

Appendix D

Traffic and Transport Impact Assessment



EA Technical Report

Traffic and Transport Impact Assessment – **Lane Cove Road eastbound on-ramp**

Road and Maritime Services, NSW

16 August 2012

Traffic and Transport Impact Assessment – Lane Cove Road eastbound on-ramp

Prepared for

Roads and Maritime Services, NSW

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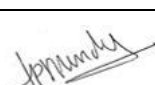
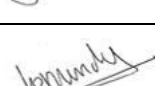
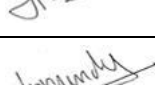
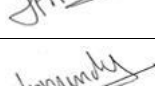
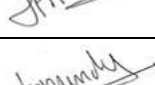
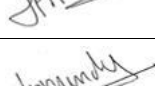
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Glossary of Abbreviations

AWE	Average Weekly Earnings
CBD	Central Business District
CPI	Consumer Price Index
CUBE	Citilabs Strategic Model Software Package
EA	Environmental Assessment
earlier TIA	M2 Upgrade Traffic Impact Assessment
FETC	Fully Electronic Toll Collection
HCM	Highway Capacity Manual (U.S. 2000)
LCT	Lane Cove Tunnel
LCRE	Lane Cove Rd East facing ramp
LoS	Level of Service
PCU	Passenger Car Units
RMS	Road and Marine Services
SCATS	Sydney Coordinated Adaptive Traffic System
SKM	Sinclair Knight Merz
SRG	Sydney's Road Group
SSD	Statistical Sub Division
STA	Sydney Transport Authority
STM	Sydney Traffic Model
BTS	Bureau of Transport Statistics
TFG	Traffic Forecast Group
TUSTM	Transurban Sydney Traffic Model
V/C	Volume to Capacity Ratio
VHT	Vehicle Hours Travelled
VKT	Vehicle Kilometres Travelled
VOT	Value Of Time

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Executive Summary

The M2 Motorway is part of the Sydney Orbital Motorway and is the principal transport link connecting Sydney's north-west to the lower north shore and the North Sydney and Sydney CBDs.

On 21 October 2010 (Approval) the Minister for Planning approved the construction and operation of a third lane on both the eastbound and westbound carriageways of the M2 Motorway for approximately 14.5 kilometres, from Windsor Road, Baulkham Hills to Lane Cove Road and provision of new on/off-ramps. The project also involves the upgrade of Intelligent Transport Systems for the upgraded M2 Motorway. Construction of these works is currently underway and expected to be completed in the first half of 2013.

The project includes:

- Widening and/or provision of a third lane along sections of the eastbound and westbound carriageways between Windsor Road and Lane Cove Road.
- Provision of new on/off ramps at Windsor Road, Christie Road and Herring Road. These ramps will be tolled via Fully Electronic Toll Collection (FETC).
- Widening and/or provision of a third lane eastbound and westbound in the Norfolk Tunnel.
- Restoration of the westbound breakdown lane from Lane Cove Road to Beecroft Road.
- Removal of the Beecroft Road bus on/off ramp.
- Upgrade of the M2 Motorway/Windsor Road, Christie Road/Talavera Road and Herring Road/Talavera Road intersections.
- Upgrades to M2 Motorway Intelligent Transport Systems.

Following agreement of scope for the M2 Upgrade, Transurban submitted an unsolicited proposal to RMS for an additional eastbound on-ramp from Lane Cove Road to the M2 as a modification. Transurban's proposal includes tolling of the on-ramp to cover the capital cost of its construction and ongoing operations and maintenance costs.

The Lane Cove Road eastbound on-ramp would provide a convenient access to the Sydney Orbital for traffic travelling from the north of the M2 to the CBD and other destinations to the east, as an alternative to the arterial road network.

The main benefits identified are:

- A faster trip from Lane Cove Road to Delhi Road and Lane Cove Tunnel by using the ramp and M2 Motorway.
- A reduction in traffic on Lane Cove Road south of the ramp resulting in reduced congestion in this section.

A reduction in traffic on alternative routes including Epping Road, and Pacific Highway As part of the preparation of the M2 Upgrade modification assessment report for the ramp, preliminary environmental risk has identified Traffic and Transport as key risk area that requires detailed assessment. This was the on the basis that the ramp modification would increase traffic volumes on the M2 Motorway between Lane Cove Road and the Lane Cove Tunnel and would have the potential to affect traffic volumes on local roads such as Ryde Road, Yanko Road, and Lady Game Drive as traffic is attracted to Lane Cove Road to access the ramp.

This assessment has been prepared to assess the level of potential impact and builds on the previous Traffic and Transport Assessment completed for the M2 Upgrade Environmental Assessment (EA), please refer to M2 Upgrade Volume 2- Part 1 Environment Assessment- Technical Papers Traffic and Transport Assessment for further details on the M2 Upgrade assessment.

Base environment

Background

Sydney's North West is expected to grow through the establishment of 140,000 new homes and 100,000 new jobs over the next 25 years. The M2 Motorway (M2) provides a motorway standard service between this rapidly growing North West sector, the Hills districts and activity centres in Macquarie, Ryde, Chatswood, North Sydney and the Sydney CBD.

A major upgrade on the M2 is ongoing, which was the subject of an earlier traffic impact assessment. This current report is focussing in on the additional proposal for the Lane Cove Road eastbound on-ramp and hence assumes base conditions as per the post-upgrade analysis of the earlier assessment; the areas of study are shown in Figure 1, whilst Figure 2 windows in on the specific area of interest for assessment of Lane Cove eastbound on-ramp.

So as to clarify nomenclature the following pertains:-

- Existing conditions - refers to conditions that would have materialised without the ongoing M2 Upgrade and is primarily described in the earlier assessment and is not repeated herein;
- **Base Conditions** – refers to forecast conditions that **are post the M2 Upgrade and hence are considered as the base for this assessment of the Lane Cove Road east facing on-ramp**, these were presented as the 'with project' conditions of the earlier assessment and are only summarised herein;
- **Project Conditions** – considers changes to the Base conditions as a direct result of introducing the Lane Cove Road eastbound on-ramp which are the primary focus for this report.

To avoid unnecessary duplication of the description of the Existing and Base conditions, the reader is referred to the previous Traffic and Transport Assessment completed for the M2 Upgrade Environmental Assessment (EA), please refer to M2 Upgrade Volume 2- Part 1 Environment Assessment- Technical Papers Traffic and Transport Assessment for further details on the M2 Upgrade assessment

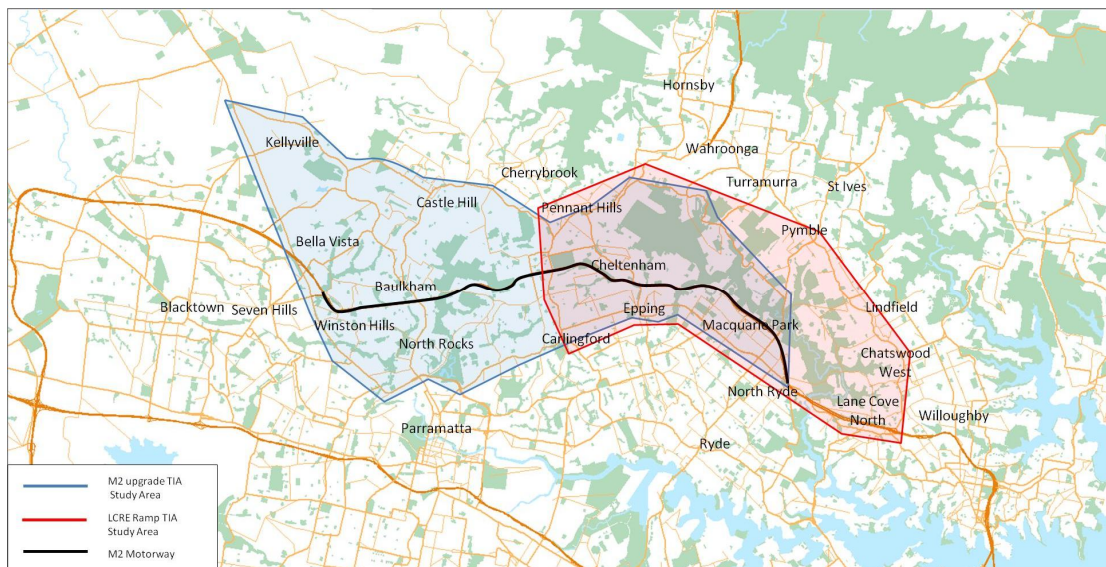


Figure 1 – Wider Study Areas

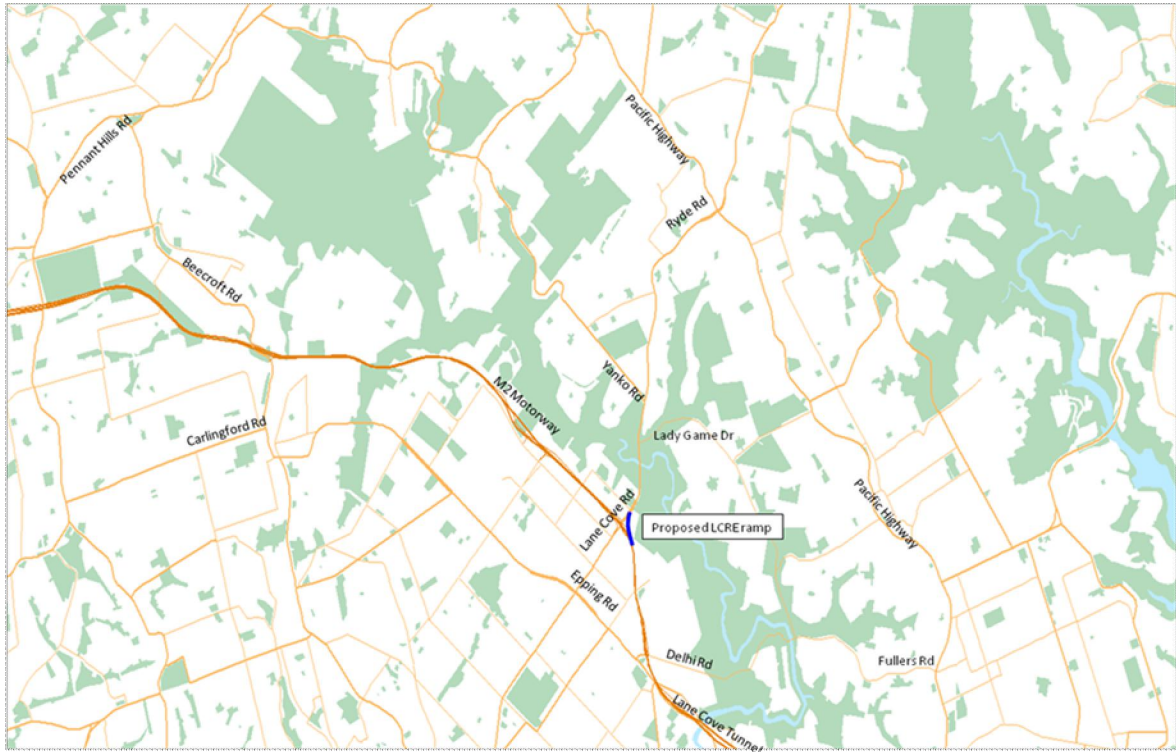


Figure 2 – Detailed Study area for assessment of Lane Cove Road eastbound on-ramp project

Impact assessment

The Project

The proposed modification to the M2 Upgrade involves:

- the construction and operation of a new eastbound on-ramp from the southbound carriageway of Lane Cove Road to the eastbound carriageway of the M2 Motorway;
- the widening of the eastbound carriageway of the M2 Motorway by one additional lane from the new on-ramp to beginning of the Delhi Road off-ramp;
- additional traffic management systems (including an over-height detection system using existing Variable Message Signage) and CCTV coverage of the new on-ramp.

These project elements are shown on Figure 3.

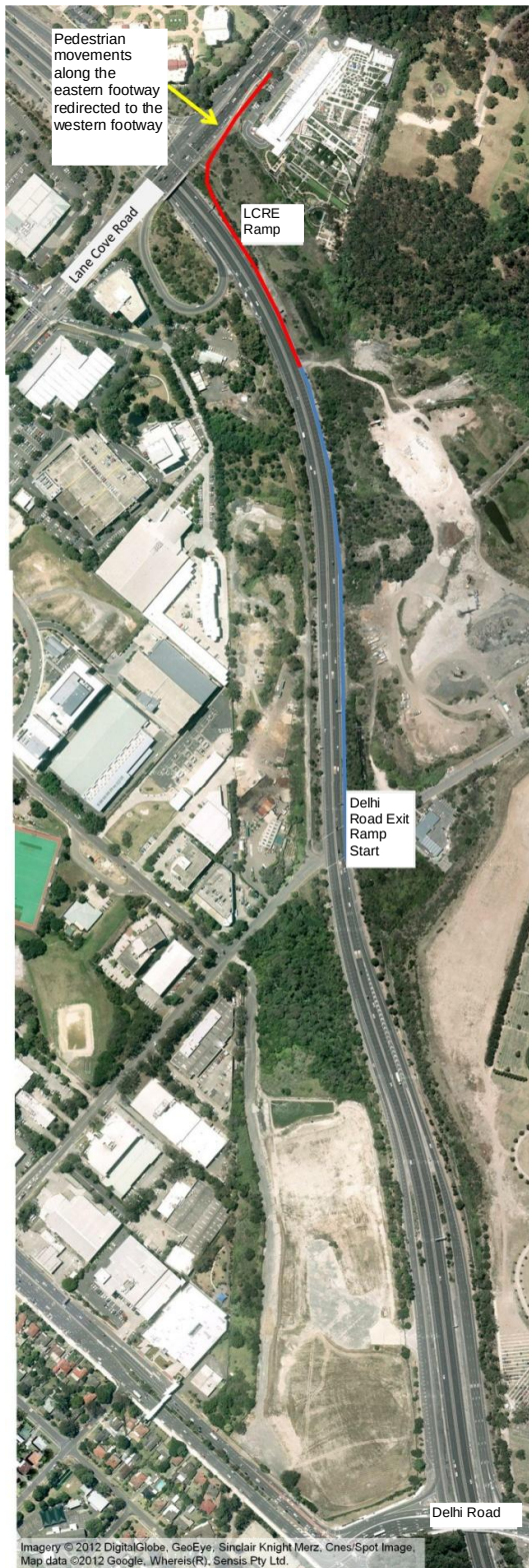


Figure 3 – Lane Cove Road eastbound on-ramp project

Basis of Assessing Base and Project (Lane Cove eastbound on-ramp) Traffic Conditions

Transurban's Strategic Traffic Model (TUSTM) was used to forecast traffic network volumes in the corridor, including with and without the proposed Lane Cove Road eastbound on-ramp for year 2011 and 2021. Broad changes in turning volume forecasts from TUSTM were also used to model intersection performance using the intersection analysis software package LINSIG.

TUSTM uses demand forecasts obtained from Bureau of Transport Statistics (BTS) which are assigned using appropriate modules from the CUBE suite of transport planning software packages. Vehicle trips are assigned in three income groups where tolls are represented in path finding costs functions as equivalent travel times based on separate values of travel time savings for each income group.

How the Project Impacts Traffic Performance in the Corridor

Unlike the M2 Upgrade project that is a more significant change, the Lane Cove Road eastbound on-ramp essentially constitutes a local improvement in access, whose impacts are summarised as follows:-

- Attracts some traffic from the Pennant Hills / Beecroft Road route to the eastbound motorway to travel via a combination of Pacific Highway, Yanko Road to access Lane Cove Road southbound and travel onto the eastbound motorway via the new ramp;
- Attracts some traffic from the eastbound Pacific Highway between Lane Cove Road and Gore Hill freeway that can now access the motorway from Lane Cove Road and new ramp - such traffic currently remains on Pacific Highway as the route to the M2 involves travel through the busy Lane Cove Road and Epping Road interchange.
- Attracts traffic currently on Lane Cove Road that is required to access the M2 via the southern end of Lane Cove Road and the merge onto the M2 from Epping Road.

All traffic that diverts from its base routes do so because they perceive a direct benefit to them. In diverting they lead to a general reduction across the arterial network (Pacific Highway east of Lane Cove Road, Lane Cove Road and Epping Road south west of the respective motorway crossing points) with traffic able to access the motorway network more efficiently. The southbound section of Lane Cove Road between Pacific Highway and the new ramp does see some modest increases in traffic and an assessment of operations was undertaken using the LINSIG software package and showed that there were some marginal decreases in the Level of Service (LOS). South of the new ramp, the LINSIG analysis generally showed an improvement in intersection delays as a result of modest decreases in southbound volumes.

As part of the project it is deemed sensible to formalise current ad-hoc pedestrian access on the eastern side of Lane Cove Road between Fontenoy Road and Talavera Road to the western side, and this again has little impact given the very light flows of cyclists and pedestrians in the vicinity.

Regards operations within the motorway, analysis of weaving and merging volumes (using the Highway Capacity Manual techniques) shows that projected volumes can be managed without issue – indeed a major benefit of the scheme is that traffic can enter directly from the new ramp and reduce entry volumes at the current merge from Epping Road that is a little constrained.

The need for ramp metering on the new ramp was considered, however it was concluded that the only rationale for ramp metering would be to limit flows entering the motorway, and given the proposed ramp would improve conditions on most sections of the M2 and Lane Cove Rd as a result of the changed patterns, ramp metering isn't considered to be justified. In any case, ramp metering would only be effective as broader traffic management strategy across a broad section of the orbital network. The design of the new ramp would not preclude any such future initiative.

Impacts during Construction

Construction generated traffic is anticipated to be approximately 40 heavy vehicle movements and 110 light vehicle movements per day, with the majority utilising the M2 Motorway and Lane Cove Road. Vehicle movements may also occur along Wicks Road, however these are anticipated to be minor. These

volumes are considered to be negligible in comparison to the daily and peak traffic volumes currently using the M2 Motorway and Lane Cove Road, and considered not to be significant.

Traffic management measures will be required on the M2 Motorway during the construction phase in order to provide a safe working environment to undertake the construction works. This will involve separation of traffic lanes and the working area using concrete barriers and the possible implementation of a reduced speed limit on the M2 eastbound carriageway. (The extent of the speed reduction will be determined at the detailed design stage of the project). There would also be occasions when the trafficable lanes on the eastbound carriageway would need to be closed to traffic, however this would be restricted to outside of peak periods and would be coordinated with the Hills M2 Motorway Control Room.

Works along Lane Cove Road would also require the occasional closure of traffic lane/s on Lane Cove Road southbound carriageway and reduced speeds limits when lane restrictions were in place. Again, this would be restricted to outside of peak periods and would be subject to approval from the RMS and Transport Management Centre of Transport for NSW.

Overall, the potential construction traffic impacts are not considered to be significant and would be temporary in nature and mitigated by planning all lane occupancies with the aim to:

- minimise the actual work area
- limit obstructions and restrictions
- avoid peak flow periods and analyse traffic volume data to identify the capacity requirements and plan works to minimise disruption

1.0 Introduction

The M2 is part of the Sydney Orbital Motorway and is the principal transport link connecting Sydney's north-west to the lower north shore and the North Sydney and Sydney CBDs.

In recognition of the need to cater for traffic growth in the corridor, Transurban, as the owner/operator of the Hills M2 Motorway, is undertaking a significant upgrade of the motorway in conjunction with the New South Wales Government. This upgrade was the subject of a full environmental appraisal through 2009 and into 2010, with major construction commencing in early 2011.

Subsequent to the major upgrade Transurban and New South Wales Government are proposing an additional ramp the so-called "Lane Cove Road eastbound on-ramp" with such ramp providing a new connection to the M2 Motorway and Lane Cove Tunnel eastbound corridor for the suburbs of Thornleigh, Turramurra, South Turramurra, Pymble and West Pymble. The new ramp will provide convenient alternative to the congested Pacific Highway corridor and the southern end of Lane Cove Road and Epping Road. The ramp would lead to greater use of the motorway network and generally reduce levels of congestion on the arterial network. Notwithstanding this overall benefit, there will be some localized increases in traffic in and around the vicinity of the ramp and the impact will need to be assessed.

Further information on the objectives and scope of the Lane Cove Road eastbound on-ramp can be found in the M2 Upgrade Modification Assessment Report. This supporting technical report aims to:

- Establish existing traffic and transport conditions in the vicinity of the proposed ramp;
- Assess the impacts of the proposed ramp on these conditions; and
- Propose suitable mitigation measures for minimising the extent of these impacts.

This report has a further 5 sections as follows:

- Section 2 summarises the Base traffic environment and performance of the transport network in the vicinity of the proposed ramp that will pertain on completion of the M2 Upgrade;
- Section 3 describes the traffic modelling undertaken to estimate and predict future changes in the traffic outlook in both a without and with Lane Cove Road eastbound on-ramp;
- Section 4 describes the Lane Cove Road eastbound on-ramp scope of works;
- Section 5 describes and assesses changes or impacts on base conditions that will result from the Lane Cove Road eastbound on-ramp and describes mitigation measures to limit / accommodate any negative impacts; whilst
- Section 6 describes the traffic impacts of the construction period.

2.0 The Base Transport Environment

The proposed Lane Cove Road eastbound on-ramp is essentially an add on to the ongoing upgrade of the M2, as such there are no “existing” conditions against which the impact of the ramp can be assessed, rather there are base conditions being those that will pertain on completion of the M2 Upgrade. These base conditions were fully outlined in the previous Traffic and Transport Assessment completed for the M2 Upgrade Environmental Assessment (EA), hence for full details the reader is referred to M2 Upgrade Volume 2- Part 1 Environment Assessment- Technical Papers Traffic and Transport Assessment. A precise only of the base transport environment as concluded through the earlier study is presented herein.

2.1 Study Areas

The study areas for the original M2 Upgrade scope and current modification (Lane Cove Road eastbound on-ramp) assessment of traffic impacts are shown in Figure 4.

The full area is bounded by the following significant road network features.

- Windsor Rd, Showground Rd, Castle Hill Rd, Pennant Hills Rd and the Comenarra Parkway to the north;
- Old Windsor Rd to the west;
- Cumberland Highway, Pennant Hills Rd, Carlingford Rd and Epping Rd to the South; and
- Junction of the M2 with the Lane Cove Tunnel to the east.

For assessment of Lane Cove eastbound on-ramp, areas to the west of Pennant Hills Road are no longer relevant whilst there is a small increase in size of the area on the eastern side to incorporate the orbital motorway through to its interface with the Pacific Highway.

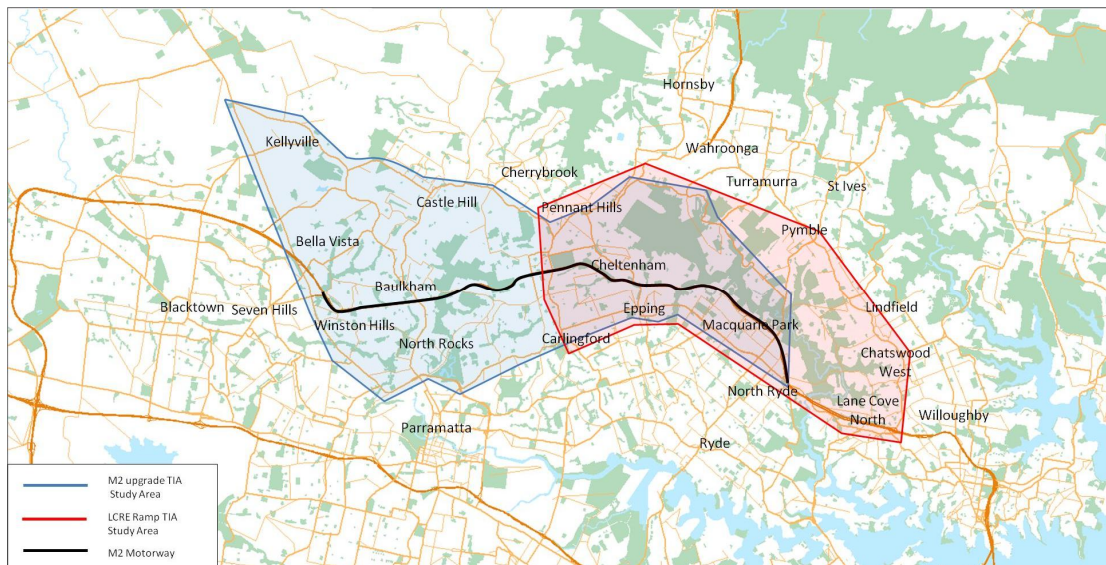


Figure 4 – Wider Study Areas

Base Traffic Conditions in the Orbital Motorway Corridor

As noted a major upgrade of the M2 corridor is currently underway and provides the base conditions for introduction of the Lane Cove eastbound on-ramp. The base conditions (post M2 Upgrade base scope) are forecast to improve over existing conditions prior to the upgrade with such changes being documented in the earlier TIA with major conclusions as follows:

Improved Levels of Service on Orbital Motorway

The overall level of peak period congestion will reduce in the corridor as a result of the M2 Upgrade compared with the existing situation. Based on an expected 15% growth in traffic demand over the next 10 years, traffic performance in the corridor will remain better than current conditions up to 2021.

The M2 Upgrade will provide a reduction in AM peak (Inbound) travel time of estimated 19 minutes and PM peak (Outbound) travel time reduction of 6 minutes for trips travelling the length of the M2 motorway by 2021.

The M2 Upgrade will re-instate the 100km/hr speed limit westbound between Lane Cove Road and Beecroft Road, and increase the eastbound speed limit through the toll plaza for electronic toll users, which will reduce off-peak travel times for M2 motorists and buses.

Improved Accessibility - New Ramps

The proposed west facing Windsor Road Ramps will provide improved access to the Sydney Orbital, including the M7, Penrith, Blue Mountains, Liverpool, Campbelltown and Canberra. The proposed ramps will provide an alternative route to the local arterial, sub-arterial and local network, and relieve peak traffic congestion along Seven Hills Road, Old Windsor Road, and Powers Road. The new Windsor Road ramps are forecast to provide direct travel time benefits of up to 4 minutes in both the AM and PM peak

The proposed eastbound ramps at Christie and Herring Road will provide improved motorway standard accessibility to Macquarie Park from the business districts of Chatswood, North Sydney and Sydney. The proposed ramps will provide an alternative route to the local arterial, sub-arterial and local network, and relieve peak congestion along Lane Cove Road and the eastern ends of Talavera Road and Waterloo Road. The new eastbound ramps at Macquarie Park are forecast to provide direct travel time benefits of up to 4 minutes in the AM peak and 5 minutes in the PM peak

Reduced Congestion and Intersection Delay on the Surrounding Road Network

The M2 Upgrade will improve future conditions on alternative toll-free routes, including a peak period travel time saving of up to 5 minutes for motorists using the alternative to the M2 along Old Windsor Road, Pennant Hills Road, Carlingford Road and Epping Road.

The new access to Macquarie Park will provide alternative to the congested Lane Cove Road and reduce intersection delay in this corridor.

Significant traffic operational and intersection improvements will occur in the AM peak periods compared with the existing situation as a result of the proposed M2 Upgrade interchange modifications at the following intersections:

- Windsor Road/M2
- Herring Road / Talavera Road
- Christie Road / Talavera Road

A major benefit of the M2 Upgrade project is to improve M2 and the motorway network capacity and hence to encourage longer distance traffic to use and stay on the motorway network rather than divert to arterial and local roads. However some roads providing access to the M2, such as some sections of Old Windsor Road, Abbott Road, Windsor Road and Pennant Hills Road will experience increased traffic volumes.

Improved Safety

With the Upgrade attracting traffic to the M2 away from alternative routes and local roads, the higher safety performance of motorways will result in an overall improvement in corridor road safety performance. The widened sections of M2 will improve safety specifically east of Windsor Road Overpass, Pennant Hills Road Interchange, Norfolk Tunnel and approaches and at the Main toll plaza.

The overall upgrade will also allow improved access for emergency vehicles within the reconfigured widened sections.

Impacts to Bus Operations and Bus Users

Widening M2 to three lanes in each direction, including provision of a T2 Lane eastbound between Terry's Creek and Lane Cove Road and the proposed ramp configurations, will provide improved bus travel times (of up to 5 minutes compared with the current situation) and improve bus service reliability.

Whilst the removal of the Bus only ramps at the M2/Beecroft Road intersection will require some bus services to be rerouted, with reduced bus access to Epping railway station for some bus passengers, modifications to the Christie Road Bridge and configuration of adjacent intersections will improve bus access to Macquarie Park interchange facilities and the new railway station. This will result in approximately 50 additional bus services using the Christie Road exit and Herring Rd entry daily instead of the bus only ramp.

Changes to Pedestrian Facilities

Pedestrian facility changes are proposed to retain existing pedestrian access. There will be additional pedestrian crossings located with the proposed Windsor Road Ramps and Christie Road Entry Ramp.

Improvements to Cyclist travel along M2

The Upgrade project restores the westbound breakdown lane between Lane Cove Road and Beecroft Road, which was reconfigured as a temporary third westbound lane and necessitated the exclusion of cyclists from this section. Cyclists will be allowed to return to use the breakdown lane instead of the off motorway detour route that was provided.

Improvements to Commercial Traffic Movement

The completion of the M2 Upgrade will generate further improvements in heavy vehicle and commercial traffic travel times, especially for the longer distance movements on the Sydney Orbital and to and from the F3.

The expected motorway trip time savings of up to 19 minutes in the 2021 morning peak will both improve reliability and reduce commercial vehicle operating costs compared with the current situation.

Overall Network-wide Benefits

Overall the M2 Upgrade will significantly improve the level of service to all users into the future compared with the conditions on the M2 without the upgrade.

While the annual Vehicle Kilometres Travelled (VKT) on M2 will increase (by up to 0.6% of the current situation VKT), traffic volumes on the major arterial and local roads in the corridor will decrease (by up to 0.5%), thus improving the effectiveness of the network, providing greater network efficiency and providing a safer transport corridor.

Annual road network travel times will reduce on all classes of road in the corridor. Average travel times will reduce by as much as 8% and average speeds will increase by as much as 10% on the M2, generating significant economic benefits

3.0 Traffic Forecasting Process

A strategic network model (TUSTM) was used to predict traffic conditions and assess the future traffic performance and traffic impacts in the study area without and with the proposed Lane Cove Road eastbound on-ramp.

This chapter describes the TUSTM modelling process that underlies the prediction of future base traffic conditions and the change that will result from an introduction of the proposed ramp.

3.1 The Transurban Sydney Strategic Traffic Model (TUSTM)

Transurban has a long term interest in traffic patterns, in and around Sydney, with major shareholding in many of the concession companies that operate much of the Orbital Motorway network. To understand current and future traffic patterns Transurban developed an in-house strategic traffic model for Sydney (TUSTM) to forecast the changes in traffic patterns that will result from major network improvements such as the proposed M2 Upgrade Project and the Lane Cove Road eastbound on-ramp.

TUSTM (or its precedent) was used for the following key projects:-

- M7 bid;
- Acquisition of Hills M2;
- Acquisition of Sydney Roads Group (SRG);
- Investment advice on additional stake in M7;
- Acquisition of Lane Cove Tunnel; and
- All Sydney asset development and enhancement opportunities.

The forecasting approach comprises:

- A strategic highway network model of the Sydney metropolitan area including all major roads within the network;
- representation of future years, 2011 and 2021 by including anticipated changes and upgrades to the network;
- representation of future demand for travel by both cars and trucks to model their varying travel patterns and behaviours;
- explicit modelling of all tolls, existing and future, on the network;
- inclusion of multiple user classes within the model to reflect drivers' willingness to pay the toll in order to save travel time; and
- the modelling of future land use which feeds into the production of future demand for travel for cars and trucks (using Transport and Population Data from NSW Ministry of Transport's Bureau of Transport Statistics).

3.2 Traffic Modelling Process – An Overview

TUSTM was developed in early 2005 by Transurban's Traffic Forecasting Group (TFG) building from research, models and data files created by consultants commissioned by Transurban prior to this time. Since then, progressive updates and enhancements by TFG have ensured its currency and accuracy for the purposes of annual reporting, prospective bids, and network changes. As such, it provides the foundation for traffic predictions, and remains a comprehensive tool for estimating the impact of significant network changes in terms of both traffic and revenue implications on Sydney toll roads. The TUSTM utilises the Cube Voyager software platform.

The modelling structure and validation of Version 8 of the TUSTM, particularly relating to the modelling investigation of the Lane Cove Road eastbound on-ramp project is summarised in Appendix A.

3.3 Traffic Modelling Assumptions

3.3.1 Land use Projections

Land use forecasts consist of future projections in population and employment and are a key input to TUSTM when determining future travel demand and road network impacts.

Table 20 (see Appendix A) shows population forecasts by Statistical Sub Division (SSD) with highlights as follows:

- 54 % of total population live “in and around” the Sydney Orbital;
- The sector with the highest population is St George Sutherland with approximately 440,000 or 10% of Sydney's population and includes the SLAs of Rockvale (Sydney International Airport Terminal), Hurstville and Kogarah with some 227,000 residents to the north of the Georges River; a further 217,000 residents in the SLAs of Sutherland Shires (East and West) located south of the Georges River and including the suburbs of Sutherland, Miranda, Caringbah and Cronulla;
- Outer South Western Sydney – the SLAs off Camden, Campbelltown and Wollondilly have the highest growth rates with a greater than 2% per annum increase for the entire period through to 2026;
- Higher percentage growths are forecast for the sectors of Fairfield-Liverpool, Central Western Sydney and Blacktown where growth of over 1% is generally forecast for the entire period through to 2026, i.e. still above the regional average of 1% or lower.

Table 21 (see Appendix A) shows employment forecast by Statistical Sub Division (SSD) with highlights as follows:

- 68% of total employment is “in and around” the Sydney Orbital;
- As with most Australian cities, the CBD is a major source of jobs/employment with Inner Sydney SSD (which includes Sydney CBD but also Sydney Port and Domestic Air Terminals) having some 25% of total regional employment. The SSD of Lower Northern Sydney which includes the employment centres of North Sydney, St. Leonards and Chatswood comprises another 11.5% of regional employment.
- The SSDs of Fairfield-Liverpool, Outer Western and Outer South Western Sydney have the highest percentage increases and together are forecast to receive some 129,000 extra jobs representing about 38% of the total regional employment growth of 460,926.

As a final commentary on future population, Outer Western Sydney is forecast to receive some 152,000 extra residents; which represents about 15% of the total regional population growth of 996,000 and an equivalent annual intake rate of 7,500 people. Blacktown is forecast to have an extra 102,000 people over the 20 year period.

Conversely, St George Sutherland has minimal growth, less than 0.3% per annum and yielding an annual intake rate of only 1,400 people.

3.3.2 TUSTM Network Assumptions

The baseline road network adopted for TUSTM was the situation as it will exist post the ongoing M2 Upgrade. The process for forecasting future growth and impacts in regards to the Lane Cove eastbound on-ramp is discussed below.

3.3.3 Forecasting of Base and Project Conditions

Forecasting of Base (with M2 Upgrade) and Project (with Lane Cove eastbound on-ramp) conditions used the following methodology:

Step 1: Forecasts for Base Conditions 2011 and 2021

- The model and forecasts as used for the Assessment of the M2 Upgrade Project was adopted.

Step 2: Determine Lane Cove eastbound on-ramp Impacts

- Add the Lane Cove eastbound on-ramp to the Base 2011 and 2021 networks to form Project Networks;
- Run TUSTM with the 2011 and 2021 Project Networks;
- Compare and extract traffic volumes for Base and Project for 2011 and 2021; and
- Apply the forecast change marginally to the 2011 and 2021 base traffic scenario.

3.3.4 Induced Traffic

Traffic growth on new or upgraded roads is generally a result of the following influences:

- Regional growth in trips resulting from population growth and expanded economic activity;
- Trips attracted from competing routes or modes as a result of improved travel times on the new or upgraded road;
- Induced traffic as a result of improved travel times between homes and destinations such as workplaces, shopping centres and education precincts which stimulate changes to regional wide trip patterns.

Even with no growth in regional population and economic activity, a new or substantially upgraded road can induce changes in trip patterns which then appear as induced traffic. Generally, changes to home/workplace trip patterns will occur over several years after opening of the new or upgraded road whereas changes to shopping and recreational trip patterns can occur in a much shorter period. A key factor for induced trips is that improvements in travel times are experienced throughout the day; as for example the significant reduction in travel times that occurred with the opening of M7.

Induced trips on the orbital motorway as a result of the proposed M2 upgrade were concluded as insignificant and the same conclusion can be drawn for the Lane Cove eastbound on-ramp given its very localised impacts.

3.4 Summary

TUSTM is a strategic transport forecasting model developed over time specifically to provide traffic demand forecasts on the motorway and arterial network of Sydney. The model has been maintained and appropriately utilises up-to-date inputs and assumptions. The model is therefore suitable for use in this study to assess the traffic and transport impacts of the Lane Cove eastbound on-ramp.

4.0 The Lane Cove Rd east-facing on-ramp Project

4.1 Project details

The Lane Cove Road eastbound on-ramp involves adding a new access point to the eastbound orbital from the southbound Lane Cove Road, widening a short section of the motorway through to current off-ramp to Delhi Road. The Project includes:

- Physical widening eastbound from the new ramp to the current exit ramp to Delhi Road
- Provision of new eastbound on-ramp from Lane Cove Road southbound;
- An extension northwards of the current southbound slip lane approach to the current westbound loop entry ramp to M2 so as to provide diverge from Lane Cove Road into the new eastbound entry ramp.
- Restriction of pedestrian access between Fontenoy Road and Talavera Road from the eastern side, thus redirecting them through existing pedestrian facilities located on the western side of Lane Cove Road
- Provision for future ramp-metering. The design of the new ramp allows for future initiative; the need for ramp metering on the new ramp was considered, however it was concluded that the only rationale for ramp metering would be to limit flows entering the motorway, and given the proposed ramp would improve conditions on both the M2 and Lane Cove Rd, ramp metering isn't considered to be justified until such time as a wider (geographically) traffic management strategy is rolled out across a broad section of the orbital network.

These project elements are shown on Figure 3.

Construction is expected to begin in last quarter of 2012 with a construction period of one year.

4.2 Project Objectives

The proposed ramp aims to improve local accessibility to the motorway network. Section 5 of this report provides an operational impact assessment with regard to these objectives

4.3 Alternatives Considered

The above scope of work reflects a preferred treatment and other forms of interchange have been considered; specifically provision of a westbound off-ramp to Lane Cove Road has not been pursued as such would have needed extensive remodelling of the interchange with Lane Cove Road including introduction of signalised control, that could have reduced overall level of service within the vicinity.

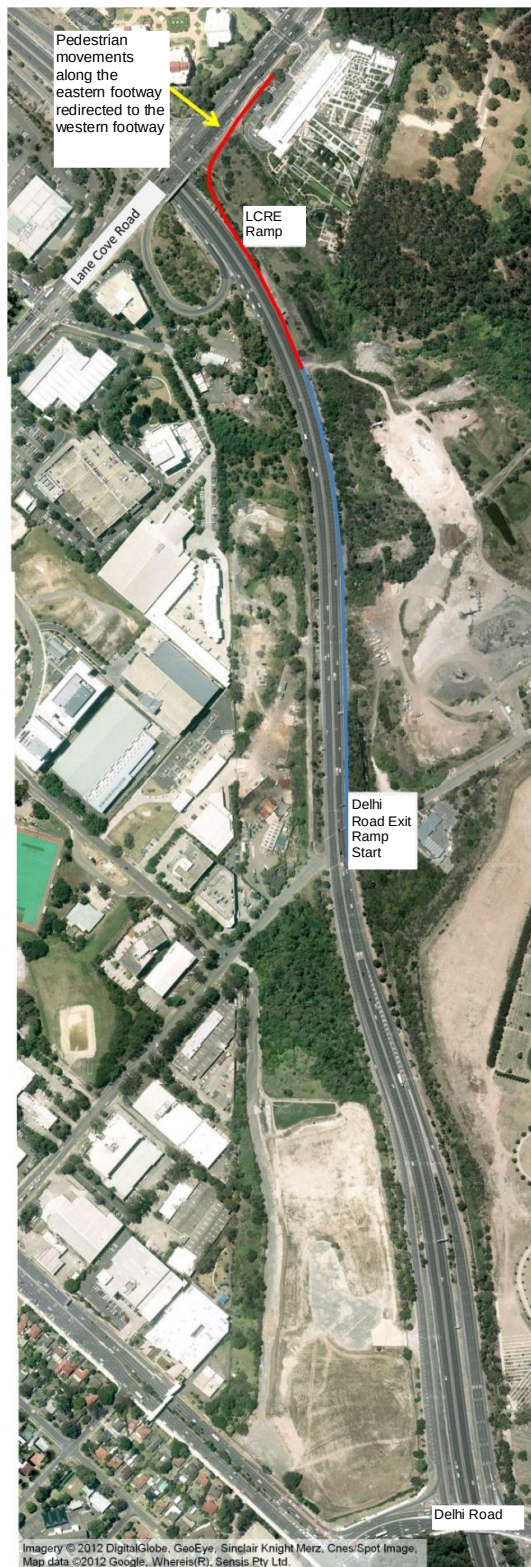


Figure 5 – Lane Cove Road eastbound on-ramp project

5.0 Operational Impact Assessment of the ramp

The operational assessment of the road network under Base and Project conditions uses the following indicators:

- Level of Service of Road Links - as defined by the US Transport and Research Board 2000 Highway and Capacity Manual (HCM), and AustRoads Guide to Traffic Engineering Practice Part 2;
- Travel speeds and times;
- Level of Service of intersections as defined by the RMS.

5.1 Definition of Level of Service

5.1.1 Uninterrupted Flow (Motorways)

For uninterrupted flow on multi-lane roads, such as the orbital motorway, Level of Service (LoS) is defined as a qualitative measure describing operational conditions within a traffic stream.

A LoS definition generally describes these conditions in terms of factors such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and safety.

By definition, there are six LoS, designated from A to F, with LoS A representing the best operating condition (i.e. free flow) and LoS F the worst (i.e. flow break-down).

The following is a description of each LoS¹:

- **LoS A:** is a condition of free flow in which drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and manoeuvre within the traffic stream is extremely high.
- **LoS B:** is in the zone of stable flow where most drivers still have reasonable freedom to select their desired speed and manoeuvre within the traffic stream.
- **LoS C:** is also in the zone of stable flow but most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream.
- **LoS D:** is close to the limit of stable flow where all drivers are severely restricted in their freedom to select desired speed and to manoeuvre within the traffic stream. Small increases in traffic flow will cause operational problems.
- **LoS E:** Traffic volumes are at, or close to, capacity. There is virtually no freedom to select desired speed and manoeuvre within the traffic stream. Minor disturbances within the traffic stream will cause breakdowns in operation.
- **LoS F:** Forced flow. The amount of traffic approaching a point exceeds that which can pass it. Flow breakdowns occur and queuing and delays occur.

All LoS calculations in this report for segments of the M2 motorway are based on the procedures in the US Transport and Research Board 2000 Highway and Capacity Manual.

5.1.2 Urban Arterial Roads with Interrupted Flow

For urban and suburban arterial roads with interrupted flow, LoS is defined in terms of average travel speed of all through vehicles and is strongly influenced by the spacing of traffic signals and average intersection delay. The following is a description of each LoS²:

¹ AustRoads (1988), "Guide to Traffic Engineering Practice, Part 2 - Road Capacity", Sydney

² AustRoads (1988), "Guide to Traffic Engineering Practice, Part 2 - Road Capacity", Sydney

- **LoS A:** Generally free flow conditions with operating speeds about 90% of free flow travel speeds. Vehicles are unimpeded in manoeuvring in the traffic stream and stopped delay at intersections is minimal.
- **LoS B:** Relatively unimpeded operation with average travel speed about 70% of the free flow speed. Manoeuvring in the traffic stream is only slightly restricted and stopped delays are low.
- **LoS C:** Stable operating conditions but with manoeuvring becoming more restricted and motorist experiencing appreciable tension in driving, longer queues and/or adverse signal coordination may contribute to lower average travel speeds of about 50% of the free flow speed.
- **LoS D:** Conditions border on a range which small increases in flow can significantly increase in intersection delay and reduce travel speed. Travel speeds are about 40% of the free flow speed.
- **LoS E:** Conditions are characterised by significant intersection delays and travel speeds of 33% of free flow speed or lower. Contributing factors may be: adverse signal progression closely spaced signals and saturated intersection conditions.
- **LoS F:** Traffic flow at this level is very low speed – below 25% to 33% of the free flow speed. Signalised intersections would be over-saturated with extensive queuing.

All LoS calculations in this report for arterial roads with interrupted flow are based on the procedures in the US Transport and Research Board 2000 Highway and Capacity Manual.

5.2 Capacity of Road Links

A common proxy for traffic performance is the ratio of traffic demand to traffic capacity (often referred to as a volume to capacity ratio or “V/C” ratio) of road sections throughout the road network. At low values of V/C, traffic conditions are perceived as good whereas high values of V/C are generally an indicator of unacceptable traffic performance.

Table 1 below lists theoretical hourly lane capacity by road type for LoS E. These theoretical capacities represent robust limits. There are instances of higher traffic throughputs being observed but local conditions such as narrow lanes, inadequate shoulders, parking and property access can also reduce volumes below these capacities.

Table 1 - Theoretical Hourly Lane Capacity of Road Links

DESCRIPTION	HOURLY LANE VEHICLE CAPACITY (LoS E)
Motorways	2,000
Ramps	1,650
Motorway-to-Motorway Ramps	1,650
Major Arterials	1,800
Arterials	1,650
Sub-arterial	1,500
Collectors	1,000
CBD Streets	900
Residential Streets	550

The Lane Cove Road eastbound on-ramp project is forecast to result in overall reduction in travel delay; however there are localised parts of the network which have increased traffic volumes.

This section presents the forecast of traffic changes and effects from the Proposal by describing:-

- The Strategic Level changes – namely vehicle kilometres and vehicle hours resulting from the proposed new ramp;
- LoS of Road Links- as defined by the US Transport and Research Board 2000 Highway and Capacity Manual;
- Travel speeds and times;
- Intersection Operations which use a LoS descriptor for intersections as defined by the RMS; and
- Opportunities for public transport.

This section presents two different future scenarios. The first future scenario being **Base** conditions post the M2 Upgrade but without the new ramp and the second scenario being the **Project** conditions being post the M2 Upgrade Project and with the new ramp.

5.3 Strategic Level Changes in Road Network Performance

The predicted change in Vehicle Kilometres Travelled (VKT)³, vehicle hours travelled (VHT) across the Sydney network are shown in Table 2 and Table 3 respectively.

While the overall change in network vehicle kilometres travelled is small, there is an expected shift in travel from arterial and local roads (reduced by 0.07% in both 2011 and 2021) to travel on Motorways (increased by 0.13% in both 2011 and 2021) on the network.

There will also be a reduction in vehicle hours travelled, of up to 0.04% across the network as a result of the additional ramp. However, the additional ramp doesn't provide an overall improvement to travel speed performance on both arterials and the motorways with the additional widening of motorway between Lane Cove Road and Delhi Road.

Table 2 - Forecast Annual Road Network Vehicle Kilometres Travelled (VKT) (millions kilometres)

Facility	2011 Base	2011 Project	Impact	2021 Base	2021 Project	Impact
Motorway	8,749	8,760	0.13%	9,924	9,937	0.13%
Arterial	14,347	14,338	-0.07%	16,368	16,357	-0.07%
Local / Sub Arterial	7,280	7,279	-0.02%	8,628	8,626	-0.02%
Sydney Network	30,376	30,376	0.00%	34,920	34,921	0.00%

Table 3 - Future Annual Road Network Vehicle Hours Travelled (VHT) (million hours)

Facility	2011 Base	2011 Project	Impact	2021 Base	2021 Project	Impact
Motorway	112.51	112.67	0.14%	143.82	144.00	0.13%
Arterial	348.55	348.20	-0.10%	427.95	427.55	-0.09%
Local / Sub Arterial	209.05	209.00	-0.02%	274.30	274.25	-0.02%
Sydney Network	670.10	669.87	-0.04%	846.07	845.80	-0.03%

5.4 Traffic Performance of Road Links

5.4.1 M2 Motorway Flows and Resultant Levels of Service

To determine the impact of the eastbound ramp on the eastbound M2 motorway operations, a Highway Capacity Manual (HCM) analysis was undertaken; The analysis is similar to the analysis undertaken in the earlier TIA but has been extended to include diverge sections in addition to mid-block and merge sections with the lower LoS being reported at each between interchange sections of the motorway.

Table 4 shows the forecast change in daily volumes on each eastbound section of the M2 Motorway. While no direct LoS can be calculated from daily volumes, the table below is useful in demonstrating that the overall forecast impact is relatively moderate in a daily sense, with a maximum increase in the eastbound direction of 4,936 vehicles by 2021 in the section between Lane Cove Road and the current Epping on-merge. This increase is essentially a mix of existing and diverted trips that are taking advantage of the additional convenience and time savings offered by the new ramp

Table 5 and Table 6 shows the forecast change in AM peak and PM peak flows respectively on each eastbound (only direction with change) section (between interchanges) of the M2 Motorway that was the

³ The annual figures below have been calculated using the following methodology:

1. Average workday VKT and VHT summed from TUSTM four model periods – AM, IP, PM, NT
2. Annual VKT and VHT converted using an annualisation factor of 325

input to the analysis. Whilst Table 7 and Table 8 shows the resultant LoS for AM peak and PM peak for each section under the base and project conditions for 2011 and 2021. Volumes and schematics diagrams used for the analysis are also provided in Appendix C.

From Table 5, it can be seen that AM peak flows will decrease slightly to the west of Lane Cove Road increasing to the east, with largest increase in the section between Lane Cove Road and the merge in from Epping Road (the latter being the current access point for much of the traffic that will in future use the more convenient on-ramp).

As noted in the earlier TIA the base condition LoS F shown for the section between Beecroft Road and the Main Toll Plaza may not occur. The prior analysis indicated that whilst the M2 Upgrade improves the eastbound Beecroft Road merge density, the forecast performance of this section of the motorway was impacted by a conservative assumption with regard to uptake of the T2 lane based on surveys of vehicle occupancy undertaken under current conditions (without any incentive for car pooling).⁴ Such assumption has been carried forward to the current assessment of Lane Cove eastbound on-ramp.

The results show that the introduction of the new ramp at Lane Cove Road does not have an adverse impact to the LoS along the M2 Motorway between Beecroft Road and the Lane Cove Tunnel. In the 2011 AM peak, the LoS is unchanged across all sections of the motorway with the exception of Delhi Rd to Epping Rd that saw a decrease in LoS from C to D under the project case. This is due to an increase in motorway flows from diverted traffic now utilising the new ramp.

In terms of the PM peak, all motorway sections have an unchanged LoS except for Lane Cove Road to Delhi Road, which has seen an improvement from C to B. The improvement is the result of additional capacity created by auxiliary lane for countering the weaving movements within this motorway section. In 2021, the LoS along the M2 Motorway is not adversely impacted due to the new ramp at Lane Cove Road. Similar to 2011, most sections of the motorway remained unchanged with the exception of:

- Delhi Road to Epping Road that saw a decrease in LoS from C to D in the AM and PM peak.
- Lane Cove Road to Delhi Rd that saw an improvement in LoS from D to C in the PM peak.

Table 4 – Forecast M2 Motorway Daily (Workday) Flows and Impacts

EASTBOUND DIRECTION		2011	2011	2011	2021	2021	2021
From	To	Base	Project	Impact	Base	Project	Impact
Pennant Hills Road	Beecroft Road	37,850	37,418	-433	46,830	46,398	-433
Beecroft Road	Christie Road	42,500	41,635	-865	51,830	50,965	-865
Christie Road	Lane Cove Road	40,150	39,112	-1,038	47,810	46,772	-1,038
Lane Cove Road	Delhi Road	30,750	34,902	4,152	37,310	42,246	4,936
Delhi Road	Epping Road	22,000	26,152	4,152	29,810	34,746	4,936
Epping Road Merge	Pacific Highway (LCT)	34,522	36,685	2,163	54,522	56,685	2,163

⁴ Occupancy surveys undertaken by AusTraffic on Friday April 11, 2008. Surveys indicated only 13% of AM peak EB traffic between Beecroft Road and Christie Road had 2 or more occupants.

Table 5 – Forecast M2 Motorway AM Peak Hourly Flows and Impacts

EASTBOUND							
From	To	2011 Base	2011 Project	Impact	2021 Base	2021 Project	Impact
Pennant Hills Road	Beecroft Road	4,430	4,391	-39	5,400	5,355	-45
Beecroft Road	Christie Road	5,380	5,302	-78	6,400	6,309	-91
Christie Road	Lane Cove Road	4,430	4,334	-96	5,300	5,188	-112
Lane Cove Road	Delhi Road	3,480	3,924	444	4,000	4,518	518
Delhi Road	Epping Road Merge	2,430	2,874	444	2,800	3,318	518
Epping Road Merge	Pacific Highway (LCT)	3,662	3,836	174	4,182	4,385	203

Table 6 – Forecast M2 Motorway PM Peak Hourly Flows and Impacts

EASTBOUND							
From	To	2011 Base	2011 Project	Impact	2021 Base	2021 Project	Impact
Pennant Hills Road	Beecroft Road	2,620	2,600	-20	3,450	3,427	-23
Beecroft Road	Christie Road	2,870	2,830	-40	3,750	3,703	-47
Christie Road	Lane Cove Road	2,920	2,867	-53	3,800	3,737	-63
Lane Cove Road	Delhi Road	2,170	2,447	277	2,950	3,277	327
Delhi Road	Epping Road	1,670	1,947	277	2,500	2,827	327
Epping Road	Pacific Highway (LCT)	2,564	2,648	84	3,708	3,842	134

Table 7 - Changes to M2 Motorway AM Peak LoS

EASTBOUND DIRECTION					
From	To	2011 Base	2011 Project	2021 Base	2021 Project
Pennant Hills Road	Beecroft Road	D	D	D	D
Beecroft Road	Christie Road	D+	D+	F+	F+
Christie Road	Lane Cove Road	D++	D++	D++	D++
Lane Cove Road	Delhi Road	D	D	E	E
Delhi Road	Epping Road merge	C	D	C	D
Epping Road Merge	Pacific Highway (LCT)	See section 5.4.1.1			

Note: + / ++ indicates LoS based on constraints at on-ramp merge / off ramp diverge respectively.
* indicates Los based upon weaving analysis

Table 8 - Changes to M2 Motorway PM Peak LoS

EASTBOUND DIRECTION					
From	To	2011 Base	2011 Project	2021 Base	2021 Project
Pennant Hills Road	Beecroft Road	B	B	C	C
Beecroft Road	Christie Road	B	B+	C+	C+
Christie Road	Lane Cove Road	B++	B++	C++	C++
Lane Cove Road	Delhi Road	C	B*	D	C*
Delhi Road	Epping Road	B	B	C	D
Epping Road Merge	Pacific Highway (LCT)	See section 5.4.1.1			

Note: + / ++ indicates LoS based on constraints at on-ramp merge / off ramp diverge respectively
* indicates Los based upon weaving analysis

5.4.1.1 Specific Impacts on Lane Cove Road and Epping Road, South of the M2.

Figure 6 highlights the 2011 and 2021 daily impacts to Lane Cove Rd and Epping Road south of the M2, in the southbound and eastbound directions respectively, as a result of the adding the new eastbound on ramp.

The figure shows a decrease in daily flow in the order of 2,000 in 2011 and 2,800 in 2021, through the Epping Road / Lane Cove Road, Epping Road / Pittwater Road and the Epping Road / Delhi Road intersections. The reduction in volumes will lower congestion, intersection delays and provide improved

travel times along Epping Road. This is direct result of traffic from Lane Cove Road southbound using the ramp as opposed to base requirement of travel through three busy intersections along Epping Road namely, Lane Cove Road, Pittwater Road and Delhi Road.

There is a marginal increase in flows on Talavera Road a result of trips rerouting from M2 Herring Road on ramp to Talavera Road due to the reduced congestion as the result of the project on Lane Cove Road and Epping Road.

Figure 7 shows the AM peak project impacts for 2011 and 2021 along with the results of the merge analysis at Epping Road.

The merge from Epping Road into the M2 just to the west of Lane Cove Tunnel, is different from other access points in as much as it is not an interchange ramp entry, but effectively a diverge from the running lanes of Epping Road into the running lanes of the M2.

This particular merge has a significant change in volumes as a result of the Lane Cove eastbound ramp with an overall increase in traffic through the merge, but also a switch of traffic onto the flow through form the motorway and a reduction in flow in from Epping Road.

Despite the overall increase in peak hour volumes as shown in Figure 8, merge performance of this section will remain satisfactory. This is due to reduced traffic volume on Epping Road improving the operation of this merge, and confirms a key objective of the Project to encourage longer distance travel along the motorway network and improve overall network operations.

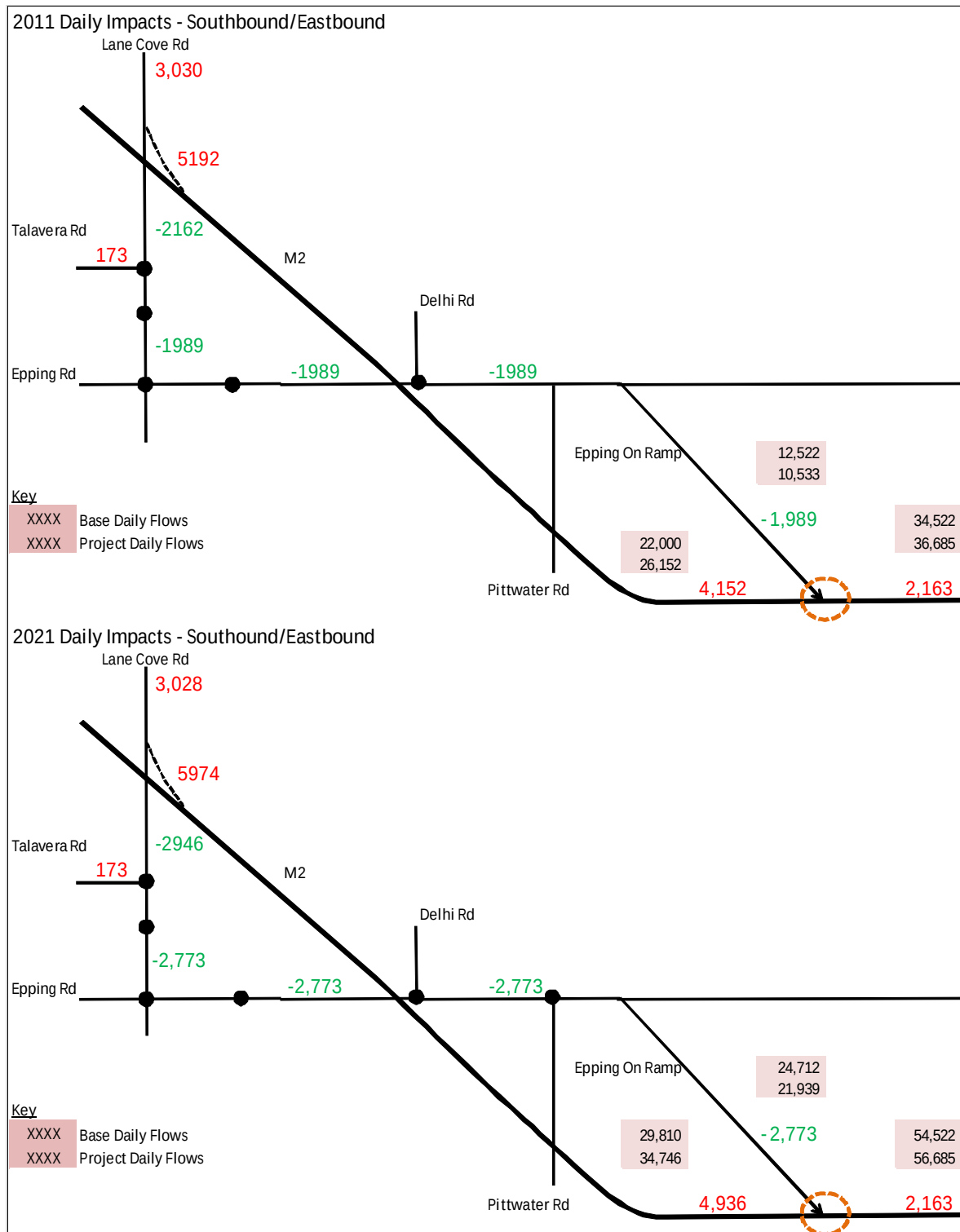
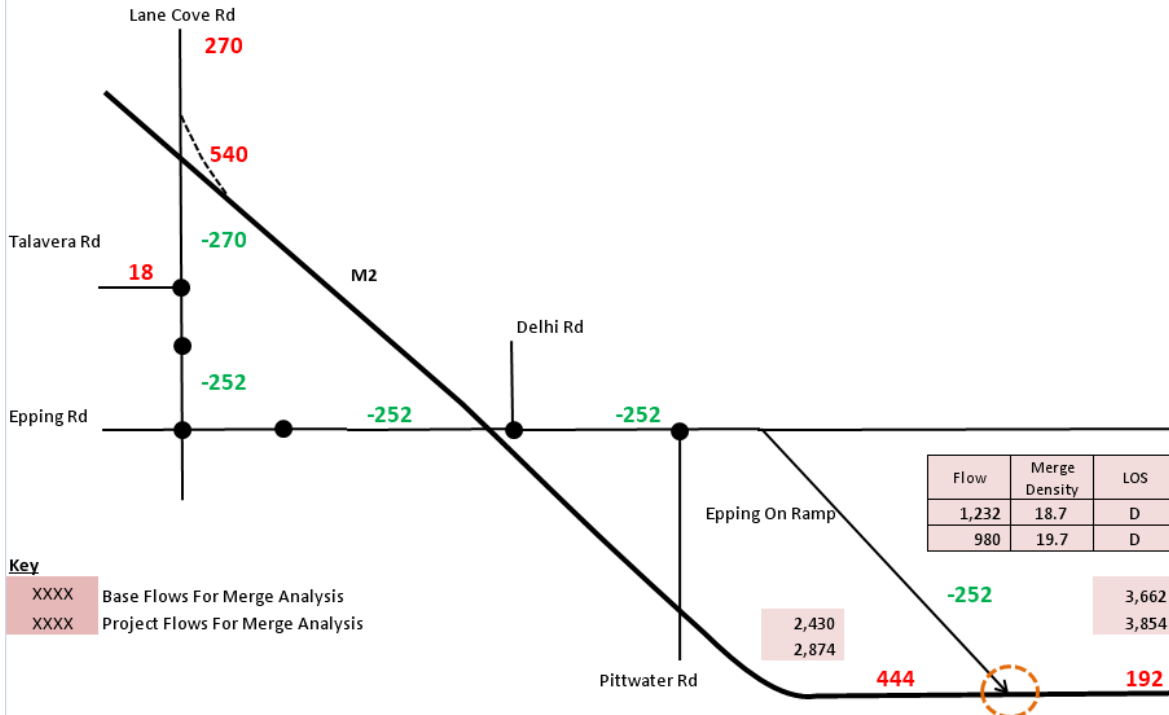


Figure 6 –2011 and 2021 Daily Impacts on Lane Cove Rd and Epping Rd, South of the M2

2011 AM Peak Hour Impacts - Southbound/Eastbound



2021 AM Peak Hour Impacts - Southbound/Eastbound

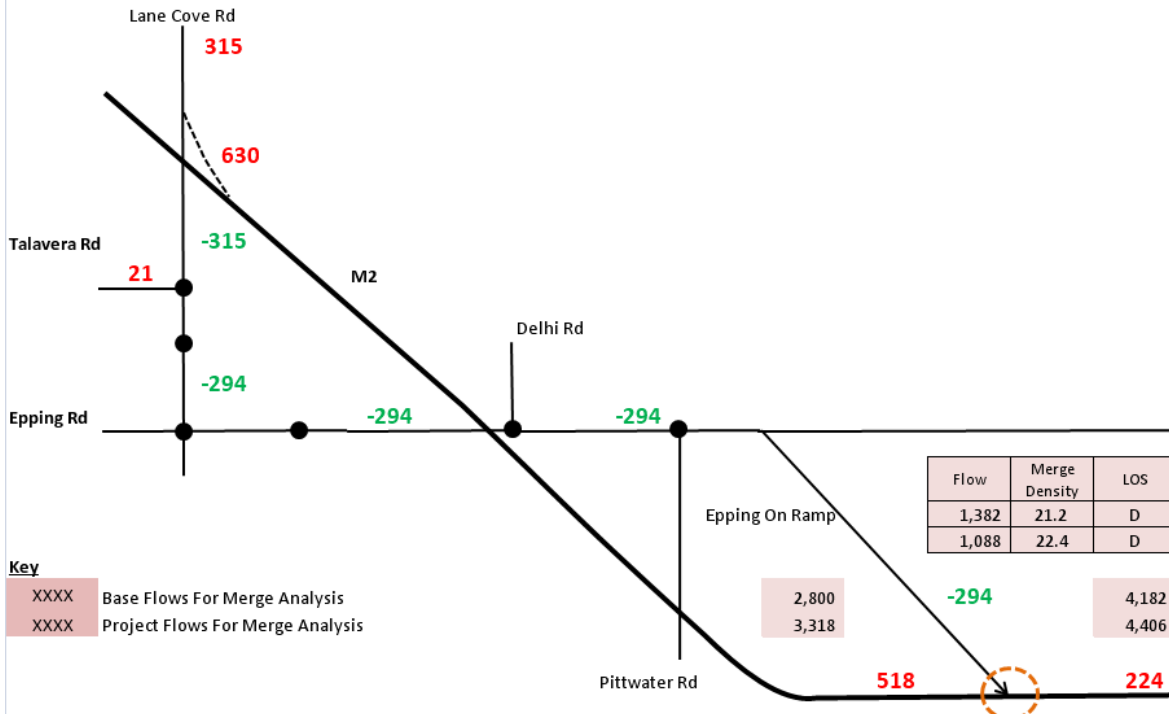


Figure 7 –2011 and 2021 AM Peak Hour Impacts on Lane Cove Rd and Epping Rd, South of the M2

5.4.2 New Lane Cove Road eastbound on-ramp

The proposed new ramp provides convenient and efficient access from the southbound Lane Cove Road into the eastbound M2 motorway.

Table 9 below summarise forecast AM, PM peak hour ramp traffic. The dominant period of travel is forecast to be the AM peak.

Table 9 - Forecast New Ramp Traffic

	2011 AM Peak	2021 AM Peak	2011 PM Peak	2021 PM Peak	2011 Daily	2021 Daily
Eastbound On-Ramp	540	630	330	390	5,190	5,974

5.4.3 Effects on the surrounding road network

When considering a road system's operation it is useful to consider traffic flows at individual points on a street or route, and on "screenlines". A screenline represents an imaginary line across a group of two or more roads that collectively comprise a corridor, or a line around a study area that comprises a cordon. By considering traffic flows across a screenline, total demand along a corridor or in and out of a study area can be assessed and effects of demand transfer from one route to another can be separated from the effects of general traffic growth.

For the purpose of assessment of the new ramp, three screenlines were defined as indicated in Figure 8. The four screenlines are as follows:

- Western Screenline (N-S): The Western screenline runs north to south between Pacific Highway and Epping Road crossing the M2 west of Beecroft Rd
- Central Screenline (N-S): The Central screenline runs north to south between Pacific Highway and Epping Road in crossing the M2 between Lane Cove Road and Delhi Road interchanges.
- Eastern Screenline (N-S): The Eastern screenline runs north to south between Pacific Highway and Church St crossing the M2 between Windsor Road and Pennant Hills Road interchanges.
- Northern Screenline (E-W): The Main Plaza screenline runs east to west between Pennant Hills Rd and Beecroft Road, in a parallel line located just to the north of M2.

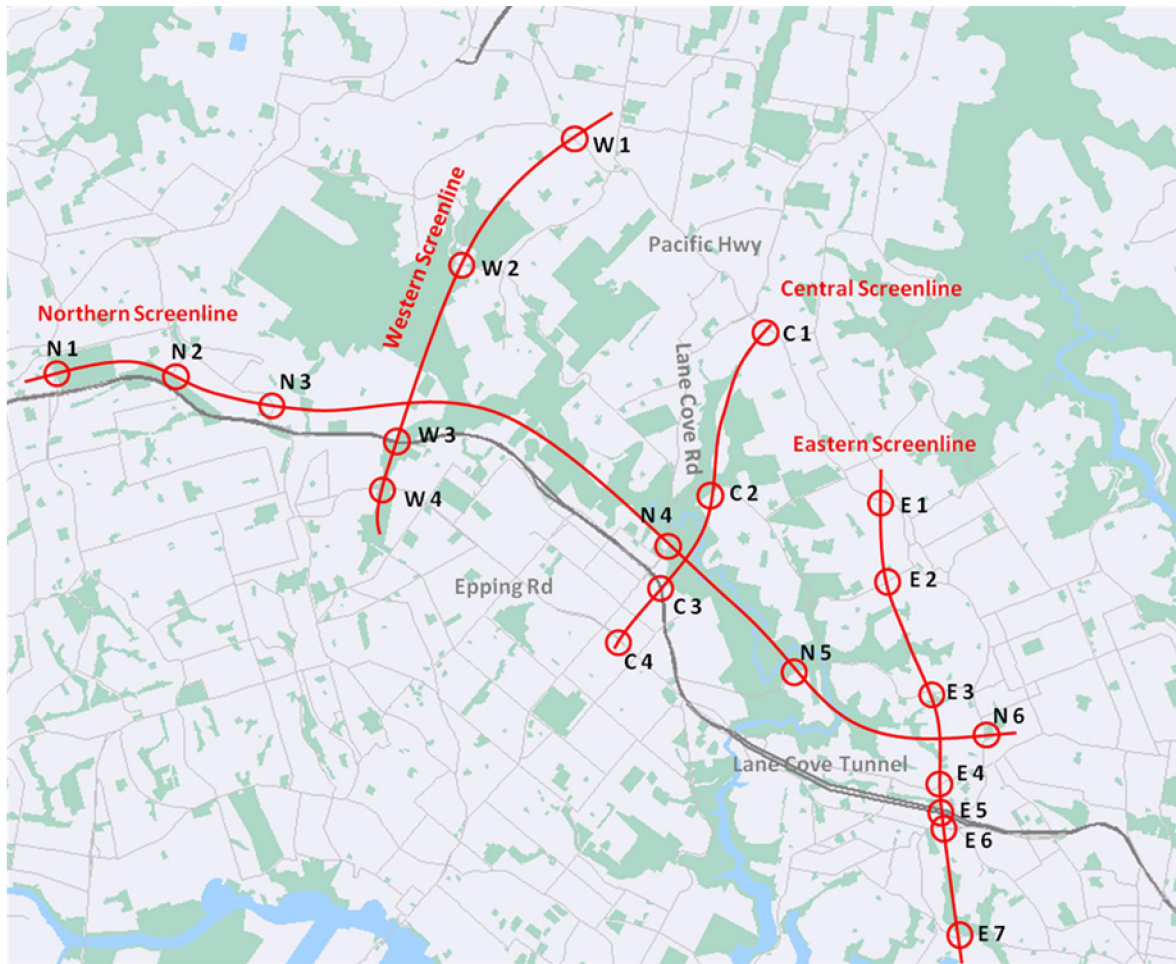


Figure 8 – Screenline adopted for Assessment of Impact to surrounding road network

Table 10 summarises forecast Daily volumes and impacts at the four screenlines.

At the Western Screenline the forecast increase in 2011 daily traffic is an additional 665 (1.5%) vehicles on the Pacific Highway and an additional 200 (2.6%) vehicles at Comenarra Parkway. The only increase in traffic at the Eastern Screenline is on the M2 motorway at 2,163 (6%), however there is a decrease at Pacific Highway of the same magnitude resulting in an approximately 6% reduction in traffic in 2011. Whilst the impacts remain constant through to 2021, base volumes change with major increases in traffic occurring on the M2 motorway.

The Central Screenline also shows an increase on the M2 of 4,152 vehicles in 2011 (13.5%) where 1,989 (4.6%) and 2,163 (4.5%) vehicles have diverted from Epping Road and Pacific Highway respectively. In 2021, the number of vehicles diverting from Epping Road increases to 2,773 (5.4%).

The Northern screenline shows no increases in total but has a redistribution effect with traffic reducing on Pennant Hills Road by 1.1% (in 2011), Beecroft Road by 2.3% (in 2011) and Pacific Highway by 4.6% (in 2011) but increasing on Lane Cove Road by 6.5% (in 2011). The increased flows (of 3,000 vehicles a day) in Lane Cove Road southbound will impact signal operations and a detailed appraisal of the signal operations has been conducted using the Linsig software in Section 5.5.

Table 11 and Table 12 shows volumes and impacts at the four screenlines for the AM peak hour and PM peak respectively and essentially reflect the pattern of daily impacts noted above.

Table 10 – Daily (Workday) Screenline Flows and Impacts

EASTBOUND/SOUTHBOUND DIRECTION	2011 Base	2011 Project	Change	2021 Base	2021 Project	Change
Western Screenline						
PACIFIC HIGHWAY, North of Kissing Point Rd	44,820	45,485	665	43,610	44,275	665
THE COMENARRA PARKWAY, East of Fox Valley Rd	7,750	7,950	200	8,050	8,250	200
M2, b/w Beecroft Road and Christie Road	42,500	41,635	-865	51,830	50,965	-865
EPPING ROAD, West of Vimiera Road	22,950	22,950	0	26,800	26,800	0
Total	118,020	118,020	0	130,290	130,290	0
Central Screenline						
PACIFIC HIGHWAY, East of Ryde Rd	47,900	45,737	-2,163	51,600	49,437	-2,163
LADY GAME DRIVE, East of Ryde Rd	9,500	9,500	0	10,500	10,500	0
M2, b/w Lane Cove Rd and Delhi Rd	30,750	34,902	4,152	37,310	42,246	4,936
EPPING ROAD, East of Lane Cove Rd	42,800	40,811	-1,989	51,100	48,327	-2,773
Total	130,950	130,950	0	150,510	150,510	0
Eastern Screenline						
PACIFIC HIGHWAY, South of Fiddens Wharf Rd	36,870	34,707	-2,163	39,800	37,637	-2,163
GROSVENOR RD, b/w Lady Game Dr and Pac. Hwy	4,160	4,160	0	4,590	4,590	0
FULLERS ROAD, b/w Millwood Ave and Pac. Hwy	14,870	14,870	0	16,290	16,290	0
MOWBRAY ROAD WEST, b/w Epping Rd and Pac. Hwy	11,910	11,910	0	13,160	13,160	0
LANE COVE TUNNEL	34,522	36,685	2,163	54,522	56,685	2,163
EPPING ROAD, b/w Longueville Rd and Pacific Hwy	24,500	24,500	0	27,060	27,060	0
RIVER ROAD, Between Bridge St and Pacific Hwy	13,290	13,290	0	14,680	14,680	0
Total	140,122	140,122	0	170,102	170,102	0
Northern Screenline						
PENNANT HILLS RD, North of the M2	38,850	38,418	-433	40,550	40,118	-433
MURRAY RD, North of the M2	4,600	4,600	0	4,100	4,100	0
BEECROFT RD, North of the M2	18,700	18,268	-433	21,600	21,168	-433
LANE COVE ROAD, South of Lady Game Dr	46,500	49,530	3,030	51,700	54,728	3,028
DELHI ROAD, East of M2	13,840	13,840	0	15,430	15,430	0
PACIFIC HIGHWAY, b/w Mowbray Rd and Fullers Rd	46,830	44,665	-2,165	49,130	46,967	-2,163
Total	169,320	169,320	0	182,510	182,510	0

Table 11 -AM Peak hour Screenline Flows and Impacts

EASTBOUND/SOUTHBOUND DIRECTION	2011 Base	2011 Project	Change	2021 Base	2021 Project	Change
Western Screenline						
PACIFIC HIGHWAY, North of Kissing Point Rd	4,630	4,687	57	4,910	4,971	61
THE COMENARRA PARKWAY, East of Fox Valley Rd	550	580	30	600	630	30
M2, b/w Beecroft Road and Christie Road	5,380	5,294	-87	6,400	6,309	-91
EPPING ROAD, West of Vimiera Road	2,750	2,750	0	3,400	3,400	0
Total	13,310	13,310	0	15,310	15,310	0
Central Screenline						
PACIFIC HIGHWAY, East of Ryde Rd	4,800	4,608	-192	5,200	4,976	-224
LADY GAME DRIVE, East of Ryde Rd	570	570	0	600	600	0
M2, b/w Lane Cove Rd and Delhi Rd	3,480	3,924	444	4,000	4,518	518
EPPING ROAD, East of Lane Cove Rd	3,800	3,548	-252	4,000	3,706	-294
Total	12,650	12,650	0	13,800	13,800	0
Eastern Screenline						
PACIFIC HIGHWAY, South of Fiddens Wharf Rd	4,320	4,104	-216	4,710	4,486	-224
GROSVENOR RD, b/w Lady Game Dr and Pac. Hwy	320	320	0	350	350	0
FULLERS ROAD, b/w Millwood Ave and Pac. Hwy	1,150	1,150	0	1,270	1,270	0
MOWBRAY ROAD WEST, b/w Epping Rd and Pac. Hwy	890	890	0	990	990	0
LANE COVE TUNNEL	3,662	3,878	216	4,182	4,406	224
EPPING ROAD, b/w Longueville Rd and Pacific Hwy	1,990	1,990	0	2,200	2,200	0
RIVER ROAD, Between Bridge St and Pacific Hwy	1,670	1,670	0	1,850	1,850	0
Total	14,002	14,002	0	15,552	15,552	0
Northern Screenline						
PENNANT HILLS RD, North of the M2	3,300	3,257	-43.3	3,350	3,311	-39
MURRAY RD, North of the M2	1,150	1,150	0.0	1,350	1,350	0
BEECROFT RD, North of the M2	2,150	2,107	-43.3	2,340	2,301	-39
LANE COVE ROAD, South of Lady Game Dr	4,100	4,403	303	4,390	4,692	302
DELHI ROAD, East of M2	1,070	1,070	0	1,210	1,210	0
PACIFIC HIGHWAY, b/w Mowbray Rd and Fullers Rd	4,270	4,054	-216	5,050	4,826	-224
Total	16,040	16,040	0	17,590	17,590	0

Table 12 - PM Peak hour Screenline Flows and Impacts

EASTBOUND/SOUTHBOUND DIRECTION	2011 Base	2011 Project	Change	2021 Base	2021 Project	Change
Western Screenline						
PACIFIC HIGHWAY, North of Kissing Point Rd	1,220	1,246	26	1,260	1,290	30
THE COMENARRA PARKWAY, East of Fox Valley Rd	950	967	17	900	917	17
M2, b/w Beecroft Road and Christie Road	2,870	2,827	-43	3,750	3,703	-47
EPPING ROAD, West of Vimiera Road	1,100	1,100	0	1,200	1,200	0
Total	6,140	6,140	0	7,110	7,110	0
Central Screenline						
PACIFIC HIGHWAY, East of Ryde Rd	2,500	2,402	-98	2,600	2,484	-116
LADY GAME DRIVE, East of Ryde Rd	700	700	0	700	700	0
M2, b/w Lane Cove Rd and Delhi Rd	2,170	2,447	277	2,950	3,277	327
EPPING ROAD, East of Lane Cove Rd	2,300	2,121	-179	2,800	2,589	-211
Total	7,670	7,670	0	9,050	9,050	0
Eastern Screenline						
PACIFIC HIGHWAY, South of Fiddens Wharf Rd	1,450	1,343	-107	1,530	1,414	-116
GROSVENOR RD, b/w Lady Game Dr and Pac. Hwy	300	300	0	340	340	0
FULLERS ROAD, b/w Millwood Ave and Pac. Hwy	900	900	0	1,000	1,000	0
MOWBRAY ROAD WEST, b/w Epping Rd and Pac. Hwy	750	750	0	830	830	0
LANE COVE TUNNEL	2,564	2,671	107	3,708	3,824	116
EPPING ROAD, b/w Longueville Rd and Pacific Hwy	1,460	1,460	0	1,610	1,610	0
RIVER ROAD, Between Bridge St and Pacific Hwy	760	760	0	840	840	0
Total	8,184	8,184	0	9,858	9,858	0
Northern Screenline						
PENNANT HILLS RD, North of the M2	2,300	2,278	-22	2,250	2,230	-20
MURRAY RD, North of the M2	400	400	0	300	300	0
BEECROFT RD, North of the M2	1,000	978	-22	1,150	1,130	-20
LANE COVE ROAD, South of Lady Game Dr	3,900	4,050	150	4,230	4,385	155
DELHI ROAD, East of M2	860	860	0	940	940	0
PACIFIC HIGHWAY, b/w Mowbray Rd and Fullers Rd	2,420	2,313	-107	2,590	2,474	-116
Total	10,880	10,880	0	11,480	11,460	0

5.4.3.1 Local Impacts on Khartoum Road, Fontenoy Road, Yanko Road and Lady Game Drive

With addition of the new ramp, it provides vehicles originating from Macquarie Park with an option to gain access to the M2 motorway by Khartoum Rd and Fontenoy Rd. Modelling has shown that there is no additional traffic to these roads as a result of adding the new ramp, refer to Table 13. The toll provides a disincentive for such traffic to use the ramp especially given the improved intersection conditions along the Lane Cove Road and Epping Road.

Likewise for Lady Game Drive, where modelling showed little to no impact on volumes through the introduction of the ramp. Combined with the toll disincentive of both the ramp and LCT, and the reduction in traffic/congestion on the Pacific Highway, there is little incentive for road users heading east to re-distribute west to the ramp.

As highlight in Table 10, Comenarra Parkway had a daily impact of 200 vehicles in the eastbound direction as a result of introducing the new ramp. This impact continues through to Yanko Road as Comenarra Parkway feeds directly into Yanko Rd.

Table 13 – Local Impacts on Khartoum Rd, Fontenoy Rd, Yanko Rd and Lady Game Drive, by Time of Day

	2011 Base	2011 Project	Change	2021 Base	2021 Project	Change
Daily Eastbound						
Yanko Rd, West of Ryde Rd	9,500	9,700	200	10,500	10,700	200
Lady Game Drive , East of Ryde Rd	9,500	9,500	0	10,500	10,500	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	4,000	4,000	0	4,400	4,400	0
Daily Westbound						
Yanko Rd, West of Ryde Rd	9,100	12,200	0	10,000	10,000	0
Lady Game Road , East of Ryde Rd	9,600	9,600	0	10,500	10,500	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	300	300	0	330	330	0
AM Peak Hour Eastbound						
Yanko Rd, West of Ryde Rd	950	977	27	1,200	1,232	32
Lady Game Road , East of Ryde Rd	570	570	0	600	600	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	400	400	0	500	500	0
AM Peak Hour Westbound						
Yanko Rd, West of Ryde Rd	270	270	0	300	300	0
Lady Game Road , East of Ryde Rd	600	600	0	600	600	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	30	30	0	0	0	0
PM Peak Hour Eastbound						
Yanko Rd, West of Ryde Rd	430	444	14	500	516	16
Lady Game Road , East of Ryde Rd	700	700	0	700	700	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	610	610	0	700	700	0
PM Peak Hour Westbound						
Yanko Rd, West of Ryde Rd	930	930	0	1,000	1,000	0
Lady Game Road , East of Ryde Rd	1,090	1,090	0	1,100	1,100	0
Fontenoy Rd/Khartoum Rd b/w M2 and Lane	10	10	0	0	0	0

5.4.3.2 Operational Impact of future ramp metering

Analysis of the possible future introduction of ramp-metering⁵ has been undertaken to assess the adequacy of on-ramp (off Lane Cove Road) storage.

Whilst RMS (formerly RTA) discusses the design aspects of ramp metering in *Traffic Signal Design-Section 15 Special Situations* there is no guidance on the assessment of queue storage and cycle lengths required for ramp metering. Hence analysis for this report has used Section 6.3 of the Vicroads⁶ Freeway Signal Design Handbook that provides tables and equations for calculating the requirements for ramp metering dependent on the local conditions.

A range of ramp flows were assessed covering the full range of forecast flows as shown in Table 14; at the lower end of the range queues can be contained within the ramp even with a relatively long cycle time of 16 seconds; as flows increase cycle time needs to reduce but at 640 vehicles on the ramp (the forecast AM peak flow) and a 11 second cycle time there is still 34 metres of storage available within the ramp itself.

Notwithstanding this analysis, it should be noted that to fully manage freeway flow and congestion ramp metering should be provided at all entry ramps as an integrated system rather than at individual locations. Additionally if meters are only provided at individual locations, motorists are likely to adjust their travel patterns to avoid metered ramps, potentially increasing congestion at other locations on the network and hence ramp metering is not included in the Project Scope of works.

⁵ Ramp metering is the use of traffic signals on a ramp to control the flow of vehicles entering a mainline carriageway so as to maintain smooth flow and reasonable level of service on the mainline.

⁶ Vicroads – Roads Authority for State of Victoria (equivalent to NSW RMS).

Table 14 - Ramp Metering Assessment

	Range of Ramp flows assessed (vehicles per hour)				
	380	450	540	630	675
Average Cycle Length (seconds)	16	16	13	11	11s
95% Queue Length (metres)	161	183	215	246	261m
Spare Storage Available (metres)	119	97	65	34	19m

5.5 Intersection Performance

In addition to the changes within the motorway, described in Sections 5.4.1, the new ramp will change traffic patterns in the southbound direction of Lane Cove Road, increasing traffic to the north of M2 whilst decreasing flows to the south of the M2.

Transurban has used LinSig to model intersections along Lane Cove Road to determine the impacts of the ramp on intersection performance.

LinSig is a software tool which facilitates the modelling of traffic signals, making due allowance of traffic capacities and queuing to optimise signal timings to reduce delay or increase capacity. As shown in Figure 9, LinSig modelling was undertaken for the following signalised intersections along the Lane Cove Road corridor:

- Lane Cove Road/Epping Road
- Lane Cove Road/Waterloo Road
- Lane Cove Road/Talavera Road
- Lane Cove Road/M2 Motorway
- Lane Cove Road/Fontenoy Road
- Ryde Road/Lady Game Drive
- Ryde Road/Yanko Road

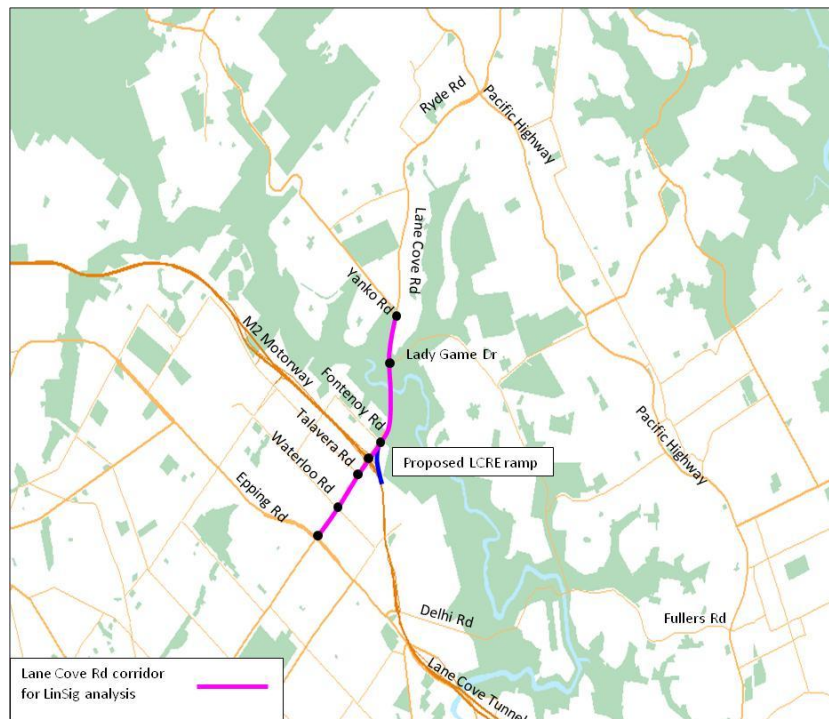


Figure 9 – Corridor on Lane Cove Rd for LinSig intersection performance analysis

The traffic demand forecasts for input to the LinSig analysis has been developed for 2011 and 2021 AM Peak (8-9am) and PM Peak (5-6pm) by the following method:

- Current Peak flows were derived from SCATS loop detector counts collected in March 2012. Such flows might be considered conservative (higher) as there is likely to be higher traffic on the arterial network than will be the Base case on completion of the M2 Upgrade – such as driven by the current diversion from the motorway due to the construction. Modelling of Existing (pre M2 Upgrade) and Base condition indicated no significant change in traffic flow along Lane Cove Road as a result of the M2 Upgrade.
- 2011 peak volumes were grown in line with the strategic modelling growth to yield 2021 flows.
- Project uplifts applied are consistent as those presented in Section 5.4.

Table 15 provides the LoS results and average intersection delay from the LinSig analysis for 2011 / 2021, AM / PM and Base / Project cases. The results show that there is generally 'no' change in the LoS for the intersections and this is consistent with the relatively small change in hourly traffic volumes. There are several exceptions, which are as follows:

- Ryde and Yanko Road in the 2011 AM peak has a slight decrease in LOS from a B to C
- Lane Cove and Fontenoy Road in 2021 AM peak has decreased from a LOS B to LOS D.
- Talavera and Lane Cove Road in 2011 AM peak has a slight increase in LOS from E to D.

Table 15 also shows the average delay across all intersections to the north and south of the M2. As expected, the northern intersections experience an increase in average delay from the additional vehicles redirecting to Lane Cove Road Eastbound Ramp. Whilst the southern intersections, in general experience a reduction in delays, as a result of less vehicles using Lane Cove Road as they divert from Lane Cove Road/Epping Road to access the new ramp/M2 motorway. The overall change in average delay for the LINSIG system is in generally zero. However, the LINSIG network doesn't consider the additional benefits that would arise from reduced flows and congestion at intersections along Epping Road between Lane Cove Road and M2 motorway

Changes to localised delays, queue lengths and the degree of saturation for individual approaches are provided in Appendix D.

Table 15 – Intersection Analysis Results

Approach	Statistics	2011				2021			
		AM		PM		AM		PM	
		Base	Project	Base	Project	Base	Project	Base	Project
Ryde/Yanko	LoS	B	C	B	B	C	C	B	B
	Average Delay	29	30	15	16	35	40	19	20
Ryde/ Lady Game	LoS	B	B	D	D	B	B	E	E
	Average Delay	19	20	47	49	21	23	58	65
Lane Cove/ Fontenoy	LoS	B	B	C	C	B	D	D	D
	Average Delay	23	29	30	33	25	49	48	49
Lane Cove/ M2	LoS	A	A	A	A	A	A	B	B
	Average Delay	9	8	13	12	9	10	16	16
Lane Cove/ Talavera	LoS	F	F	E	D	F	F	F	F
	Average Delay	112	82	63	55	146	116	86	84
Lane Cove/ Waterloo	LoS	F	F	D	D	F	F	F	F
	Average Delay	72	72	44	44	131	132	77	79
Lane Cove/ Epping	LoS	C	C	C	C	C	C	D	D
	Average Delay	35	41	39	39	40	41	50	45
Average Delay of Intersections North of M2		20	22	27	28	22	30	37	39
Average Delay of Intersections, South of M2		73	65	48	46	106	97	71	70
Average delay of the System.		43	40	36	35	58	58	50	46

See Appendix D for more detailed intersection performance results

5.6 Travel Times and Speeds

5.6.1 Travel Time Benefits of Lane Cove eastbound on-ramp

To assess impacts on travel times three routes have been selected, each looking at travel from the Pacific Highway / Ryde Road interchange through to the Pacific Highway / M2 Motorway interchange as indicated in Figure 10, with description as follows:-

- **Route 1:** Start at Pacific Hwy Junction with Ryde Road/ (at Gordon) travel south along Ryde Road and enter M2 from the new ramp and travel east along the M2/LCT until the junction with the Gore Hill Freeway.
- **Route 2:** Start at Pacific Hwy Junction with Ryde Road/ (at Gordon) travel south along Ryde Road and then left to Epping Rd, enter the LCT until the Junction with Gore Hill Freeway.
- **Route 3:** Start at Pacific Hwy Junction with Ryde Road (at Gordon) and continue along Pacific Highway to the junction with the Gore Hill Freeway at Artarmon

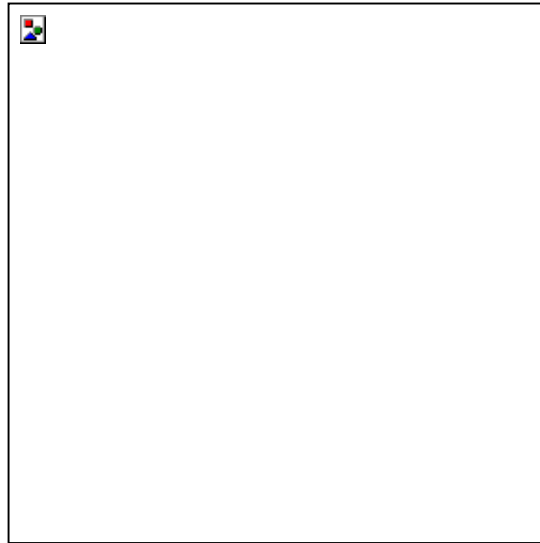


Figure 10 – Travel Time Routes

Typical travel time savings (have been estimated using TUSTM and are presented in Table 16. Route 1 (utilising the new ramp) generally offers time savings of up to 7 minutes against the two existing route options. Whilst time savings of Route 1 versus Route 3 are at the lower end (and are deemed neutral in the AM Peak) Route 1 requires travel through 20 less signalised intersections and drivers are likely to choose such route with only nominal time savings given the uncertainty and stop / start nature of travel through signalised intersections.

Table 16 - TUSTM Travel Time route outputs (minutes)

Indicative	AM PEAK	INTER PEAK	PM PEAK
Route 1 (new Lane Cove Road and new ramp)	25	9.5	12
Route 2 (existing via Lane Cove Road)	29.5	15	19
Route 3 (existing via Pacific Highway)	25	12	16
Time Savings (Route 1 vs Route 2)	4.5	5.5	7
(Route 1 vs Route 3)	0.0	2.5	4
Reduction in Signals (Route 1 vs Route 2)		6	
(Route 1 vs 3)		20	

Source: TUSTM 2011 project condition

5.7 Impacts on Pedestrian and Cyclist Access

The Lane Cove eastbound on-ramp introduces traffic complexity to an area which currently has very ad-hoc and hap-hazard pedestrian and cyclist facilities.

Transurban engaged GHD to undertake analysis on the impacts of the LCRE ramp on pedestrian movements on Lane Cove Road. To inform the analysis four pedestrian and cyclist movement counts were undertaken for Lane Cove Road between Fontenoy Road and Talavera Road, as shown in Figure 11 with results as shown in Table 17. The counts were conducted between 7 am and 9 am on April 5, 2012.

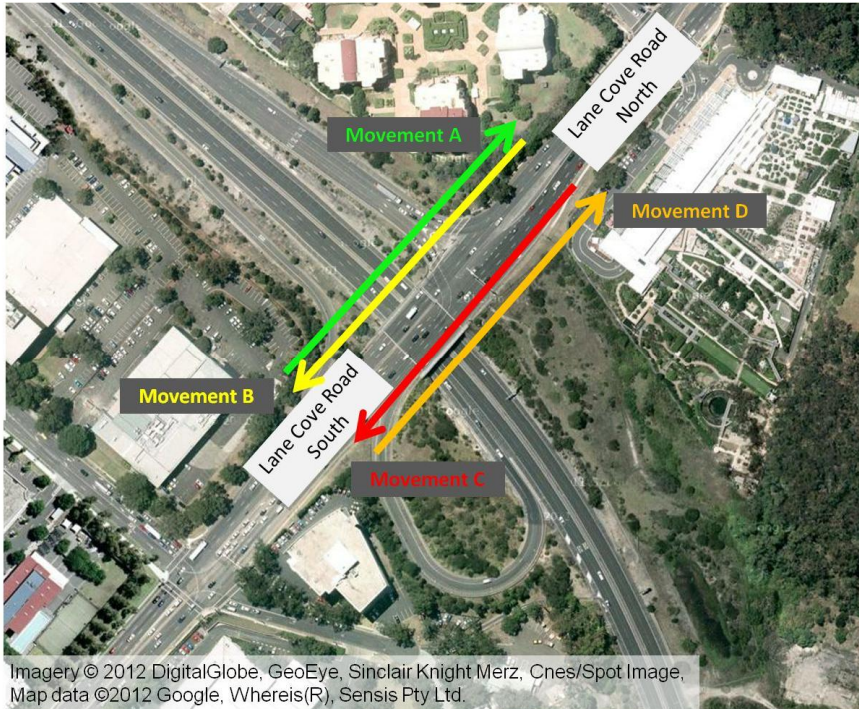


Figure 11 – Pedestrian and Cyclist movements on Lane Cove Road

Table 17 – AM Peak Pedestrian and Cyclist Counts across Lane Cove Road

	No. of Pedestrians				No. Of Cyclists			
	A	B	C	D	A	B	C	D
7:00 to 7:30	13	0	1	1	0	0	1	0
7:30 to 8:0	19	1	2	2	4	2	1	0
8:00 to 8:30	23	0	0	0	1	0	4	0
8:30 to 9:00	21	1	0	0	0	1	2	0
Total	76	2	3	3	5	3	8	0

Six pedestrians walked along the eastern side of Lane Cove Road where no formal crossing facilities are provided and crossed the M2 westbound entry loop. However, the majority of pedestrians (78) used the formal pedestrian facilities on the western side of Lane Cove Road.

Eight cyclists utilised the on-road bicycle lane travelling southbound on Lane Cove Road, while five southbound cyclists and three northbound cyclists travelled on the western side of Lane Cove Road, where no formal bicycle facilities are provided.

There are no formal pedestrian facilities on the eastern side of Lane Cove Road crossing the bridge over the M2. A concrete footpath is provided along the front of the Eden Gardens development; however this

terminates approximately 70 metres north of the M2 overpass. Likewise, a footpath extends north of Talavera Road and ends approximately 40 metres south of the M2 entry ramp. Pedestrians continue without a formal path, following a dirt track to the bridge over the M2. No formal crossing facilities are provided at the M2 northbound entry ramp. 'No Pedestrians' and 'No Cyclists' signs have been erected at the start of the entry ramp, however it is unclear whether this applies to pedestrians and cyclists using the ramp or attempting to cross it.

Photos of the current arrangement are available in Appendix E.

5.7.1.1 Proposed Future Arrangement

It is proposed that all pedestrian access on the eastern side of Lane Cove Road between Fontenoy Road and Talavera Road be closed. Pedestrians will be redirected via the signalised crossing at Fontenoy Road and the signalised crossing at Talavera Road. This aims to improve pedestrian safety due to the lack of formal pedestrian facilities and crossings on the eastern side of Lane Cove Road.

Pedestrian access would be restricted through the use of additional signage to direct pedestrians to facilities along the western side of the road.

The on-road bicycle lane for cyclists on Lane Cove Road will be maintained.

5.7.1.2 Pedestrian and Cyclist Assessment

The impacts of the proposed closure on Lane Cove Road eastern footway have been assessed by estimating the extra delays, travel times and distances for pedestrians travelling between the southeast corner of the Fontenoy Road/Lane Cove Road intersection and the northeast corner of the Talavera Road/Lane Cove Road intersection, as shown in Figure 12.

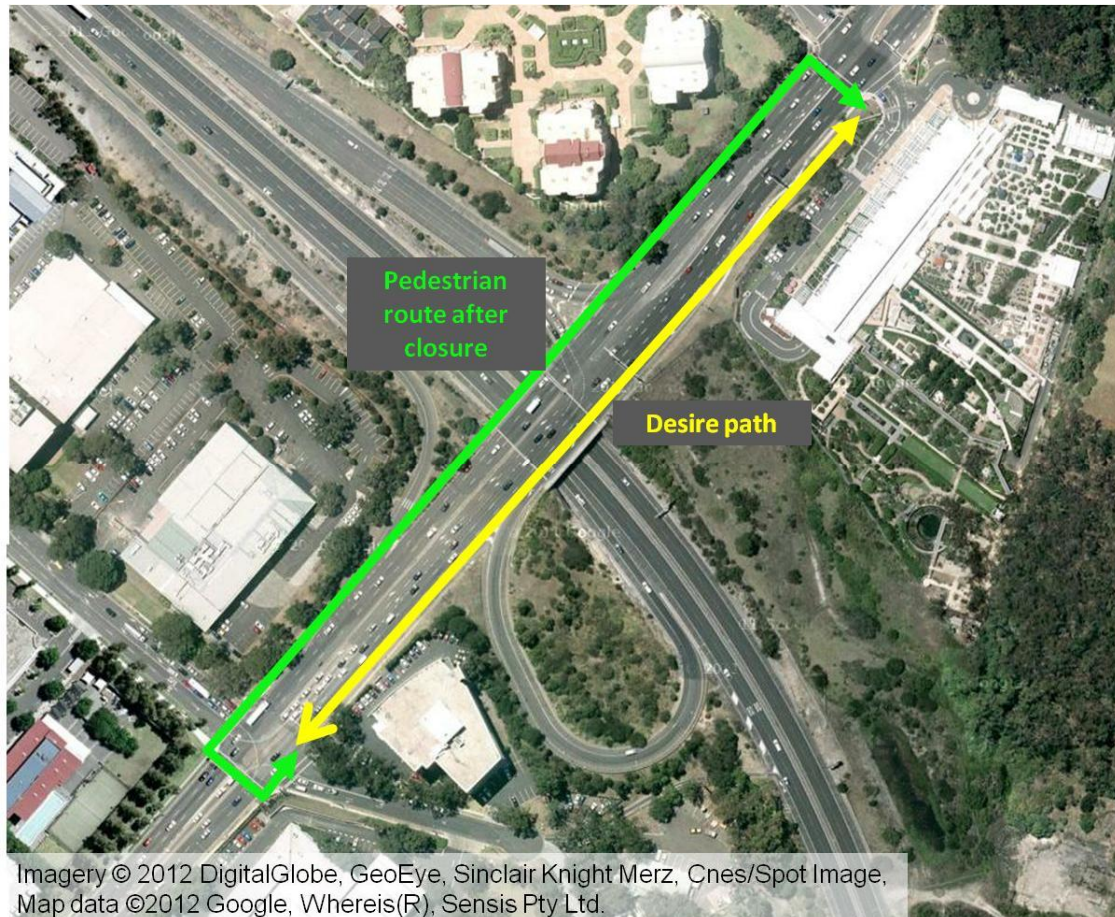


Figure 12 – Re-directed route for pedestrians after closure

Under the proposed treatment, pedestrians will walk across four signalised crossings, as there is currently no east-west crossing for pedestrians on the northern side at Talavera Road. The average pedestrian delay in the AM peak at the Fontenoy Road intersection is 106 seconds, and at the Talavera Road intersection it is 96 seconds. Using this information, the average total delay for pedestrians to cross Lane Cove Road at these intersections will be 202 seconds. The additional distance pedestrians are required to walk will be approximately 140 m, which would increase their travel time by approximately 116 seconds, based on AustRoads guidelines of 1.2 m per second. This would result in an increase of 318 seconds to the travel time of pedestrians being diverted to the western side of Lane Cove Road. However, as the existing utilisation of pedestrians walking on the eastern side of Lane Cove Road is very low, these extra travel times and distances are minor.

5.8 Commercial Vehicle Movements

Whilst commercial vehicles will be able to get the advantages as described above – they are a very low proportion of the vehicle fleet in the vicinity.

5.9 Emergency Service Vehicles

A direct ramp into the M2 motorway provides better access for emergency service vehicles in response to an accident or incident along the motorway.

5.10 Public Transport

Currently Sydney Transport Authority (STA) buses run 2 services along Lane Cove Road past the proposed Lane Cove Rd eastbound ramps (LCRE). These are:

- 292- Marsfield to Sydney CBD (Queen Victoria Building) via Epping Road and Gore Hill Freeway
 - o 8 services during AM Peak (7am-9am) at approximately 15 minute headways
- 545- Parramatta to Chatswood via Eastwood Station and Macquarie University
 - o 10 services during AM peak (7am-9am) at approximately 12 minute headways

The routes in the vicinity of LCRE are shown in Figure 13. Both services use Lane Cove road southbound to Epping Road and then continue down Epping Road. Service 545 then turns onto Delhi Road to Chatswood while the 292 continues south along Epping Road.

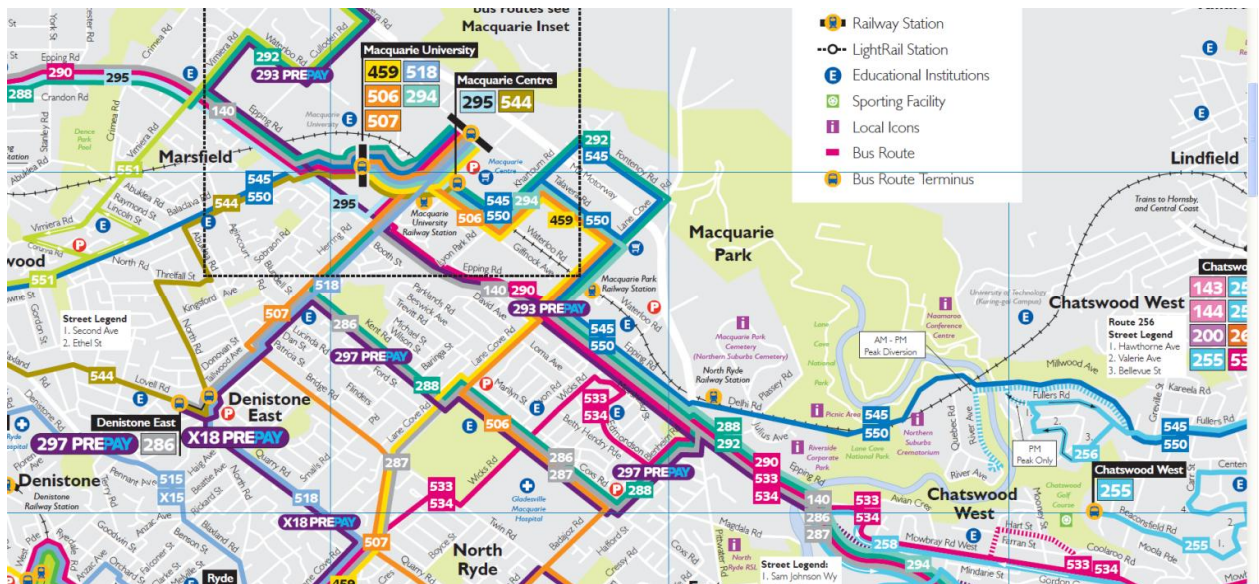


Figure 13 – Bus Routes in vicinity of LCRE

Given the frequency of these services it is unlikely they will be impacted by additional traffic on Lane Cove Road because of LCRE. The provision of LCRE does provide the opportunity to run express 292 bus services via the M2 and Lane Cove Tunnel to the Gore Hill freeway as an alternative to Epping Road. However; given the availability of several other bus services as well as heavy rail options to the city it is unlikely that this would be a viable option.

5.11 Summary of Project Outcomes

The Lane Cove Road eastbound on-ramp essentially constitutes a local improvement in access, whose impacts are summarised as follows:-

- Attracts some traffic from the Pennant Hills / Beecroft Road route to the eastbound motorway to travel via a combination of Pacific Highway, Yanko Road to access Lane Cove Road southbound and travel onto the eastbound motorway via the new ramp;
- Attracts some traffic from the eastbound Pacific Highway between Lane Cove Road and Gore Hill freeway that can now access the motorway from Lane Cove Road and new ramp - such traffic currently remains on Pacific Highway as the route to the M2 involves travel through the busy Lane Cove Road and Epping Road interchange.
- Attracts traffic currently on Lane Cove Road that is required to access the M2 via the southern end of Lane Cove Road and the merge onto the M2 from Epping Road.

All traffic that diverts from its base routes do so because they perceive a direct benefit to them. In diverting they lead to a general reduction across the arterial network (Pacific Highway east of Lane Cove Road, Lane Cove Road and Epping Road south west of the respective motorway crossing points) with traffic able to access the motorway network more efficiently. The southbound section of Lane Cove Road between Pacific Highway and the new ramp does see some modest increases in traffic and an assessment of operations was undertaken using the LINSIG software package and showed that there were marginal decreases in the level of service. South of the new ramp, the LINSIG analysis generally showed an improvement in intersection delays as a result of modest decreases in southbound volumes.

As part of the project it is deemed sensible to formalise current ad-hoc pedestrian on the eastern side of Lane Cove Road between Fontenoy Road and Talavera Road to the western side, and this again has little impact given the very light flows of cyclists and pedestrians in the vicinity.

Regards operations within the motorway, analysis of weaving and merging volumes shows that projected volumes can be managed without issue – indeed a major benefit of the scheme is that traffic can enter directly from the new ramp and reduce entry volumes at the current merge from Epping Road that is a little constrained.

The need for ramp metering on the new ramp was considered, however it was concluded that the only rationale for ramp metering would be to limit flows entering the motorway, and given the proposed ramp would improve conditions on most sections of the M2 and Lane Cove Rd as a result of the changed patterns, ramp metering isn't considered to be justified. In any case, ramp metering would only be effective as broader traffic management strategy across a broad section of the orbital network. The design of the new ramp would not preclude any such future initiative.

6.0 Construction Impacts

The potential construction related traffic impacts relate to:

- Generated construction traffic on the M2 Motorway and surrounding roads.
- Traffic management measures required to be established on the M2 Motorway and Lane Cove Road during construction.

Construction generated traffic is anticipated to be approximately 40 heavy vehicle movements and 110 light vehicle movements per day, with the majority utilising the M2 Motorway and Lane Cove Road. Vehicle movements may also occur along Wicks Road, however these are anticipated to be minor. These volumes are considered to be negligible in comparison to the daily and peak traffic volumes currently using the M2 Motorway and Lane Cove Road (refer to section 5.4.1 and 5.4.3).

Traffic management measures will be required on the M2 Motorway during the construction phase in order to provide a safe working environment to undertake the construction works. This will involve separation of traffic lanes and the working area using concrete barriers and the possible implementation of a reduced speed limit on the M2's eastbound carriageway. (The extent of the speed reduction will be determined at the detailed design stage of the project). There would also be occasions when the trafficable lanes on the eastbound carriageway of the M2 Motorway would need to be closed to traffic, however this would be restricted to outside of peak periods and would be coordinated with the Hills M2 Motorway Control Room.

Works along Lane Cove Road would also require the occasional closure of traffic lane/s on Lane Cove Road's southbound carriageway and reduced speed limits when lane restrictions were in place. Again, this would be restricted to outside of peak periods and would be subject to approval from the RMS and the Transport Management Centre of Transport for NSW.

Overall, the potential construction traffic impacts are not considered to be significant and would be temporary in nature and mitigated by planning all lane occupancies with the aim to:

- minimise the actual work area
- limit obstructions and restrictions
- avoid peak flow periods and analyse traffic volume data to identify the capacity requirements and plan works to minimise disruption.

Cyclists

Cyclists are currently temporarily excluded from using the M2 Motorway during the M2 Upgrade Project as construction activities occupy the breakdown lane. The construction of the new on-ramp would occupy the breakdown lane between Lane Cove Road and Delhi Road, necessitating the exclusion of cyclists along this section.

An alternative off-motorway cycle route has been established as part of the approved M2 Upgrade Project between Delhi Road in the east and Old Windsor Road in the west. The section of the alternative off-motorway cycle route between Lane Cove Road and Delhi Road may be utilised by cyclists during the construction of the proposed on-ramp.

Whilst this route is longer than the route along the M2 Motorway, safe cycling facilities cannot be provided on this section of the motorway during construction.

Appendix A Model Development and Assumptions

TUSTM was originally developed in early 2005 by Transurban's Traffic Forecasting Group (TFG) building from research, models and data files created by consultants commissioned by Transurban prior to this time. Since then, progressive updates and enhancements by TSG have ensured its currency and accuracy for the purposes of annual reporting, prospective bids, and network changes. As such, it provides the foundation for traffic predictions, and remains a comprehensive tool for estimating the impact of significant network changes in terms of both traffic and revenue implications on Sydney toll roads. The TUSTM utilises the Cube Voyager software platform.

The modelling structure and validation of Version 8 of the TUSTM, particularly relating to the modelling investigation of the M2 Upgrade is summarised below.

Traffic Forecasting Methodology

TUSTM is used as a forecasting tool, predicting traffic conditions at defined future points in time, namely the forecast years of 2011, 2016 and 2021 having been calibrated and validated to a base year of 2006. The input land use assumptions are based on TDC's published land use information. The capacity of the road network links are based on actual lane configuration and sign posted speed limits. For future links such as F3 to M2 assumptions have been made as to lane capacity, toll rates and sign posted speed limits similar to other motorways in the Sydney network.

TUSTM General Characteristics

The general characteristics of the TUSTM are:

- Trip tables for base and future years; the base year trip tables used in TUSTM have recently been developed and validated by consultant Sinclair Knight Merz (SKM) using data supplied by the Bureau of Transport Statistics (BTS). Future year trip tables apply growth factors derived from future year land use projections. The tables are segmented into five categories and assigned to the transport network as separate vehicle classes:
 - Car Commute;
 - Car Business;
 - Car Other;
 - Rigid Trucks; and
 - Articulated Trucks.
- The model is segmented to 4 time period (AM peak, inter peak, PM peak and overnight) an average workday model and calibrated to a "base year" of 2006 using strategic screen-line counts and travel time data;
- Primarily a road based model with public transport travel addressed through direct cross elasticity;
- Model includes 919 travel zones covering the Sydney metropolitan area;
- The travel times on a road link vary depending on the traffic volume, the number of mid-block lanes and the road type, according to "speed-flow" relationships. Strategic intersection delay, acknowledging the volume into a junction and its capacity are incorporated in the speed-flow relationships as are the impact of varying availability of lanes by time of day;
- The input networks include network upgrades and demand management measures that can affect the traffic behaviour including assumptions regarding future projects and timing of works. The future projects are based on the approved list of projects, major network changes and upgrades; as discussed and agreed with RMS;
- The perceived out-of-pocket toll cost is incorporated into a generalised cost function which is used as the measure of impedance in the trip assignment process;

- The equivalent time penalty is calculated from the toll price using relevant Value of Travel Time (VOT). This time penalty is then included in the generalised cost of the tolled route and the assignment algorithm is free to allocate trips between tolled and untolled routes;
- Toll caps are fully captured in the process (specifically that of Westlink M7);

The assignment process works iteratively until such point that balance is achieved between travel demands and network delays for each zone-to-zone paths.

Assignment within TUSTM

Figure 14 describes the process of assignment in TUSTM.

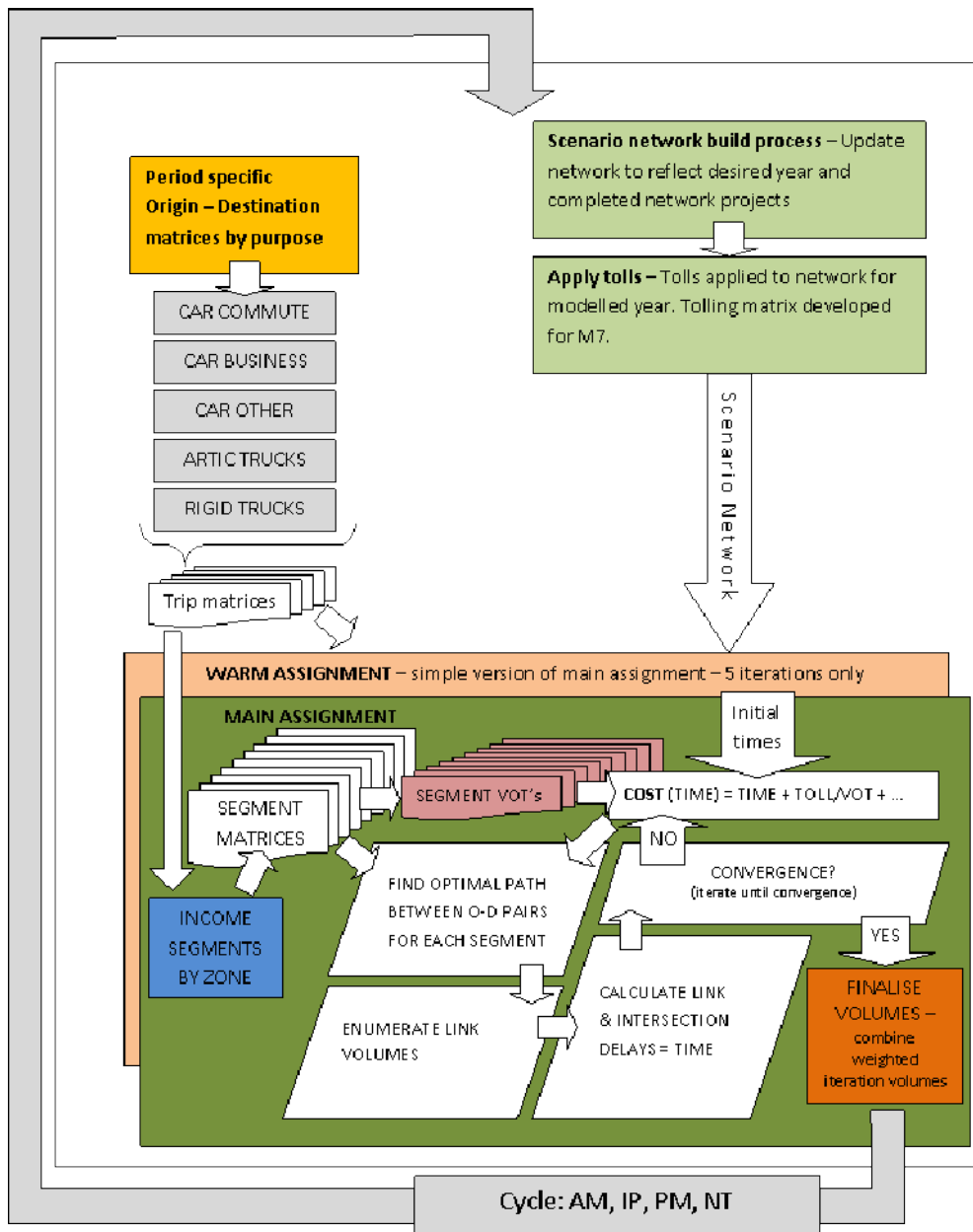


Figure 14 - Overview of TUSTM Assignment

The trip matrices are split by vehicle type and purpose. The private car purposes (commute, business and other) are further segmented by 3 household income groups being high, middle and low. This further segmentation allows for further divisions of value of travel time (VOT), and by increasing the number of segments allows a more detailed assessment of tolled versus non-tolled choice across the network. The segmentation occurs at a zonal level and is based on household income data from the 2006 census. The sensitivity to geography is important as it acknowledges that there are lower income and higher income suburbs across the Metropolitan area.

Figure 15 shows the family income bands by statistical sub-division and indicates a reasonably wide range of family incomes across Sydney. Observations are:

- Lowest family incomes are in the South West of Sydney (Fairfield, Liverpool, Canterbury and Bankstown) where some 40% to 50% of families have a weekly family income of \$1,000 or less;
- Highest family incomes are in the Lower North Sydney suburbs of Kirribilli and Mosman and the Eastern Suburbs where 60% to 65% of families have a weekly income of \$2,500 or meaning 35% to 40% of families have a weekly income of over \$2,500.

This pattern will lead to differential values of times across the region and explains the presence of cashback⁷ on the M4 and M5 motorways where the former Labour Government was looking to offer some relief to the less well-off families of the South and West.

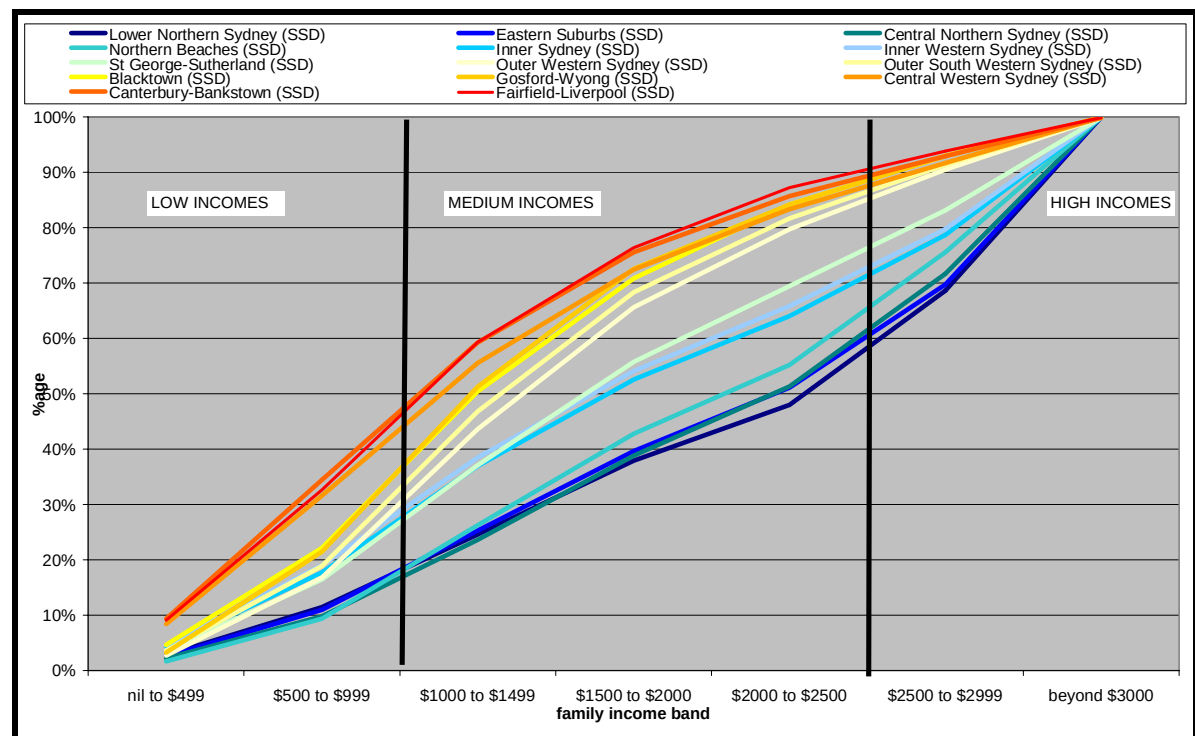


Figure 15 - Sydney Income Distribution

⁷ The NSW Government introduced the M4/M5 Cashback Scheme on 1 January 1997. Cashback allows NSW residents to claim back the value of tolls (excluding GST) paid while using privately registered vehicles on the M4 and M5 motorways.

Road Network Representation

The roads that are generally represented within the traffic model network are Secondary Main Roads, Primary Main Roads, Motorways and Tollways, according to SYDWAYS classification. Road characteristics such as the number of lanes, road type, posted speed, trams, parking bans, divided road, distance and intersection flaring have been included in the model and have been used to determine road capacity.

The model network comprises a series of nodes and links. Nodes represent transport zone centroids and intersections between roads and connectors. A connector is a link that connects a transport zone centroid with the road network. Links generally represent both road sections between two intersections (nodes) and centroid connectors. Links also store the road characteristic information that the model requires for modelling.

The model contains 919 transport zones, of this 906 are internal zone and 13 are external zones. A transport zone represents a small area of metropolitan Sydney. The external zones represent connections between major highways and Motorways beyond the boundaries of metropolitan area, i.e. Hume Highway to Melbourne.

All links in the network have been adjusted to reflect:

- Time period and the directionality of lanes (i.e. tidal flow arrangements);
- Presence of Transit lanes (high occupancy vehicle lanes) which restrict access to those cars with 2 or more occupants (T2 lanes) or 3 or more occupants (T3 lanes) and in so doing restrict the capacity available for single occupancy vehicles; Transit lanes can be time of day specific;
- Bus lanes - restrict all cars from the lanes and are only for buses; and
- Parking restrictions also vary by time of day with AM or PM peak clearways increasing lane availability in the peak periods above that available in the inter-peak and off peak periods.

Networks for each forecast year are built from a base year network and a set of network changes to represent future projects and/or changes in operating conditions along routes.

Vehicle Type and Passenger Car Unit

In describing the capacities of links, the term “passenger car unit” (PCU) has been introduced. The PCU is the means of reflecting the impact of trucks on the network whereby they take up more road space, are generally slower to accelerate and hence take up more capacity than the car. PCU values adopted within TUSTM are:

- Cars have a PCU value of 1;
- Rigid Trucks have a PCU value of 2; and
- Articulated Trucks have a PCU value of 2.5.

A capacity of a motorway lane is often taken as 2,000 vehicles per hour per lane, however it will be dependent on the vehicle type mix and implies a higher PCU capacity. As noted in section 5.1 TUSTM adopts a PCU capacity of 2,200 PCUs per lane per hour for motorways which comprises of vehicle type mix of order:

- 1850 Cars yielding 1850 PCUs;
- 90 Rigid Trucks yielding 180 PCUs; and
- 60 Articulated Trucks yielding 150 PCUs.

Hence in total some 2,000 vehicles equate to 2,180 PCUs

Link Types within TUSTM

The TUSTM allocates each and every real road link to one of nine categories, whilst symbolic links between zones and the real road network (centroid connectors) are a tenth category.

The link type is the key to describing the “base” hourly capacity per traffic lane available. The link types and the nominated base capacity are shown in Table 18.

Table 18 - TUSTM Hourly Lane Capacities

DESCRIPTION	LINK TYPE	HOURLY LANE CAPACITY (VEHICLES)	HOURLY LANE CAPACITY (PCU)
Freeways/Motorways	1	2000	2200
Ramps	2	1650	1300
Motorway-to-Motorway Ramps	2.5	1650	1815
Major Arterials	3	1800	1980
Arterials	4	1650	1815
Sub-arterial	5	1500	1650
Collectors	6	1000	1100
CBD Streets	7	900	1000
Residential Streets	8	550	600
Centroid	9	N/A	N/A

Table 18 above details theoretical hourly lane capacity based on the number physical lanes in the network. However, in practice the number of available lanes can vary by:

- Time period and the directionality of lanes (i.e. tidal flow arrangements to maximise peak direction flows);
- Presence of Transit lanes (high occupancy vehicle lanes) which restrict access to those cars with 2 or more occupants (T2 lanes) or 3 or more occupants (T3 lanes) and in so doing restrict the capacity available for single occupancy vehicles; Transit lanes can be time of day specific;
- Bus lanes - restrict all cars from the lanes and are only for buses;
- Parking restrictions also vary by time of day with AM or PM peak clearways increasing lane availability in the peak periods above that available in the inter-peak and off peak periods.

These factors are individually catered for within TUSTM and lanes are adjusted accordingly to match conditions of the 2006 Base Network. Within TUSTM the following capacity adjustments are made for Transit Lanes:

- T2: 20% of link type theoretical capacity; and
- T3: 5% of link type theoretical capacity.

The above assumptions apply equally across all time periods.

For the purposes of modelling the proposed M2 Upgrade T2 lane, a car occupancy survey was undertaken by AusTraffic during the AM and PM peaks at various locations along the M2 motorway. The following capacity adjustment has been made to the proposed M2 upgrade T2 lane based on the survey results:

- AM EB T2 Lane between Terry's Creek and Lane Cove Road assumed 13% of motorists T2 or above. Therefore total AM capacity equivalent to 2.13 lanes
- PM, OP and NT EB T2 Lane between Terry's Creek and Lane Cove Road assumed 21% of motorists T2 or above. Therefore total PM and Off Peak capacity equivalent to 2.21 lanes

Modelling of Network Times and Delays

Travel times along each link comprise of:

Time / delay incurred whilst traversing the mid-block section of a road between intersections – these are a function of mid-block distance, free-flow speed and the prevailing volume-to-capacity ratio of each iteration;

Additional delays due to intersections – these are a function of approach volume (sum of all link volume), approach capacity (can be different from link capacity i.e. flared lanes at stop lines) and interaction with other traffic (from other links) through the intersection i.e. needs consideration of total flows and capacities of all links into the intersection as well as some regard to intersection capacity.

Figure 16 shows speed-flow curves within TUSTM.

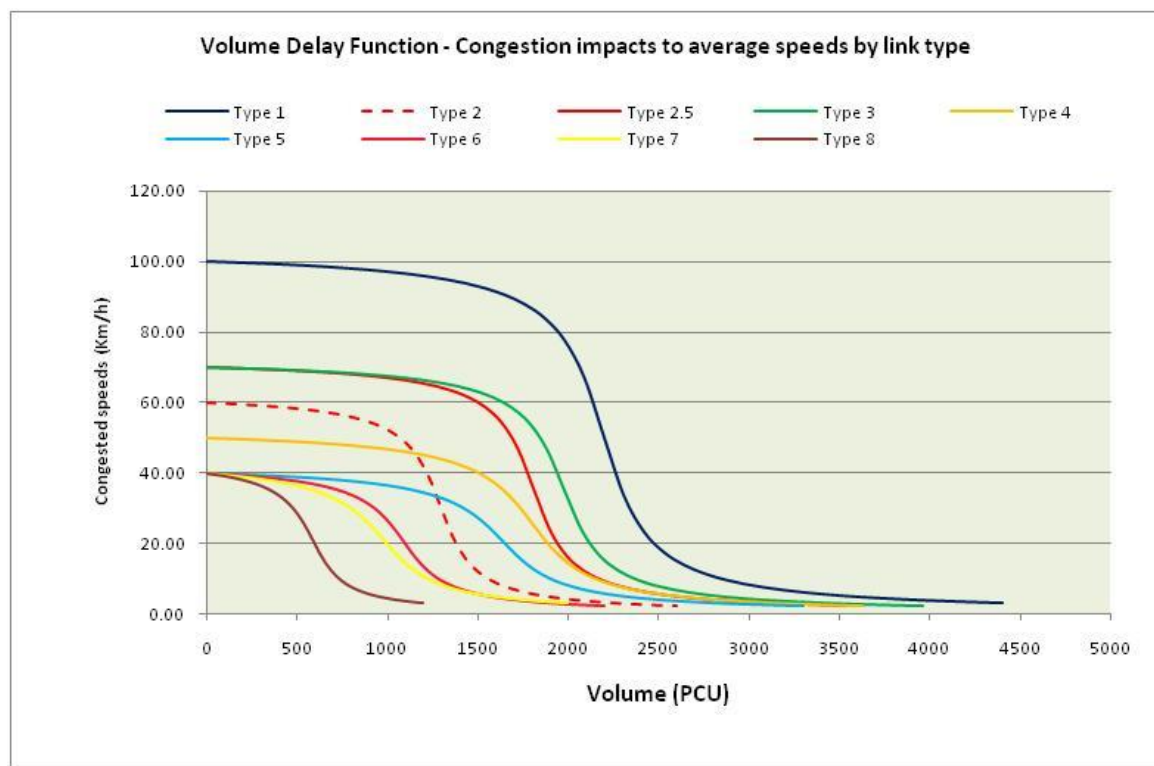


Figure 16 - TUSTM Volume Delay Functions

Base Year Model Calibration/Validation

Base Year Trip Tables

Sinclair Knight Merz (SKM) were commissioned by Transurban in 2006 to estimate and validate base year trip tables (2006) for each of the market segments and time periods of the TUSTM. Trip tables were estimated for the five categories of Car Commute, Car Business, Car Other, Rigid Trucks and Articulated Trucks and for the four time periods of AM Peak, Inter Peak, PM Peak and Night Time.

SKM estimated the 2006 trip tables from data and raw model outputs from the Sydney Traffic Model (STM) of The Bureau of Transport Statistics (BTS), and utilised the earliest implementation of the STM non-home based models; the lack of non-home based models in earlier STM releases has always been acknowledged as a weakness for the estimation of trip tables outside of the peak periods.

Network Audit

As part of the calibration and validation of the base year model, a full independent network audit was undertaken by SKM to ensure the accuracy of all link attributes such as:

- Traffic lanes available;
- Link type; and
- Link distance.

Attributes were confirmed using recent aerial photography and road inventories where appropriate. A detailed report noting all amendments was provided by SKM.

Validation Criteria

A set of model validation criteria has been adopted for assessing the TUSTM performance and its “fitness for purpose”. These are based on recognised international best practice for modelling. Specifically the threshold criteria adopted for TUSTM has been drawn from traffic model calibration guidelines published by the UK Highways Agency (Traffic Appraisal Advice, Highways Agency, May 1996) and Land Transport NZ (at the time called Transfund NZ).

Screenline Validation

The RMS has a system of screenlines at which it collects traffic data on a regular and continuous basis. Screenlines are used to ensure that the model accurately represents the movement of vehicles along natural corridors within the network. They are designed to cover all of the logical choices available to drivers moving between the major segments of the city. As such they provide a comprehensive and detailed method of evaluating whether there are geographic distortions in the model that would otherwise not be evident.

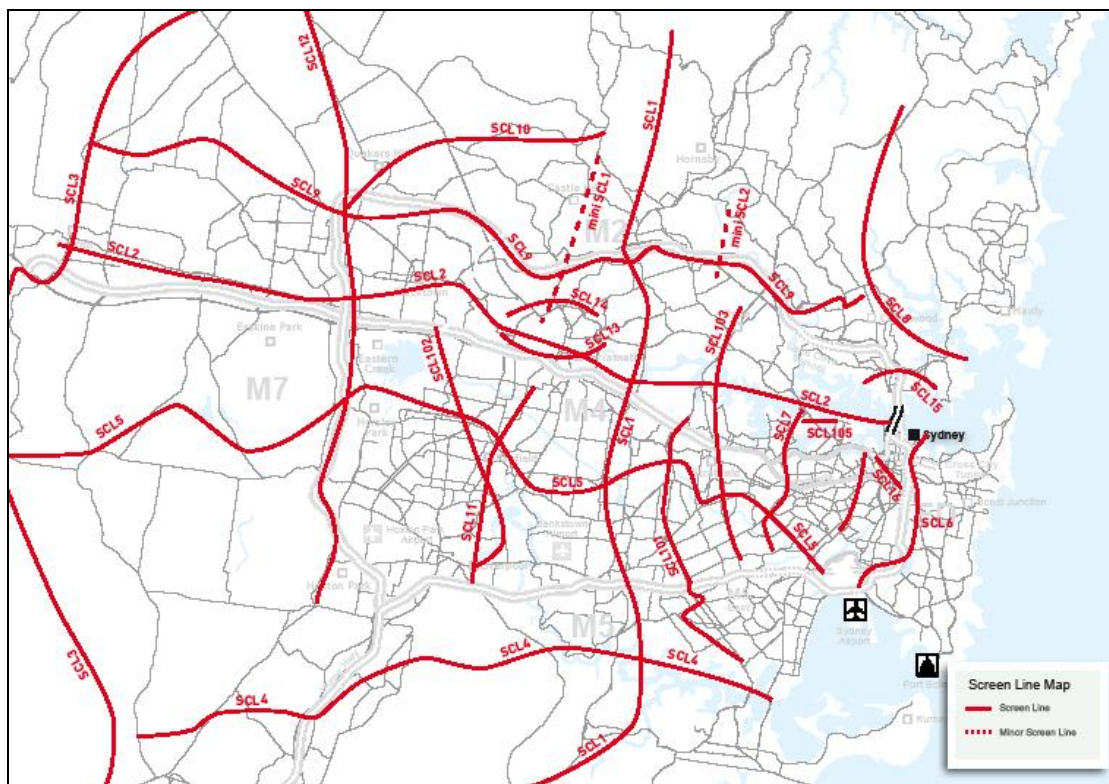


Figure 17 - Screenline Locations

Figure 17 above shows all screenline locations as maintained by RMS. The RMS continuously collects data at specific points along each screenline.

In order to validate the screenline volumes, scatter plot analysis has been undertaken. Modelled and observed volumes are plotted as part of the scatter plot analysis and a linear regression line of goodness-of-fit derived. The target criterion for the scatter plot analysis is given by two measures:

- A coefficient of determination (R²) of 0.85 is generally considered to represent a high level of correlation between the two data sets; and
- the slopes for the best-fit line should be in the range of 0.9 and 1.1 to represent a strong goodness-of-fit.

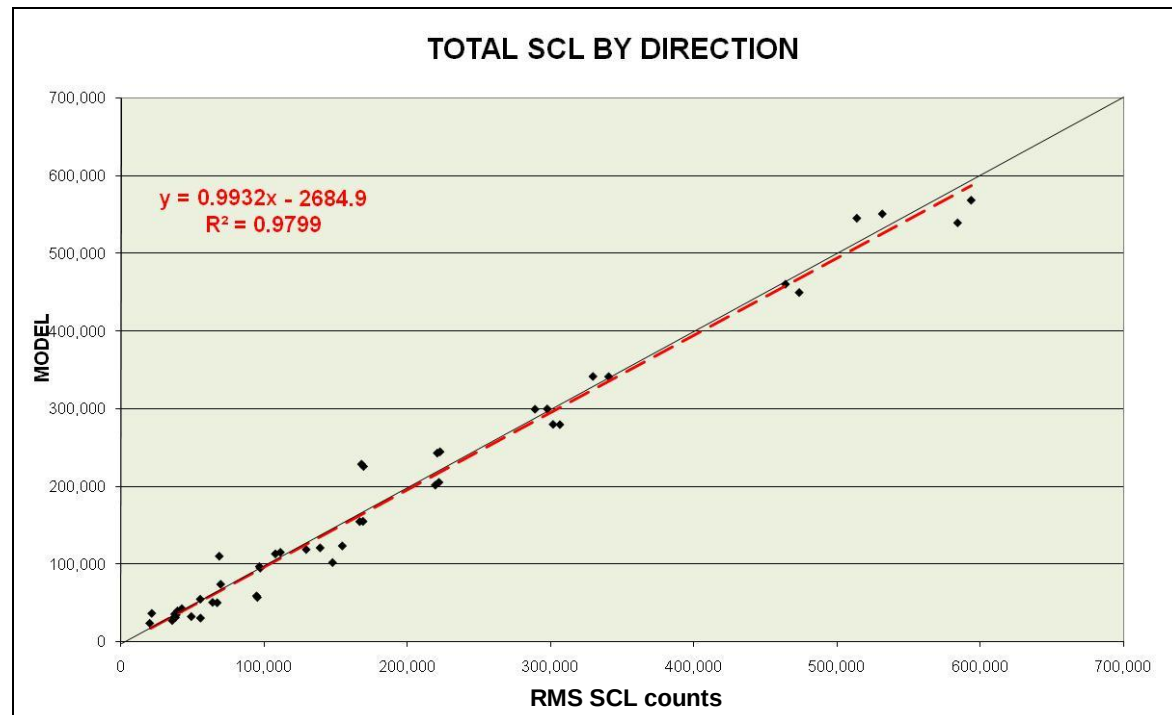


Figure 18 – 2006 Daily Screenline Validation

Figure 18 represents scatter plot analysis for daily screenline totals by direction. It shows an excellent “goodness of fit” (0.98) and equally good slope (0.99), indicating that the assigned trip matrices are fit for purpose.

Toll Point Validation

The GEH statistic is named after Geoff E. Havers (hence the name GEH) of the Greater London Council and is in the form of the Chi-square measure of fit. It is defined as:

$$GEH = \sqrt{\frac{(V_2 - V_1)^2}{0.5(V_2 + V_1)}}$$

V_1 = Modelled Flow (in Vehicles/Hour)

V_2 = Observed Flow (in Vehicles/Hour)

The GEH statistic is considered a useful measure of the performance of a model in a particular area. Examination of absolute or relative differences can provide misleading results over a wide range of volumes. A large percentage difference may relate to a small absolute difference on a lightly trafficked

link, and a small percentage difference may relate to a large absolute difference for links with greater volumes. The GEH statistic is less sensitive to these variations and gives roughly the same result for both large and small volumes with the same degree of error.

Generally accepted GEH targets are:

- At least 60% of individual link volumes should have a GEH value of ≤ 5
- At least 95% of individual link volumes should have a GEH value of ≤ 10
- All individual link volumes should have a GEH value ≤ 12

Table 19 – 2006 Daily Toll Point Validation

TOLL POINT	OBSERVED DAILY	MODEL DAILY	GEH
M2 Main	71,660	71,296	0.27
M2 Pennant Hills	24,567	19,896	6.40
M4	113,391	116,586	1.92
M5	114,404	115,836	0.86
ED	52,068	41,592	9.88
M7	119,858 ⁸	136,306	9.38

Table 19 is a comparison of modelled and observed daily toll point volumes. As seen, all locations are within the prescribed criteria.

Journey Times

Journey time surveys have been collected for a wide range of routes throughout Sydney and include number of the key routes relevant to the study area. Validation of modelled travel times against the observed travel times involves plotting the two sources on an accumulating distance axis – thereby providing an understanding of any variation between travel times and where on the network the variation may occur.

The results presented in Figure 19, Figure 20, Figure 21 and Figure 22 show comparison of modelled and observed AM and PM peak travel times along the M2 and the alternative free route. As shown the modelled results is-compare extremely well to observed travel times along both M2 and alternative in both periods and directions.

⁸ Observed data effected by ramp up

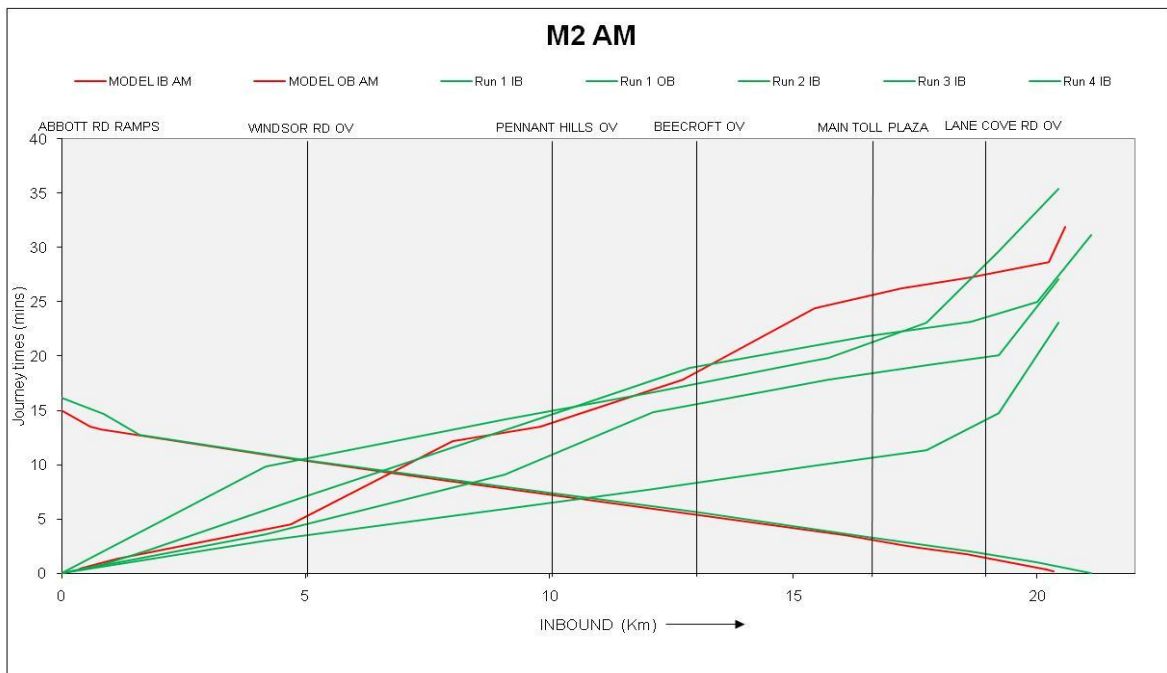


Figure 19 - Modelled M2 AM Peak Travel Time

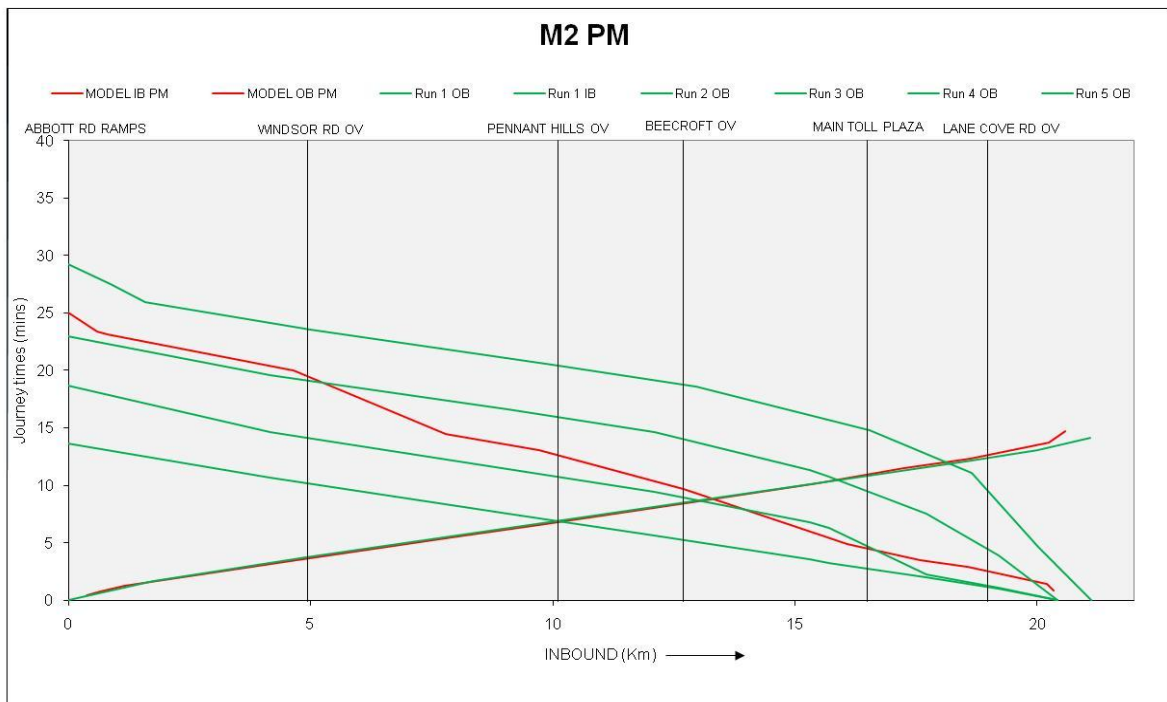


Figure 20 - Modelled M2 PM Peak Travel Time

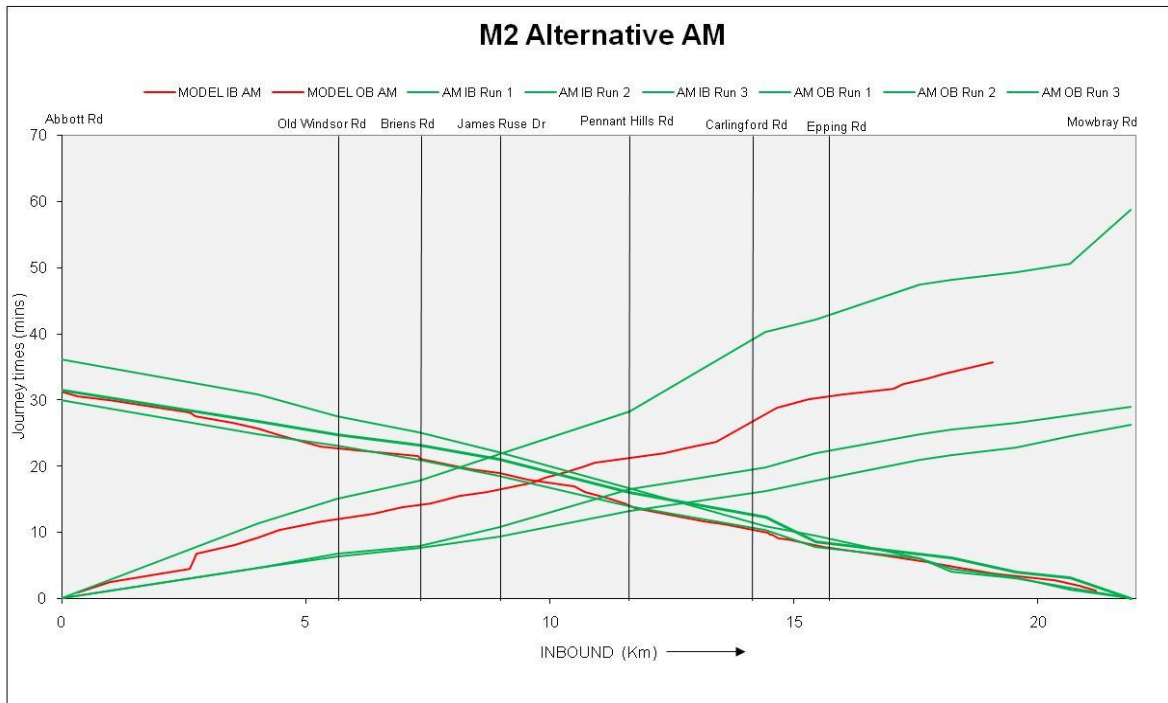


Figure 21 - Modelled M2 Alternative Travel Time

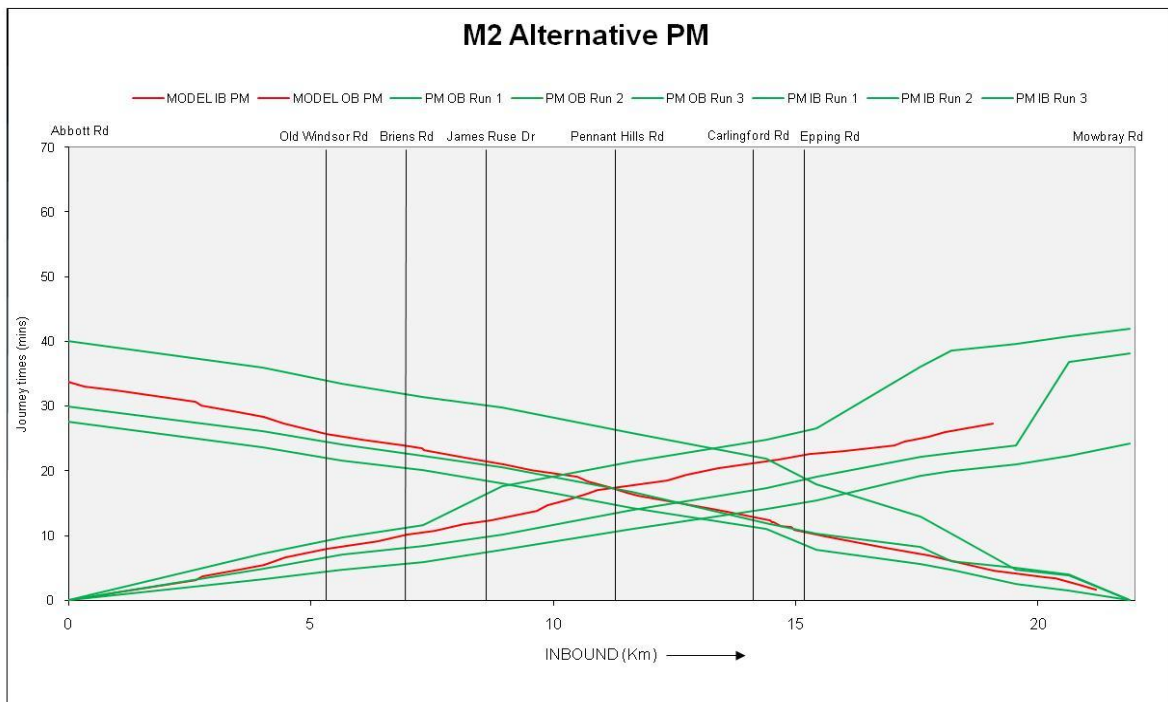


Figure 22 - Modelled M2 Alternative PM Peak Travel Time

Demographic Assumptions

Table 20 - TDC Forecast Population

Sector Description	2006	2011	2016	2021	2026	Average p.a. Growth
Inner Sydney	294,088	328,500	360,178	385,240	398,834	1.5%
Eastern Suburbs	238,635	241,684	248,699	252,734	253,954	0.3%
Inner Western Sydney	162,856	174,445	187,092	196,194	201,912	1.1%
Lower Northern Sydney	292,978	301,453	309,780	315,767	323,859	0.5%
Canterbury-Bankstown	309,486	312,694	320,237	327,535	333,418	0.4%
Fairfield-Liverpool	348,080	361,191	380,752	401,756	417,218	0.9%
Central Western Sydney	295,796	311,905	334,990	354,471	374,654	1.2%
Blacktown	264,799	282,003	297,062	315,770	339,562	1.3%
Central Northern Sydney	406,900	431,833	449,987	471,048	491,252	0.9%
Northern Beaches	231,230	236,562	240,889	244,202	252,844	0.4%
St George-Sutherland	433,055	443,692	456,123	462,705	460,961	0.3%
Outer South Western Sydney	234,032	246,927	269,476	296,946	339,248	1.9%
Outer Western Sydney	303,381	306,539	316,974	330,381	345,780	0.7%
Gosford-Wyong	299,089	316,589	334,493	354,252	372,354	1.1%
TOTAL	4,114,405	4,296,017	4,506,734	4,709,001	4,905,851	0.9%

Source: Based on the Bureau of Transport Statistics (BTS) data

Table 21 - TDC Forecast Employment

Sector Description	2006	2011	2016	2021	2026	Average p.a. Growth
Inner Sydney	503,951	533,420	544,697	560,196	571,631	0.6%
Eastern Suburbs	75,328	79,561	81,864	82,295	81,920	0.4%
Inner Western Sydney	69,505	76,402	79,421	80,825	81,906	0.8%
Lower Northern Sydney	228,503	244,929	258,940	268,502	277,739	1.0%
Canterbury-Bankstown	102,288	108,700	111,722	111,839	110,686	0.4%
Fairfield-Liverpool	111,229	119,501	128,733	136,327	143,846	1.3%
Central Western Sydney	179,849	192,555	204,529	207,544	211,756	0.8%
Blacktown	83,087	91,372	101,004	112,904	119,771	1.8%
Central Northern Sydney	131,636	156,652	178,118	193,405	200,442	2.1%
Northern Beaches	82,841	89,603	94,540	97,690	99,650	0.9%
St George-Sutherland	127,309	137,435	144,793	149,915	154,479	1.0%
Outer South Western Sydney	64,993	74,045	81,781	89,012	96,575	2.0%
Outer Western Sydney	94,823	104,590	111,255	119,672	126,976	1.5%
Gosford-Wyong	95,603	109,457	119,915	128,270	134,493	1.7%
TOTAL	1,950,945	2,118,222	2,241,313	2,338,397	2,411,871	1.1%

Source: Based on the Bureau of Transport Statistics (BTS) data

Values of Time

The values of time applied to tolls for conversion to equivalent travel minutes are given in Table 22. These values comprise a wide ranging review of survey and values applied in toll road forecasts around Australia and are hence of the right order.

Table 22 - Base Year 2006 Value of Time (\$2006)

Purpose	Income Segment		
	Low	Medium	High
Car Commute	\$15	\$17	\$20
Car Business	\$20	\$30	\$40
Car Other	\$8	\$10	\$15
HCV Rigid	(skewed) distribution with a mean VOT of \$30		
HCV Artic			

In future years it can reasonably be expected that the relative difference between users' willingness-to-pay and the toll rates will become more apparent due to differential changes in disposable incomes and tolling rates.

Users' willingness-to-pay can be expected to increase over time as disposable incomes increase (as indicated by the higher AWE growth above CPI growth). The relative difference between these factors has been reflected in the model by de-escalating the willingness-to-pay parameter by a rate that is the expected difference between AWE and CPI.

Table 23 documents the AWE inflators and the resultant values of time applied in each year of the model.

Table 23 - Future Year VOT

Purpose	2011 AWE Inflator 1.07			2016 AWE Inflator 1.13			2021 AWE Inflator 1.22			2026 AWE Inflator 1.31		
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Car Commute	\$16	\$18	\$21	\$17	\$19	\$23	\$18	\$21	\$24	\$20	\$22	\$26
Car Business	\$22	\$32	\$43	\$23	\$34	\$45	\$24	\$37	\$49	\$26	\$39	\$52
Car Other	\$9	\$11	\$16	\$9	\$11	\$17	\$10	\$12	\$18	\$10	\$13	\$20
HCV Rigid	(skewed) distribution with a mean VOT of \$32			(skewed) distribution with a mean VOT of \$34			(skewed) distribution with a mean VOT of \$37			(skewed) distribution with a mean VOT of \$39		
HCV Artic												

Lane Cove Eastbound On-Ramp Toll Assumptions

The tolls modelled for cars for the proposed Lane Cove Ramp were \$1.46 in the base year (2011) and escalated in line with other toll points on the M2 for future model years and three times this rate for trucks.

Appendix B Detailed Model Outputs

Lane Cove Tunnel Screenline AM Peak

Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	EB	622	730	17%	3
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	EB	2,237	3,080	38%	15
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	EB	1,733	2,093	21%	12
LANE COVE TUNNEL	EB	5,544	6,023	9%	2
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	EB	3,871	4,963	28%	6
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	EB	3,245	2,420	-25%	6
		17,252	19,309	12%	11
Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	WB	572	175	-69%	15
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	WB	2,128	2,282	7%	2
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	WB	1,839	1,511	-18%	6
LANE COVE TUNNEL	WB	4,315	3,735	-13%	7
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	WB	2,935	3,883	32%	12
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	WB	1,474	1,021	-31%	10
		13,263	12,607	-5%	4

Lane Cove Tunnel Screenline PM Peak

Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	EB	886	999	13%	2
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	EB	2,629	2,854	9%	2
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	EB	2,195	1,923	-12%	3
LANE COVE TUNNEL	EB	5,622	4,160	-26%	12
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	EB	4,249	7,034	66%	21
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	EB	2,202	1,670	-24%	7
		17,784	18,640	5%	4
Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	WB	1,203	176	-85%	23
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	WB	3,944	4,102	4%	1
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	WB	2,151	2,166	1%	0
LANE COVE TUNNEL	WB	8,904	11,744	32%	16
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	WB	5,868	6,381	9%	4
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	WB	4,079	2,541	-38%	15
		26,149	27,110	4%	3

Lane Cove Tunnel Screenline Daily

Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	EB	4,034	3,023	-25%	3
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	EB	14,430	17,790	23%	5
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	EB	11,562	7,448	-36%	9
LANE COVE TUNNEL	EB	28,421	23,536	-17%	6
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	EB	23,781	39,067	64%	18
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	EB	12,899	9,648	-25%	6
		95,127	100,512	6%	4
Location	Dir	Obs	Mod	% Diff	GEH
GROSVENOR ROAD, Between LADY GAME DRIVE and PACIFIC HIGHWAY	WB	4,020	639	-84%	14
FULLERS ROAD, Between MILLWOOD AVENUE and PACIFIC HIGHWAY	WB	16,726	16,934	1%	0
MOWBRAY ROAD WEST, Between EPPING ROAD and PACIFIC HIGHWAY	WB	11,634	8,999	-23%	5
LANE COVE TUNNEL	WB	29,818	39,480	32%	11
LONGUEVILLE ROAD, Between RIVER ROAD and PACIFIC HIGHWAY	WB	28,288	30,759	9%	3
RIVER ROAD, Between BRIDGE STREET and PACIFIC HIGHWAY	WB	13,685	7,924	-42%	11
		104,171	104,735	1%	0

Appendix C HCM Motorway Merge and Segment Analyses

2011 Base
Level Of Service

AM		PM	
Merge density	LoS	Merge density	LoS

9.3	B	18.3	D
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8.9	B	18.6	D
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11.6	B	17.2	D
------	---	------	---

11.4	B	18.0	D
------	---	------	---

9.2	B	16.2	C
-----	---	------	---

AM		PM	
Merge density	LoS	Merge density	LoS

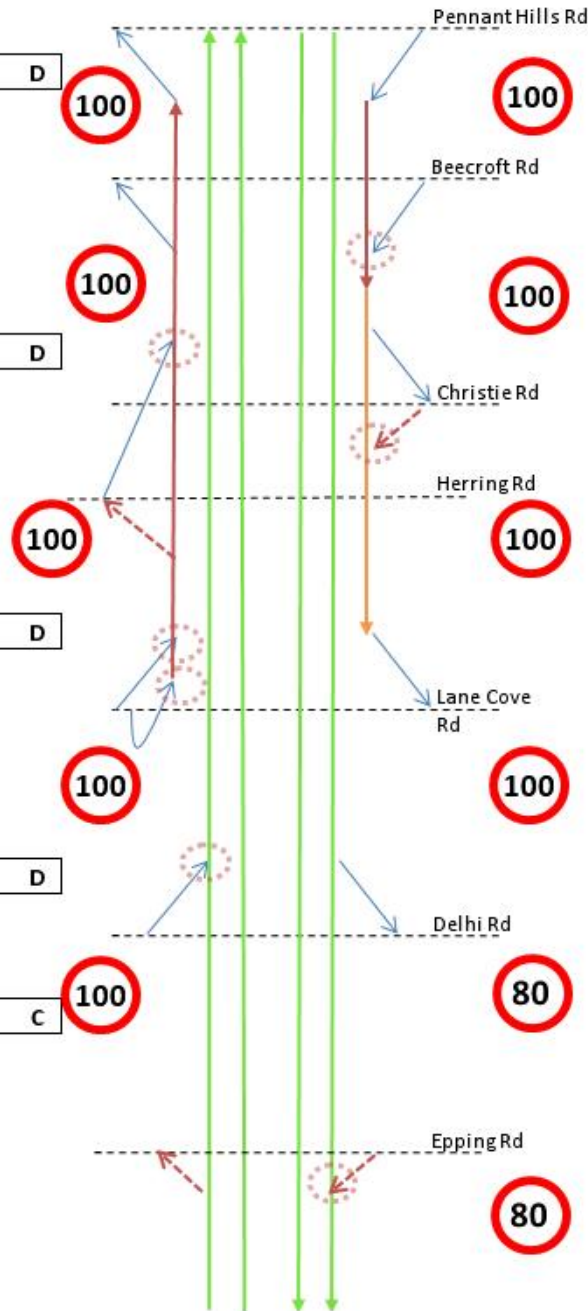
17.4	D	10.5	B
------	---	------	---

20.3	D	11.0	B
------	---	------	---

17.0	D	11.9	B
------	---	------	---

20.7	D	13.1	C
------	---	------	---

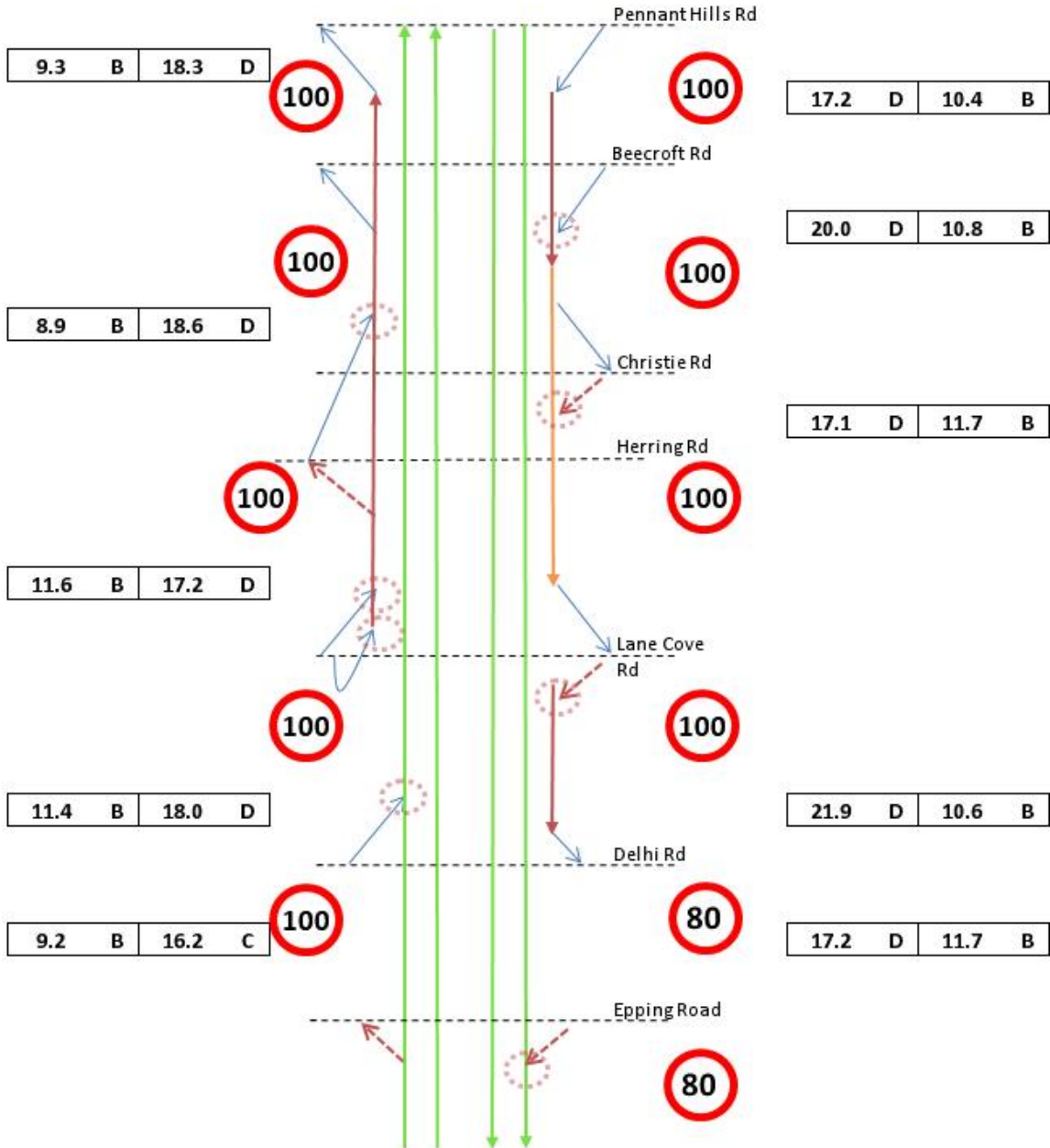
14.5	C	10.0	B
------	---	------	---



2011 LCRE
Level Of Service

AM	PM
Merge density	Merge density
LoS	LoS

AM	PM
Merge density	Merge density
LoS	LoS



2021 Base
Level Of Service

AM	PM
Merge density	Merge density
LoS	LoS

12.6	C	19.9	D
------	---	------	---

12.0	B	21.4	D
------	---	------	---

14.4	C	19.4	D
------	---	------	---

14.1	C	20.4	D
------	---	------	---

12.1	C	18.5	D
------	---	------	---

AM	PM
Merge density	Merge density
LoS	LoS

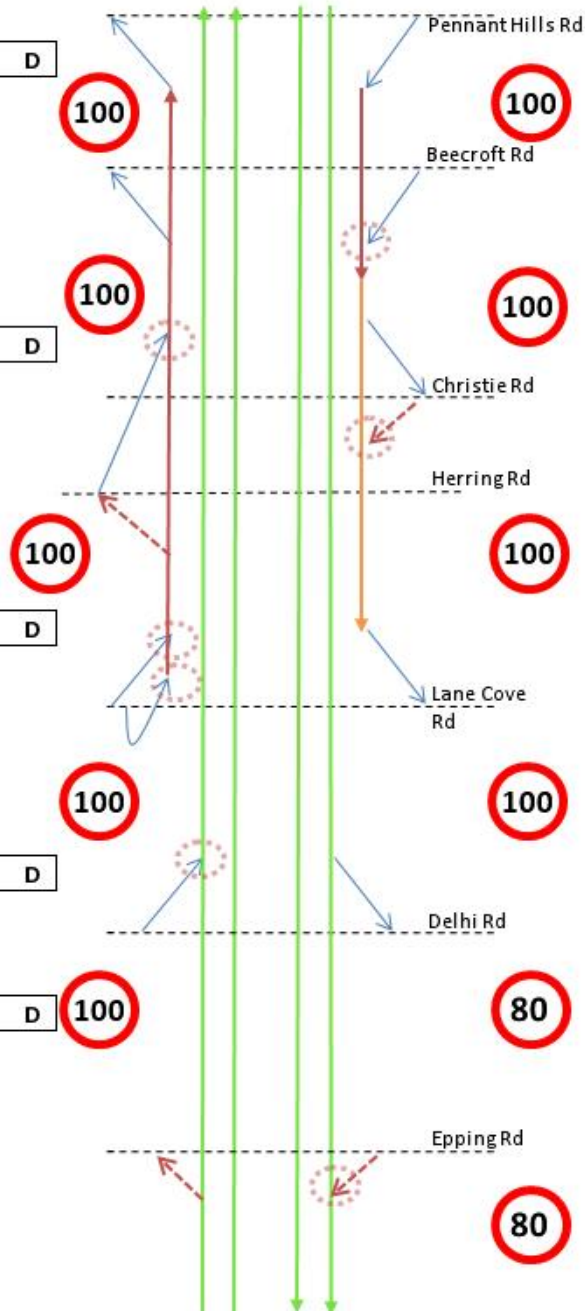
21.2	D	13.8	C
------	---	------	---

23.7	F	13.9	C
------	---	------	---

18.1	D	13.5	C
------	---	------	---

23.8	E	17.8	D
------	---	------	---

16.7	C	15.0	C
------	---	------	---



2021 LCRE
Level Of Service

AM		PM	
Merge density	LoS	Merge density	LoS

12.6	C	19.9	D
------	---	------	---

12.0	B	21.4	D
------	---	------	---

14.4	C	19.4	D
------	---	------	---

14.1	C	20.4	D
------	---	------	---

12.1	C	18.5	D
------	---	------	---

AM		PM	
Merge density	LoS	Merge density	LoS

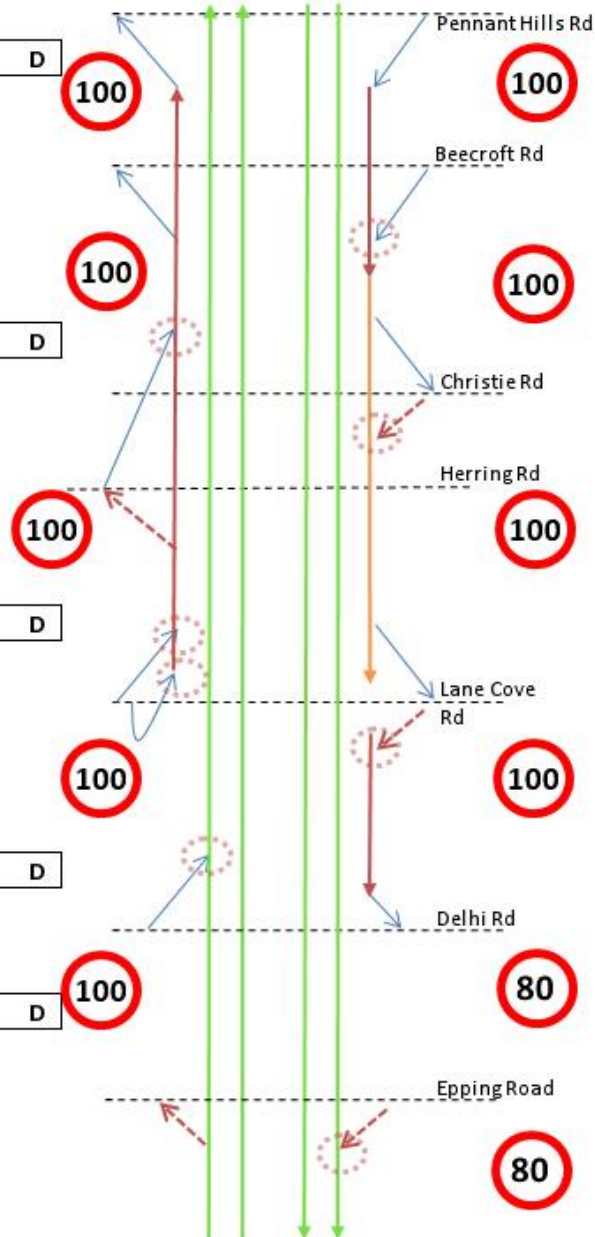
21.0	D	13.7	C
------	---	------	---

23.3	F	13.7	C
------	---	------	---

19.6	D	14.8	C
------	---	------	---

26.3	E	14.5	C
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19.8	D	17.0	D
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Appendix D LINSIG Intersection Analyses

2011 AM Peak

Location	Approach	LOS		DOS		Max Queue Length (pcu)		Average Delay by Approach		Intersection LOS		Intersection Average Delay	
		Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp
Ryde Rd/ Yanko Rd	Ryde North	B	B	0.64	0.71	24	30	22	25	B	C	29	30
	Ryde South	B	B	0.54	0.54	15	15	18	19				
	Yanko West	E	E	0.84	0.69	23	24	68	68				
Ryde Rd/ Lady Game Dr	Ryde North	A	B	0.73	0.78	50	54	14	15	B	B	19	20
	Ryde South	B	B	0.42	0.43	8	9	14	15				
	Lady Game East	E	F	0.79	0.81	14	15	69	74				
Lane Cove Rd/ Fontenoy Rd	Lane Cove North	C	C	0.89	0.95	58	66	31	41	B	B	23	29
	Lane Cove South	A	A	0.45	0.45	8	8	8	6				
	Eden Gardens	D	D	0.02	0.02	0	0	56	56				
	Fontenoy West*	A	A	0.36	0.36	3	3	13	13				
Lane Cove Rd/ M2	Lane Cove North	A	A	0.58	0.53	3	4	3	3	A	A	9	8
	M2 Exit West	D	E	0.36	0.51	6	10	53	65				
	Lane Cove South	A	A	0.52	0.40	5	3	8	3				
Lane Cove Rd/ Talavera Rd	Lane Cove North	F	F	1.04	0.99	62	51	165	108	F	F	112	82
	Lane Cove South	B	B	0.72	0.76	34	35	22	25				
	Talavera East	D	D	0.18	0.17	3	3	56	55				
	Talavera West	F	F	0.67	0.72	7	10	127	168				
Lane Cove Rd/ Waterloo Rd	Lane Cove North	D	D	0.86	0.81	35	31	54	49	F	F	72	72
	Lane Cove South	F	F	0.87	0.89	111	111	91	96				
	Waterloo East	F	E	0.69	0.63	8	7	88	69				
	Waterloo West	E	E	0.56	0.56	14	14	66	66				
Lane Cove Rd / Epping Rd	Lane Cove North	B	B	0.66	0.68	31	18	16	17	C	C	35	41
	Lane Cove South	C	D	0.67	0.73	21	30	41	49				
	Epping East	E	F	0.71	0.67	16	23	69	71				
	Epping West	D	E	0.67	0.72	6	7	51	57				

* Fontenoy Road West approach contains a left hand turn allowance on the red signal, which has been modelled as a priority/giveway movement in LINSIG.

2011 PM Peak

Location	Approach	LOS		DOS		Max Queue Length (pcu)		Average Delay		Intersection LOS		Intersection Average Delay	
		Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp
Ryde Rd/ Yanko Rd	Ryde North	A	A	0.44	0.47	12	13	9	9	B	B	15	16
	Ryde South	A	A	0.78	0.78	17	17	11	11				
	Yanko West	F	F	0.75	0.76	11	11	84	86				
Ryde Rd/ Lady Game Dr	Ryde North	D	D	0.86	0.91	31	40	45	53	D	D	47	49
	Ryde South	C	C	0.86	0.86	39	39	40	40				
	Lady Game East	F	F	0.74	0.74	35	35	76	76				
Lane Cove Rd/ Fontenoy Rd	Lane Cove North	B	C	0.75	0.79	37	46	29	33	C	C	30	33
	Lane Cove South	B	C	0.85	0.85	28	34	28	31				
	Eden Gardens	D	D	0.05	0.06	1	1	49	50				
	Fontenoy West*	C	C	0.74	0.74	14	14	41	43				
Lane Cove Rd/ M2	Lane Cove North	A	A	0.43	0.40	22	2	6	2	A	A	13	12
	M2 Exit West	D	E	0.69	0.73	20	21	56	59				
	Lane Cove South	A	A	0.70	0.69	9	8	9	10				
Lane Cove Rd/ Talavera Rd	Lane Cove North	D	D	0.79	0.78	15	16	50	50	E	D	63	55
	Lane Cove South	D	D	0.84	0.88	34	35	45	46				
	Talavera East	E	E	0.41	0.41	7	7	61	61				
	Talavera West	F	F	0.97	0.89	28	19	139	89				
Lane Cove Rd/ Waterloo Rd	Lane Cove North	B	C	0.72	0.75	29	34	23	35	D	D	44	44
	Lane Cove South	A	B	0.47	0.53	24	14	13	18				
	Waterloo East	C	C	0.55	0.55	7	8	31	35				
	Waterloo West	F	F	0.94	0.79	59	76	131	96				
Lane Cove Rd / Epping Rd	Lane Cove North	C	B	0.86	0.83	25	16	33	29	C	C	39	39
	Lane Cove South	B	B	0.29	0.28	8	8	29	28				
	Epping East	D	E	0.73	0.77	14	15	52	58				
	Epping West	E	F	0.82	0.87	9	12	64	80				

* Fontenoy Road West approach contains a left hand turn allowance on the red signal, which has been modelled as a priority/giveway movement in LINSIG.

2021 AM Peak

Location	Approach	LOS		DOS		Max Queue Length (pcu)		Average Delay		Intersection LOS		Intersection Average Delay	
		Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp
Ryde Rd/ Yanko Rd	Ryde North	C	C	0.74	0.82	33	43	29	36	C	C	35	40
	Ryde South	B	B	0.65	0.65	19	20	24	24				
	Yanko West	F	F	0.90	0.78	28	32	71	79				
Ryde Rd/ Lady Game Dr	Ryde North	B	B	0.79	0.86	57	65	16	20	B	B	21	23
	Ryde South	B	B	0.48	0.49	11	11	16	17				
	Lady Game East	F	F	0.82	0.82	15	16	73	75				
Lane Cove Rd/ Fontenoy Rd	Lane Cove North	C	F	0.93	1.00	58	85	36	75	B	D	25	49
	Lane Cove South	A	A	0.51	0.51	8	7	6	8				
	Eden Gardens	E	E	0.03	0.03	0	0	60	57				
	Fontenoy West*	B	B	0.42	0.42	3	3	20	17				
Lane Cove Rd/ M2	Lane Cove North	A	A	0.62	0.61	23	3	4	4	A	A	9	10
	M2 Exit West	E	E	0.54	0.48	10	9	64	57				
	Lane Cove South	A	A	0.46	0.55	2	5	3	6				
Lane Cove Rd/ Talavera Rd	Lane Cove North	F	F	1.10	1.04	98	61	232	172	F	F	146	116
	Lane Cove South	B	C	0.80	0.86	44	47	24	33				
	Talavera East	E	D	0.19	0.19	3	3	57	56				
	Talavera West	F	F	0.64	0.69	6	8	109	143				
Lane Cove Rd/ Waterloo Rd	Lane Cove North	E	E	0.92	0.86	37	32	69	61	F	F	131	132
	Lane Cove South	F	F	1.01	1.02	203	204	199	205				
	Waterloo East	F	F	0.81	0.81	20	20	173	173				
	Waterloo West	E	E	0.55	0.55	13	13	67	66				
Lane Cove Rd / Epping Rd	Lane Cove North	B	B	0.68	0.65	21	9	14	14	C	C	40	41
	Lane Cove South	D	D	0.81	0.81	32	33	48	49				
	Epping East	F	F	0.72	0.72	15	15	75	75				
	Epping West	F	F	0.82	0.83	12	12	74	75				

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2021 PM Peak

Location	Approach	LOS		DOS		Max Queue Length (pcu)		Average Delay		Intersection LOS		Intersection Average Delay	
		Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp	Base	Ramp
Ryde Rd/ Yanko Rd	Ryde North	A	A	0.48	0.51	14	15	9	9	B	B	19	20
	Ryde South	B	B	0.85	0.85	23	23	16	16				
	Yanko West	F	F	0.84	0.85	13	14	96	103				
Ryde Rd/ Lady Game Dr	Ryde North	D	E	0.91	0.94	41	45	51	58	E	E	58	65
	Ryde South	D	D	0.93	0.92	51	50	46	47				
	Lady Game East	F	F	0.76	0.79	51	62	131	163				
Lane Cove Rd/ Fontenoy Rd	Lane Cove North	C	C	0.79	0.83	40	42	31	34	D	D	48	49
	Lane Cove South	E	E	0.98	0.98	65	65	60	60				
	Eden Gardens	D	D	0.08	0.08	1	1	53	53				
	Fontenoy West*	D	D	0.82	0.82	21	21	56	56				
Lane Cove Rd/ M2	Lane Cove North	A	A	0.45	0.44	8	11	4	5	B	B	16	16
	M2 Exit West	E	E	0.82	0.81	27	25	63	63				
	Lane Cove South	A	A	0.79	0.78	29	11	14	13				
Lane Cove Rd/ Talavera Rd	Lane Cove North	E	D	0.87	0.79	34	30	62	55	F	F	86	84
	Lane Cove South	F	F	0.98	0.98	47	49	80	78				
	Talavera East	E	E	0.46	0.46	8	8	63	63				
	Talavera West	F	F	0.98	1.00	44	44	166	170				
Lane Cove Rd/ Waterloo Rd	Lane Cove North	C	C	0.87	0.82	40	35	40	41	F	F	77	79
	Lane Cove South	B	B	0.59	0.60	26	23	25	26				
	Waterloo East	D	F	0.70	0.74	14	18	53	79				
	Waterloo West	F	F	0.96	0.93	144	140	222	211				
Lane Cove Rd / Epping Rd	Lane Cove North	D	C	0.94	0.92	46	36	43	41	D	D	50	45
	Lane Cove South	B	B	0.34	0.34	9	9	28	29				
	Epping East	D	D	0.69	0.70	12	13	52	53				
	Epping West	F	F	0.96	0.86	17	13	117	80				

* Fontenoy Road West approach contains a left hand turn allowance on the red signal, which has been modelled as a priority/giveway movement in LINSIG.

Appendix E Pedestrian Infrastructure Photography

Lane Cove Road facing south



The pedestrian desire path erosion, as shown below illustrates pedestrians are currently walking beyond the formal pedestrian facilities and onto the grass section. Whilst measured count flows are low, a sustained low demand over a long period of time is likely to have lead to the erosion.

Lane Cove Road facing north



A formal footpath is provided on the western side of Lane Cove Road crossing over the M2, as shown below. Pedestrians can use this footpath to walk between Fontenoy Road and Talavera Road. There are no on-road bicycle lanes for cyclists travelling northbound on Lane Cove Road.

Lane Cove Road facing south



A signalised crossing is provided to allow pedestrians walking along the western side of Lane Cove Road to walk across the M2 western exit ramp, as shown below.

Lane Cove Road exit ramp facing north



Pedestrians on the western side of Lane Cove Road may walk across the westbound entry ramp via the zebra crossing, as shown below

Lane Cove Road entry ramp facing north

