cross Railway Station. Bus priority measures will be implemented throughout the corridor, including full and part time lanes on selected arterial roads and signal priority at major intersections. A recent study carried out for DoI investigated numerous options for bus rapid transit in this corridor. The preferred option involved the upgrade of selected routes to Smartbus standards (15 minute daytime frequency, extended hours of operation). The option in this report describes this preferred option.

Design Considerations:

- Bus Operations

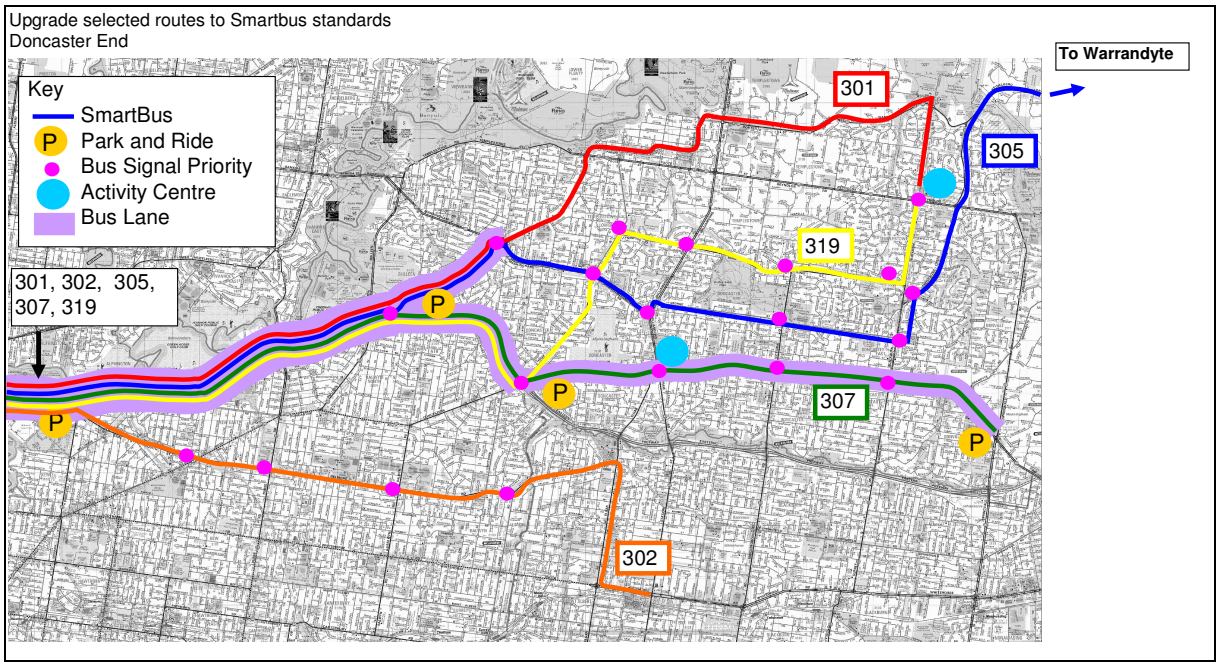
Existing bus routes (numbers shown) would be upgraded to Smartbus standards i.e. 7 day operation to midnight, 15 minute or better peak and daytime service.

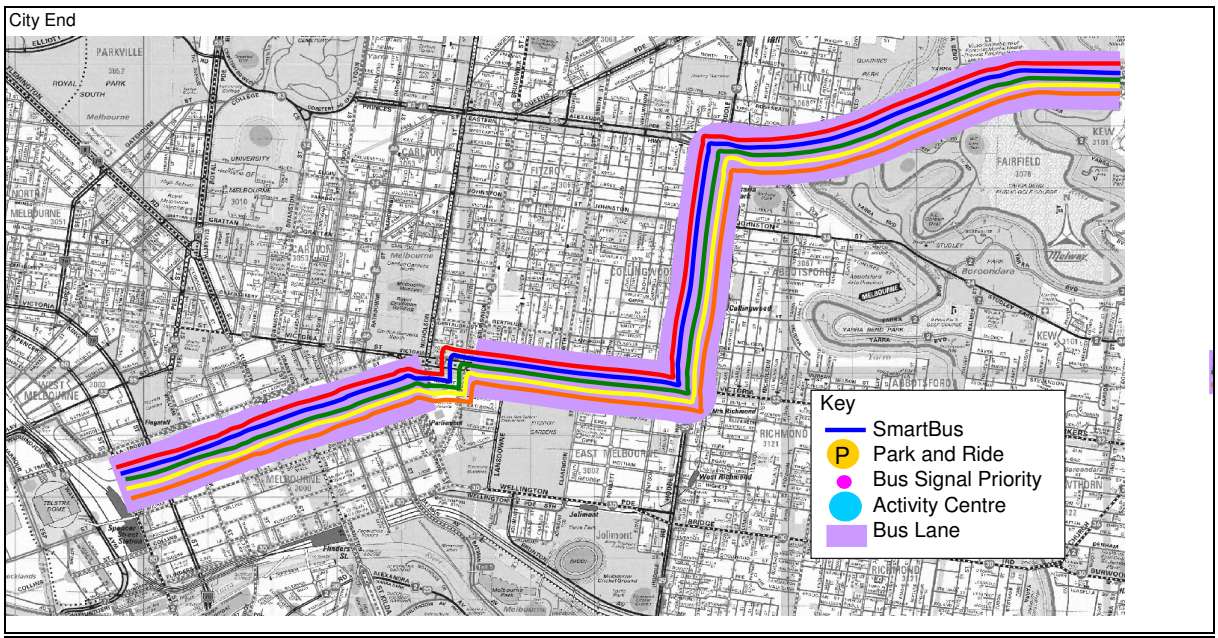
Buses would operate at posted speed limits on all arterial roads. On the Eastern Freeway, buses may use the emergency stopping lane, where they would be limited to 70km/hr.

- Bus Infrastructure

Bus priority measures would be implemented wherever practicable. Bus only lanes would be provided on Doncaster Road, Thompsons Road, Hoddle Street, Victoria Parade and Lonsdale Street. Signal priority at intersections would be provided on all routes.

Bus stops will be upgraded to Smartbus standards ensuring full accessibility and real time information.

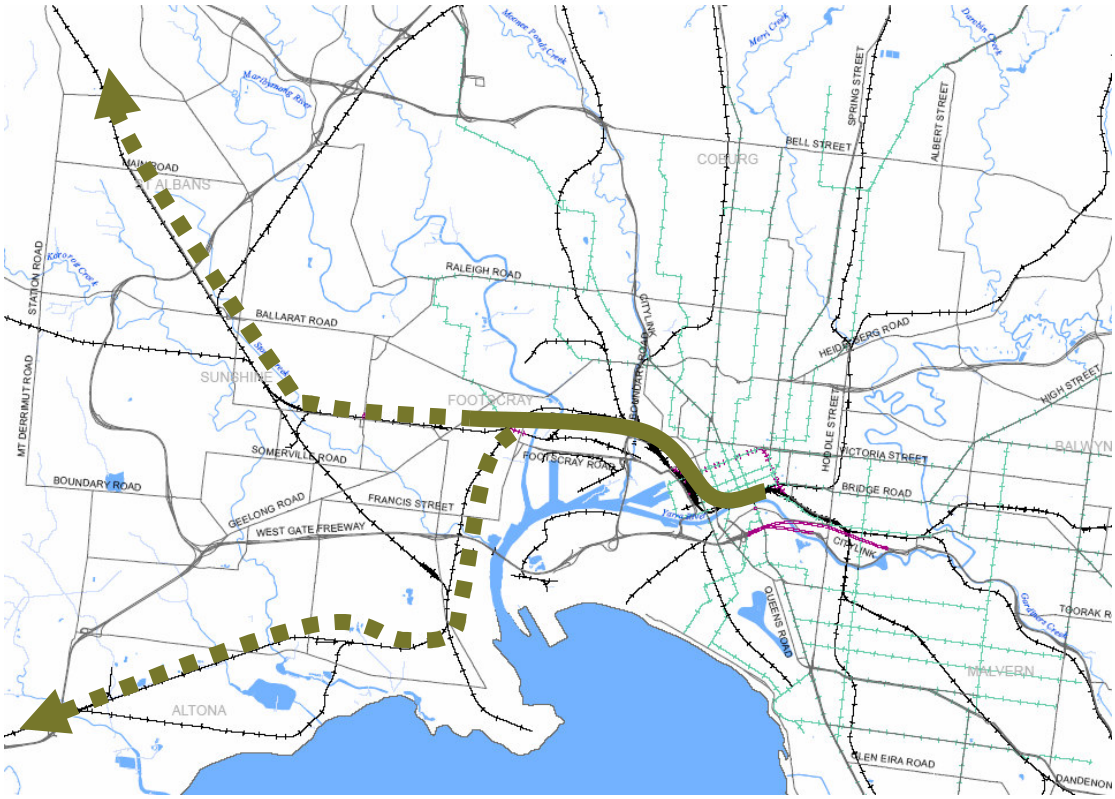




Operational Issues:

- The service has the potential to be unreliable due to the high proportion of operation on arterial roads, any of which could experience an unplanned disruption.
- There is a risk that not all bus priority measures will be able to be implemented, which would adversely impact bus travel times and possibly patronage.

Option 6 – Rail Improvements to the West



Description:

Option 6 comprises upgrades to existing rail lines west of Melbourne as shown in the plan above. The main improvements would include electrification to Sunbury and Bacchus Marsh. Duplication of the Melton line from Deer Park to Melton would also be required along with associated signalling works. This option would permit higher frequencies for these lines.

The work required can be described as follows:

Electrification

Electrification of approximately 15km of existing double track on the Sunbury Line between Watergardens and Sunbury; approximately 26km of duplicated track on the Melton line between Sunshine and Melton and approximately 12km of existing single track between Melton and Bacchus Marsh. It is worth noting that the current power supply is 1500 V DC and there is a possibility that the network may be converted in future to 25kV AC which is a more efficient power supply.

Track Duplication

No duplication works are required on the Sunbury Line, although some minor track works such as crossovers and turnouts may be required. On the Melton line, approximately 17km of track duplication and associated minor track works are required between Deer Park and Melton.

Signalling

Whilst no signalling works are required on the Sunbury line, on the Melton line new signalling works would be necessary for the duplicated track together with possible works between Melton and Bacchus Marsh if a significant increase in service frequency is envisaged.

Stations

The following station works are currently envisaged with this option:

- Sunbury line: upgrade of Diggers Rest and Sunbury stations.
- Melton line: upgrade of Ardeer, Deer Park, Rockbank, Melton and Bacchus Marsh stations plus a new station at Christies Road.
- Possible other new stations on the new electrified track sections are under investigation and may be constructed at a later date.

Stabling

No works are required to the Sunbury Line as it has been assumed that stabling would occur in the existing and proposed facilities in the metro area. On the Melton line, stabling would be required for six electric multiple unit trains at Melton or Bacchus Marsh.

Delivery Staging

The Sunbury line would be likely to be electrified first due to the smaller amount of work required. The electrification of the Melton line could be undertaken in parallel with the Sunbury line, however the additional scope of works would extend the duration of construction. However, it is possible that electrification on the Melton line could be staged i.e. Sunshine to Melton first, then onto Bacchus Marsh at a later date. Extra electric trains will need to be procured. Diesel trains will still need to utilise those corridors to serve Bendigo, Ballarat etc.

Constraints:

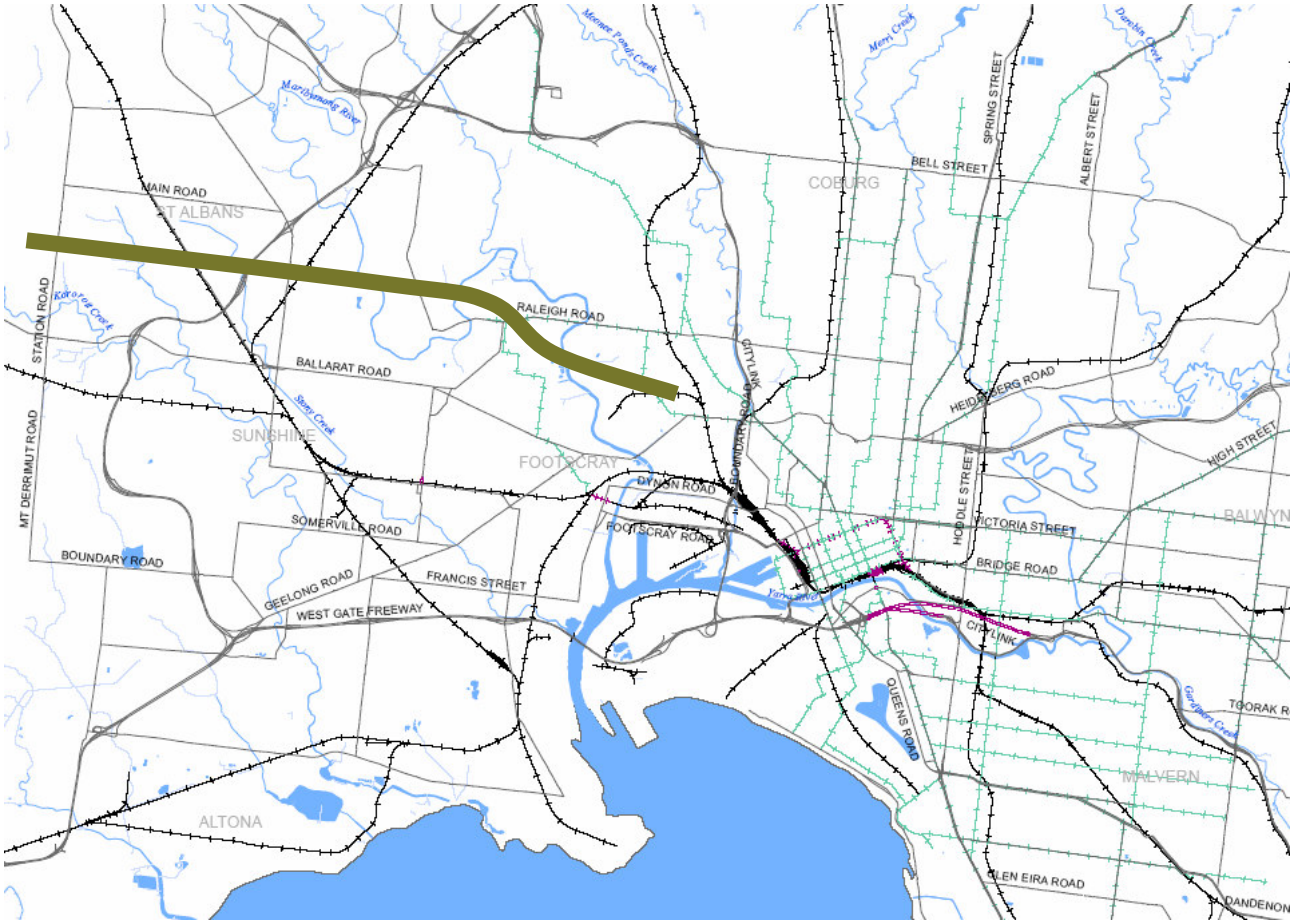
The major constraints with Option 6 are as follows:

- There would be network capacity constraints inbound from Sunshine, especially in the city loop and inner core area, if current operations and track configuration is unchanged. This may restrict the level of service provided to the newly electrified lines and have adverse implications on reliability on other lines.
- Additional services may require additional works on existing metro tracks for example, the need for upgraded power supply or enhanced signalling.

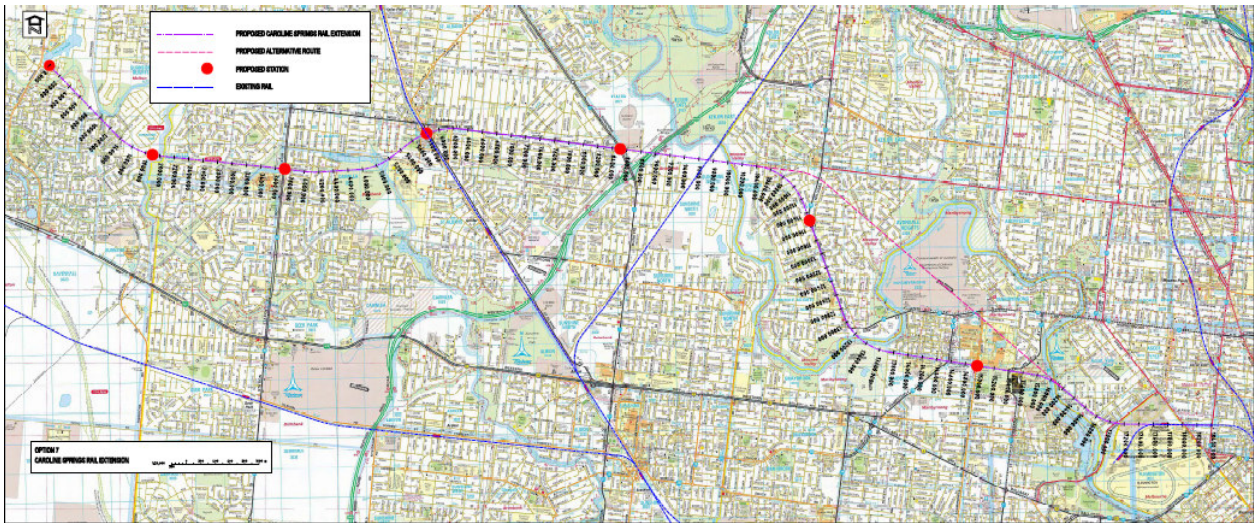
Operational Issues:

- Current metro rail operations in inner Melbourne have traditionally seen all trains travelling via the city loop. There would not be sufficient signalling capacity in the loop for the new services from Sunbury and Melton lines. The direct route to Flinders Street via Southern Cross may also be at capacity following the planned major service enhancements on the Werribee and Craigieburn lines.
- Additionally, there would be no platform capacity at Flinders Street station for the new services as those corridors are currently served by diesel trains terminating at Southern Cross. Consideration will therefore need to be given to through-routing of direct trains between the Northern and other groups in order to ensure sufficient capacity for projected service frequencies.
- There will also be operational constraints where the two lines converge at the flat junction on the down side of Sunshine. Trains will be performing conflicting manoeuvres at this junction which may affect reliability if any services are late-running. This junction may require upgrading to a fly-over.
- Currently only two tracks inbound from Sunshine (1 up, 1 down) will be available for use by Melton and Sunbury trains as well as V/Line services from Ballarat and Bendigo. Extended journey times and reduced reliability may be experienced by all passengers if this configuration is unchanged. A 3rd and 4th track are proposed between Sunshine and Footscray in MOTC “Meeting our Transport Challenges” – these would almost certainly be required to maximize the benefits of this project

Option 7 – A new Caroline Springs Rail Line



Option 7 encompasses a new Caroline Springs rail line. The route would commence at the upside of Flemington Racecourse Station and descend into a tunnel that would then proceed west, running beneath the existing St. Albans Station to provide an interchange with the Sydenham line and emerge from tunnel at Caroline Springs where the rail line would terminate. This option would provide additional rail services to the north-western suburbs of Melbourne in an attempt to relieve congestion along the existing western rail corridors including the Melton and Sydenham lines.



Design Considerations:

Design Speed:

The alignment route passes through medium density industrial and residential areas. The alignment would predominantly be beneath the surface and as a result, there is opportunity to provide a direct route between Caroline Springs and Flemington via St. Albans at a design speed of 80km/hr. The route would provide 7 new stations, with six of these being subway stations and one at Caroline Springs being a surface station.

Geometry:

Due to tight geometry along the proposed alignment, the alignment has been assessed for the following grades;

- Maximum vertical grade of +/-2.5%
- Horizontal curvature radii between 550m and 1005m
- Maximum Cant of 80mm.

Staging: Potential staging of construction could be;

Stage 1: Flemington Racecourse Station to High Point Shopping Centre;

Stage 2: High Point Shopping Centre to St. Albans;

Stage 3: St. Albans to Caroline Springs.

Geology

Caroline Springs to Maribyrnong River at Moonee Valley	Thin basaltic clays over Newer Volcanics basalt.	The basalt will provide sound foundations for rail infrastructure. The ballast should be founded in soils at a depth below the influence of seasonal moisture fluctuation. Cuttings will require heavy ripping to blasting.
Maribyrnong River crossing at Moonee Valley	Thin basaltic clays over Newer Volcanics basalt on upper river banks. Valley floor consists of Tertiary sediments (possibly dense sands, gravels and clays) over weathered Silurian Siltstone.	Footings should extend to dense materials or the siltstone.
Maribyrnong River crossing at Moonee Valley to the crossing at Medway Golf Club.	Thin basaltic clays over Newer Volcanics basalt.	The basalt will provide sound foundations for rail infrastructure. The ballast should be founded in soils at a depth below the influence of seasonal moisture fluctuation. Cuttings will require heavy ripping to blasting.
Maribyrnong River crossing at Medway Golf Club.	Thin basaltic clays over Newer Volcanics basalt on upper river banks. Valley floor consists of Tertiary sediments (possibly dense sands, gravels and clays).	Footings should extend to dense materials.
Maribyrnong River crossing at Medway Golf Club to the crossing at Humes Pipe Park.	Thin basaltic clays over Newer Volcanics basalt.	The basalt will provide sound foundations for rail infrastructure. The ballast should be founded in soils at a depth below the influence of seasonal moisture fluctuation. Cuttings will require heavy ripping to blasting.
Maribyrnong River crossing at Humes Pipe Park and Riverside Golf Course.	Recent (Coode island silt) over Tertiary sediments and Older Volcanics basalt.	Footings should extend to dense materials.
Flemington Showgrounds.	Weathered basaltic soils over Older Volcanics basalt.	The basalt will provide sound foundations for rail infrastructure. The ballast should be founded in soils at a depth below the influence of seasonal moisture fluctuation.

Constraints:

- Department of Defence Facility. A Department of Defence Explosives Facility is located north-west of High Point Shopping Centre. The route alignment would need to avoid this facility;
- Maribyrnong River. The Maribyrnong River is in close proximity to Flemington Racecourse Station where the alignment would connect into the existing rail network. If the tunnel route passed beneath the Maribyrnong River, there would be insufficient space to emerge from the tunnel at grade and link into the existing rail network. Alternatively, if the alignment emerged from the tunnel prior to reaching the Maribyrnong River, and crossed the river overhead, a significant number of residential and industrial properties would need to be acquired to enable the alignment to gain sufficient height, rising at a grade of 2.5% from the tunnel portal;
- Lack of capacity on the Craigieburn line into the city. To justify a tunnel through these areas it is likely that a high frequency would be required – say 15tph. By 2020 the Craigieburn line is likely to be close to capacity, therefore additional infrastructure would need to be found to accommodate the Caroline Springs trains down the line (eg. a 3rd track, or alternative route into the city);
- Links into the existing network where there is already lack of capacity at Flinders Street Station;
- The concept of option 7 could be better serviced by extensions to existing rail lines and development of new lines (such as Airport line).

Operational Issues:

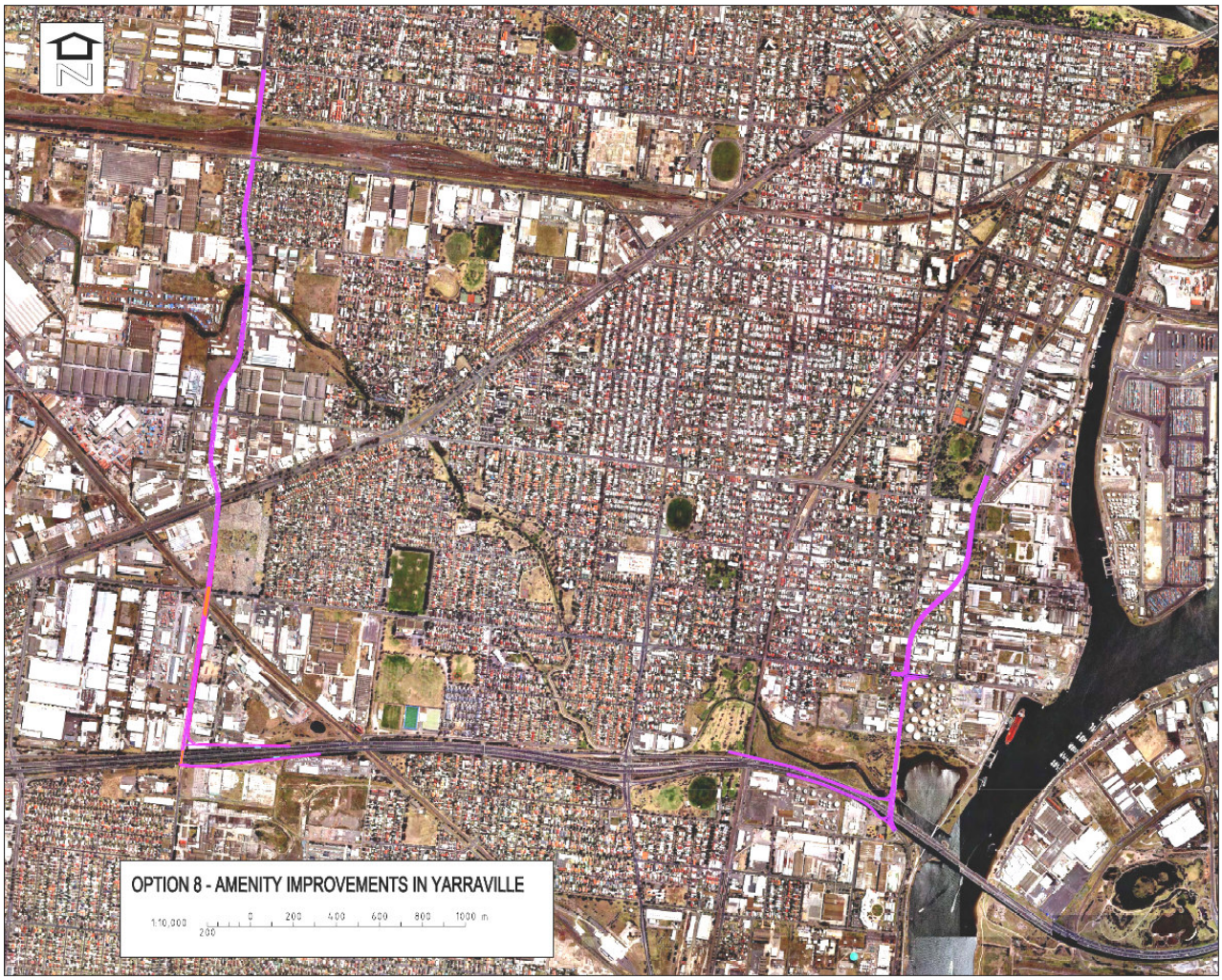
- For train operations, studies will have to be conducted to determine whether track vibration isolation will be required. Having the tunnels at least 10m deep is a reasonable starting point in any pre-feasibility level studies of the route concepts;
- The proposed alignment connects with the existing Craigieburn Line which is already capacity constrained, and placing more trains along this route would exacerbate the current capacity issues;
- Increase in flat junction conflicts and increase unreliability along the Craigieburn Line.

Further Comments:

- The alignment chosen has avoided the Department of Defence Explosives Facility. If this facility shut down in the near future, an alternative alignment would be possible whereby it would be possible to run the tunnel alignment directly beneath the superseded Defence Facility, offering a more direct route to High Point Shopping Centre and subsequently linking into Flemington Racecourse Station. This would reduce the costs of the tunnel alignment if this alternative option was possible.

Option 8 – Amenity Improvements in the West

This option was aimed at improving amenity in Yarraville by providing an upgraded route for freight traffic, avoiding the local residential areas. The concept design which evolved would provide an alignment with access control from Whitehall Street via the West Gate Freeway, Cemetery Rd, Paramount Rd and Ashley St to West Footscray.



This would require the following works:

- Duplication upgrading of approximately 1.5km of Whitehall Street and Hyde Street with minor realignment in the vicinity of Francis Street, new direct connections from Hyde St to the West Gate Freeway west of Williamstown Road and a half diamond interchange at Cemetery Road with easterly orientated ramps.
- A new short link from the freeway interchange to connect to the duplication of Cemetery Road over a length of 1.2km up to Geelong Road would also be necessary, including a new overpass over Francis Street and the existing rail line.
- A 1.6km duplication upgrade for Tottenham Parade, Paramount Road and Dempster Street to Sunshine Road.

- An upgrade to the existing grade separation at Ashley Street rail underpass and duplication of Ashley Street over a length of approximately 300m between Sunshine Road and Barkly Street.
- In addition to providing improved access for freight movement between Yarraville and the west, there is also the potential for improved access to be provided along Cemetery Road to Cawley Industrial Park.

This scheme would require repositioning of the existing westerly ramps at Williamstown Road to facilitate direct links to Hyde Street and substantial intersection treatments would be required at Geelong Road, Somerville Road and at Sunshine Road.

There is also the potential for staging the construction in three phases to gain immediate amenity improvements in Yarraville. The staging could be broken down as follows:

- Phase 1, Whitehall Road to Williamstown Road which allows port access to West Gate Freeway and then access to the Footscray area via Millers Road.
- Phase 2, Tottenham Parade, Paramount Road, Dempster Street and Ashley Road underpass upgrade. This provides more direct access to the south of Ashley Road to connect to Millers Road and the connection to Phase 1.
- Phase 3, Cemetery Road interchange and road duplication which relieves congestion at Millers Road and provides a more direct link between Phases 1 and 2.

Option 9 – Non Infrastructure Policy Options

Option 9 relates to the use of non infrastructure policy options to address the East West need. As such no engineering development work was required within this option.

3
Short-listed Feasible Option Description

By combining a number of the discrete road and public transport elements described in the previous chapter, four separate intermodal options were developed as follows:

OPTION A

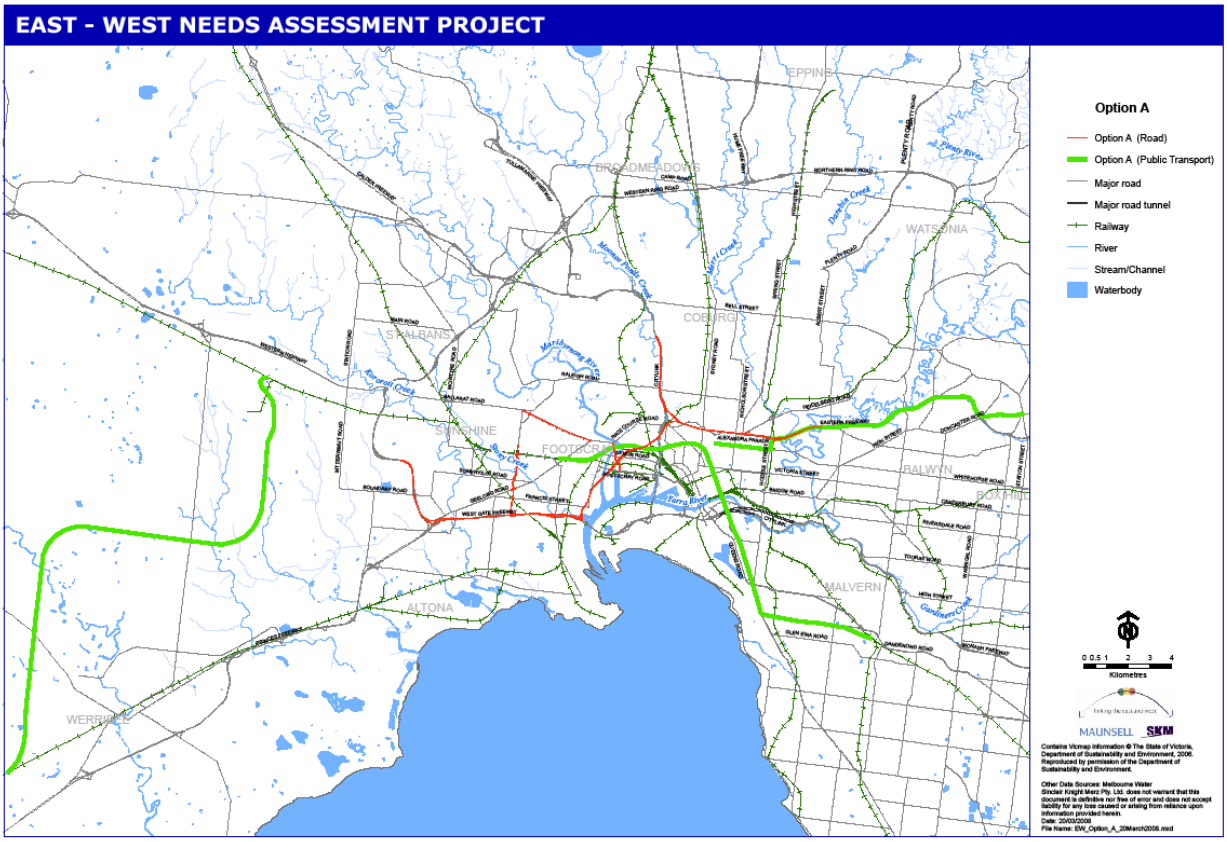
Public Transport initiatives:

- CBD rail tunnel from Tottenham rail yards (Sydenham Line) to Caulfield Station (Dandenong line).
- Doncaster Rapid Transport – upgrade of the DART bus services to incorporate bus only exit and entry from / to Eastern Freeway, bus interchange at Victoria Park Station and upgrading of Johnston Street or Alexandra Parade, to a Strasbourg-style bus lanes and reduction of Johnson Street traffic to one lane in the east bound direction only.
- Tarneit Rail – connection of V/Line Services from west of Werribee to Deer Park. Provides for additional capacity to accommodate future growth on the Werribee line by the removal of V/Line Services from this line.

Road Network Development initiatives:

- East-West Road connection from Eastern Freeway to West Gate Freeway (east of Williamstown Rd) and Western Ring Road. Has connections to the existing network at Hoddle Street/Alexandra Parade, Queens Parade, CityLink, the Port, Hyde Street and West Gate Freeway.
- Freight network connectivity enhancements, comprising:
  - Upgrade of Ballarat Road between Ashley Street and Geelong Road
  - Upgrading Ashley Street / Paramount Road to two lanes each direction from Geelong Road to Ballarat Road.
  - Connection of Ashley Street to West Gate Freeway via Cemetery Road upgrade
  - Connection from Hyde Street to West Gate Freeway
  - Connection from Wurundjeri Way at Dudley St to Dynon Rd
  - Connection from Dynon Rd to Smithfield Rd
  - Upgrading of Western Ring Road (Deer Park bypass to West Gate Freeway) and West Gate Freeway (Williamstown Road to Western Ring Road)

Figure 3.1 Option A overview



OPTION B

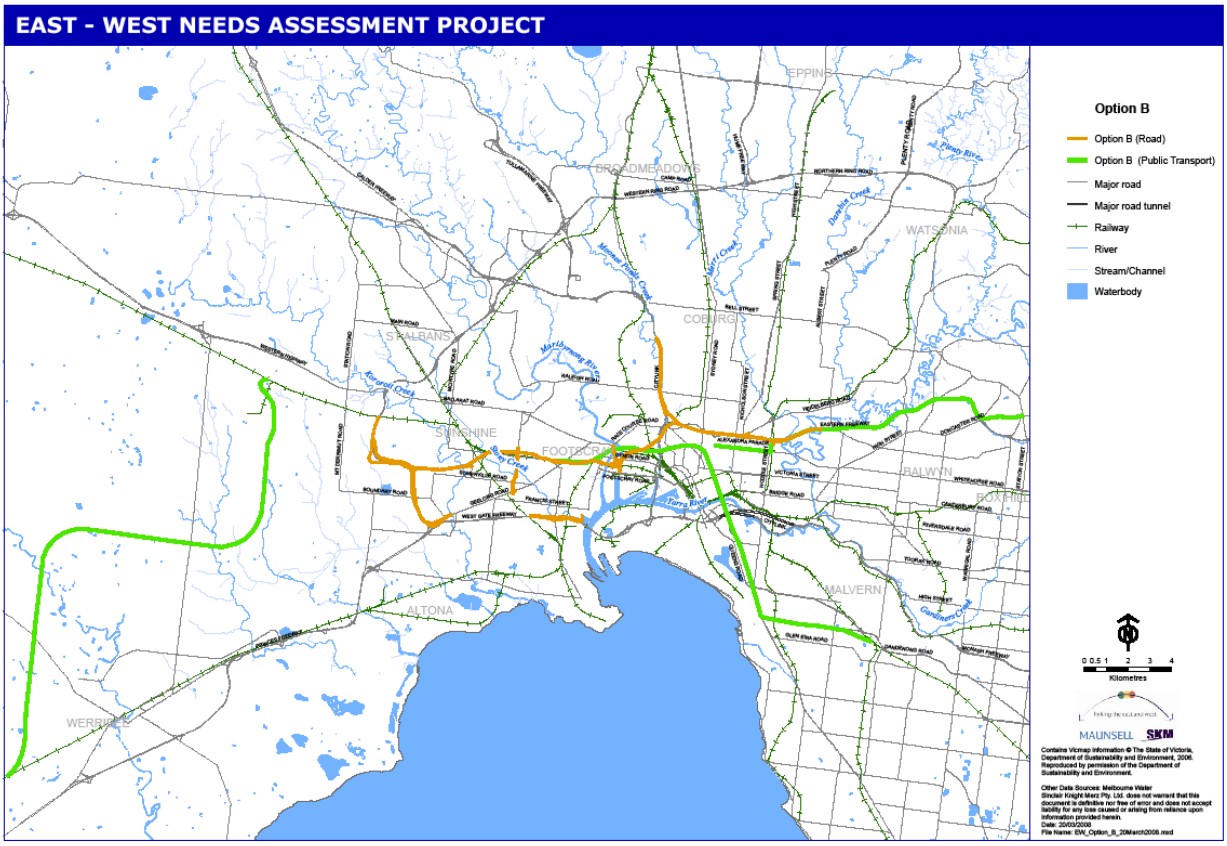
Public Transport initiatives:

As for Option A

Road Network Development initiatives:

- East-West Road connection from Eastern Freeway to Deer Park Bypass. Has connections to the existing road network at Hoddle Street/Alexandra Parade, Queens Parade, CityLink, the Port, Sunshine Road /Geelong Road, Ashley Road / Paramount Street and Market Street.
- Freight network connectivity enhancements, comprising:
  - Upgrading Ashley St / Paramount Rd to two lanes each direction between Geelong Road and Ballarat Road.
  - Connection from Hyde Street to West Gate Freeway
  - Connection from Wurundjeri Way at Dudley St to Dynon Rd
  - Direct connection from Princes Highway west to the Western Ring Road and upgrade of Western Ring Road (between Deer Park bypass and West Gate Freeway)

Figure 3.2 Option B overview



OPTION C

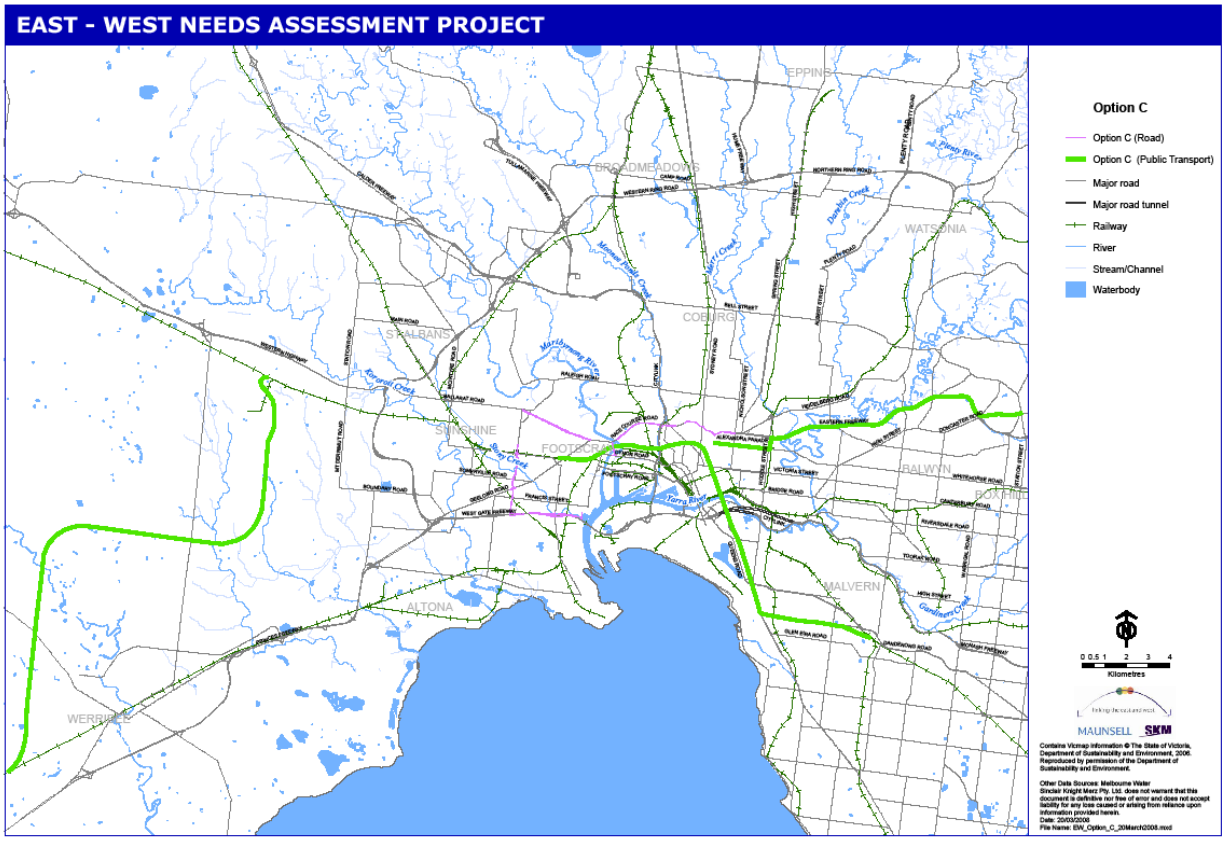
Public Transport initiatives:

As for Option A

Road Network Development initiatives:

- Upgrade of the existing road system from Eastern Freeway to Smithfield Road, comprising widening of Alexandra Parade, Cemetery Road to Royal Park; Tunnel from Royal Park to Smithfield Road;
- Freight network connectivity, comprising:
  - Widening of Ballarat Road
  - Upgrading Ashley Street / Paramount Road to two lanes each direction between Geelong Road and Ballarat Road.
  - Connection of Ashley Street to West Gate Freeway via Cemetery Road upgrade
  - Connection from Wurundjeri Way at Dudley St to Dynon Road
  - Direct connection from Hyde Street to West Gate Freeway
  - Connection from Dynon Road to Smithfield Road

Figure 3.3 Option C overview



OPTION D

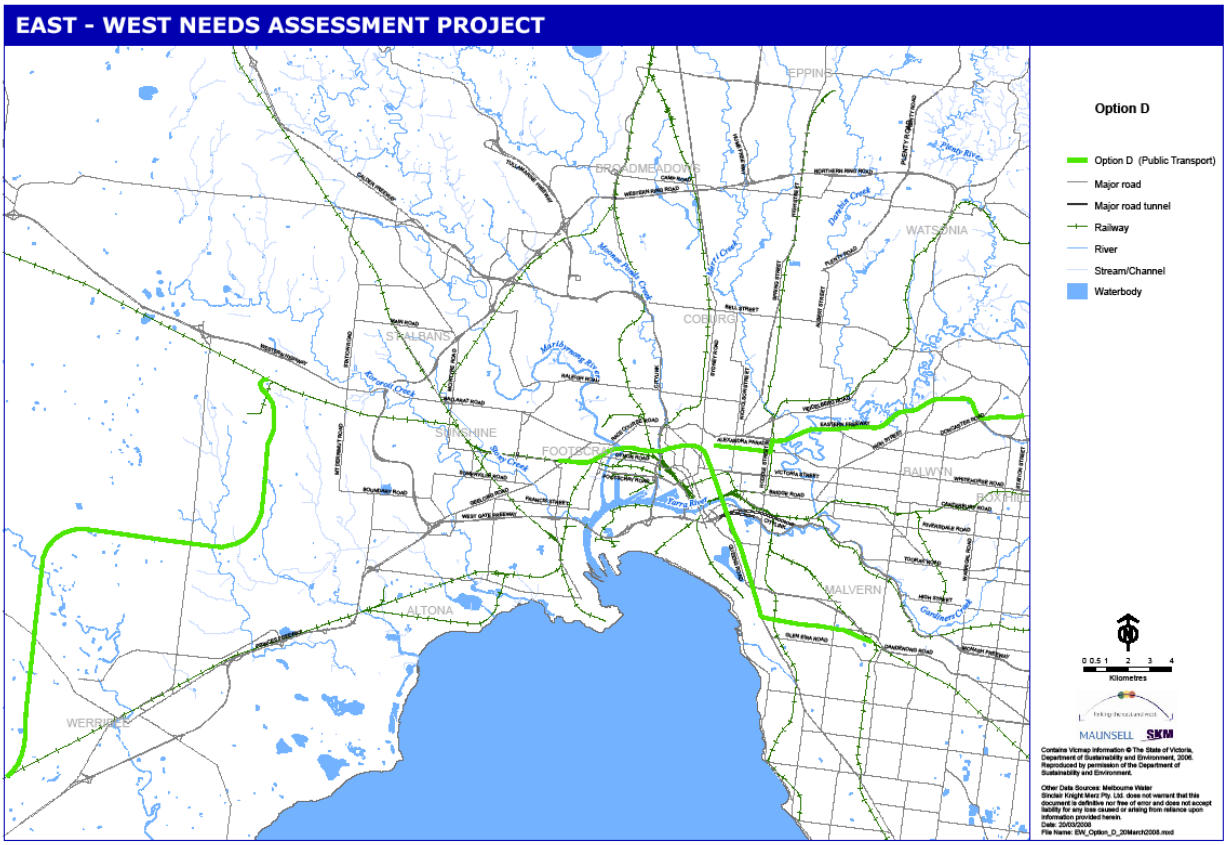
Public Transport initiatives:

As for Option A

Road Network Development initiatives:

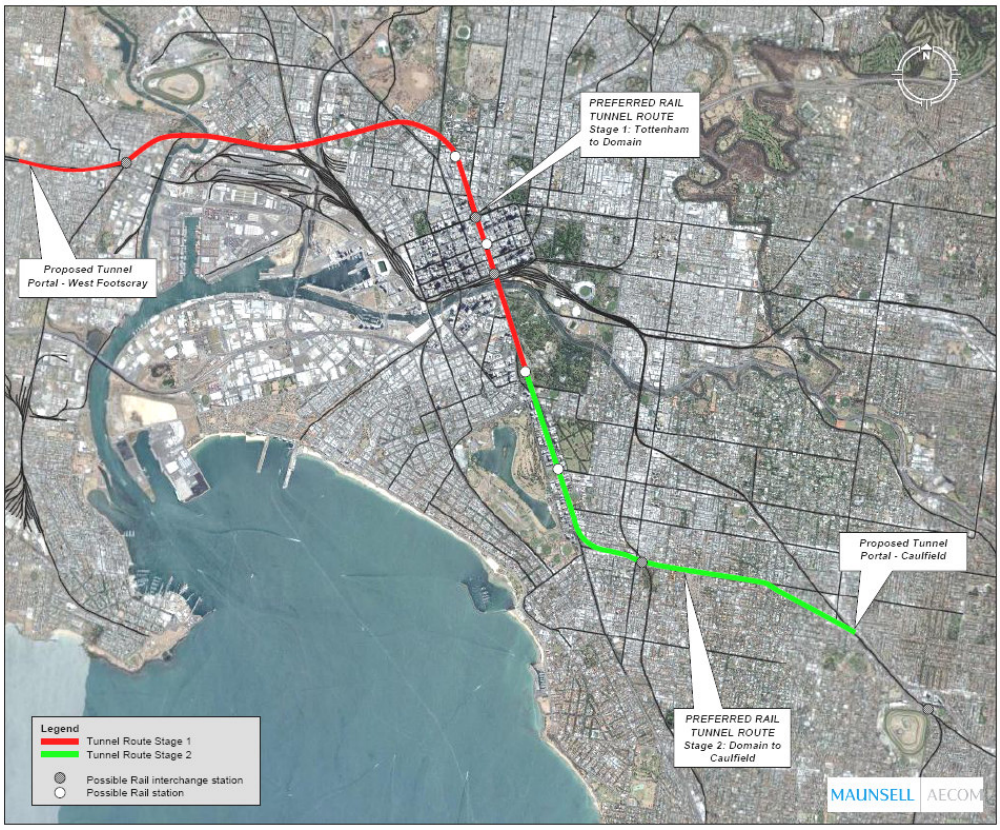
- Nil

Figure 3.4 Option D overview



3.1 Public Transport Components

3.1.1 CBD Rail Tunnel



This option involves the construction of a new pair of underground tunnels running from west of West Footscray station on the Sunbury corridor to the down side of Caulfield. Tunnelling would commence near West Footscray station and run under the existing rail reserve to Footscray. After Footscray the tunnel would travel under various land uses to a new station near Melbourne University. From there it would continue under Swanston or Elizabeth Streets to Melbourne Central and Flinders Street stations before running under St Kilda Road. After this point the line would travel under Dandenong Road or Balaclava Road to Caulfield station.

New platforms could be located at the following stations:

- Footscray;
- a new station at Melbourne University;
- Melbourne Central;
- Flinders Street;
- A new station at Domain;
- A new interchange station with the Sandringham line at Windsor or Balaclava;
- Plus, potentially, further additional new stations depending on the chosen alignment.

The new underground tracks would be linked to existing suburban corridors at both ends of the tunnel with all trains from the Dandenong corridor connecting to the Sunbury line in the west to form a new cross-city group.

3.1.2 Rapid Transit Bus Route to Doncaster and new terminal at Victoria Park

This option involves the construction of a new bus-only link between the Eastern Freeway and Victoria Park station along Lulie Street for both inbound and outbound buses. A bus-rail interchange facility would also be built adjacent to Victoria Park railway station to enable easy interchange between bus and rail services. Other associated works could include bus priority measures, new signals, bus stop upgrades and a dedicated cycleway.

The proposed new bus interchange would be situated beside Victoria Park railway station on disused rail sidings. The new interchange would provide full-length shelters, raised platforms to enable level boarding, direct DDA-compliant pedestrian links between bus and rail services, real time information and other amenities. The interchange would be staffed for passenger assistance. Bus access into the new interchange would be via Lulie Street. Figure 3.2 shows an example of such a facility.

Figure 3.2Mawson Bus–Rail Interchange in Adelaide

New traffic signals would be required at the intersection of Lulie Street and Johnston Street to provide easy access for the high volume of right-turning buses. Bus stops would be upgraded to Smartbus standards ensuring full accessibility and other amenities such as real time information.

Bus priority measures would be implemented wherever practicable. Signal priority at intersections would be implemented at intersections along each route corridor between Victoria Park and the Central Activities District. Existing peak direction bus lanes in Hoddle Street (see Figure 3.3), Victoria Parade and Lonsdale Street would be retained and extended to become permanent in peak periods in both directions.

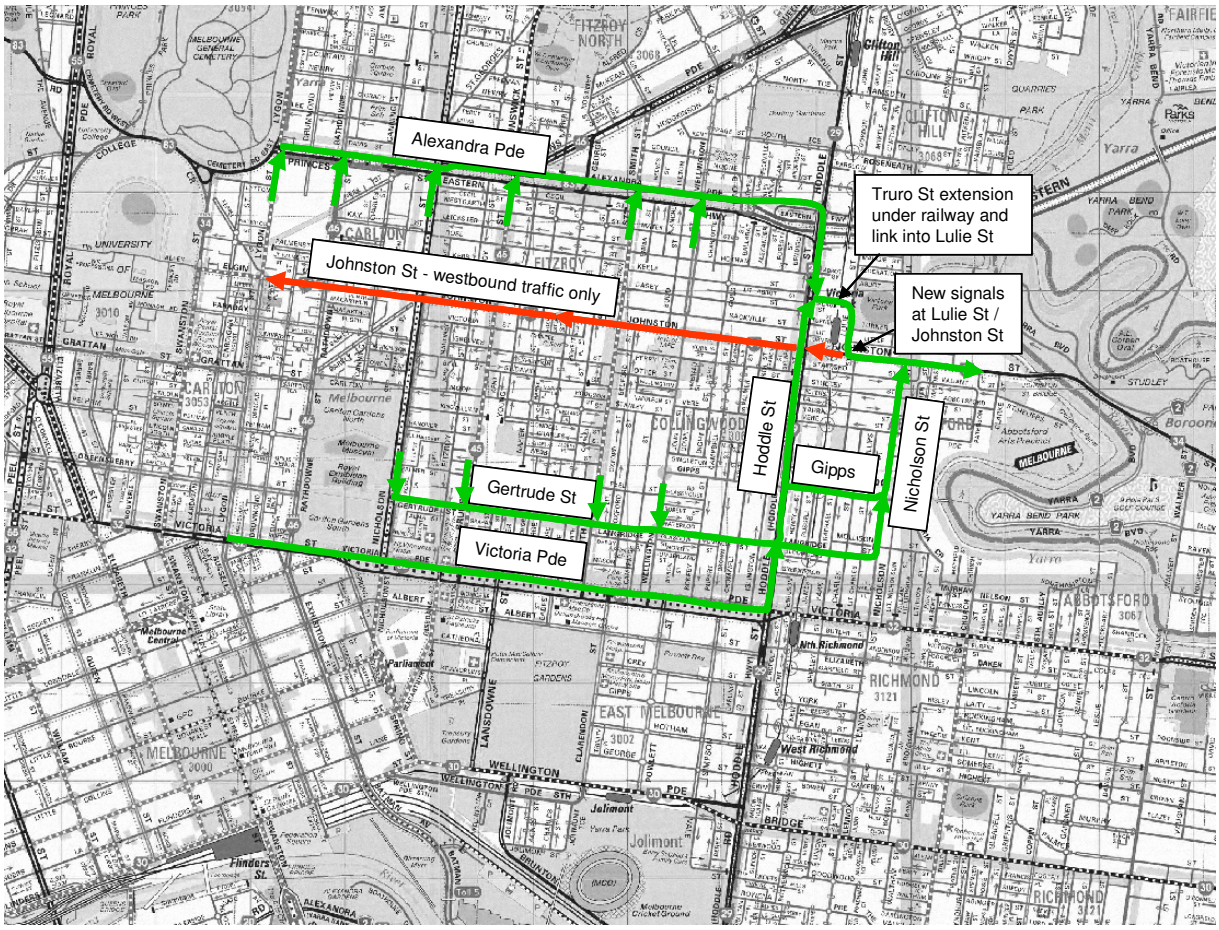
Due to traffic reductions associated with an East West tunnel, it will also be possible to re-allocate existing road space on either Alexandra Parade or Johnston Street to bus lanes.

Figure 3.3 Existing Hoddle Street bus lane

In Johnston Street, the number of westbound traffic lanes would be reduced from two to one, while eastbound traffic lanes would be removed. A new off-street cycle lane and parking lane would also be provided as part of the reconfiguration of Johnston Street. To accommodate eastbound traffic displaced from Johnston Street, Truro Street would be extended eastwards under the rail line to intersect with Lulie Street. Alternative routes for eastbound traffic could be via Alexandra Parade, Victoria Parade or Gertrude/Langridge Streets. Figure 3.4 outlines alternative traffic routes.

Other configurations for Johnston Street may also be considered. An alternative is to reallocate one lane in each direction in Alexandra Parade, although provision for this link into the city may be more difficult. Selection of the final arrangement will be influenced by the location of stations selected for the CBD rail tunnel, in order to promote the best intermodal interchange opportunities.

Figure 3.4 Possible eastbound traffic arrangements if Johnston Street closed



3.1.3 Tarneit Rail Line

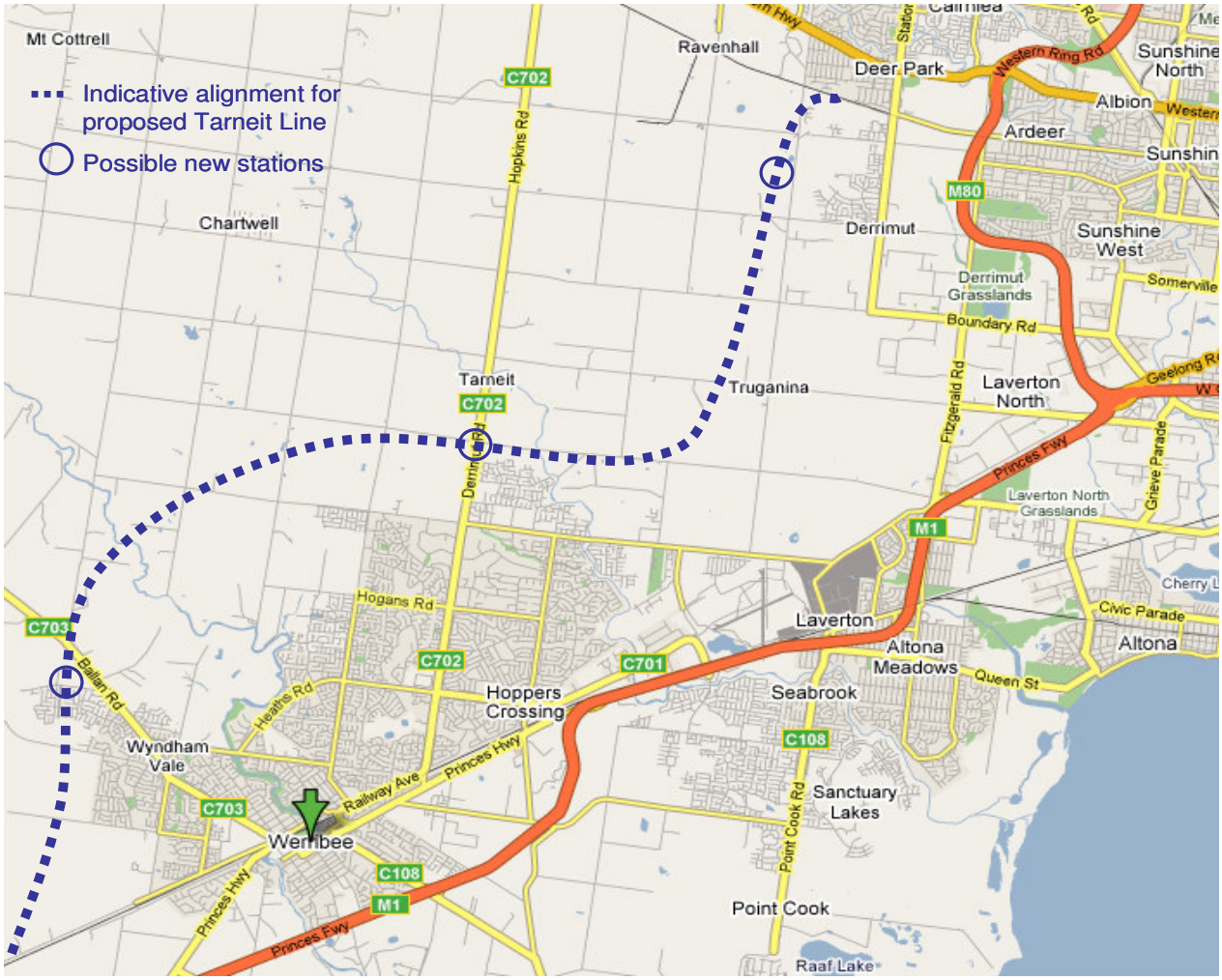
The Tarneit rail line is a proposed new rail corridor between Footscray and West Werribee via Deer Park and Tarneit. This new corridor would be used by diverted Geelong services, freeing up the existing corridor for Werribee metro services, improving capacity and reliability for both. The new alignment would service an entire new regional area and provide an opportunity for new stations at locations within new growth corridors.

This option would involve the construction of a new track pair from Browns Road Werribee West, through existing and proposed residential estates before joining with the Melton line at Deer Park. The proposed line would follow the transport corridor detailed in the 1990 Werribee Growth Area Plan. A new track pair would also need to be built between Sunshine and Footscray (MOTC scheme).

Figure 3.5 shows an indicative alignment of the proposed Tarneit line. V/line trains from Geelong would branch off from the Werribee line at Browns Road, West Werribee and follow the new line through to Deer Park, joining with other V/line trains from Ballarat, Bendigo and Melton. Only metro trains would operate on the Werribee line (apart from freight trains using the parallel standard gauge track). In addition, some additional V/Line diesel services could commence journeys from West Werribee or Lara and provide suburban services similar to existing Sunbury and Melton services. The separation of express V/Line

services from stopping all stations metro services will improve reliability and reduce journey times for all train types as well as significantly improving capacity on the Sunbury and Werribee lines.

Figure 3.5: Proposed Tarneit line alignment



The exact scope of the works will differ according to the capacity enhancement scheme implemented between Footscray and the CBD. Regardless, this scheme would require land acquisition along the length of the corridor, the construction of new rail lines, signalling and associated infrastructure as well as some grade separations in some places.

The proposed Tarneit rail line is an integral part of the Public Transport component in order to extract the maximum benefits from the CBD rail tunnel.

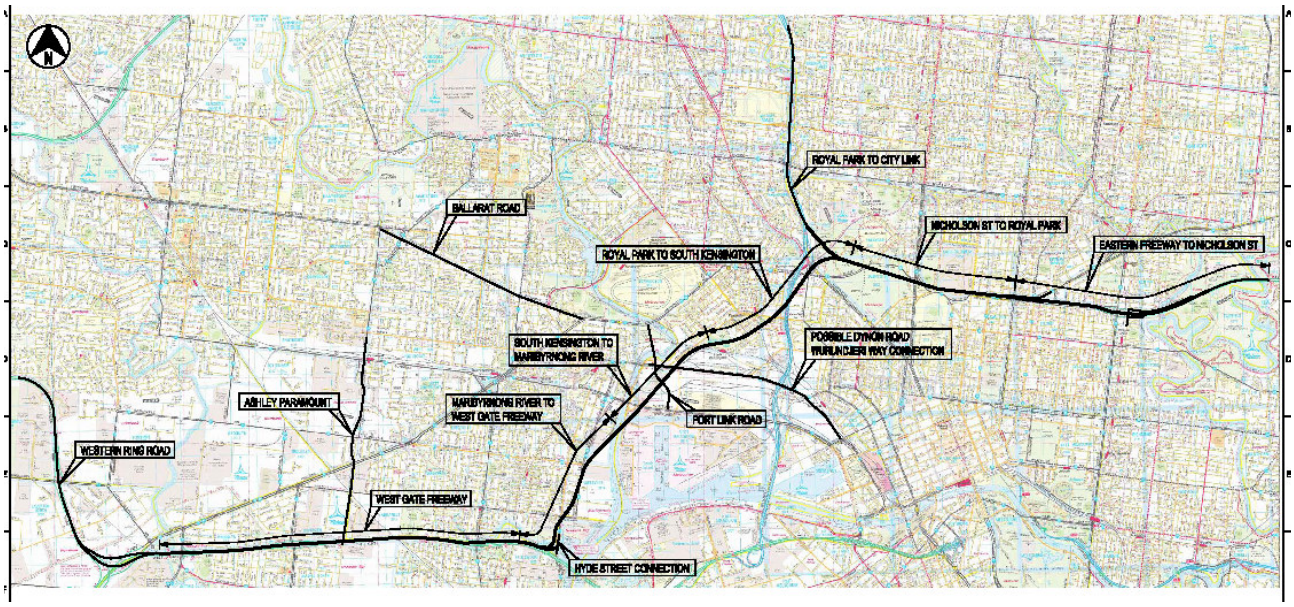
3.2 New Road Alignment Options

In reviewing the options developed during Phase 2 of the study against the original long list concepts from Phase 1 and the objectives of the Study, it was recognised that no freeway to freeway option connecting the Eastern Freeway to the West Gate Freeway had been retained. After further consideration, the Southern

East West Road Link described below was developed which offered a viable alternative to the Northern East-West Link Road, by connecting the Eastern Freeway to the West Gate Freeway by a shorter and cheaper length of new urban freeway.

3.2.1 Southern East-West Road Link

This alignment provides a freeway to freeway connection linking the end of the Eastern Freeway at Hoddle Street to the West Gate Freeway at Williamstown Road with direct connection to City Link North and a Port Interchange.



Eastern Freeway to Nicholson Street

This section involves the construction of two 3 lane tunnels under the alignment of Alexandra Parade. In order to retain the existing capacity of the Eastern Freeway and enable through traffic to access the tunnel and be segregated from the Alexandra Parade traffic, one lane widening of the existing Eastern Freeway east to the Yarra River and an additional inbound lane are proposed in this option.

An interchange is proposed at Queens Parade to enable eastbound traffic in the tunnel to exit to the surface in order to connect to Hoddle Street and the local road network. Similarly, a westbound entry ramp is included which would allow vehicles from Hoddle Street and the surrounding area to enter the tunnel.

Nicholson Street to Royal Park

Between Nicholson Street and Royal Park, the vertical alignment of the tunnel gives the opportunity to reduce the impact on residential properties along Alexandra Parade as the existing reserve narrows, the form of tunnel construction changes from a cut and cover tunnel constructed from the surface, to twin 3 lane

bored tunnels which would be driven from one end using a tunnel boring machine (TBM), or other suitable tunneling techniques.

In Royal Park, the two tunnels bifurcate forming a 'Y' junction, to provide northbound and southbound access to CityLink. It would be extremely difficult to construct this junction arrangement underground, so it is currently envisaged that a large area of open excavation in the shape of a 'box' would be opened in Royal Park. This box would intersect with the bored tunnels and the junction constructed within the box. Once complete this area would be covered and carefully reinstated. Improvements to the existing parkland could also be undertaken as part of this process.

Royal Park to CityLink

Between Royal Park and CityLink, twin 2 lane tunnels would be provided to allow an underground freeway connection between City Link and the Eastern Freeway. It is currently envisaged that these tunnels would be partially constructed using a TBM or other suitable tunneling technique and partly in cut and cover. The existing topography north of the existing railway line between Royal Park and Flemington Bridge would be suitable for the construction of a tunnel portal with a bored tunnel beneath the railway line connecting to the 'Y' junction described above. North from the portal could then be constructed using either cut and cover or bored tunnel to twin portals in the existing median of City Link where the tunnels would emerge.

In order to provide improved access to the new East West Link for local traffic, the option of providing south facing ramps from Brunswick Road was investigated. This would enable northbound traffic coming from the east, to either continue north on CityLink towards Melbourne Airport or exit onto the local road network via Brunswick Road. Similarly, local traffic, wishing to get onto the Eastern Freeway would be able to utilize new ramps from Brunswick Road to get access into the new east west tunnel.

On CityLink, pavement widening is also proposed from Brunswick Road, north to Moreland Road to provide one additional lane in both the north and southbound directions to assist with merging and diverging of additional traffic.

Royal Park to South Kensington

From the 'Y' junction in Royal Park, twin two lane tunnels continue in a south westerly direction, passing beneath City Link and the Broadmeadows railway line to exit in a new portal constructed at the east end of JJ Holland Park, just west of Altona Street.

South Kensington to Maribyrnong River

From JJ Holland Park, the road would continue south west in cutting, passing beneath Dynon Road and the existing railway line between Footscray and South Kensington station. A new 'Port Link' with 3 lanes in each direction connecting Dynon Road and Footscray Road is also included in this scheme. This link would be elevated above the existing ground over much of its length in order to provide the required clearance to the existing railway line servicing the Melbourne Freight Terminal. Part of this work also requires realignment of the existing 'W track' rail lines and siding yards.

Ramps from the freeway in cutting would rise up to connect into the new Port Link via an elevated interchange. This interchange provides connections from the tunnel to the Port Interchange where a direct link is provided between Dynon Road and Footscray Road.

Maribyrnong River to West Gate Freeway

From the Port Interchange, the freeway would continue south west, climbing from the cutting to cross the Maribyrnong River above ground on a bridge, with the required clearance for navigation. It then continues above existing ground as an elevated arterial road providing a direct connection from the Port Interchange to Hyde Street near West Gate Freeway via west facing entry and exit ramps. This work includes collector distributor access roads along the freeway from Hyde Street to a new interchange at Cemetery Road.

West Gate Freeway to Western Ring Road

Between the West Gate Freeway and the Western Ring Road, a number of standard freeway on line widening options were investigated as potential Stage 1 works. These involved symmetrical, parallel widening of the existing freeway either within the existing median, or by constructing an additional lane on the outside of the existing freeway and retaining the existing median. A more complex option, for possible implementation as Stage 2 works, was also investigated. This provided segregated 'Collector Distributor (CD) lanes' running parallel to the existing freeway. These enable local traffic to enter and leave the freeway without having to merge or diverge across the through traffic. In addition to improving safety, this arrangement helps to increase capacity by reducing the weaving movements.

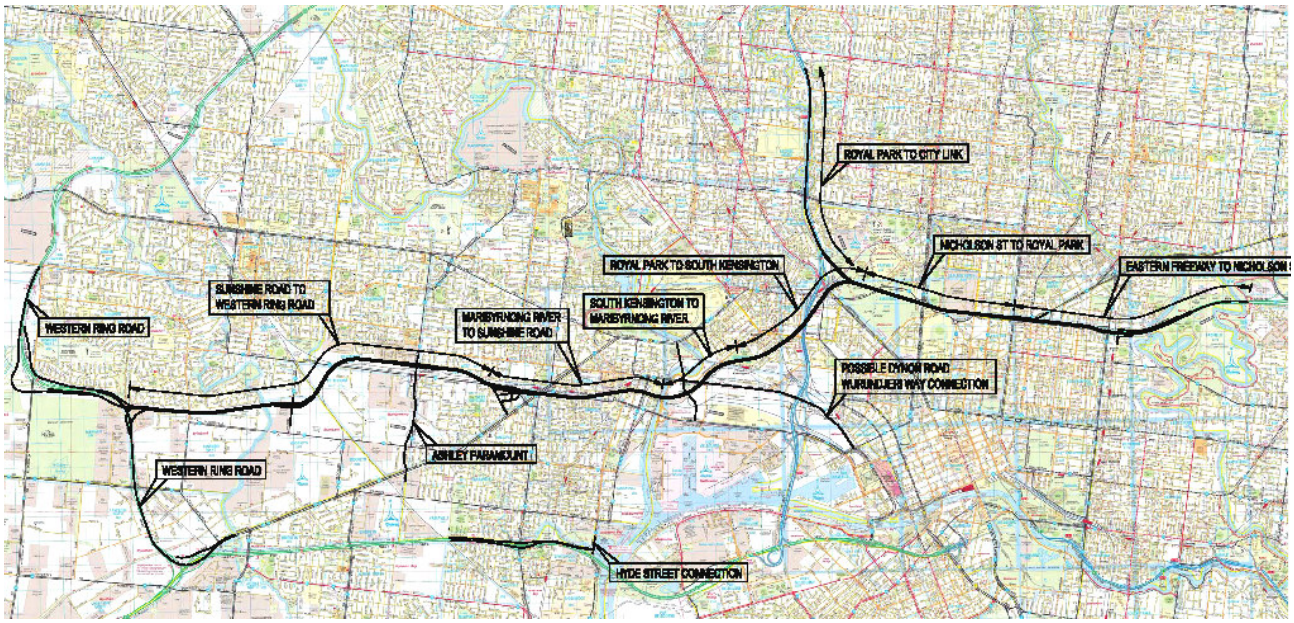
It is likely that in the short term one lane widening of the West Gate Freeway from Williamstown Road to the Western Ring Road will be necessary. Also included would be a full diamond interchange at Cemetery Road with collector distributors to Millers Roads and additional works within the Western Ring Road interchange, with the option to implement the Collector Distributor Lanes at some other stage in the future as a second phase to add additional capacity. It is anticipated, were the scheme to go ahead, that at detailed design, these two options could be developed to complement each other in order to maximize the road space created in Stage 1 within the Stage 2 works.

Western Ring Road to Deer Park Bypass

One lane widening of the Western Ring Road between West Gate Freeway and Deer Park Bypass is proposed as part of this scheme.

3.2.2 Northern East-West Road Link

This option provides a freeway to freeway standard connection linking the end of the Eastern Freeway at Hoddle Street with the Deer Park Bypass on the Western Ring Road and also gives direct connection to CityLink north and a new port interchange.



Eastern Freeway to South Kensington

Between Chandler Highway on the Eastern freeway and the proposed tunnel portal in JJ Holland Park, this alignment is exactly the same as the Southern East West Link Road described above.

South Kensington to Maribyrnong River

From the portal in JJ Holland Park, the alignment continues south west, passing beneath the existing railway line and Dynon Road in a cutting, then turns west to cross in tunnel beneath the Maribyrnong immediately north of and parallel to the existing rail bridge.

A Port Interchange is also provided in this option but with slightly different connections, although the same functionality.

Maribyrnong River to Sunshine Road

The alignment continues west beneath Footscray in twin 2 lane bored tunnel, passing beneath Moreland Street, Whitehall Street, Cowper Street and Hyde Street and then beneath the rail line between Footscray and Seddon station. It continues west in tunnel, running approximately midway between Buckley Street and the Footscray rail line before emerging in two portals west of Geelong Road near to West Footscray station, where it connects to Geelong Road. Due to the limited depth of the proposed road around Geelong Road in the vicinity of the portals it is currently envisaged that a section of between 100 – 200m of the tunnel east of the portal could be constructed using cut and cover techniques as an alternative to a bored tunnel.

Sunshine Road to Western Ring Road

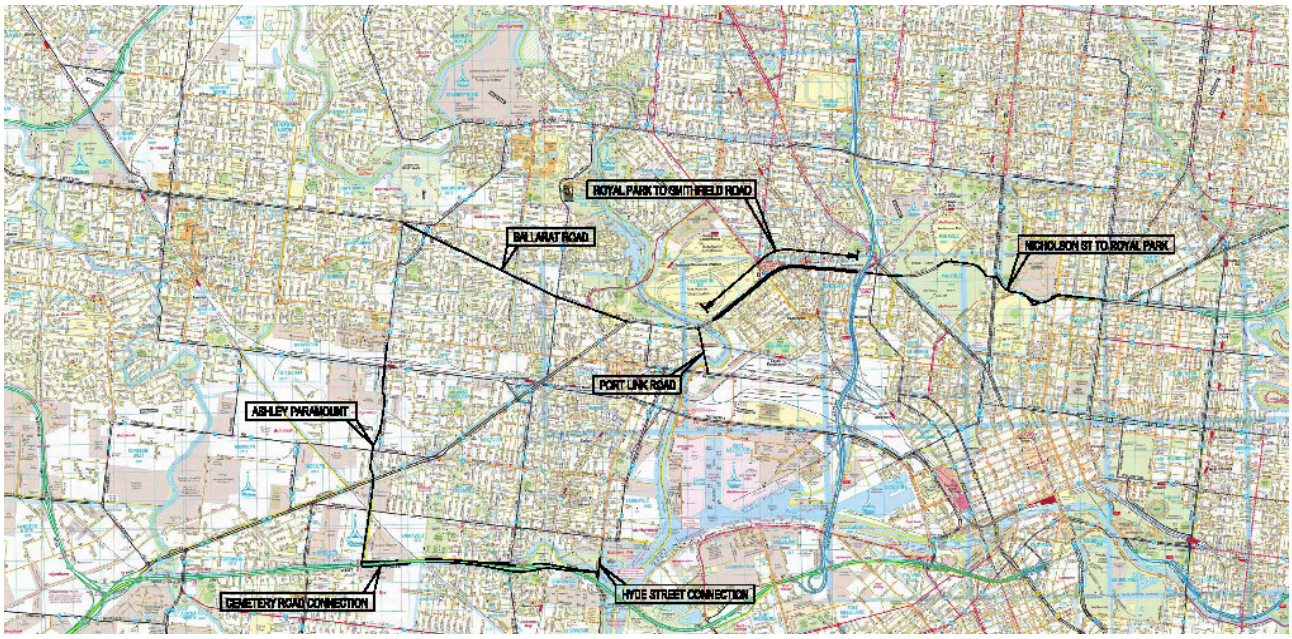
From Sunshine Road to the Western Ring Road, the alignment climbs from the tunnels to existing ground and then continues to climb on an elevated structure to cross above the existing east west rail lines which form part of the Tottenham rail yard. Once on the north side the road continues to run due west using the existing reserve immediately north of the rail yard. It crosses over Ashley Street on a bridge, with a diamond interchange giving access to Ashley Street for local traffic via ramps before turning south west and crossing above Sunshine Road, the existing rail line, Market Street and Kororoit Creek on structure. Direct connections are proposed to Market Street. Once over the Creek, the alignment continues west running approximately along the line of the existing drainage reserve and crossing Fairbairn Road, before dropping back to the existing surface level on the approach to the Western Ring Road. New northbound and southbound freeway ramps are proposed to connect to the Western Ring Road giving full freeway to freeway connectivity between the new link and the Western Ring Road.

Western Ring Road

Two lane direct connections each way between Geelong Road and Western Ring Road are proposed. These would require the use of elevated structures. Additional widening by one additional lane on each existing carriageway is also proposed from Geelong Road to the new Deer Park Bypass Interchange.

3.2.3 Upgraded Road Network

This scheme includes new roads and upgrades to the existing road network via road widening. Details of works included in each section are as follows:



Widening Princes Street to Royal Park

In this scheme, Princes Street would be widened to provide three lanes westbound with indented parking between Lygon Street and Nicholson Street. Between Lygon Street and west of Rathdowne Street, three eastbound lanes would be provided. From west of Rathdowne Street to Nicholson Street, four eastbound lanes with indented parking would be provided. Single right turn lanes would be provided at Rathdowne Street and Lygon Street as per the current lane configuration.

Between Lygon Street and Royal Parade, the existing east-west route would be widened to provide three through lanes in each direction. Double right turn lanes and a single left turn lane for westbound traffic would be provided at the Swanston Street roundabout. Double right turn lanes would be provided for westbound traffic at the Royal Parade intersection.

It is anticipated, based on the current level of detail, that the road widening would be accommodated within the existing road reserve by removing on road parking and narrowing footpaths and verges in some locations. Removal of trees within the road reserve would also be required in some locations.

Macarthur Road would be widened between Royal Parade and Brens Drive. The three through lanes provided on Cemetery Road West would continue across Royal Parade and merge to two lanes approximately 70m west of The Avenue. At the Royal Parade Intersection, single right and left turn lanes would be provided in addition to the three through lanes for westbound traffic. Between Brens Drive and west of The Avenue a four lane undivided cross section would be provided to minimise the road footprint through Royal Park. This would match to the existing four lane divided cross section at Brens Drive.

The Elliot Avenue/MacArthur Road intersection would be modified to provide a left turn slip lane for eastbound traffic and a single right turn lane from Elliot Avenue to the west. Signalisation of this intersection may be required.

At Flemington Road, Elliot Avenue would provide two right turn lanes, two through lanes and a single left turn lane for westbound traffic. Two through lanes would be provided for eastbound traffic as per existing conditions. Widening on both sides would be required to accommodate the additional turning lanes for westbound traffic.

Racecourse Road would be widened between CityLink and Flemington Road to provide additional turn lanes for eastbound traffic at Flemington Road, turn lanes for westbound traffic at Boundary Road, and an additional westbound lane between Flemington Road and CityLink feeding a double left turn onto the CityLink's southbound entry ramp.

At Flemington Road, two right turn lanes, two through lanes and a single left turn lane would be provided for eastbound traffic. At Boundary Road, single left and right turn lanes would be provided for westbound traffic. Widening is proposed on the south side of Racecourse Road to accommodate the additional lanes and this would require property acquisition between Flemington Road and the CityLink entry ramp. Realignment of the tram tracks would be required between Boundary Road and Flemington Road.

Tunnel Royal Park to Smithfield Road

Due to significant existing surface development and infrastructure constraints in the Kensington area, the only available option is to provide a short tunnel. West of CityLink, a new road link would be provided between Racecourse Road and Smithfield Road by a 1.5km long four lane bored tunnel. The tunnel would generally follow the alignments of Racecourse Road and Smithfield Road. The tunnel portals would be located approximately 250m west of CityLink and 350m north east of the Maribyrnong River. The eastern tunnel portal would require property acquisition on both sides between Stubbs Street and Nottingham Street, but the western tunnel portal could be accommodated in the existing road reserve. Single lane connections to the existing surface roads would be provided at both tunnel portals to maintain access to Flemington and Kensington.

Widening Ballarat Road

Ballarat Road would be widened to provide three lanes in each direction between Geelong Road and Ashley Street. The current planning scheme for this section of Ballarat Road includes a 6m wide overlay for road widening. This 6m width would be used for additional road pavement to provide the additional through lane. The location of the road widening overlay varies from one side of the road to the other throughout this section and the widening proposed follows this overlay. Realignment of the tram tracks between Droop Street and Gordon Street would be required. Property acquisition would be required as per the current planning scheme.

3.3 Truck Action Plan

Heavy vehicle volumes impacting on amenity in the inner west of Melbourne are considered to be unsustainable in the longer term. Due to the population and industrial growth expected to the west and in the port, and the serious capacity constraints over the Maribyrnong River, this issue will not be resolved by existing management measures. Longer term solutions are required which provide alternative access across the city and to the Port of Melbourne.

The requirement to better provide for freight movements in the inner west, whilst considering the amenity of the residential and retail/business areas has resulted in the following infrastructure and non-infrastructure options being considered:

- Widening of Ballarat Road between Ashley Street and Geelong Road;
- Widening of the Ashley Street/Paramount Road route to provide a four lane connection from Geelong Road to Ballarat Road, with a possible connection from West Gate Freeway to Geelong Road in the longer term (providing an alternative to Millers Road);
- A direct connection from Hyde Street to West Gate Freeway, obviating the need for vehicles to use other east-west routes such as Francis Street, Somerville Road and Buckley Street;
- A direct connection from Smithfield Road to Dynon Road, as an alternative to a widening of Moore Street through Footscray.

The combination of these physical infrastructure options provides an effective alternative for freight vehicles currently travelling straight through the inner west area. These physical measures will need to be reinforced by expansion of the existing truck bans to remove all non-local freight traffic.

3.4 Ancillary Road Work

There are other road works that could be provided to improve connectivity and preserve access from the western suburbs if port expansion impacted on the operation of Footscray Road. These include widening of Dynon Road and the connection of Dynon Road to Wurundjeri Way.

3.4.1 Dynon Road widening

A proposal to improve access from the west includes widening of Dynon Road by two lanes between the Port Interchange and City Link.

3.4.2 Wurundjeri Way connection

A new direct connection between Dynon Road and Wurundjeri way (through the E-Gate rail area), via a six lane divided facility partly in cut and partly on structure is also proposed as one of the option components to provide improved access.

4 Engineering Assessment of Feasible Options

4.1 Design Criteria

4.1.1 Use of VicRoads Design Standards

The concept designs have been developed using the relevant VicRoads and Austroads publications and Australian Standards. In addition to these standards, a number of additional criteria have been adopted, as outlined below. The design criteria will be reviewed at the next stage of design once a preferred route has been chosen.

4.1.2 Road Tunnel Design Criteria

Each of the road options includes a significant length of tunnel in order to minimise the impact on the existing urban infrastructure. The following design criteria have been adopted for the purpose of developing, assessing and costing of options:

- 80 km/h horizontal and vertical alignment
- Ramp speed 60km/h
- Two or three lane tunnels on the main alignment
- One or two lane tunnels on ramps depending on traffic requirements
- 3.5 metre lane widths
- Generally 0.5m shoulders with additional widening if required for sight distance and a 3.0m inner shoulder on elevated structures.
- Vertical clearance of 4.8m
- Grade on main tunnels
  - Absolute maximum of 4%
  - General maximum of 3%
- Grade on ramp tunnels
  - Absolute maximum grade of 6 %
  - General maximum of 4 %

Typical cross sections for two and three lane tunnels used in developing the concept designs are included in Appendix B.

4.1.3 Urban Freeway Design Criteria

For the road components of Option A and B, the urban freeway elements which are not within tunnel have been developed based on the following criteria:

- 100km/h horizontal and vertical alignments
- 3.5 metre lanes

Typical cross sections for two lane freeway in cutting and on elevated structure are shown in Appendix B.

4.1.4 Local Road Standards

The design speed adopted for the at grade road improvements in the road component in Option C were based on the current posted speed limit and designed in accordance with VicRoads standards.

4.1.5 Rail Tunnel Design Criteria

The proposed track geometry within the tunnel alignment has been designed with a Line Speed of V_{max} = 80kmh. For the concept design, track curvature will vary between R350m and R950m curve radii.

A tight radius curve of R350m is required for the tunnel alignment to remain within the existing road reserve below St Kilda Junction. Curve radii of R400m are also required in the reverse curve alignment along Dandenong Road through Chapel Street. The Line Speed through this part of the alignment has been designed for a maximum V_{max} = 60kmh.

Although there is a speed reduction, the proximity of Commercial Road and Windsor Stations means that trains would be required to decelerate on approach or would be accelerating from stationary. Without detailed train performance calculations being performed as part of a simulation, it is expected that trains would not normally attain 80kmh speeds through this section of track under normal operating conditions.

The maximum cant applied to the track in tunnel is 60mm of cant through the R350m radius curve. The maximum vertical alignment applied in the concept design is a grade of +/- 2.5% compensated gradient.

Constraints:

The key engineering constraints of these options are:

- Tunnel alignment would need to follow the paths of roadways through the CBD due to soil conditions and deep foundations of the multi-storey buildings within this area;
- The tunnel alignment would need to descend below the City Link Domain and Burnley tunnels and would be restricted to a vertical grade of 2.5%
- The tunnel depth would be restricted to the depth adopted for the proposed subway stations. Station platform depths below 35m are not advisable as it may affect station patronage and also the evacuation times during an emergency.

4.2 Design Methodology

4.2.1 Photogrammetry and Survey

The Study area is covered by AUSIMAGE ortho-rectified aerial photographs. These formed the base for the design. No on-site topographical survey has been undertaken for this Study.

4.2.2 Integration of constraints / opportunities

Use was made of a GIS database to log each of the major physical, environmental and social factors. This allowed each of the individual factors to be assessed individually and in conjunction with one another.

4.3 Utility Services

4.3.1 Utility Enquiries

The location of existing services was initially undertaken through MOCS (Melbourne One Call Service) Enquiries. These were then followed up with separate meetings with the major utility companies to determine in more detail the location and nature of any services likely to be affected by the options.

The following service providers were contacted during the development of the concept designs:

Telecommunications

- AAPT, Optus, Powertel Ltd. VIC, Primus Telecom, Telstra, UE COMM, VERNet Pty Ltd

Electricity

- AGL/ Alinta, Citipower, Powercor Australia, SP AusNet

Gas

- Alinta Gas, GasNet Australia, Gas Pipelines Victoria, Multinet, Envestía / Origin Energy, SPI Networks, TRUenergy, WAG Pipeline Pty Ltd

Water

- City West Water Ltd, Melbourne Water Corporation, Yarra Valley Water Ltd

Sewer

- Melbourne Water Corporation

Of this list a number of service providers did not have assets within the study area and others did not have assets within the area affected by the options.

Following on from an initial assessment, details of all major services have been sought and located for the purpose of this study. However, no service provider was able to guarantee the reliability of the information provided but further development of the options will allow more detailed investigation including trial pits and on site mapping to determine their exact location and where necessary, the scope of work required to relocate them.

4.3.2 Option Services Assessment

Any significant civil engineering construction works in an urban area, even at existing ground level, involve the need for service diversions. The results of the utility enquiries indicated that based on the current concept designs, the major services likely to be affected by the road component would be the existing main drain under Alexandra Parade, trunk sewers crossing the line of the proposed tunnels and overhead high voltage electricity pylons adjacent to the West Gate Freeway.

At this stage no major conflicts have been discovered between the line and depth of known drains, sewers and water mains along the CBD Rail Tunnel route. The one exception is the “Graingers Road to Stoney Creek Drain” passing below the existing rail in the vicinity of the proposed western tunnel portal west of West Footscray Station. The records obtained from Melbourne Water indicate this drain to be a 1.5m wide x 1.9m deep brick culvert. In addition to these major works, each of the schemes would affect existing trunk and local gas, water and electricity services.

It should be noted that any surface road widening works and all road and rail tunnel portals will impact on services close to the surface. In general, shallow buried services are readily relocatable and service owners are able to advise or undertake changes as required.

Whilst a desktop study of the water mains, trunk sewers and drains has been undertaken along the proposed tunnel routes, a detailed investigation of existing service assets and redundant service infrastructure would be undertaken as part of the further development of road and rail tunnel solutions. This would be particularly important for proposed construction activities at or close to the surface such as portals, stations, entrances and concourses; access provision, ventilation shafts and power substations.

4.4 Property Impacts

An assessment of the impact of Option A, B, C and D on properties was undertaken, based on the layouts as shown, by overlaying the options over the existing cadastral base. This exercise was undertaken to gain an appreciation of the scale and cost of property acquisition. In reality, following further development of the design, the precise impact may be considerably different although the scale is expected to be of a similar level. This assessment indicated that the following number of properties would be affected by each option.

Table 4-1 Number of properties affected by Options

	Option A	Option B	Option C	Option D
Total Number of Properties affected at surface	496	226	354	3

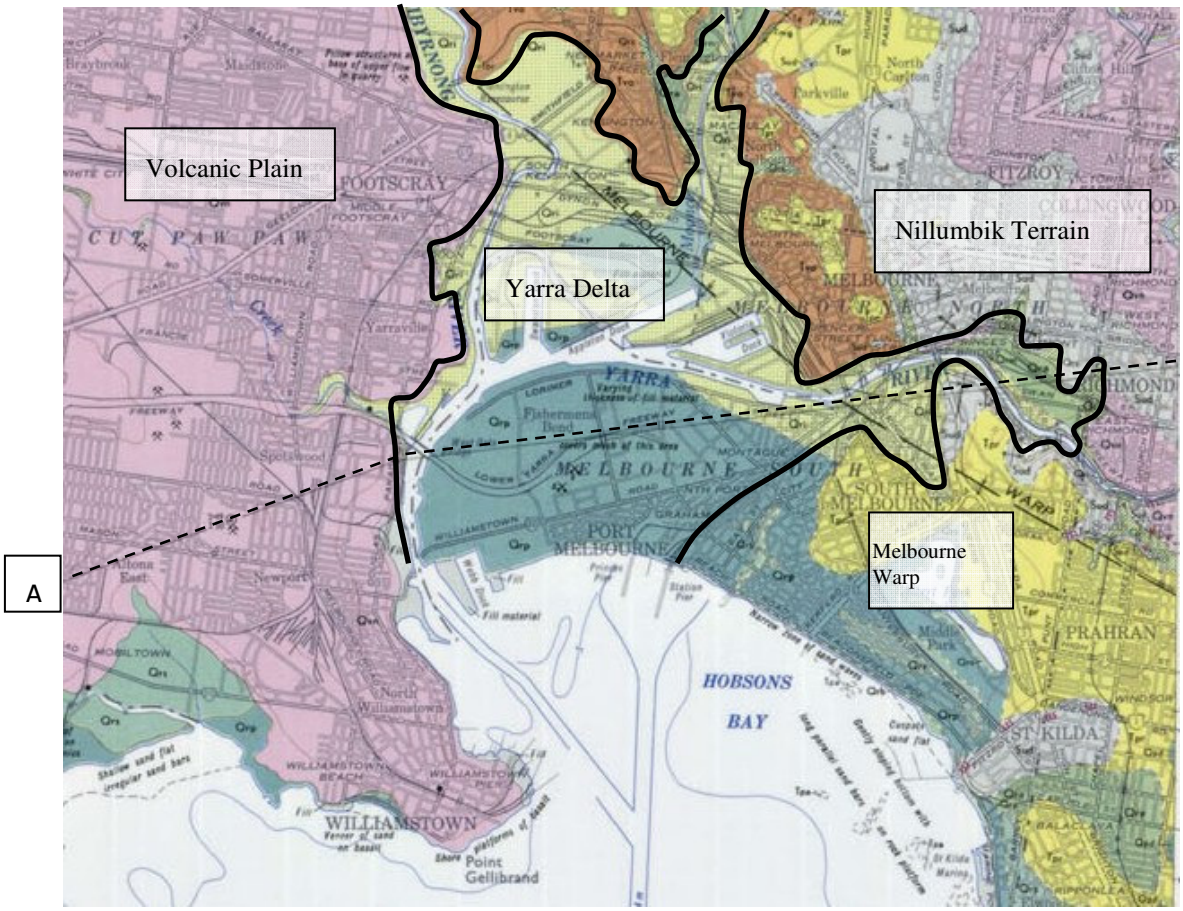
The valuation estimates have been prepared having regard to the existing zoning. A number of properties that are currently utilized for parkland and public purposes have been included in the total estimate.

In the concept design for the CBD rail tunnel, a section of the new tunnel will pass under existing properties between Carlton and North Melbourne. This 2.5km connection between North Melbourne and Carlton is required for the tunnel alignment to meet the project objectives as there is no vacant land available in this area and no direct route beneath an existing road reserve. As this section of the tunnel is proposed to be approximately 50m below ground level, it is anticipated there will be little or no impact at surface level. The full extent of property impacts cannot be determined within the CBD until a preferred alignment and location of new underground station infrastructure is selected. However, based on the current design, it has been assumed that three properties located around the proposed rail tunnel portals will be affected by the CBD rail tunnel.

4.5 Geomorphic Regions

Since some of the options would involve extensive tunnelling, it is important to understand the underlying geology and the engineering challenges this presents. The study area is divided into three distinct regions as shown below;

- Volcanic Plain
- Yarra Delta, and the
- Nillumbik Terrain



The Volcanic Plain is a flat lying region approximately 10 to 20 m above sea level that occurs in the area immediately to the west of the Maribyrnong River and the mouth of the Yarra River. The geology of the region comprises Silurian aged Siltstones and Sandstones overlain by Tertiary aged unconsolidated sediments which are overlain by Quaternary aged Basalt which form the surface of the Volcanic plain. The tertiary sediments comprise approximately 50 m thickness of Werribee Formation overlain by approximately 10 m of the Newport Formation, and then 10 to 20m of the Brighton Group. Overlying the Brighton group is 20 to 40 m thickness of Quaternary aged Newer Volcanics basalt.

The Nillimbuk Terrain is a hilly region east of Docklands that comprises Silurian aged Siltstones and Sandstones that rise from beneath the Volcanic Plain and Port Phillip Bay (Neilson, 1992). In places the Siltstones and Sandstones are capped by Newer Volcanic Basalts and Tertiary aged Sediments. Thin and often discontinuous sequences of Tertiary aged sediments (often called a "Deep Lead during the Gold mining era") may also occur beneath the Basalt caps.

Located between the Volcanic Plain and the Nillumbik Terrain is a very low lying region know as the Yarra Delta. The geology of the region comprises Silurian aged Siltstones and Sandstones overlain by unconsolidated Early and Late Tertiary aged sediments and early Tertiary Basalts, which are in turn overlain by Quaternary and Recent aged unconsolidated sediments deposited by the Yarra River, Maribyrnong River and Moonee Ponds Creek. The combined Quaternary and Tertiary sediments range between 50 m to 100 m in thickness and comprise silts, clays, sand and gravels. Interbedded with the Tertiary sediments are Older Volcanics basalts that are between 0 m and 20 m thick and occur at depths between 20 m and 70 m below ground surface. A geotechnical desk top study and report was separately commissioned as part of this study. Each of the engineering options developed has been assessed in more detail against this geotechnical database, later in this report.

4.6 Construction Costs

4.6.1 Estimating Approach

Comparative cost estimates were prepared for each option. Indicative plans and long sections for each option were prepared for this purpose, based on the nominal centrelines of the alignments. At this stage only a high level risk analysis has been undertaken on the contingency provisions and a strategic review of overall costs carried out.

Cost estimates have generally been prepared assuming a two or three lane dual carriageway urban freeway. The cost estimates for the tunnels have been based on two or three-lane dual tunnels. Within the cost estimate, allowances for service relocations and traffic management have been included for each section of each option.

The estimates also include a contingency to allow for:

- Development of each design option into a preliminary design with sufficient additional survey and geotechnical investigation required to confirm the construction methodologies which have been assumed for this study,
- Variations in the quantities (such as increased length due to connections at either end of the link or modifications to the alignments)
- Contingencies have been applied as a range to give upper and lower band estimates.

4.6.2 Assumptions

- Construction costs have been estimated at January 2008 prices.
- There is no allowance for escalation in prices to the time of construction.
- Operational costs are not included in the construction rates.
- In most cases, quantities have been scaled off concept design 1:10,000 aerial photographic alignment plans. Elements costed have been itemised based on elements identified on plans for each option.
- The elemental rates consider assumed ground conditions based on available information.
- Allowances have been included for service relocations, expected construction methods and traffic management requirements but these may change when sufficient investigation and engineering work has been done during the preliminary design stage when likely construction methods and staging are determined.

4.6.3 Elemental Costs

The cost estimates were developed from broad elemental unit rates for various components ranging from new rail stations, cut and cover road tunnel, bored road tunnel, bored rail tunnel, surface and elevated roadways, etc. These rates were per kilometre run or per square metre or cubic metre as appropriate and were derived from current similar large scale infrastructure civil engineering projects generally within Australia and New Zealand. They are in June 2007 prices, factored up to January 2008.

4.6.4 Construction costing

In developing the costs, the scope of work has relied on the available information on plans and long sections which have been developed from aerial photographic, engineering alignment software and the currently available geotechnical information. Cross sections have generally not been developed for any of the options, although typical cross sections were developed to establish the elemental cost rates.

4.6.5 Property Costing

Property acquisition has been costed separately by the Valuer General based on information supplied by the East West Study Team. In general, costs for the whole property affected by the proposed alignment have been assessed with some exceptions. Where considered appropriate, large parcels that have a relatively small proposed acquisition area have had the value adjusted accordingly. It should be noted that ownership details have not been independently verified.

The estimates are based on 2006 levels of value which have been adjusted to reflect market movements to January 2008. Sales evidence was compiled and analysed to confirm that the final estimates are consistent with current market levels as at 31 January 2008.

4.6.6 Comparison Table of Costs

Concept construction cost estimates for the four options have been calculated using the concept designs scoped on the plans and long sections. These are included in the table below with the construction cost ranges for each option after adjustment from June 2007 to January 2008 prices.

4.6.7 Operating and Maintenance Costs

In addition to the capital cost of each option, an assessment was also made of the ongoing O & M costs over a thirty year period for each option. In deriving these, a number of assumptions were made for the Public transport and road components relating to maintenance regimes for the tunnels, road and track, staffing levels, maintenance costs for new rolling stock, stations and track etc:

Table 4-2 - Cost Comparison of Options (in January 2008 prices)

	Description	Project Cost	Construction Cost	O&M Cost (30 Year figure)
		$billion	$billion	$billion
Public Transport (Options A, B, C &D)	• **Public transport* only**	**7.5 - 8.5**	**7.2 – 7.9**	**3.0**
Option A (Road component)	• **Eastern Fwy to West Gate Fwy link** • **Other road works**	**8.0 – 9.0**	**6.7 – 7.2**	**1.4**
Option B (Road Component)	• **Eastern Fwy to Deer Park Interchange link** • **Other road works**	**8.5 – 9.5**	**7.8 - 8.1**	**1.4**
Option C (Road Component)	• **Nicholson Street to Ballarat Road** • **Other road works**	**2.0 – 2.5**	**1.6 – 1.9**	**0.3**

* Public transport comprises: Bus rapid transit between the City to Doncaster

CBD rail between Footscray and Caulfield

Tarneit rail link between Werribee and Deer Park

4.7 Assessment of Road Options

4.7.1 Tunnelling Techniques

Possible construction techniques that have emerged from the feasibility and evaluation of geotechnical issues for application throughout the tunnel construction include:

- Bored Tunnel Construction
- Cut and Cover or Top Down Construction.

Bored Tunnel Construction

Bored tunnel construction normally involves machine excavation of a tunnel cavity below ground using either

- A roadheader machine, or
- A tunnel boring machine (TBM)

Roadheaders allow flexibility in the excavation geometry and generally require smaller construction site areas to support roadheader tunnelling operations, however their use in the harder basalt is expected to be problematic.

Tunnel Boring Machines (TBMs) are purpose built 'all in one' tunnelling machines which can operate in a wide range of ground conditions, including rock and soil. The machine excavates materials using a full face (ie. full tunnel diameter) rotating cutter head. The cutting head components vary dependent on the ground conditions and groundwater conditions. A shield surrounds the machine to provide temporary protection to the operators from falling rock. In some cases, the shield also provides tunnel wall support.

As the TBM progresses forward, temporary or permanent tunnel lining is placed through or behind the shield. The TBM progresses forward by either jack / pushing off the edge of the placed tunnel lining or by 'gripping' onto the natural materials of the tunnel walls and pushing forward. Materials are removed from the machine by means of a conveyor.

Although bored tunnels are a specialist area within the field of civil engineering, they are increasingly commonly used in the construction of new major urban corridors as they can be designed to deal with varying ground conditions, can be accurately 'steered' to tight horizontal and vertical tolerances underground and cause no surface disruption apart from at the portal locations and the ventilation shafts.

Open cut / Cut and cover / Top Down Construction

Cut-and-cover is a method of tunnel construction that is typically used for shallow depth tunnels. Generally speaking the construction involves the excavation of a cavity / trench from the surface (cut) which is roofed over (cover) to form the tunnel. The benefits of this form of construction are that construction is generally easier to control, difficult ground conditions are not so significant and costs are generally cheaper than bored tunnels. The work also uses standard civil engineering construction techniques. The main disadvantages are the significant disruption to the existing surface during the construction period, the impact on existing services which cross the excavated box and traffic management requirements.

Cut and cover tunnel construction typically is used where depth to road or rail is shallow, as in an open slot, and to maximum depths of about 25 to 30m to road surface or rail level. For greater depths, the cost of excavation support and the logistics of providing access to the tunnel level tend to favour the use of bored tunnel construction methods.

Both the TBM and cut and cover construction methodologies have been considered for any tunnelling in both the road and rail components.

4.7.2 Tunnelling Issues

Key issues in relation to long urban road tunnels include:

- fire and life safety
- psychology of tunnel use
- ventilation (including tunnel air quality control)
- tunnel gradients
- construction
- impacts on other infrastructure, including rail lines

All the above issues have a significant effect on the project complexity and its construction and operating costs. Each of the key considerations has been addressed at a strategic level of investigation to determine both feasibility and cost to acceptable confidence levels. A full risk analysis would be part of the project development and planning processes undertaken at a later stage.

Fire and Life Safety

The probability of a major incident in a tunnel is low. However, the consequences of such an event can be high. The design of long urban tunnels needs to address fire and other situations impacting on the safety of tunnel users. To this end, designers address tunnel architecture, ventilation, fire detection/suppression systems, control and communications to ensure that the risk of incident and its impact is minimised. Fire and life safety provision also allows for inclusion of points of safety, tunnel refuges, points of access and egress from the tunnel, emergency access and egress shafts to ground level and fire service equipment. For any road tunnel, together with good design there is also the need for ongoing driver education and awareness. As part of further design development, all aspects of fire and life safety would be considered in a comprehensive incident and emergency management plan. These aspects are non negotiable in any of the options selected.

Psychology of Tunnel Use

Long tunnels raise a number of issues related to driver psychology and driver behaviour. These issues can in practice affect both traffic flow and tunnel safety but at this stage of concept design, have only been considered at a high level and more detailed investigation will need to be undertaken in any further development.

Tunnel Ventilation

The possible tunnel ventilation design adopted in this report is the longitudinal method of ventilation using jet fans and aerial fans in the ventilation shafts for air quality and ducts for extraction. Tunnel enlargements and ducting near tunnel portals would be required to direct air back from the portals to limit portal emissions. Air extraction and fresh air intake points would be spaced at 2km to 3km intervals along the tunnel. In some cases quite long ventilation tunnels could be required to connect the ventilation shafts at suitable sites. The ventilation system in each of the east and westbound tunnels would operate independently with no air transfer between tunnels. Ventilation of the tunnels would require a number of ventilation stations along the route, probably between four to six. The location of these stations would be subject to extensive design analysis and planning approval processes.

Tunnel Gradients

It is important for the effective operation of the tunnels and to minimise vehicle operating costs that tunnel gradients are minimised. This is because traffic, especially large commercial vehicles, generate higher exhaust emissions and reduce speed on steeper grades. To cater for National Highway standards, a maximum gradient of 4% was adopted as a guideline for the road tunnel and a compensated gradient of 2.5% for the rail tunnel.

Power Requirements

The first step would be to analyse the anticipated load requirements of the tunnel. The existing substation infrastructure would then be analysed to assess the capability of the different surface substations to accommodate the additional load.

If additional capacity was required, discussions would be opened with the electricity providers to determine whether substation upgrades or new substations would be the best method to provide the additional capacity. This would be determined on a location by location basis.

4.8 Road Component Option A

Eastern Freeway to Nicholson Street

Construction

The length between the end of the Eastern Freeway and Nicholson Street, which is common to both Option A and B poses a number of engineering challenges.

The new tunnels beneath Alexandra Parade can be constructed as cut and cover under the existing road, involving considerable construction impacts. As an alternative, driven tunnels have also been considered. With either method, providing connections to the existing road network involves at grade reconstruction in the vicinity of Hoddle Street of between 2 and 3 lanes on the north and south side of the Eastern Freeway, to enable new tunnel portals for 3 lanes in either direction to be constructed.

Initially freeway ramps were proposed at Nicholson Street to give access to the CBD from the tunnel, but these were ultimately rejected due to varying geology, conflict with existing services, impact on existing frontage development, long lengths of cutting from the tunnel or steep gradients to allow the ramps to 'daylight' to the surface and operational issues related to the potential for traffic to queue in the tunnel.

After considering a number of other alternatives, ramps were developed at Queens Parade for east and westbound traffic. Due to the engineering difficulties normally encountered in constructing these interchanges underground, plus the wide existing right of way in this area, it is envisaged that these ramps would be constructed within an open excavation from the surface, using cut and cover techniques as described previously. The work could then be covered over again following completion and the surface road and services reinstated, allowing potential for improvement of the existing streetscape. This allows the vertical alignment of the tunnel to be bought closer to the surface than with a bored tunnel option, thereby reducing the length of the ramps and budget cost savings are also achieved. It also allows for reconstruction of the main drain in Alexandra Parade to be undertaken as part of the cut and cover process.

Traffic Management

Traffic management would be complex as existing surface routes and junctions would need to be diverted and maintained whilst a large open box is excavated within Alexandra parade. One possible sequence of traffic management and construction would be to divert the existing traffic onto a new temporary alignment on the north side of Alexandra Parade to allow the westbound carriageway on the south side to be excavated and constructed within a 'box' type construction. Once complete and covered with a concrete slab at approximately existing ground level, local traffic could then be diverted back onto this cover to enable the eastbound carriageway to be excavated and constructed on the north side of Alexandra Parade. Once both the eastbound and westbound underground carriageways were finished and covered, Alexandra Parade could then be permanently reinstated on the surface.

Traffic management would also be required around the tunnel portals. In order to provide sufficient working space around these, existing east and westbound traffic would be separated away from these portals using newly constructed lanes, within the existing right of way but outside the limits of the current road to create a working space and sufficient room to develop the lanes descending into the main tunnel.

Services

Unlike a bored tunnel, existing services would be affected by the use of cut and cover construction techniques. It is likely that in some cases, services would need to be relocated more than once to tie into the phased construction previously described. In addition to the main services identified, all local shallow services would need to be relocated during the cut and cover excavation.

Geology

The expected geology along this section is Newer Volcanics, overlying sediments and the Melbourne Formation.

The Newer Volcanics consist of residual clays overlying basalt. The residual clays may be up to 7m thick. The thickness of the Newer Volcanics may vary as the Melbourne Formation is exposed both north and south of the alignment. The weathering and fracturing of the rock is expected to vary given the proximity to the edge of the basalt flow. The Newer Volcanics may represent a series of lava flow deposits with significance period to time between flows allowing weathering of the surface to residual clays.

For any construction in this section using cut and cover techniques within the road reserve would be preferred. The road reserve is about 60m wide and the proposed road would be constructed in one half of the road reserve while the other half contains diverted traffic. The excavations are expected to be less than 12m deep along this section. It may be possible to maintain a significant portion of the existing median strip.

Excavation of the basalt is expected to require either blasting or mechanical rock breaker. Traditional blasting may not be a viable construction option within an inner Melbourne suburb, but recent advancements may offer blasting options which are viable. Alternatively, using a mechanical rock breaker could be slow progress and would need to be considered in the project programming and costing. It is expected that the cuts would be supported with retaining structures such as soldier or secant piles wall most likely installed down into the underlying Melbourne Formation. Driven piles would not be suitable given the possibly of encountering basalt at a shallow depth. Retaining structures may need to be propped or anchored. Any required ground support outside of the road reserve would need to be temporary.

Consideration would need to be given to the impact the design and construction of the cut and cover section would have on the footings of the Hoddle Street Overpass and Rail Corridor. These Overpasses would most likely be supported on piles. The impact of the project on other buildings, in particular, those with frontages onto Alexandra Parade would need to be considered. A number of multi-level brick or steel framed buildings exist on Alexandra Parade. Dewatering of the residual basaltic clays, which are highly sensitive to moisture content would need to be investigated and managed to avoid adverse impact on building footings founded in the clays.

Hydrogeology

Although there is no groundwater level data available, levels are expected to be between 5 and 10 m below ground surface.

Due to the cut and cover nature of the excavation, groundwater inflow would be expected from the Newer Volcanics Basalt, Tertiary sediments that may underlie the Basalt, and the Melbourne Formation. In general groundwater inflows would be expected to be in the order of 1 L/sec per 100m length of cut, but due to the highly variable nature of the Basalt and the Tertiary Sediments (if present) inflows could be as high as 10 L/sec in localised regions of the excavation. Inflows from the Melbourne Formation are generally less than 1 L/sec/100m. However, high fracture permeability in the Melbourne Formation can occur in the highly weathered zones which typically occur in the top 10 m. Given that the invert level is expected to intersect the top 5 m of the Melbourne Formation there is significant potential for highly permeable fractures to be intersected. Permeability testing of the full geological profile to a depth at least 10 m below invert level and measurement of groundwater depth should be undertaken to provide an initial indication of potential groundwater inflow rates.

4.8.1 Nicholson Street to Royal Park

Construction

West of Nicholson Street, the existing right of way reduces in width and there are existing tram lines along Nicholson Street. Continuing with a top down cut and cover construction method would have required the acquisition of a number of existing properties along Alexandra Parade and caused disruption to the existing tram service during construction. As a result, in the current design, the alignment is lowered on the approach to Nicholson Street and would be constructed via a bored tunnel, to avoid impact to the existing properties and Nicholson Street.

The route then continues in tunnel following the line of Princes Street and continues underneath the Melbourne General Cemetery. An alternative alignment running beneath Cemetery Road, to the south of the cemetery itself was also investigated and could be achieved in accordance with design standards but was not the preferred option due to existing deep foundations beneath the College square student accommodation, the additional length of tunnel required and additional engineering complexity with this alternative.

Generally the bored tunnels have been designed to be at the same level and parallel to each other with approximately one tunnel diameter between the tunnels. This is to prevent any local ground disturbance when driving one tunnel from affecting the adjacent tunnel. The one diameter spacing is generally used as a rule of thumb at this level of concept design and it may be possible at the next stage to reduce this horizontal clearance between the tunnels, if required. Within Royal Park the eastbound and westbound 3 lane tunnels bifurcate into a ‘Y’ type arrangement to enable tunnels to connect north into CityLink and continue west to the Port Interchange. In order to help with the vertical separation and gradients of the 2 lane tunnel where they cross, within Royal Park, the two 3 lane tunnels have been designed stacked one above the other, so that the 2 lane tunnels cross each other with a clear vertical separation between them.

Again, due to the change in cross section from the 3 lane to the two 2 lane tunnels and the complex engineering issues involved, this Y junction would be constructed using cut and cover techniques. This would require the excavation of a cutting a minimum of 300m long and 20m – 40m wide at the base, in Royal Park for an extended period of time but once construction is complete and the open excavation covered, offers rehabilitation opportunities for Royal Park. The excavation would also be of the order of 30 – 40m deep based on the current vertical design as a result of the 'stacked' tunnel arrangement.

In developing the concept design, a number of alternative alignments through the park have been produced, in an effort to minimise the impact on the existing constraints. The current alignment passes beneath Anzac Hall, although this building could be retained by constructing this section in tunnel. Similarly across the Park itself, the line with least existing tree cover was chosen.

Traffic Management

As the route is in tunnel over most of this section, traffic management would be minimal, aside from some impact on the existing tramway and Elliott Avenue in Royal Park during excavation of the open box for the 'Y' interchange described above.

Services

As with traffic management, with the route generally in tunnel, service diversions and relocation are expected to be minimal.

Geology

The expected geology along this section is predominately Melbourne Formation. Ground conditions at the Nicholson Street portal may be mixed with the potential for Newer Volcanics overlying the Melbourne Formation.

The geological maps indicate that the alignment would be passing through concertina type folds with a strike of N 20° E. The geological maps indicate the tunnel intercepting the Whittlesea Anticline at about Royal Parade. Locally occurring structural features comprising sheared and crushed seams, intensely fractured zones, sheared zones, crushed zones and dykes, and to a lesser extent sills, are common and may be encountered in the Melbourne Formation.

Driller's logs for the North Yarra Main along College Crescent indicate the depth to moderately weathered rock to be 2 to 5m and depth to slightly weathered rock to be 15 to 25m. The North Yarra Main is located at a depth of about RL -10m AHD. It is not possible to identify any structural features from the driller's logs.

Brighton Group sediments overline the high relief areas of Royal Park. The Brighton Group normally consists of 'flat lying to gently dipping, variably iron-stained and cemented, mostly sandy sediments' (Engineering Geology of Melbourne, p191).

Hydrogeology

Groundwater levels are expected to be between 10 m and 20 m below ground surface. Drilling will be required to provide more reliable data on groundwater levels. Most of this section occurs in Melbourne Formation which typically produces low groundwater inflow rates. The areas where there is significant potential for high groundwater inflow rates is the contact zone between the Melbourne Formation and Newer

Volcanics Basalt and Tertiary sediments underlying the Basalt. To assess this issue usually requires several boreholes due to the uncertainty and variability of such zones. Identifying the location and nature of this contact in detail is considered a design issue and, as such, is not included in the scope of this investigation. If possible one geotechnical bore should be drilled at each of these contact zones to provide greater certainty of their general location. Permeability testing of the full geological profile in all proposed geotechnical bores should be undertaken to provide an initial indication of potential groundwater inflow rates.

Although groundwater dependent ecosystems (GDE) are unlikely to be impacted by groundwater inflows into the tunnel excavation, the tunnel section where GDE's may be an issue are the trees in Royal Park and Melbourne Cemetery. Measurement of groundwater levels from geotechnical bores drilled at these two sites will provide sufficient data to determine whether GDE's require more detailed assessment during the design stage of the investigation. The loss of stream flow from Moonee Ponds Creek due to tunnel inflows may also impact on aquatic ecology if this causes the tidal influence to be drawn further upstream into the creek channel. Examination of this issue requires detailed information that is beyond the scope of this preliminary investigation.

This section is driven tunnel and is expected to be constructed using a TBM. The depth to tunnel pavement top ranges from about 20m at the Nicholson Street portal to nearly 40m below the Melbourne General Cemetery in Carlton North.

Predominately, the driven tunnel will be through Melbourne Formation. A number of tunnels have been driven through the Melbourne Formation (or equivalent materials) in Melbourne including CityLink, EastLink, Melbourne Underground Rail Loop, Dandenong Valley Trunk Sewer, and South Eastern Trunk Sewer with mixed results. Tunnelling performance in the Melbourne Formation is influenced greatly by the structural defects, intrusions and the proximity of water bearing sediments.

4.8.2 Royal Park to City Link

Construction

From Royal Park north to CityLink, the twin 2 lane eastbound and westbound tunnels would start in tunnel from the western end of the 'Y' junction in Royal Park described above. After passing north, beneath the existing rail line connecting Royal Park and Flemington Bridge Stations, the existing ground slopes down in Ross Straw Field. At this location the form of construction could change at a portal transition from driven tunnel – which has been chosen to avoid impact to Royal Park and the railway line, to cut and cover across Manningham Reserve and the wetlands off Manningham Street which were originally built as part of the CityLink project. Consideration will need to be given to impact of the wetlands on the design and construction of the cut and cover section, especially if the wetlands are to be retained.

Between Mt. Alexander Road and Brunswick road, CityLink would need to be widened to allow sufficient room in the existing median for the new north and southbound tunnel portals. This widening has been designed on the west side of CityLink to avoid impact to the new development of Parkville Gardens, (formerly known as the Commonwealth Games Village). However, this widening would extend the new northbound

carriageway on an elevated structure over the top of Moonee Ponds Creek, which at this location is currently contained within a large concrete channel.

Additional one lane widening on either side of CityLink, between Brunswick Road and Moreland Street has been included. This is primarily to allow for merging movements between CityLink and the new East- West tunnel. This widening can be achieved within the existing right of way by utilising the existing shoulders to form the additional lane. At the existing overbridges, the shoulder would be removed to provide for the existing lane and additional bridge protection would be required.

Traffic Management

Construction of the portals in the median would involve significant construction issues, mainly related to traffic management and the sequencing of construction. A high level program has been thought out which would involve the construction of new carriageway on the west side first to allow the existing traffic streams to be diverted horizontally to provide a large enough construction area within the existing median for the portals. The process would be similar to that used recently on the construction of the new Tulla Calder Interchange.

Services

A number of underground services may be encountered within this section. They may need to be diverted. Moonee Ponds Main Sewer runs along Oak Street and the Moonee Ponds Main Diversion does a dogleg to run underneath CityLink. The IL is 0.6m AHD and the sewer is a 1050mm size pipe. Melbourne Water records indicate that the sewer was constructed in 1899 and of is brick construction. The records indicate that the Diversion was constructed in 1969. Consideration must be given to the impact of any construction activities on the sewer given its age and type of materials used in this sewer. It most likely will need to relocated, as the proposed Cut and Cover section would intercept the current sewer pipeline.

Expected Geology

The expected geology along this section is Yarra Delta Sediments or Older Volcanics overlying the Melbourne Formation. The surface boundary between the Older Volcanics and Yarra Delta sediments is located at about the middle of Ross Straw Field. Ground conditions at the CityLink connection may be mixed with the potential for Yarra Delta Sediments overlying Melbourne Formation.

The Yarra Delta Sediments may contain potential Acid Sulphate soils.

Hydrogeology

Little is known about the hydrogeology along this section. Artificial wetlands have been constructed on both sides of Oak Street, north of Ross Straw Field. Moonee Ponds Creek runs parallel to CityLink.

4.8.3 Royal Park to South Kensington

Construction

From the 'Y' junction in Royal Park, the other twin 2 lane tunnels continue south-west to the Port Interchange. It is currently envisaged that the tunnel boring machine would be launched from the open excavation in Royal Park. 2 lane tunnels have been adopted in the current design, as the traffic modelling

indicates lesser demand between Royal Park and the port, although 3 lanes could also be considered if required.

The vertical alignment over this section is constrained in a number of areas;

- by the separation required with the northbound tunnel to CityLink described above
- by poor geology under CityLink
- by existing building foundations
- by Moonee Ponds Creek
- by existing sewers crossing the proposed alignment

JJ Holland Park was selected as the location of the portal for a number of reasons. The existing alignment and geology at the eastern end lends itself as a location for a transition portal between a driven tunnel and a cut and cover tunnel. The park itself could be used by a contractor as a site storage and layout space and the adjacent railway line could be used for removing the tunnel spoil, thereby reducing the need for vehicle movements on the roads. Upon completion there are also reinstatement opportunities in the park.

Traffic management

Traffic management would be minimal over this section as the tunnel is bored over the entire length and the two portal locations have been selected to minimise the impact on existing roads and properties.

Services

Similarly, a minimal allowance has been allowed for in the cost estimate for service diversions over this section.

Expected Geology

The expected geology along this section is expected to range from Melbourne Formation with Tertiary aged basalt and sediments beneath Royal Park, to the unconsolidated sediments infilling the paleaovalley beneath the current Moonee Ponds Creek, and the Tertiary basalts and sediments in Kensington.

The Melbourne Warp is expected to pass across the alignment somewhere between the Moonee Ponds Creek and the JJ Holland Portal. This Tertiary aged flexure of the Melbourne Formation and older Tertiary units resulted in the Melbourne Formation, Werribee Formation and Older Volcanics dipping to the south west. The Yarra Delta sediments now cover the downthrown arm between Kensington and Port Philip Bay. The flexure is likely to have caused localised distress to the Melbourne Formation near the fold hinge, including fracturing, minor faulting and shearing, and possibly the intrusion of igneous dykes and sills.

The sediments within Moonee Ponds paleovalley are expected to be the equivalent to the Quaternary aged sediments within the Yarra Delta.

Hydrogeology

Groundwater levels are expected to be between 10 m and 20 m below ground surface beneath Royal Park, and approximately 1 m below ground surface over the lower lying areas of this section, although artesian conditions have been encountered in the Coode Island Silt and in deeper Yarra Delta sediments such as the Moray St Gravels (MSG). In the Kensington Hill area groundwater levels could be up to 20 m below ground surface. Drilling will be required to provide more reliable data on groundwater levels. Much of this section

occurs in Melbourne Formation which typically produces low groundwater inflow rates. Permeability testing of the full geological profile in all proposed geotechnical bores should be undertaken to provide an initial indication of potential groundwater inflow rates.

Although groundwater dependent ecosystems (GDE) are unlikely to be impacted by groundwater inflows into the tunnel excavation the tunnel section where GDE's may be an issue are the trees in Royal Park. Measurement of groundwater levels from geotechnical bores drilled at this site will provide sufficient data to determine whether GDE's require more detailed assessment during the design stage of the investigation. The loss of stream flow from Moonee Ponds Ck due to tunnel inflows may also impact on aquatic ecology if this causes the tidal influence to be drawn further upstream into the creek channel. Examination of this issue requires detailed information that is beyond the scope of this preliminary investigation.

Sand layers within the Coode Island Silt (CIS) often have very high permeability which can lead to inflows in excess of 100L/sec/100m. Natural gas also occurs in these sand layers which could present an OHS risk during excavation. Although the Moray St Gravels (MSG) are not shown on the geological section there is a small risk that they are present. Given that the MSG generally have very high permeability's, bores should be drilled bedrock to evaluate the potential for their occurrence. The Werribee Formation and the highly weathered zones in the top of the Melbourne Formation can also have very high permeability's which can lead to high inflows.

Groundwater in the Yarra Delta Sediment may be as high as 10,000 mg/L, particularly if MSG is present. The MSG and CIS are know to have a high sulphur content which could lead to high dissolved Hydrogen Sulphide gas which may create an OHS risk and impact on concrete liners. Although there is a high risk of industrial contaminants occurring in the sediments of the Yarra Delta the low permeability of the CIS is likely to have prevented contamination of groundwater at tunnel depth risks.

The Coode Island Silt is highly compressible so there is a high risk of ground subsidence in response to groundwater inflow to the excavation. The location of sand lenses within the Coode Island Silt or other highly permeable sediments that could lead to the drainage of groundwater from the Coode Island Silt will need to be identified to enable reliable calculations of subsidence to undertaken

4.8.4 South Kensington to Maribyrnong River

Construction

From JJ Holland Park – the tunnels continue south west towards the Maribyrnong, passing beneath the existing railway line between Footscray and South Kensington and continuing just to the east of Kensington Road before passing underneath Dynon Road. In the concept design, it has been assumed that generally this section would be in an open cutting with vertical retained sides as this provides an opportunity for the tunnel to daylight and would enhance the driver experience. New overbridges would be required for the railway line, Childers Street and Dynon Road to cross this open 'slot'. Furthermore, by adopting an open slot, ramp connections to the port are easier to arrange and construct compared to a deeper driven tunnel, although there would be considerable property impact along Kensington Road.

Once the alignment has passed beneath Footscray Road it climbs from cutting to grade and then continue to climb to cross the Maribyrnong River on an elevated structure.

Several options for connecting into the port were examined in order to provide an effective connection. Two of the most effective alternative arrangements are described below.

1) The first of these is to lower the main alignment notionally 6m below existing ground, allowing Dynon Road and the 'W' track rail line from Bunbury to cross it at existing ground level and the new port link road connecting Dynon and Footscray Road would then need to be elevated approximately 6 – 7m above existing ground so as to gain sufficient clearance to the 'W' Track. Connecting ramps between the main east-west alignment and the port link road would thus have a level difference of between 12 – 13m with resulting grades of 6% and ramp lengths of approximately 900m which is not desirable, particularly where it is reasonable to expect a large percentage of commercial vehicles from the port using this interchange.

2) The alternative is to lower the main alignment 12 – 13m below existing ground, allowing Dynon Road and the 'W' track still to cross it at approximately existing ground level. The Port Link road is then designed vertically at approximately 6 – 7m below existing ground. Connecting ramps between the main east-west alignment and the port link road would thus have a level difference of between 6 – 7m with resulting grades of 3.5% and much shorter ramp lengths at 300m.

As part of the new port interchange, some associated rail works are required to relocate the existing 'W' track and port sidings adjacent to the proposed interchange. Much of the land along the proposed alignment is currently occupied by private industrial facilities, main railway lines and reserves and Port of Melbourne land to the south. Interface with these land owners will need to be considered during investigation, design and construction, including issues such as maintaining rail operation during construction. The rail corridors are constructed on filled embankments, and significant bridging structures are likely to be required to support the railways prior to excavation beneath.

One of the other construction challenges in this location is the local flooding which occurs around Dynon Road due to occasional flooding from the Maribyrnong. Flood modelling based on a 1 in 100 year flood indicates that Dynon Road would be flooded to a depth of 300mm. With the first alternative described above, flood protection measures would only be required to protect the slot from flooding by the use of a cut off wall or levee greater than 300mm in height. For the second alternative, this flood protection would also need to be extended to include the new Dynon Road to Footscray Road link, making this alternative a more complex arrangement.

The local Coode Island Silt (CIS) will be soft, and the preparation of trafficable haul roads during excavation will be difficult. Horizontal sand lenses within the CIS may be water bearing, and will result in some water inflow into the excavation. The excavation will act to draw the water table down locally, which will result in loss of buoyancy within the soft CIS, increasing consolidation and surface settlement. If the cutting is designed to be a tanked (ie no allowance for groundwater inflow once constructed), consideration will need to be given to the effect of temporary drawdown. Temporary groundwater cut off walls may need to be constructed along the length of the cut to prevent a groundwater drawdown cone forming and accelerating

surface settlement around the excavation. Temporary groundwater recharge may also be necessary to supplement any water inflow into the excavation. Exposing the CIS to oxygen can lead to the formation of acid sulphate soil and leachate. Care will need to be taken when handling the soil and water inflow during construction, and when treating and disposing of the soil and water during construction and service.

The pavement level within the cut will be beneath groundwater level, and as such will be subject to uplift forces due to buoyancy. The pavement may need to be anchored into underlying units such as the Older Volcanics or Melbourne Formation to maintain stability.

The elevated structure is likely to be constructed on bored piles, socketed into the Older Volcanics (where present and suitable), or into the Melbourne Formation. One borehole log indicates the Older Volcanics may exist on the east side of the Maribyrnong River, but this would need to be confirmed with further investigation. The top of the Older Volcanics at this location is approximately RL-10m, where as it is estimated that the top of the Melbourne Formation is somewhere in the order of RL -60m. If the Older Volcanics are encountered east of the Maribyrnong River, and are considered suitable for founding bored piles in, care should be taken when grouting up any investigation boreholes to prevent groundwater from the underlying pressurised Werribee Formation flowing into the bored pile excavations during construction.

Filled abutments to the elevated structure will be constructed on compressible soils, and the design of the abutments will need to consider the induced settlement beneath any placed fill.

The proposed eastern abutment of the Maribyrnong River crossing will be located close to the backfilled Yarra River channel. The exact location of the backfilled channel should be identified during an investigation phase.

Traffic management

The most significant traffic management impacts from the Port Interchange would be disruptions to the port rail service and to the surrounding local roads, including Dynon Road and Footscray Road. Restrictions would also be necessary to the navigation on the Maribyrnong River during construction of the elevated structure in Option A and the tunnel in Option B.

Services

There are several major existing services which would be affected by the Port Interchange. These include a 2.4m trunk sewer in Dynon Road and a trunk water main between Dynon and Footscray Road. In addition to these major services it is anticipated that numerous local services in Dynon and Footscray road would also need to be diverted.

Expected Geology

The ground surface along the proposed alignment between Altona Street and the Maribyrnong River Crossing is typically flat, characteristic of much of the Yarra Delta. The geological boundary between the Tertiary aged Older Volcanics that outcrop along the alignment between Moonee Ponds Creek and Altona Street, and the Yarra Delta sediments is unconforming, and inferred to be steep. The topography of the alignment indicates a 15 metre rise in ground surface near the interface between the Older Volcanics and the Quaternary sediments over a horizontal distance of 150 metres. The log of a borehole drilled at the toe of the outcrop in JJ Holden Park indicates 8.5 metres of fill and black silty sand overlying basalt. The park was created when 'Seagull Swamp' was reclaimed in the 1960's.

The abrupt boundary may be a result of erosion of the tertiary units by the Maribyrnong River flowing along a river course 500m or so east of its current alignment. Nielson refers to the Proto-Maribyrnong Depression, a now buried ancient river channel that completely eroded the Tertiary aged Older Volcanics and Werribee Formation to expose the underlying Melbourne Formation. The depression passes to the east of Swanson Dock, from the north. The abrupt boundary between the Older Volcanics and Yarra Delta sediments at JJ Holden Park may represent an upstream portion of the Proto-Maribyrnong Depression.

The inferred subsurface Quaternary aged geology along the proposed alignment between Altona Street and the Maribyrnong River Crossing comprises of Coode Island Silt (CIS) (or a time equivalent unit of similar properties, related to alluvial deposits on the Maribyrnong flood plains near Kensington) overlying Fishermans Bend Silt. Moray Street Gravels (MSG) is expected in some locations beneath the FBS.

The CIS consists of soft to firm clays and silts, occasionally with sand. A significant amount of fill is expected to exist along the alignment. Much of the Yarra Delta consists of reclaimed swamp, and the thickness of fill will depend on the pre-existing ground conditions and quality of fill used. The alignment passes beneath two filled railway embankments that have been constructed approximately 3 metres above the adjacent ground level. The thickness of the CIS varies along the alignment, and is expected to be greatest between Altona Street and Dynon Road, where borehole information indicates the base of the CIS at about RL -10m, and potentially to a depth of RL -20m. Limited borehole information south of Dynon Road indicates a thickness ranging between 3 and 5 metres between Dynon Road and the Maribyrnong River.

A number of bore holes encountered water bearing sand within (or directly below) the CIS (approx RL-10m) near the intersection of Dynon Road and Kensington Road. The water was under pressure, with the logs describing that 'the water came (into the borehole) very fast' and the 'water filled the hole'. The sand layer was not penetrated.

The stiff and very stiff silty clay (and other minor components) of the FBS is expected to be encountered beneath the CIS for the entire length of Section 105A, except in South Kensington, where the Tertiary Older Volcanics dip below the Yarra Delta sediments. Two boreholes in the vicinity of JJ Holden Park indicate the base of the CIS may be in direct contact with the Older Volcanics down to a depth of about RL -10m.

Published cross sections (Neilson, Engineering Geology of Melbourne) and borehole information indicate the thickness of the FBS will be greatest between MacKenzie Road and Dynon Road, ranging from 10m to 25m (approximately). South of MacKenzie Road, borehole logs indicate basalt at RL -10m, while north of Dynon Road, the overlying CIS increases in thickness, with FBS only identified, at a depth of approximately RL-20m, in one borehole. The MSG is expected to be present beneath the FBS in channels eroded in the underlying Tertiary Older Volcanics, Werribee Formation, and possibly the Silurian Melbourne Formation. Published cross sections and available borehole logs indicate the top of the MSG will be at about RL-30m, although as the alignment approaches the mouth of the Maribyrnong Valley in South Kensington, the top of the MSG may be slightly closer to the surface.

No borehole logs along the alignment between Altona Street and the Maribyrnong River encounter the Melbourne Formation. Published cross sections (Neilson) suggest the depth to the top of the Melbourne Formation increases from approximately RL -30 in South Kensington to somewhere in the vicinity of RL -60 near the Maribyrnong River crossing.

Prior to the excavation of the Coode Canal in the late 19th Century, the course of the Yarra River continued up the Maribyrnong River, through the north of the present day Swanson Dock, returning to the current river course at Appleton Dock. The old river course was backfilled subsequent to the cutting of the Coode Canal, and the land has since been developed. There are no obvious surface features left to indicate the exact location of the buried river course.

The eastern approach of the proposed elevated crossing of the Maribyrnong River passes within a few hundred metres of where it is understood the buried river course is located.

Hydrogeology

Groundwater levels are expected to be approximately 1 m below ground surface over most of this section but inflows are expected to be very low, probably less than 0.1 L/sec/100m. Very high inflows may occur if sand lenses within the CIS are intersected. The occurrence of these lenses could have a significant impact on groundwater inflows, particularly if they occur at invert level (ie this assumes that diaphragm walls will be used to control later inflows). Permeability testing should be undertaken on the most permeable sediments encountered in the geotechnical boreholes. Drilling depth should be to RL –10 m AHD.

A significant issue along this section is likely to be the high risk of groundwater being contaminated due to the shallow depth of the excavation and the presence of dissolved H_2S and CO_2. Although the volume of groundwater inflow is expected to be very small there may be significant costs to handle and treat any groundwater contamination, as well as OHS risks. The shallow nature of the excavation may also cause acidification of the shallow groundwater which could impact on the concrete liner and/or cause an acid waste that would require appropriate treatment and disposal. Evaluating the potential for acid generation is a complex process that would require modelling which is likely to be beyond the scope of the preliminary investigation. However, sampling of the shallow soils immediately below the water table would provide an indication of whether the issue would require further examination.

Groundwater salinity is expected to be 5,000 to 10,000 mg/L which, if it is not contaminated, could probably be discharged directly to the Maribyrnong River. It is recommended that groundwater samples be taken from

all geotechnical bores drilled in this section and be analysed for industrial contamination and salinity, and soil samples be taken and tested for their acidification potential.

There is an elevated risk of subsidence occurring due to groundwater inflows to the excavation site during and after construction. Detailed investigations, such as pumping tests and numerical modelling are required to fully assess subsidence risks.

4.8.5 Maribyrnong River to West Gate Freeway

Construction

For the elevated section of the link between the Port Interchange and the West Gate Freeway, one of the controls is the crossing of the Maribyrnong River. From existing information shown in the table below, the existing constraint for navigation clearance is 4 metres maximum clearance at Lynch's Bridge at low tide. A clearance of 6 metres minimum at low tide has been adopted for use in developing the concept designs, similar to Footscray Road over Shepherd Bridge.

Table 4-3 – Bridges on the Lower Maribyrnong River

BRIDGES ON THE LOWER MARIBYRNONG RIVER

BRIDGES					CLEARANCES			
Name/Type	Location	Distance from Mouth of Yarra River [km]	Recom-Mended Navigation of Channel	River Invert Level [m AHD]	Maximum Level Underside Bridge [m AHD]	Maximum Clearance Low Tide [m]	Maximum Clearance High Tide [m]	Minimum Width between Piers [m]
Shepherd	Footscray Rd	1.14	Centre	-3.47	5.60	5.90	5.30	24.00
Railway	Bunbury St	1.38	Centre	-5.41	6.71	7.01	6.41	44.00
Hopetoun	Dynon Rd	1.77	Centre	-4.50	6.58	6.88	6.28	21.00
Railway (Old)	Kensington Rail Bridge	2.56	Centre	-3.60	6.69	6.99	6.39	43.00
Railway (New)		2.58	Right	-3.60	4.68	4.98	4.38	28.00
Stock		2.82	Left	-3.70	4.85	5.15	4.55	30.00
Lynchs'	Ballarat Rd	3.05	Centre	-2.90	3.87	4.17	3.57	15.50
Farnsworth Ave	Farnsworth Ave	4.21	Centre	-3.40	4.76	5.06	4.46	15.50
Raleigh Rd	Raleigh Rd	6.93	Centre	-3.50	4.27	4.57	3.97	15.00
Afton St Pedestrian	Afton St		Centre					
Canning St	Canning St	11.70	Centre	-1.30	10.06	10.36	9.76	23.00
Solomons Ford	Canning St. West	15.30						

Note: Low Tide = 0.3 m AHD [0.22m Chart Datum]
High Tide = 0.3 m AHD [0.82m Chart Datum]

After crossing the Maribyrnong on elevated structure, the route continues south west remaining elevated over the existing container storage area (previously rail sidings). Typically, elevated structures are supported on piles with a pile cap, such as the Western Link Elevated Structure. Most likely the piles will be bored piles socketed into rock, in this case, basalt. Alternatively, driven piles may be used subject to loads and moments constraints.

Some property acquisition will be required between Whitehall and Hyde Street, although the alignment avoids the Mobil Yarraville terminal refinery. A tunnel option was investigated along this same alignment but due to the poor ground conditions and significant opportunities for redevelopment on the surface along the west bank of the Maribyrnong River, the elevated option was preferred. Selection of the form of structure at the detailed design stage also offers substantial urban design opportunities.

Although detailed noise modelling has not been undertaken, it is expected that noise walls will be required to provide noise attenuation to the residential properties in Yarraville fronting the new road.

Traffic Management

Traffic management would be required in Whitehall Street, Francis Street and Hyde Street during construction of the elevated structure. This would impact on the existing residential and freight traffic accessing the port storage areas.

Services

In addition to local service diversions, based on the current design, two high voltage overhead electricity towers near to Hyde Street would need to be relocated.

Expected Geology

The current alignment of the proposed East-West Link between the West Gate Freeway and Maribyrnong River crossing is likely to be similar to the elevated Western Link of the CityLink network. The West Gate Freeway east Williamstown Road is constructed on the fill embankments of the western bridge abutment, and passes onto the concrete deck of the West Gate Bridge at the Melbourne-Werribee railway line. It is anticipated that the freeway intersection ramps will also be constructed on a combination of fill embankments and elevated roadway.

Stony Creek and Stony Creek Back Water are located immediately north of the existing western approach of the West Gate Bridge. There is extensive surface fill present along the southern bank of Stony Creek adjacent to the bridge, and it is anticipated that CIS and alluvial deposits associated with the creek are likely to be present adjacent to the creek and back water to unknown depths. These materials will be susceptible to settlement beneath any fill embankments constructed as part of a freeway interchange. Piled supports for elevated structures will need to penetrate any fill and soft sediments, and be founded in material of suitable strength, which would likely be the near surface basalt of the Newer Volcanics.

The presence of basalt cobble and boulder ‘floaters’ within the basaltic residual clay may cause driven piles to refuse above desired toe depths in unsuitable material. Depending on the depth of the basalt below surface, pad footings on the Newer Volcanics, or bored piles socketed into the Newer Volcanics, are likely to be the preferred foundation treatment for pylons supporting an elevated road structure.

Hydrogeology

There is little published information regarding the hydrogeology within the Quaternary and Tertiary units along the western edge of the Yarra Delta. An Environmental Audit Report prepared for the EPA (GHD, 2006) investigated the hydrogeology of the geological units along the western bank of the Yarra and Maribyrnong Rivers north of the West Gate Bridge. Local experience indicated that near surface hydraulic gradients along much of the western bank of the Maribyrnong River flow west away from the river into subsurface services.

4.8.6 West Gate Freeway to Western Ring Road

The philosophy behind the ultimate arrangement between the Western Freeway and the Western Ring Road is to maintain the existing freeway capacity and connections by widening the West Gate Freeway by two lanes on either side to create four carriageways of 3 lanes. The centre two carriageways of 3 lanes run all the way from the Western Ring Road to West Gate Bridge without interchanges to service through traffic (which is approximately 50% of the traffic on this section).

The outer two carriageways of 3 lanes replicate the existing functionality over this section providing interchange connections at Grieve Parade, Millers Road, Cemetery Road extension, Williamstown Road and onto the Port and Hyde Street via the new East – West Link.

Construction

Construction of the new Collector Distributor (CD) lanes alongside the West Gate Freeway as part of the ultimate arrangement would involve significant new construction including freeway widening, new interchanges and elevated structures. However the engineering challenges and solutions would be no different to those currently being used on the Monash CityLink West Gate Upgrade.

Traffic Management

Traffic management would be a key issue over this section due to high traffic flows throughout the day and night, using this section of the West Gate Freeway to access West Gate Bridge and the limited number of alternative routes. Although a traffic management plan has not been developed at this level of design, it may be possible to construct the new collector distributor lanes first and then use these to carry freeway traffic, during construction of the new interchanges.

Services

Major high voltage overhead services would be relocated, based on the current concept to accommodate the CD lanes on the north side of West Gate Freeway. Other affected major services would also include a large diameter sewer near Hyde Street. An allowance has also been included in the cost estimates for other service diversions at the existing interchanges along this section of the West Gate Freeway.

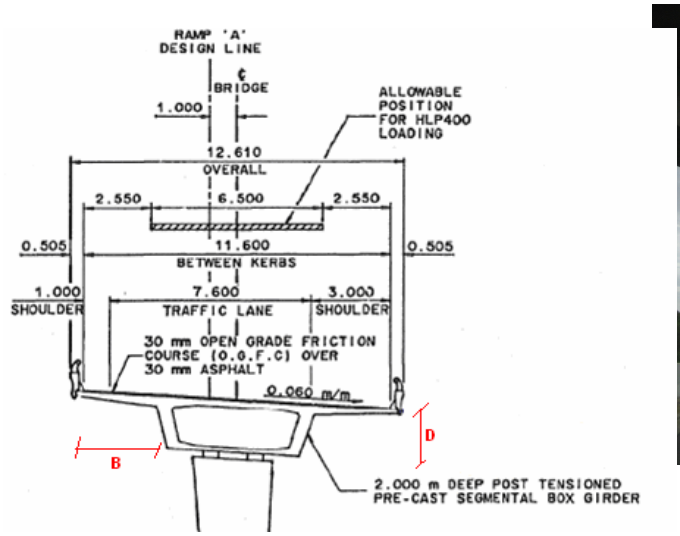
Expected Geology and Hydrogeology

Construction of the new collector distributors would generally be carried out either at existing ground level or on elevated structures. As such geology and hydrogeology would be less significant over this section.

4.8.7 Western Ring Road

As part of this option, there is a requirement to provide additional lanes on the connection between the Western Ring Road and the West Gate Freeway. However, complex issues arise when considering widening of the interchange structures. The existing elevated superstructure which connects West Gate Freeway and the Western Ring Road consists of a 2-metre deep post tensioned pre-cast segmental box girder. The roadway incorporates two 3.8m traffic lanes and adjacent shoulders which are 1m and 3m in width respectively. A cross section diagram of the current arrangement is depicted in the figure below.

Figure 1 Existing structure cross section



The width of the flange overhang is directly related to the depth of the box girder section regarding structural strength. As a result, widening of these flanges to allow additional lanes to be connected to this structure without increasing the depth of the box girder is not possible. To accommodate additional lanes along the off-ramp alignment, an additional elevated structure will need to be constructed adjacent to the existing structure. The additional structure could then be tied to the existing structure to cater for additional lanes at this interchange.

4.9 Road Component Option B

4.9.1 Eastern Freeway to South Kensington

Options A and B are identical between the connection with the Eastern Freeway and the tunnel portal in JJ Holland Park.

4.9.2 South Kensington to Maribyrnong River

Construction

Between the portal in JJ Holland Park and the Maribyrnong River, Option A and B are similar with alternative Port Interchange arrangements previously described under Option A, although only the second interchange alternative is possible with this alignment. The major difference with Option B is that whereas in Option A the alignment crosses above the Maribyrnong, heading towards the Hyde Street connection with the West Gate Freeway, Option B turns west and crosses beneath the Maribyrnong heading towards the connection at Sunshine Road.

To enable the depth of cutting through the Port Interchange area to be minimised, the vertical alignment has been designed based on constructing the tunnel underneath the Maribyrnong in cut and cover. This will require the use of cofferdams, dewatering techniques and staged construction to enable navigation to continue to use the Maribyrnong during the construction period. From the west bank of the Maribyrnong, the tunnel will continue due west towards Sunshine Road as a driven tunnel, in order to avoid impact to the residential properties.

For Option B, the issues would be similar to those previously raised in Option A for traffic management, services, expected geology and hydrogeology.

4.9.3 Maribyrnong River to Sunshine Road

Construction

The twin 2 lane tunnels continue west from the Maribyrnong River, initially as driven tunnels, but start to climb to existing ground level to provide a surface connection to Sunshine and Geelong Roads. The portal location for the road tunnels has been designed to take account of the adjacent rail portals proposed as part of the CBD Rail tunnel component. Although the permanent tunnel portal has been designed on the west side of Geelong Road, during construction, as the tunnel nears existing ground level, the form of construction will change from a bored tunnel to cut and cover construction. This will affect properties, existing services and roads along and to the east of Geelong Road.

Traffic management

Local residential streets as well as Sunshine Road and Geelong Road will be affected by construction of the cut and cover section of the tunnel and the proposed new interchange arrangements to Sunshine Road and Geelong Road.

Services

No exceptional major services have been identified in this section and a typical allowance based on a percentage of the construction cost has been included in the cost estimates.

Expected Geology

The geology at or near invert level along this section is poorly known. The tunnel invert is most probably located in Newer Volcanics Basalt (NVB) but Brighton Group, Newport Formation sediments as well as Older Volcanics could also be present. Werribee Formation may also be present although the probability is relatively low.

Hydrogeology

Maribyrnong River to Albert St

Groundwater levels are unknown but are expected to be approximately 15 m below ground surface.

Due to the uncertainty regarding the geology at invert level and the highly variable nature of the NVB groundwater inflows may vary from low (1L/sec/100m) to very high (>10L/sec/100m). Permeability testing of the full geological profile in rock sections, and at approximate tunnel level in all geotechnical bores should be undertaken.

Groundwater salinity is expected to be approximately 5,000 mg/L and, due to the relatively high depth of the tunnel the risk of encountering contaminated groundwater is considered relatively low. Disposal of groundwater inflows may be an issue due to the lack of an obvious disposal site. However, it might be possible to use the stormwater system for groundwater disposal if it discharges to the Maribyrnong River. Groundwater should be sampled and analysed for salinity to provide some background data for the future assessment of groundwater disposal options.

Albert St to Geelong Rd

This section is expected to be entirely within the NVB with groundwater levels approximately 15 m below ground level. In general groundwater inflows would be expected to be in the order of 1 L/sec per 100m length of cut, but due to the highly variable nature of the Basalt inflows could be as high as 10 L/sec in localised regions of the excavation. Permeability testing of the full geological profile in rock sections, and at approximate tunnel level in all geotechnical bores should be undertaken.

Groundwater salinity is expected to be approximately 5,000 mg/L. Groundwater should be sampled and analysed for salinity to provide some background data for the future assessment of groundwater disposal options. The relatively shallow nature of the tunnel in this section increases the potential for contaminated groundwater to be intersected. Sampling for the presence of industrial contaminants in groundwater should be undertaken from at least one of the geotechnical bores drilled in this section.

4.9.4 Sunshine Road to Western Ring Road

Construction

Construction of a new interchange would be required to connect Sunshine and Geelong Road to the east and westbound tunnels. Due to the existing infrastructure which already exists including the Tottenham Rail yards, West Footscray station, Geelong Road on elevated structure and the limited available space, a

number of alternative interchange arrangements have been developed. The design and construction is further complicated by the vertical separation and crossing ramps which are required to provide all movements connections. At the same time, the main alignment continues to climb west from the portal as an elevated roadway above Sunshine Road. Once it has gained sufficient clearance, it then diverts north west, crossing the rail yard on a 'straddle structure', spanning the rail lines, before continuing due west still on elevated structure, making use of the existing reserve on the northern side of the existing rail lines. Construction of the elevated freeway over the rail lines would involve a number of track possessions to enable overhead construction work to progress. The route then continues west on structure, crossing Ashley Street north of the Tottenham underpass with connections from the freeway to Ashley Street via a closed diamond interchange. West of Ashley Street, the freeway continues to be elevated, initially still on the north side of Sunshine Road and the rail lines before crossing south west and crossing above Sunshine Road, the existing rail line, Market Street and Kororoit Creek on structure. Direct connections are proposed to Market Street. Once over the Creek, the alignment continues west running approximately along the line of the existing drainage reserve and crossing Fairbairn Road, before dropping back to the existing surface level on the approach to the Western Ring Road. New northbound and southbound freeway ramps are proposed to connect to the Western Ring Road giving full freeway to freeway connectivity between the new link and the Western Ring Road.

The elevated Option B roadway between Sunshine Road and the Brooklyn Loop is expected to be similar to CityLink's elevated Western Link, with the road supported on concrete pylons, founded on either spread footings or piles. Access ramps and transitions from at-grade to elevated road are expected to be constructed on filled embankments.

It is anticipated that all footings will be founded in the Newer Volcanics. The choice between spread footings or piles will depend on the depth to and thickness of suitable basalt to found on. Where overturning moments are high, bored piles may well need to be socketed into the basalt. Driven piles may encounter rock cobbles (floaters) in the residual clay sequence, or highly resistant layers in otherwise weathered rock which may impede pile penetration (Peck et al, 1992), which may not provide a suitable founding solution. Design and costing will dictate the type of piles adopted. The presence of soft or reactive surface soils may affect the design of embankments, and should be investigated during the detailed design.

Traffic management

Aside from normal traffic management in constructing the new interchange to Sunshine Road and the connection to Market Road and Deer Park bypass, the most significant traffic management issue would be disruption to the rail yard during construction of the elevated section.

Services

Aside from the overhead power lines for the rail yard, it is anticipated that there would be numerous underground historical services associated with the rail yard which would need to be located, identified and where necessary diverted.

Expected Geology

The alignment is situated on the Volcanic Plain (Werribee Plains Phase) geomorphic region, and the surface geology consists predominantly of the variably weathered basalt lavas, pyroclastics, and residual clays of the Newer Volcanics (Spencer-Jones in Geological Survey of Victoria, 1967). Surface fill of varying thickness is expected along the alignment, particularly through Tottenham, where much of the rail yard is located on an embankment, and on the eastern bank of Kororoit Creek, where geological maps (Geological Survey of Victoria, 1972, 1974) indicate rock quarries have existed in the past. Alluvial deposits are expected to be present at the crossings of Stony Creek and Kororoit Creek.

The Newer Volcanics abut the sediments of the Yarra Delta at the Maribyrnong River, and gradually thicken to the south and west. Cross sections in Geological Survey of Victoria (1967) suggest the Newer Volcanics are about 20 metres thick between Footscray and Stony Creek. The Newer Volcanics overly the Brighton Group, Fyansford Formation, Older Volcanics, Werribee Group, and the Melbourne Formation.

4.10 Road Component Option C

4.10.1 Nicholson Street to Royal Park

The main construction issues arising from the widening of Princes Street to Royal Park will be the traffic management and service diversions. As the widening is all at existing ground level, geotechnical and groundwater considerations will be of relatively minor significance.

4.10.2 Royal Park to Smithfield Road

Construction

The concept design includes widening of Racecourse Road from Elliott Avenue west under CityLink to Pridham Street. This is to allow for improved at-grade junctions with Flemington Road and CityLink access. It also provides room within the centre of Racecourse Road for the new tunnel portals to be located, with the surface road diverted to the north and south around these portals. The section from the tunnel portal in Racecourse Road just west of CityLink and Smithfield Road consists of twin 2 lane driven tunnels which are most likely to be constructed using a tunnel boring machine. A number of underground services will be encountered within this section and may need to be diverted. Consideration must be given to the impact of any construction activities on the existing underground services.

The abutment for the CityLink elevated structures is located near the alignment. The abutment will be supported on piles.

Issues to be addressed during construction may include:

- Handling and disposal of Coode Island Silt (considered to be a low level contaminated soil, and potentially an acid sulphate soil)
- Dewatering of Yarra Delta Sediments.
- Potential dewatering of Werribee Formation

An alternative arrangement for the tunnel was also investigated which would extend the tunnel east to exit in a portal in Royal Park, thereby reducing the impact to the existing surface roads around Flemington and Racecourse Roads and avoiding disruption to the existing tram lines.

4.11 Truck Action Plan

4.11.1 Ashley Paramount

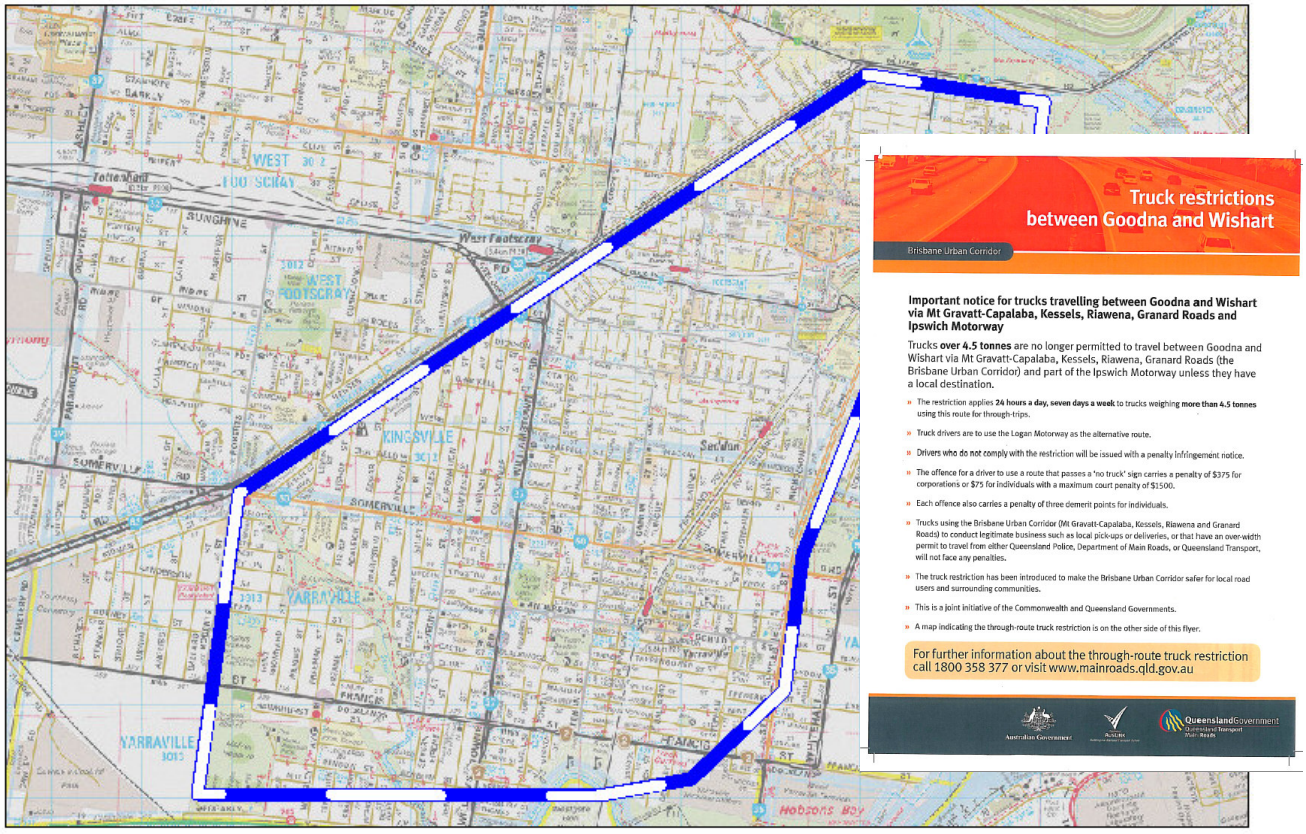
A new link north south link is proposed, providing alternative freight connections around Footscray and Yarraville. This would generally follow the line of the existing Ashley / Paramount Road connection but the existing road would be upgraded to provide a new 4 lane divided arterial road with upgrades to the existing intersections to provide fully signalized intersections, widening of the existing rail underpass at Tottenham and construction of a new 4 lane road bridge over the existing St. Albans rail line This new road would bisect the current local east west truck movement which would then be directed either north to Ballarat Road and then to the new port interchange, or south to the West Gate Freeway, from where it could either access the port via the elevated freeway connection in Option A or via the Hyde Street connection in Option B. This would remove freight movements within the residential area.

In Option C, a four lane arterial road at grade would be provided between the Ashley Street/Barkly Street intersection and Geelong Road at the Cemetery Road intersection. This road would be provided via a combination of a new alignment and duplication of part of Paramount Road. The road would pass under the rail lines at Tottenham requiring widening of the existing underpass and provide signalised at-grade intersections at Sunshine Avenue, Somerville Road and Geelong Road.

South of Geelong Road, a four lane arterial road would link Geelong Road to a new, westerly oriented half diamond interchange on the West Gate Freeway. This road would follow the alignment of an extension of Cemetery Road. This road would include a grade separation of the rail line at Francis Street.

4.11.2 Truck Bans

In addition to the infrastructure works, described above to provide a new link along Ashley Street / Paramount Road, the area in inner Footscray / Yarraville would also have a truck ban imposed to the local area as shown on the plan below.



Similar truck restrictions have been imposed in other major cities eg Brisbane and have been advertised as per the notice shown. Similar consultation and advertising would be required before implementation of such a scheme. To help enforce the truck ban, ITS systems would be required with number plate recognition technology.

4.11.3 Connection Dynon Road to Smithfield Road

In Phase 2, this movement / demand was catered for by the Moore Street widening. An alternative is an elevated four lane divided arterial, crossing over the Maribyrnong River, providing direct connection between Dynon Road near the junction with Sims Street and Smithfield Road with signalized intersections at both ends. This connection would be on structure throughout its 630m length due to the clearances required over the river and railway line it crosses. This road is on a new alignment so a new road reserve would be required.

4.11.4 Widening Ballarat Road

Ballarat Road would be widened to provide three lanes in each direction between Geelong Road and Ashley Street. The current planning scheme for this section of Ballarat Road includes a 6m wide overlay for road widening. This 6m width would be used for additional road pavement to provide the additional through lane. The location of the road widening overlay varies from one side of the road to the other throughout this section and the widening proposed follows this overlay. Realignment of the tram tracks between Droop Street and Gordon Street would be required. Property acquisition would be required as per the current planning scheme.

4.11.5 Hyde Street Connection

In Options A and B new connections would be provided between the westerly oriented ramps of the West Gate Freeway Williamstown Road interchange and Hyde Street south of the Francis Street intersection. The connections would be two lane ramps and provide direct access to Hyde Street for traffic travelling to and from the west of the West Gate Freeway. The ramps would merge with the existing westerly oriented ramps, pass over Williamstown Road, the existing easterly oriented ramps and the railway line before dropping to existing surface level. The ramp carrying westbound traffic from Hyde Street would pass over the West Gate Bridge. A signalised at-grade intersection would be provided at Hyde Street north of Stony Creek. Widening of Hyde Street would be required over approximately 200m in the vicinity of the intersection to accommodate turning lanes.

In option C, new connections would be provided between the westerly oriented ramps of the West Gate Freeway / Williamstown Road interchange and Hyde Street south of the Francis Street intersection. The connections would be two lane ramps and provide direct access to Hyde Street for traffic traveling to and from the west of the West Gate Freeway. The ramps would merge with the existing westerly oriented ramps, pass over Williamstown Road, the existing easterly oriented ramps and the railway line before dropping to existing surface level. The ramp carrying westbound traffic from Hyde Street would pass over the West Gate Bridge. A signalised at-grade intersection would be provided at Hyde Street north of Stony Creek. Widening of Hyde Street would be required over approximately 200m in the vicinity of the intersection to accommodate turning lanes.

4.12 Tabulated Summary of Road Engineering Options

Southern East West Link Road (Option A Road Component)

Section	Length Km	Elevated/ at grade/ in cutting / in tunnel
Eastern Freeway to Royal Park	4.5	In tunnel
Royal Park to City Link	1.5	In tunnel
Royal Park to JJ Holland Park	2.1	In tunnel
JJ Holland Park to Dynon Road	0.5	In cutting
Dynon Road to Maribyrnong River	1.3	In cutting / Elevated
Maribyrnong River to Hyde Street	2.3	Elevated
Hyde Street and WGF connections	2.6	Elevated / At grade
WGF – new link to WRR	3.8	At grade
Total	**18.6***	* this length includes some connections to existing

Northern East West Link Road (Option B Road Component)

Section	Length Km	Elevated/ at grade/ in cutting / in tunnel
Eastern Freeway to Royal Park	4.5	In tunnel
Royal Park to City Link	1.5	In tunnel
Royal Park to JJ Holland Park	2.1	In tunnel
JJ Holland Park to Dynon Road	0.5	In cutting
Dynon Road to Maribyrnong River	1.3	In cutting
Maribyrnong River to Sunshine Road	2.0	In tunnel
Sunshine Road to Tottenham Rail Yards (west)	2.8	Elevated
Tottenham Rail Yards to Kororoit Creek	1.5	Elevated
Kororoit Creek to WRR	2.1	At grade
Total	**18.3***	* this length includes some connections to existing

Upgraded Road Network (Option C Road Component)

Section	Length Km	Elevated/ at grade/ in cutting / in tunnel
Princes Street widening (Nicholson Street to Lygon Street)	0.7	At grade
Cemetery Road widening (Lygon Street to Royal Parade)	1.1	At grade
Macarthur Road widening (Royal Parade to Royal Park)	0.8	At grade
Racecourse Road widening (Royal Park to CityLink)	0.8	At grade
Tunnel under Kensington (CityLink to Smithfield Road)	1.5	Tunnel
Ballarat Road Widening	3.4	At grade
Total	**8.3**	

Truck Action Plan

Section	Length Km	Elevated/ at grade/ in cutting / in tunnel
Paramount / Ashley Street 4 lane construction	1.9	At grade
Cemetery Road to WGF	1.2	At grade
Hyde Street connections	2.6	At grade
Smithfield Road to Dynon Road	0.6	At grade
Total	**6.3**	

5 CBD Rail Tunnel (Options A, B, C and D)

A CBD Rail Tunnel route has been selected to be used as the basis for pre-feasibility engineering and costing development. This is not intended to be the final alignment but to be used as a starting point for feasibility, development and evaluation.

The purpose of this development work has been:

- To identify new underground station opportunities;
- To determine the constructability issues associated with a new tunnel and stations through the CBD;
- To examine the constraints affecting the tunnel alignment and station identification; and
- To gain a better understanding of the impacts from proposed tunnelling methodologies on the tunnel route and configuration.

5.1 Horizontal Alignment

The horizontal alignment selected for the CBD Rail Tunnel includes a proposed 19km route contained below existing rail and road reserves to minimise potential land acquisition and planning issues.

The key objectives identified in assessing the tunnel alignment shown include:

- A new connection to the Northern Group of operating Lines and in particular the Sydenham Lines,
- A new north south rail corridor through the CBD to relieve pressure on the Swanston Street and St Kilda Road Tram services and CityLoop Train services,
- Opportunities to provide new connectivity to destinations in the CBD,
- Opportunities to integrate more public transport services through the CBD,
- A new connection to the Caulfield Group of operating Lines and in particular the Dandenong Lines.

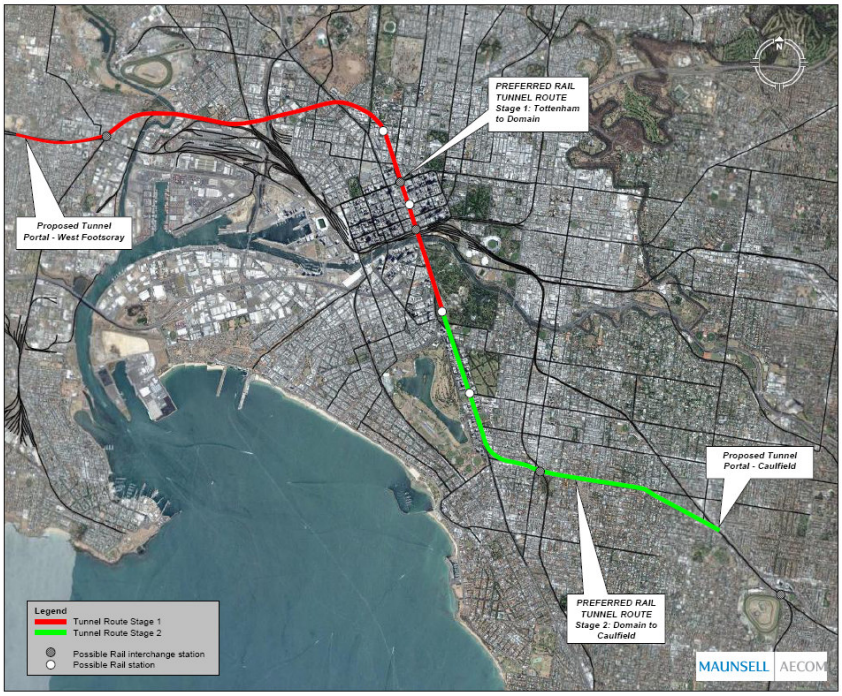


Figure 5.1: CBD Rail Tunnel – Selected Route

The proposed tunnel alignment includes the following features:

- Western portal connecting to the Watergardens Lines Down side of West Footscray Station,
- Follows the existing rail corridor between Tottenham and South Kensington,
- Diverts north east under North Melbourne from South Kensington towards Carlton,
- A large radius curve under Carlton to align with Swanston Street,
- Runs north south through the CBD under Swanston Street,
- Runs north south under St Kilda Road and to the west of the Shrine,
- Turns under the St Kilda Junction from St Kilda Road towards Dandenong Road,
- Follows the Dandenong Road reserve from St Kilda Junction to Glenferrie Road,
- Passes below the Dandenong Road underpass and realigns with the rail corridor between Malvern and Caulfield,
- Eastern portal connecting to the Dandenong Lines up side of Caulfield Station.

Horizontal Constraints

Features along the preferred route that may affect or impact on the horizontal alignment of the East West Rail Tunnel have been identified as follows:

- Future track requirements on the Sunshine Corridor between Tottenham and North Melbourne,
- Future passenger track requirements through Footscray Station,
- Future freight track requirements through Footscray,
- Future Footscray Station layout,
- Existing layout within North Dynon Terminal,

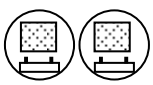
- Existing properties in Carlton and North Melbourne above the proposed tunnel alignment,
- Existing basement car park at University Square near Melbourne University,
- Existing road reserve width along Swanston Street,
- Tram Lines along Swanston Street,
- Existing and former buildings and foundations along Swanston Street,
- Existing and former buildings and foundations on or adjacent to City Square site,
- Existing and former buildings and foundations between Flinders Street Station and Federation Square,
- Princes Street Bridge and Foundations
- Existing and or proposed future road reserve modifications along St Kilda Road including Domain Interchange,
- Existing and proposed future Tram Lines along St Kilda Road,
- The Shrine of Remembrance and surrounding park and gardens,
- St Kilda Junction alignment,
- Queens Road / Dandenong Road Underpass,
- Existing road reserve width along Dandenong Road,
- Tram Lines along Dandenong Road,
- Dandenong Road and Rail Underpass at Malvern,
- Location of services along, adjacent to or crossing the rail tunnel,
- Heritage Overlays along the route including Swanston Street; St Kilda Road and Dandenong Road,
- Future track requirements through Caulfield Station,
- Future Caulfield Station layout

Likewise, many of the features identified above may be impacted on or affected by the tunnel alignment. These effects and impacts should be considered and assessed in further development of the CBD Rail Tunnel.

5.1.1 Track and Tunnel Configurations

Development of alignment options for the CBD Rail Tunnel will consider two main tunnel configurations:

Single Tracks in Dual Tunnels



Twin Tracks in a Single Tunnel

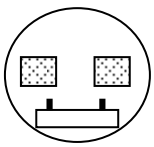


Table 5.1 Single Track Tunnel Configurations

Tunnel Design Option	*Advantages*	*Disadvantages*

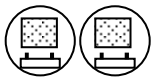
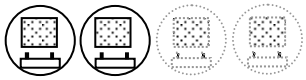
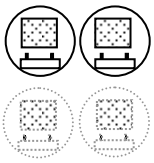
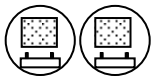
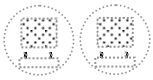
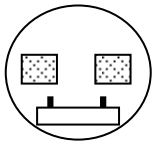
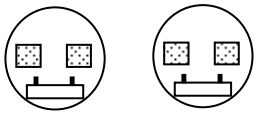
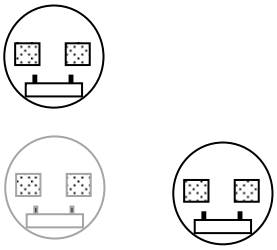
Dual Tunnels
 
Expansion Options:
- side by side
 
- vertically separated
 
- alternative route
 
 
	▪ Typical diameters 5.5m(metro) to 7m(suburban heavy rail)
	▪ Expect to have wide choice of TBM both new and reconditioned –
	▪ Open face
	  ▪ Shielded open face
	  ▪ Mixed face
	  ▪ Closed face – slurry or EPBM
	▪ Considered best option for fire, life safety, smoke control etc with the availability for cross tunnel links providing escape through an adjacent tunnel
	  ▪ Maximum flexibility in developing alignments especially where superelevation of tracks is required
	▪ Spread construction and program risk over more than one tunnel drive
	▪ 2x7m drives generate less spoil than a single 11m drive required for a double track tunnel
	▪ Allows full flexibility in choice of track support:
	  ▪ Ballasted
	  ▪ Fixed track slab
	  ▪ Floating track slab
	▪ Allows either island or side platform configurations for stations
	▪ Where more than one track pairing is required for capacity, then opportunity to consider alternative routing
	▪ Able to stage development from two to four tracks as demand requires
		▪ Two separate mechanical and engineering system installations required for the two tunnels
		▪ Wider footprint required in the corridor where tunnels are placed side by side.
		▪ Requires separate structures for track crossovers (impact on construction program)
		▪ Separate cross-passages required (impact on construction program)

Table 5.2 Twin Track Tunnel Configurations

Tunnel Design Option	*Advantages*	*Disadvantages*
Single Tunnel  Expansion Options: - side by side  - vertically separated and or offset 	▪ Tunnel bore size nominally around 11m ▪ Minimum footprint in corridor for areas where tight clearances may apply ▪ Track crossovers can be incorporated with no extra excavation ▪ Emergency escape provisions and smoke control can be facilitated by installing central dividing wall ▪ Generally restricted to side platform configuration for the stations ▪ Where more than one track pairing is required for capacity, then opportunity to consider alternative routing ▪ Able to stage development from two to four tracks as demand requires	▪ Circular section is not efficient for double track – width required leads to dead space below the track formation ▪ If no dividing wall – less than ideal solution for fire, life safety smoke control etc ▪ More spoil generated compared with 2 single track tunnels ▪ TBM machines would more likely need to be purpose built – possible construction program impact ▪ Fixed track slab or floating track slab would require additional track support structures (due to the extra space below track level.

5.2 Vertical Alignment

Potential alignments for deep and shallow tunnel solutions have been investigated to provide a starting point for the identification of constructability issues.

The key features that have been considered in developing the longitudinal sections include:

- The proposed grade line of the new rail alignment and the relative tunnel invert.
- New Underground Station Opportunities identified.
- Location of key cross tunnel interfaces.
- Identification of key vertical constraints.
- Identification of key geotechnical constraints.
- Identification of existing major features (CityLink, Yarra River, City Loop and Stations, Princes Bridge, etc).

5.2.1 Deep Tunnel Solution

The driver for the deep tunnel alignment is the aim to construct as much of the tunnel in the Silurian Aged Melbourne Formation as possible. This aim becomes feasible when aligning the tunnel to avoid key vertical constraints along the preferred tunnel route.

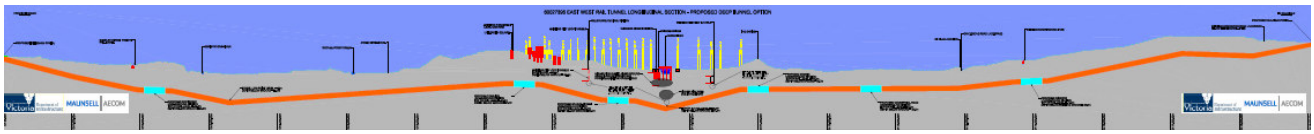


Figure 6: Vertical Alignment – Deep Tunnel Option

The tunnel is proposed to pass deep beneath the CBD to avoid the mixed ground conditions and the aquifer area below the Princes Bridge. The significance of these features is important because attempts to avoid tunnelling through the area will result in a maximum tunnel depth of 63m below the Princes Bridge.

5.2.2 Vertical Constraints

Key vertical constraints identified along the tunnel route include the need to pass under the:

- Bunbury Street Tunnel west of Footscray Station,
- Maribyrnong River,
- Moonee Ponds Creek,
- City Link Bridge Structure,
- City Loop Lines and Melbourne Central Station,
- High risk area due to aquifers below Yarra River,
- St Kilda Junction, and
- Dandenong Road Underpass.

The deep tunnel option provides a consistent solution to all of these vertical constraints. In each case the deep tunnel option will eliminate the vertical constraints by passing below them with a clearance safety factor.

5.2.3 Shallow Tunnel Solution

The aim of the shallow tunnel option is to provide a tunnel solution that minimises the depth of stations and provides opportunities for less expensive construction methodologies. In turn this solution would be expected to result in a lower cost and potentially more attractive option.

The proposed shallow tunnel solution has been produced to test the potential alignment of a shallow tunnel and assess the land use opportunities and possible construction issues that may arise as shown below.

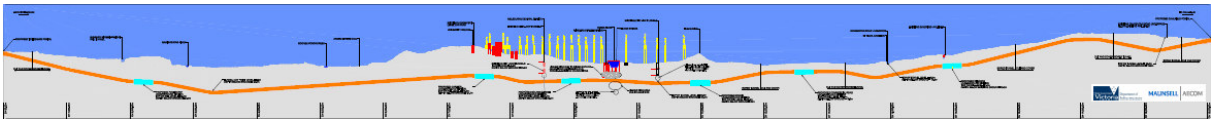


Figure 7: Vertical Alignment – Shallow Tunnel Section

5.2.4 Vertical Constraints for a Shallow Tunnel

Key vertical constraints identified along the tunnel route for the shallow tunnel include the need to pass under the:

- Bunbury Street Tunnel west of Footscray Station,
- Maribyrnong River,
- Moonee Ponds Creek,
- City Loop Lines and Melbourne Central Station,
- High risk area due to aquifers below Yarra River,
- St Kilda Junction,
- Sandringham Lines, and
- Dandenong Road Underpass.

5.3 Station Opportunities

5.3.1 New Underground Station Opportunities

High level station planning and concept design has been carried out for new underground stations along the CBD Rail Tunnel route. Potential new opportunities to locate underground stations along the route have been identified and the following key issues have been considered:

- Access arrangements for pedestrians
- Integration with existing public transport infrastructure
- Interface management
- Vertical circulation
- Pedestrian movements
- Identification of key planning and infrastructure constraints
- Constructability and construction staging
- Review of Cost Estimates

New underground station opportunities have been identified along the CBD Rail Tunnel route with respect to a new location within the CBD and new locations outside the CBD:

5.3.2 Underground Station Construction

Construction techniques for the stations may vary and will need to be considered on a site specific basis. Possible techniques for station cavity construction will include top down construction / cut and cover and mined excavation from the TBM drive, or a combination of the two.

Planning and design of a new underground station will need to take into account the potential construction methodology from an early stage of development.

Issues to be considered in determining the construction methodology for underground stations are highlighted below including design parameters, benefits and disadvantages of each particular methodology.

5.3.3 Station Issues within CBD area

The main constraint restricting opportunities for new underground stations within the CBD is the lack of available space. Already much of the CBD has been redeveloped and for the few vacant blocks remaining, reconstruction work has begun or planning for new development is well under way. Opportunities for open cut construction such as for the original Museum City Loop Station do not currently exist.

Without available vacant land, new underground stations can be accommodated in the following scenarios:

1) Under existing rail reserves,
2) Through acquisition of existing property for large scale redevelopment,
3) Under existing buildings,
4) Under existing road reserves

In any event, construction of the CBD Rail Tunnel under Swanston Street will be constrained by the inner city environment however it is probable the benefits of a new north south link relieving public transport pressure will outweigh the short term impacts during construction.

5.3.4 Existing Interchange Stations and Accessibility Upgrades

The interchange between services running on a new CBD Rail Tunnel and CityLoop services may be more important for passengers departing the CBD. The majority of passengers on the Watergardens and Werribee Lines will have the opportunity to interchange at Footscray Station and select either a CityLoop, Flinders Street Station direct or new CBD Rail Tunnel route. Likewise, passengers on the Dandenong and Frankston Lines will have the opportunity to select routes to the CBD at Caulfield Station.

Whilst the function of these stations will not change, it will enhance the roles of Caulfield and Footscray Train Stations to become even more major transport nodes in the metropolitan train network. Upgrades of these stations beyond the introduction of new surface and underground platforms may need to be considered to help improve the access and flow of pedestrians within the station.

As one of the main objectives for the CBD Rail Tunnel route is to relieve existing tram pressure on the north south corridor, it could be argued that a new CBD underground station does not have to be directly linked to an existing CityLoop station. This would allow a new station to be developed with new infrastructure sufficient to provide for future forecast capacity and to activate a new transit area in the CBD. This may also provide some relief to the existing CityLoop services and stations where current station capacities are rapidly being approached during peak periods.

Passengers entering the train system from a new central CBD station with a destination in the outer metropolitan area will still have the opportunity to interchange at either Caulfield or Footscray Station.

Passengers accessing other metropolitan train lines will still be able to do so from existing CityLoop stations.

5.3.5 Station Opportunities outside the CBD Area

The majority of the CBD Rail Tunnel route passes below existing road reserves to avoid existing properties, planning and land acquisition issues. Thus with the exception of alignment deviations through parks and public open spaces, the constraints of the built up environment can also shape the selection of new underground station locations outside of the CBD.

5.4 Geotechnical Assessment

There are no serious impediments to tunnelling within the study area. The tunnel alignment that is likely to present the most favourable tunnelling conditions through the CBD is a deep tunnel aligned beneath St. Kilda Road, Swanston St and passing up to University Square, and vertically aligned such that the tunnel is formed completely within the rock of the Melbourne Formation.

Tunnelling within the rock of the Melbourne Formation is likely to present less difficult challenges in tunnel construction than tunnelling at a shallower depth through the mixed ground of the Basalt and Yarra Delta sediments.

Tunnelling within existing road envelopes avoids the conflict with the foundations and basements associated with existing structures. The number of tunnels, tunnel configuration and diameter will all impact on the tunnel footprint and therefore the potential to interact with the sub-surface structures that exist outside of the road envelope. This will need close consideration once the preferred tunnel alignments are identified.

The factors that will influence the minimum tunnel depth along this alignment will be the depth of the Yarra Delta sediments, the existing Melbourne Rail Loop Tunnels, the CityLink Tunnels and the existing foundations and sub-surface structures. It is expected that to pass beneath the Yarra River, and stay within the Melbourne Formation, the tunnel will have to be in the order of -42mAHD deep. At the intersection of Grant Street and St Kilda Road a tunnel depth of approximately -20mAHD is likely required to pass beneath the CityLink Tunnels and at Lonsdale Street a depth of approximately -15mAHD is likely required to pass beneath the existing rail loop tunnels. These tunnel levels will achieve a minimum clearance of one tunnel

diameter below the stated existing sub-surface structures. Depths will need to be confirmed once an alignment has been confirmed.

At the northern extent of the city various surface structures overlie the proposed tunnel alignment. Within this area it is likely that the Melbourne Formation is present at shallow depth and therefore the structural foundations should also be relatively shallow. In meeting both the minimum depths stated above and the requirements for maximum track grade the tunnel should be of sufficient depth not to pose a high risk to the surface structures.

The main disadvantage of a deep tunnel will be the increased costs associated with the construction of stations at a greater depth (e.g. -42m at Flinders Street Station), the higher running costs associated with trains operating on tracks at the limiting vertical geometry and stations at the low points, and longer passenger access travel distances.

Alternatively a shallow tunnel alignment may be feasible, however, there are several additional significant risks to be considered. These include:

- A higher potential to lower the ground water table which may induce increased regional settlement of the Coode Island Silt and cause damage to existing infrastructure.
- High potential to intersect significant groundwater aquifers beneath the Yarra River which will result in challenging tunnelling conditions and potential groundwater drawdown and surface settlement.
- Mixed ground conditions may impede tunnel progression and increase tunnelling equipment costs.
- Higher risk of undermining / intersecting / interacting with existing foundations, services and subsurface structures.

The main advantage of the shallower tunnelling option is the reduced cost associated with the construction of the stations at shallower depth. However, this saving may be offset by the increased tunnelling costs associated with the above risks. The assessment of the feasibility of either vertical tunnel alignment is subject to obtaining further information on ground conditions and existing structures.

5.5 Construction

Probably the biggest issue that needs to be resolved as part of the tunnel construction is the access points for construction and the disposal for spoil. The locations for the extraction of spoil and the insertion of tunnel segments will be critical in assessing the feasibility of staging options. Considerable quantities of spoil will need to be extracted from the tunnel bore, transferred to a stockpile and transported to a suitable site for landfill, treatment, and or redistribution.

5.6 Staging Considerations

Consideration of the tunnel construction methodology, shaft locations, installation and start points and staging should be undertaken with more detailed planning.

Key issues to be considered when assessing the staging requirements are included in

Table 5.3 Staging Issue Considerations

Key Issues for Staging
What are the benefits of this staging option?
What are the construction timeframes?
How soon can tunnel or partial tunnel operations begin?
When can construction of the tunnels commence?
When can construction of the stations commence?
What supplementary works need to be completed ready for operations to begin?
What turn back arrangements are required to return trains from the end of the line?
How shall the turn back be configured?
What is the line capacity?
What should the turn back capacity be able to handle?
What will be the line speed on approach to the terminus?
What signalling system will be installed to control trains on approach?
What buffer stops will be applied at the end of the track/s?
How many tracks does the station box width, or TBM insertion chamber width (30m) accommodate?

5.7 Tunnel and Station Ventilation Requirements

Identification of the potential issues/design steps need to be investigated as part of the design process for ventilation. Questions that are important to ask at the inception of a new underground railway project re ventilation include;

- Type of underground system - ie first class metro (separating screens between platform and track, automatic train operation, full air conditioning, open platforms, improved passenger safety, requires ATO) or similar to existing underground stations (no separation between passengers and trains, reduced effectiveness of air conditioning, reduced passenger safety)
- Signal headway within tunnel - determines the frequency of intercede ventilation portals.
- Whether the rolling stock uses regenerative or friction braking - determines energy transfer/heat dissipation requirements.
- Changes in grade - how much tractive effort is required to maintain speed, accelerate from stations and how often brakes are applied to maintain speed/stop at platforms - longer/flatter grades are preferable over shorter/steeper grades
- Plant operation within platform areas.

This information would then be used to undertake a ventilation analysis which will determine;

- Appropriate layout/dimensions of fan/plant room
- Ducting sizes
- Surface Intake/Outflow requirements

6 Rapid Transit Route to Doncaster and new terminal at Victoria Park (Options A, B, C and D)

There are a number of engineering considerations and issues relating to the upgrade of Doncaster Area Rapid Transit (DART) services. Initial works that could be undertaken to improve the proposed DART services are the provision of a bus only entry and exit to the freeway from Lulie Street. As part of these works, the provision of a new intermodal terminal at Victoria Park is proposed and bus priority signals at Lulie Street and Johnston Street. Also included are improvements to the northbound bus operations in Hoddle Street, by the provision of bus only lanes.

The traffic reductions associated with the new East West tunnel also provide opportunity to allocate road space on the surface for buses on either Johnston Street or Alexandra Parade. Alexandra Parade provision would involve converting 2 existing traffic lanes to bus only lanes. In order to use Johnston Street, more significant civil work will be required.

The proposed outbound bus-only ramp between the Eastern Freeway and Lulie Street would involve the construction of a new road linking the stopping lane of the Eastern Freeway with the northern end of Lulie Street. The ramp will involve the construction of elevated roadway, earthworks, and traffic management works. The inbound ramp will involve similar features, although the elevated roadway component will be much smaller.

The extension of Truro Street required for the implementation of the new bus lane in Johnston Street, will involve the removal of a portion of railway embankment and the construction of a new rail bridge and construction of a new portion of Truro Street eastwards, connecting to Lulie Street. Associated works include lines and signs.

Significant works will be required on Johnston Street to accommodate the new road configuration. This would mainly involve kerbworks and surfacing, along with ancillary measures such as signage and linemarking. There will also be similar works on Lulie Street and Truro Street.

Further consideration of priority works into the CBD will also be required, dependant on the choice of route and the final location of the CBD rail tunnel.

7 Tarneit Rail Line (Options A, B, C and D)

Recent developments in this investigation have identified construction of the proposed Tarneit Line in Melbourne's west as a project that could provide some early relief to the network's current capacity constraints. The Tarneit Line is a new double track railway proposed to be constructed between West Werribee on the Geelong Line and Deer Park on the Melton Lines. The Tarneit Line would consist of non-electrified lines servicing Regional Passenger Services.

Construction of a 3rd and 4th broad gauge track on the Watergardens Lines between Sunshine and West Footscray, would also be required as part of the Tarneit Line works. This scheme has already been identified in MOTC. Also required would be optimisation works between Footscray and Southern Cross to maximise the benefits.

The key engineering issues that are associated with construction of the new rail line via Tarneit include bridge structures and level crossings, land and housing acquisition, signalling and connections to existing rail lines.

There are no existing bridge structures that would be affected by the proposed rail alignment. However there would be a number of new bridge structures required along the alignment route and would present cost implications if construction of the proposed alignment was completed at a later date. The following river/creek bridge crossings would be required;

- Lollypop Creek (minor structure);
- Werribee River (major structure);
- Davis Creek at 3 separate locations (minor structure);
- Skeleton Creek (minor structure);
- Dohertys Creek (minor structure).

There are also a number of road crossings that would require either grade separation or level crossings at the following locations;

- Ballan Road;
- Sewells Road;
- Sayers Road;
- Leakes Road;
- Taneit Road;
- Derrimut Road;
- Robinsons Road;
- Middle Road;

- Boundary Road;
- Woods Road.

At this stage, high level construction cost estimates were based on the provision of grade separations at all locations, however it could be argued that the level of traffic on some roads would be low enough to justify new level crossings (if allowable) or road closures.

Land acquisition may be required in the rural area, alongside the proposed rail alignment, if this alignment is implemented.

The signalling aspect would be designed for a design speed of 90km/hr and 5-minute headways. Indicative cost estimates for the signalling have been included in the construction cost for this option.

8 Option Staging

With each of the infrastructure options described above, there is the potential to stage the construction. The general issues that inform staging decisions would be;

- Size and cost of work for the industry. Consultants and contractors would be assessing the ability to physically deliver these options if all components were tendered at once, although similar concerns were expressed when EastLink was being tendered and this scheme is expected to open months ahead of schedule.

- Other infrastructure projects in Australia. There has been a general and sustained boom in infrastructure in Australia and contractors and consultants would only be planning to tender for a limited number of these major national projects at any one time, due to the commitment required to submit a winning tender and the demands of delivering a number of these throughout Australia concurrently.

- Access to specialist equipment and skilled resources. Procurement of specialist construction plant, for example tunnel boring machines require significant lead in times as they are manufactured to order based on the required tunnel diameter and expected ground conditions. They are also operated by experienced skilled staff. Availability of this specialist equipment and resources will be a factor in whether to stage implementation of an option.

- Access to materials. The sheer quantity of materials that would be required for any of these options, be it crushed rock, asphalt or concrete would need to be considered.

- Availability of skilled resources. Aside from specialist skills, mentioned above, there is a national and international shortage of skilled engineers. However, this can be overcome to a degree by focussed recruitment, training and upskilling of staff.

Aside from the general industry wide issues, there are a wide range of project specific issues which need to be taken into consideration related to possible staging. These include;

- The ability to be able to build and operate sections ‘standalone’. For the road components of Options A and B, it is possible that the section from the West Gate Freeway to the Port Interchange in Option A or Sunshine Interchange to the Port Interchange in Option B could be constructed before the remainder of this component. Similarly, the section from Eastern Freeway to CityLink and the Port Interchange could also be constructed in it’s own right. Associated freeway widening of West Gate Freeway, Western Ring Road could also be separately staged.

- For the road component of Option C, the surface road upgrades and the tunnel could be designed, constructed and operated independently.

- In the Public Transport components, the CBD rail tunnel could be constructed in two stages between Footscray and Domain Station and Domain Station to Caulfield, dependant on the transport demand.

- Tarneit could be constructed independent of the other Public Transport components but the CBD Rail Tunnel would need to be complete at least between West Footscray and Domain in order for it to operate effectively.

- For the bus component, the dedicated bus ramps to the Eastern Freeway and the modal interchange could be built independently. Reallocation of the road space in Johnston Street or Alexandra Parade would be best undertaken after completion of the road tunnel.

9 Considerations for further development

In developing these options for consideration as part of the overall East West Needs Study, it must be recognised that the level of detail appropriate at this stage of concept development is only sufficient to ensure that the schemes could be constructed from an engineering perspective and that the costs are sufficiently robust and are built up from elemental rates and quantities.

At the next stage of scheme development, there are a number of areas that have been identified during this Study that would require further investigation as follows:

9.1 Service information.

As mentioned previously, costs for service diversions were developed from desktop identification of the major existing services and allocation of percentage costs, adjusted for the anticipated complexity of existing services beneath existing roads and footpaths.

Trial pits and service trenches would need to be dug during the next stage of design development to accurately locate the position and depth of these existing major services so that the design can be modified wherever possible to avoid them.

9.2 Geotechnical

Although a desktop geotechnical study has been undertaken, to identify the location of existing borehole and geotechnical information, a number of data gaps associated with each of the options were observed in the database that was developed.

It is recommended that the geotechnical site investigation for a project of this size and complexity be undertaken in stages as follows:

- Stage 1 – Geotechnical Desktop Study (this report)
- Stage 2 – Initial Geotechnical Site Investigations (an initial site investigation to gain a better overall understanding of the geology)
- Stage 3 – Preliminary Geotechnical Site Investigations (collect data to form part of Design and Construction Tender Documents)
- Stage 4 – Geotechnical Site Investigations (undertaken by Contractor for detailed design purposes)

The following scope of work is for Stage 2 investigations. The site investigations shall allow a conceptual geotechnical design to be developed. The geotechnical site investigation should be undertaken in accordance with Australian Standard AS1726-1993.

Based on ‘gaps’ in information identified during the geotechnical desktop study, additional boreholes would need to be drilled.

Standpipe piezometers should be installed in all to measure the groundwater levels. Separate piezometers should be installed in the sediments if encountered. Representative soil and rock samples should be collected and sent to a NATA registered laboratory for testing to assist in characterising the strata, and assessing the geotechnical parameters of the strata. Groundwater samples should also be collected and sent to a suitable laboratory for chemical testing to assist in assessing the aggressitivity of the groundwater and potential durability issues. Contamination issues would also need to be considered and contamination investigation may be undertaken in conjunction with geotechnical investigations. Downhole packer tests should be undertaken at regular intervals in the boreholes to assist in assessing the permeability of the geology.

The recommended investigations provided above are only to assist in filling gaps in the database and provide some information to feed into the risk management and cost estimating for the project. It is expected that geotechnical investigations are ongoing throughout the life of the project and including during construction. Further geotechnical investigations will be required to undertake design of the proposed road and rail components.

As part of the risk management, it is recommended that a register of geohazards be maintained throughout the project. The register should identify and assess risks and list mitigation strategies.

9.3 Development of the engineering concept designs

9.3.1 Road Components

The road component has been developed based on current road design standards. Further development may include optimisation of interchanges, horizontal and vertical alignment and interaction between bored tunnel sections and cut and cover sections.

9.3.2 CBD Rail Tunnel

Although the route has been developed based on current rail design standards, there is scope for further optimisation at preliminary design stage, particularly in refining the horizontal and vertical alignment between the new stations. The final decision regarding station location in the CBD can only be made once further detailed work is carried out. Ongoing conflict checks between the proposed CBD rail tunnel and existing underground infrastructure and between the proposed rail and road tunnel would be required.

9.3.3 Road, Rail and Bus Interaction

The design of the CBD Rail tunnel has been undertaken in parallel with the development of the three road alignments. During option development, a combined road and rail tunnel was examined but initial indications were that this was uneconomical since both components were compromised from their optimum design. However, further investigation of the potential synergies between the road, rail and bus components should be part of any ongoing development.

9.4 Feasibility / operational impact of bus terminal

The new bus terminal proposed at Victoria Park Station would affect both the existing local bus services and the existing traffic arrangements. These have been reviewed from both an operational and engineering perspective but these new arrangements have not been modelled in detail and further work would be required at preliminary design stage to develop a revised timetable and route plan for Doncaster buses travelling to the CBD.

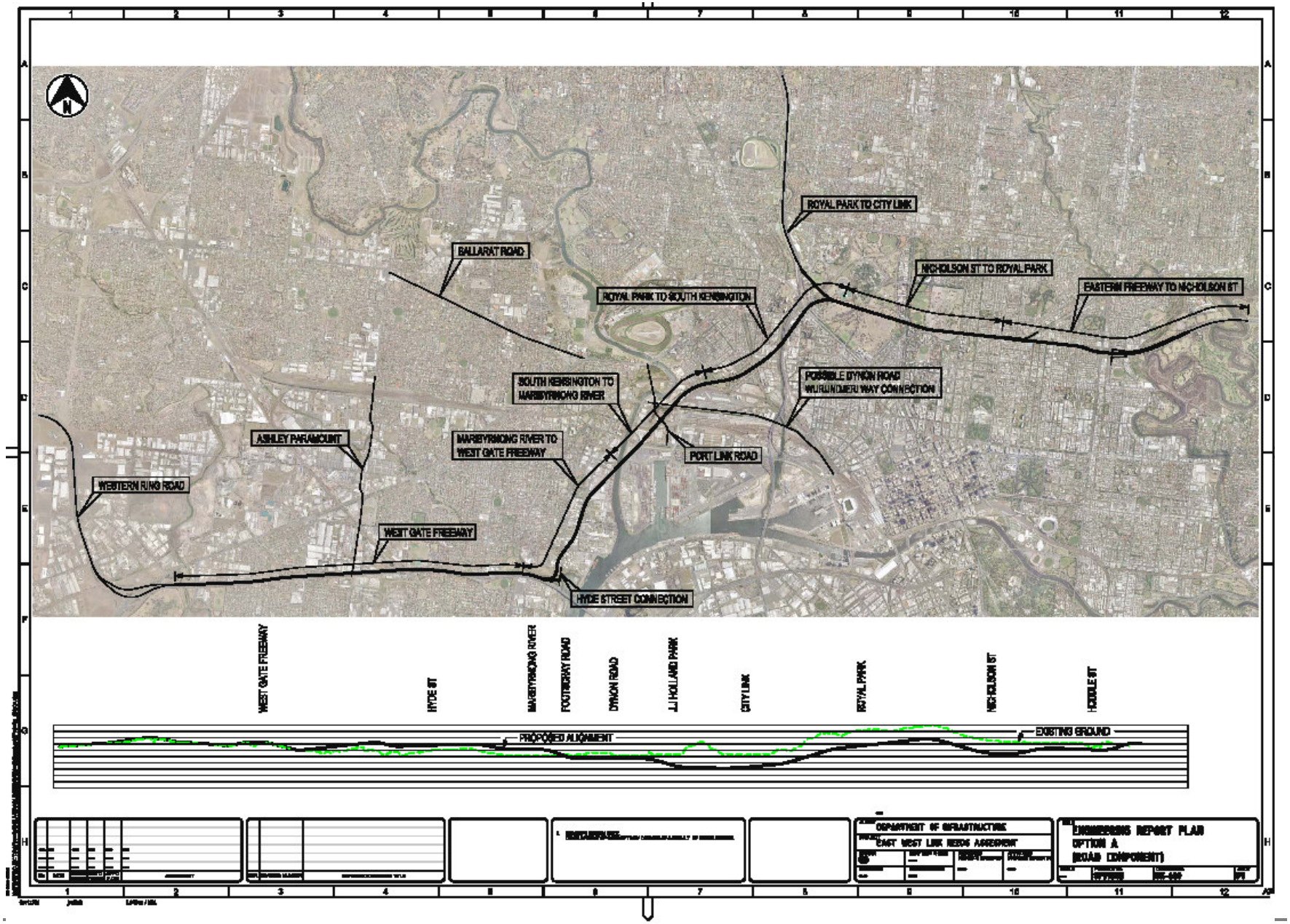
9.5 Tarneit Rail Line

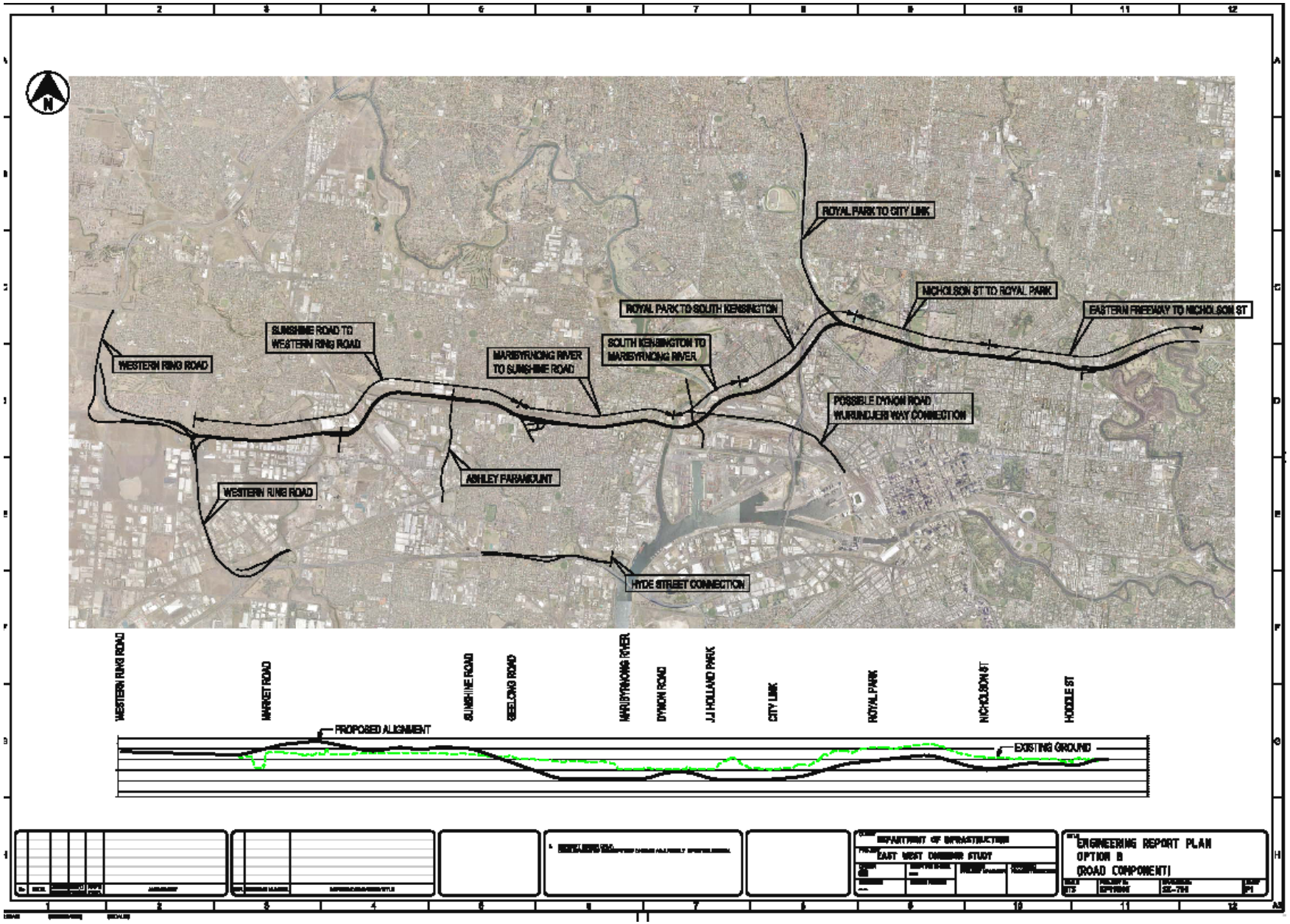
Although the proposed Tarneit Rail Line has been developed to a similar level of detail as the other engineering options contained in this study, more detail will be required at the next stage of design. Some specific issues which will need to be investigated include;

- Coordination of this project with other related rail projects to achieve the planned benefits
- Archaeological values of the corridor
- Potential hydrology / hydrogeology issues
- Grade separation requirements
- Allowance for future land use and road network requirements
- Alignment geometry and land acquisition
- The most effective future operating regime of V / Line and metro services.

APPENDIX A

ENGINEERING PLANS OF ROAD COMPONENTS


ROYAL PARK TO CITY LINK
BALLARAT ROAD
NICHOLSON ST TO ROYAL PARK
EASTERN FREEWAY TO NICHOLSON ST
ROYAL PARK TO SOUTH KENSINGTON
SOUTH KENSINGTON TO MARIBYRNONG RIVER
POSSIBLE DYNON ROAD WURUNDJERI WAY CONNECTION
ASHLEY PARAMOUNT
MARIBYRNONG RIVER TO WEST GATE FREEWAY
PORT LINK ROAD
WESTERN RING ROAD
WEST GATE FREEWAY
HYDE STREET CONNECTION
WEST GATE FREEWAY
HYDE ST
MARIBYRNONG RIVER
FOOTSCRAY ROAD
DYNON ROAD
J.J HOLLAND PARK
CITY LINK
ROYAL PARK
NICHOLSON ST
HODDLE ST
PROPOSED ALIGNMENT
EXISTING GROUND
DEPARTMENT OF INFRASTRUCTURE
EAST WEST LINK NEEDS ASSESSMENT
ENGINEERING REPORT PLAN
OPTION A
ROAD COMPONENT


ROYAL PARK TO CITY LINK
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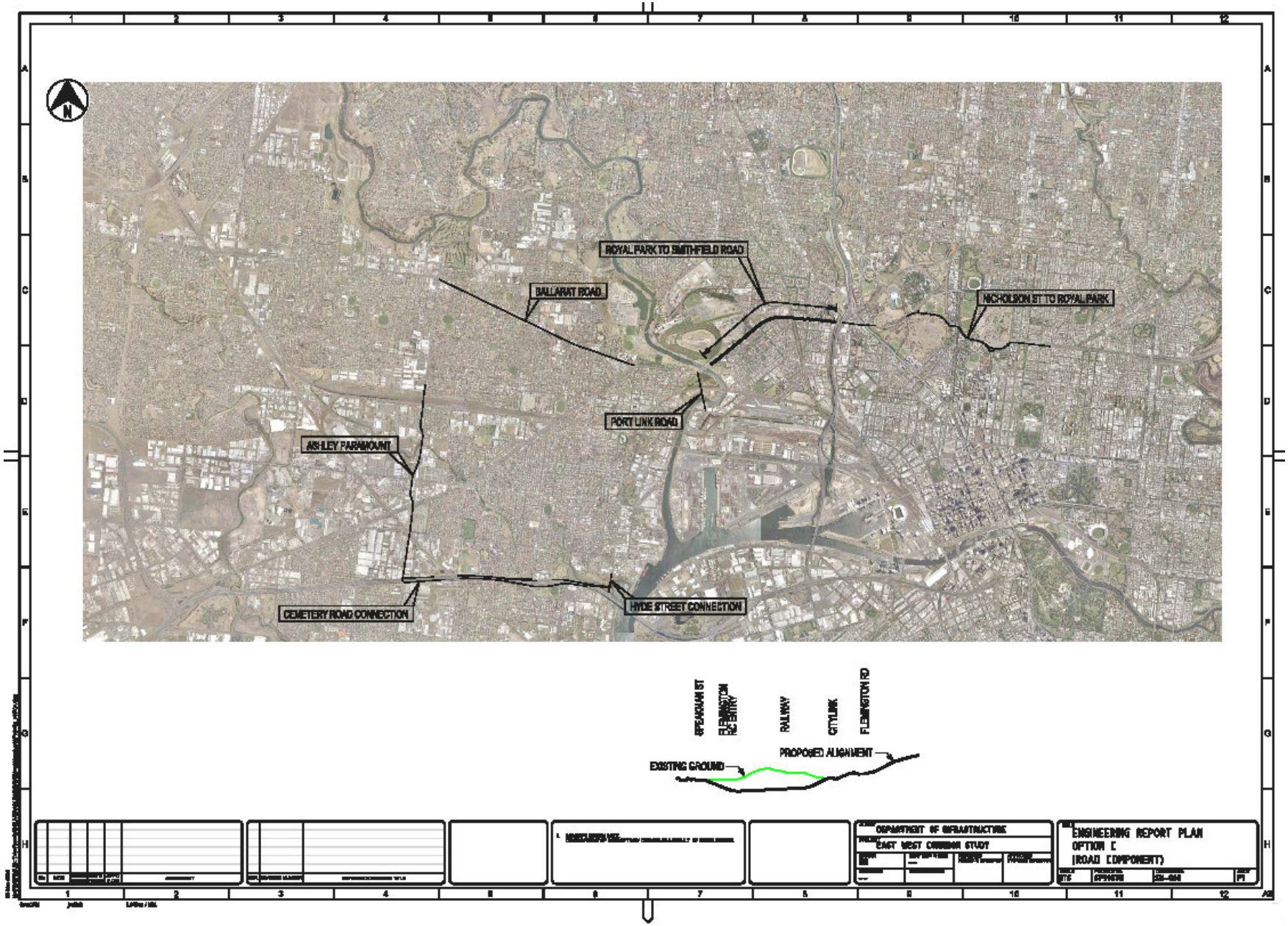
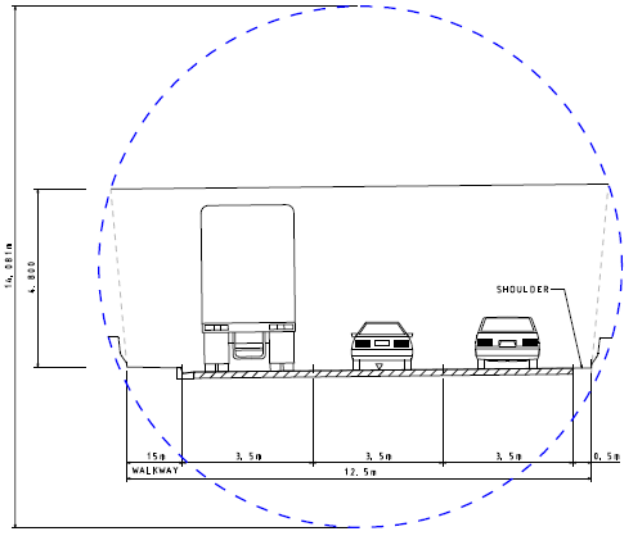
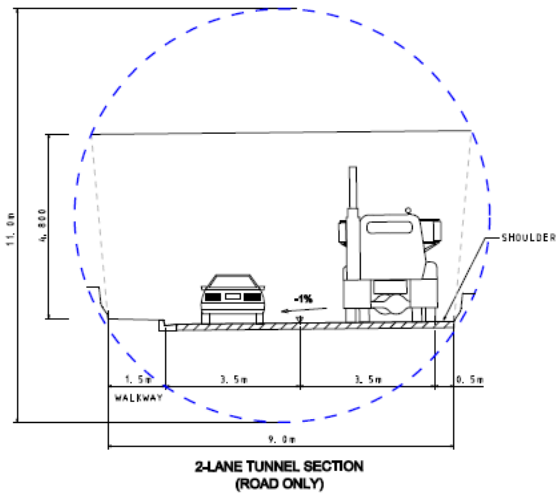
EASTERN FREEWAY TO NICHOLSON ST
ROYAL PARK TO SOUTH KENSINGTON
SUNSHINE ROAD TO WESTERN RING ROAD
SOUTH KENSINGTON TO MARIBYRNONG RIVER
MARIBYRNONG RIVER TO SUNSHINE ROAD
WESTERN RING ROAD
POSSIBLE DYNON ROAD WURUNDJERI WAY CONNECTION
ASHLEY PARAMOUNT
WESTERN RING ROAD
HYDE STREET CONNECTION
WESTERN RING ROAD
MARKET ROAD
SUNSHINE ROAD
GEELONG ROAD
MARIBYRNONG RIVER
DYNON ROAD
J.J HOLLAND PARK
CITY LINK
ROYAL PARK
NICHOLSON ST
HODDLE ST
PROPOSED ALIGNMENT
EXISTING GROUND
DEPARTMENT OF INFRASTRUCTURE
EAST WEST OWNERSHIP STUDY
ENGINEERING REPORT PLAN
OPTION B
(ROAD COMPONENT)

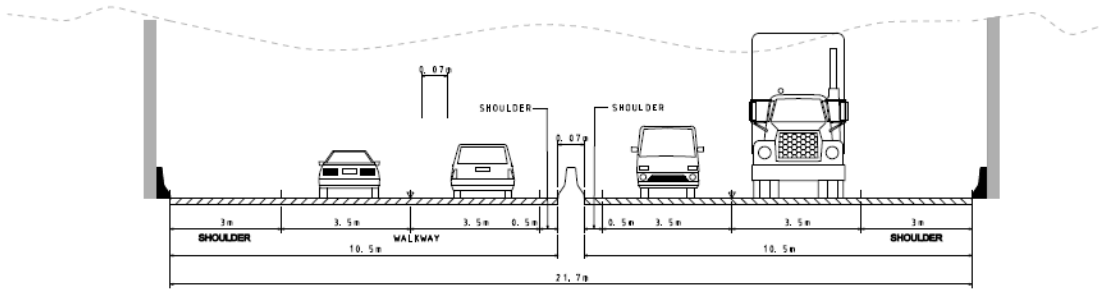

ROYAL PARK TO SMITHFIELD ROAD
BALLARAT ROAD
NICHOLSON ST TO ROYAL PARK
PORT LINK ROAD
ASHLEY PARAMOUNT
CEMETERY ROAD CONNECTION
HYDE STREET CONNECTION
SPENCER ST
FLEMINGTON RD CITYLINK
RAILWAY
PROPOSED ALIGNMENT
EXISTING GROUND
DEPARTMENT OF INFRASTRUCTURE
EAST WEST CORRIDOR STUDY
ENGINEERING REPORT PLAN
OPTION C
(ROAD COMPONENT)

APPENDIX B

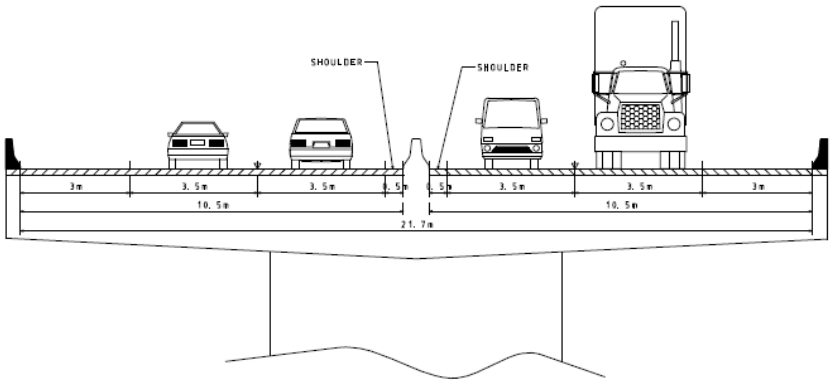
TYPICAL CROSS SECTIONS







2-LANE IN CUT SECTION
(ROAD ONLY)



2-LANE EACH WAY - ROAD OVER STRUCTURE

APPENDIX C

DETAILED COSTING BREAKDOWNS

Option A including Southern East-West Road Link

Section	Construction Cost $M
Eastern Freeway to Port including CityLink	4,800
Port to West Gate Freeway	1,000
West Gate Freeway to Western Ring Road	500
Truck Action Plan	400
Sub Total (Road Component)	*6,700*
CBD Rail: Footscray to Domain	3,600
CBD Rail: Domain to Caulfield	2,300
Tarneit Rail Link	1,100
Bus Rapid Transit to Doncaster	200
Sub Total (Public Transport)	*7,200*
Total	*13,900**

* Contingency to be applied to give range following risk assessment

Option B including Northern East-West Road Link

Section	Construction Cost $M
Eastern Freeway to Port including CityLink	4,800
Port to Sunshine Road	1,700
Sunshine Road to Western Ring Road	1,000
Truck Action Plan	300
Sub Total (Road Component)	*7,800*
CBD Rail: Footscray to Domain	3,600
CBD Rail: Domain to Caulfield	2,300
Tarneit Rail Link	1,100
Bus Rapid Transit to Doncaster	200
Sub Total (Public Transport)	*7,200*
Total	*15,000**

* Contingency to be applied to give range following risk assessment

Option C including Upgraded Road Network

Section	Construction Cost $M
Nicholson Street to Flemington Road	100
Flemington Road to Smithfield Road	1,000
Ballarat Road	100
Truck Action Plan	400
Sub Total (Road Component)	*1,600*
CBD Rail: Footscray to Domain	3,600
CBD Rail: Domain to Caulfield	2,300
Tarneit Rail Link	1,100
Bus Rapid Transit to Doncaster	200
Sub Total (Public Transport)	*7,200*
Total	*8,800**

* Contingency to be applied to give range following risk assessment