M2 Upgrade Environmental Assessment

Volume 2 – Part 1: Technical Papers

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EA Technical Report

Traffic and Transport Impact Assessment

Road and Traffic Authority, NSW

22 April 2010

Traffic and Transport Impact Assessment

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Prepared by

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Executive Summary

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 proposing a significant upgrade of the motorway to the New South Wales Government. The proposed works, to be known as the M2 Upgrade, would reduce levels of congestion, accommodate traffic demand growth and generate significant benefits to private, commercial and bus transport travelers in one of the busiest and growing transport corridors in Sydney.

An environmental assessment is being prepared and the Director-General of the Department of Planning issued requirements for the assessment on 6 April 2009. This Report has been prepared to address the key issues relating to Traffic and Transport.

Existing 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.

The M2 is shown with its associated corridor of interest in Figure 1.

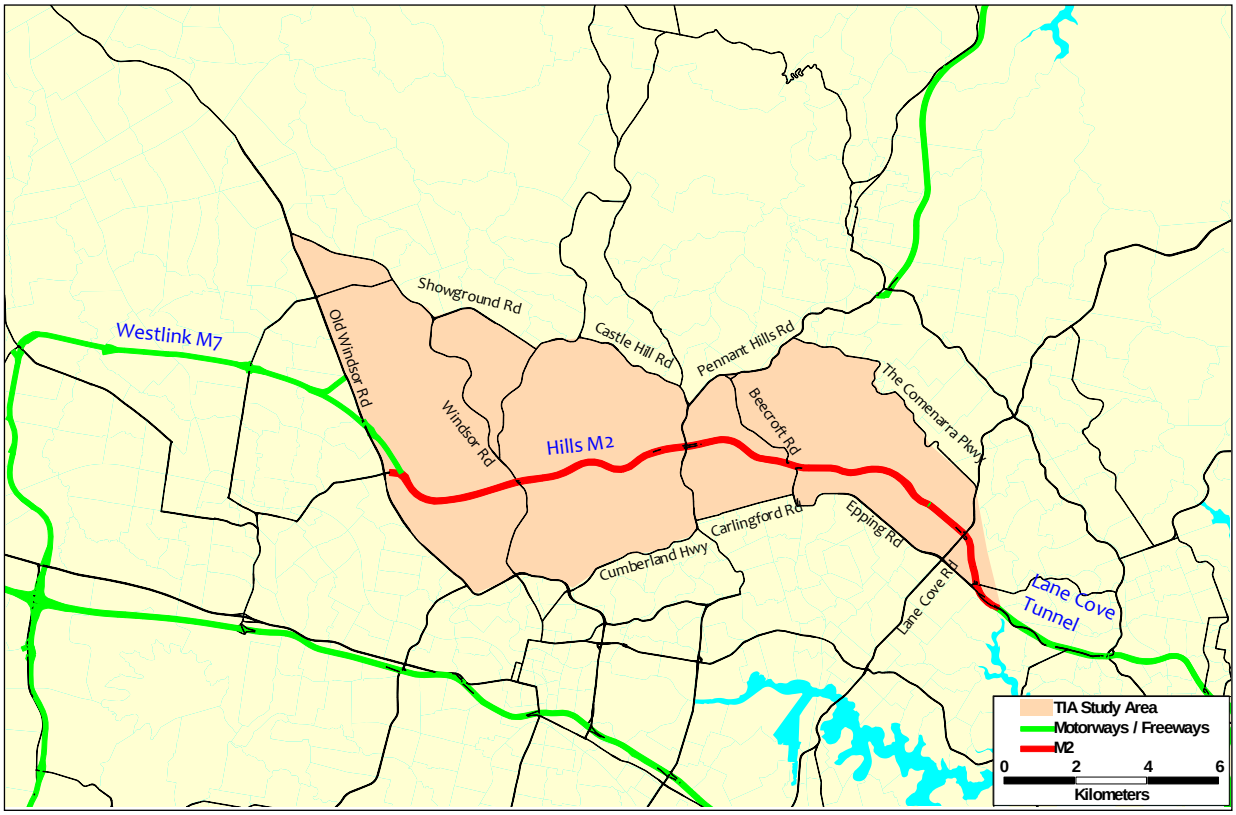

Figure 1 - Study Area

On an average workday, M2 is used by over 100,000 vehicles and more than 17,000 bus passengers. It is operating at practical capacity during morning and afternoon peak periods, causing peak congestion on the road network and delays to all users.

Although an Epping-Chatswood rail service was recently opened, further investment in rail transport is not currently planned for the corridor.

Existing Traffic Conditions in the M2 Corridor

The M2 experiences high levels of congestion in the weekday morning peak periods, with commuter congestion most noticeable in the eastbound (inbound) direction. Significant delays are experienced on weekdays, effecting travel time reliability for private cars, commercial movements and buses using the M2 and the alternative routes in the corridor.

The motorway carries high levels of commercial and heavy vehicular traffic west of the Pennant Hills interchange, servicing long-distance traffic to and from the west (M7) and the north (F3).

A temporary third westbound lane was constructed and opened in March 2007 between Lane Cove Road and Beecroft Road. Removal of the westbound carriageway breakdown lane whilst increasing westbound capacity also required reduced speed limits with consequent increased journey times, particularly in non peak periods.

The M2 opened in 1997 at a time when most tolls were paid in cash at toll booths. Access and egress of the motorway was limited to minimise the need for toll booths / plazas. As a result, accessibility to a range of destinations is limited. The Pennant Hills Road / M2 interchange is the only M2 interchange where all movements are possible. The advent of electronic toll collection has created an opportunity to increase the number of access/egress points along the motorway.

Traffic Conditions in the Corridor without Improvements to M2

Traffic forecasts for the corridor indicate worsening traffic conditions on M2 and other roads, in the form of lower traffic speeds, particularly during peak periods, and increasing bus transit times. Safety conditions, particularly where traffic entering the motorway merges with mainline traffic, are also expected to worsen.

Traffic performance at intersections in the corridor will deteriorate over the next 10 years as a consequence of a forecast 15% growth in traffic demand.

Inbound morning peak journey speeds on M2 are forecast to deteriorate from 37 km/h in 2009 to 30 km/h in 2021. On alternative routes speeds will decline from 30 km/h to 18 km/h. Corresponding estimates for outbound evening peak are 46 km/h to 34 km/h on M2 and from 29 km/h to 26 km/h on alternative routes.

Impact assessment

The Project

The M2 Upgrade involves widening sections of the motorway and additional access/egress points with consequent improvements in accessibility, traffic performance and road safety. The Project includes:

- Physical widening eastbound from Windsor Road on-ramp to Pennant Hills Road off-ramp by one additional lane;
- Physical widening eastbound and westbound from Pennant Hills Road to Beecroft Road by one additional lane in each direction. The bus on/off ramps near Beecroft Road would be removed to minimise land acquisition required to provide additional lanes;
- Physical widening eastbound from Beecroft Road to Lane Cove Road by one additional lane. One of the eastbound lanes east of Terrys Creek would be marked as a transit lane;
- Physical widening westbound from Lane Cove Road to Beecroft Road to reinstate the breakdown lane and provide wider through lanes;
- Physical widening of Norfolk Tunnel just east of Beecroft Road eastbound and westbound to provide an additional lane eastbound and wider lanes westbound;
- Provision of new west facing on/off-ramps at Windsor Road, Baulkham Hills. Windsor Road will be widened to accommodate turning movements between Torrs Street and Woodlands Street;
- Provision of new east facing on-ramp at Christie Road, Macquarie Park;
- Provision of new east facing off-ramp at Herring Road/Talavera Road, Macquarie Park;
- Improvement and physical widening of Talavera Road, Macquarie Park, between the entrance of Macquarie Graduate School and Alma Road to provide two through lanes in each direction with a right turn bay;

- Physical widening of Christie Road bridge, Macquarie Park, to 5 lanes over the M2 Motorway including the provision of new traffic control signals on Christie Road at the northern ramps;
- Bridge modifications on the M2 between Windsor Road and Christie Road to accommodate the widening work; and
- Intelligent Transport System (ITS) upgrades along the corridor including upgrade to the cableway.

These improvements are shown on Figure 2.

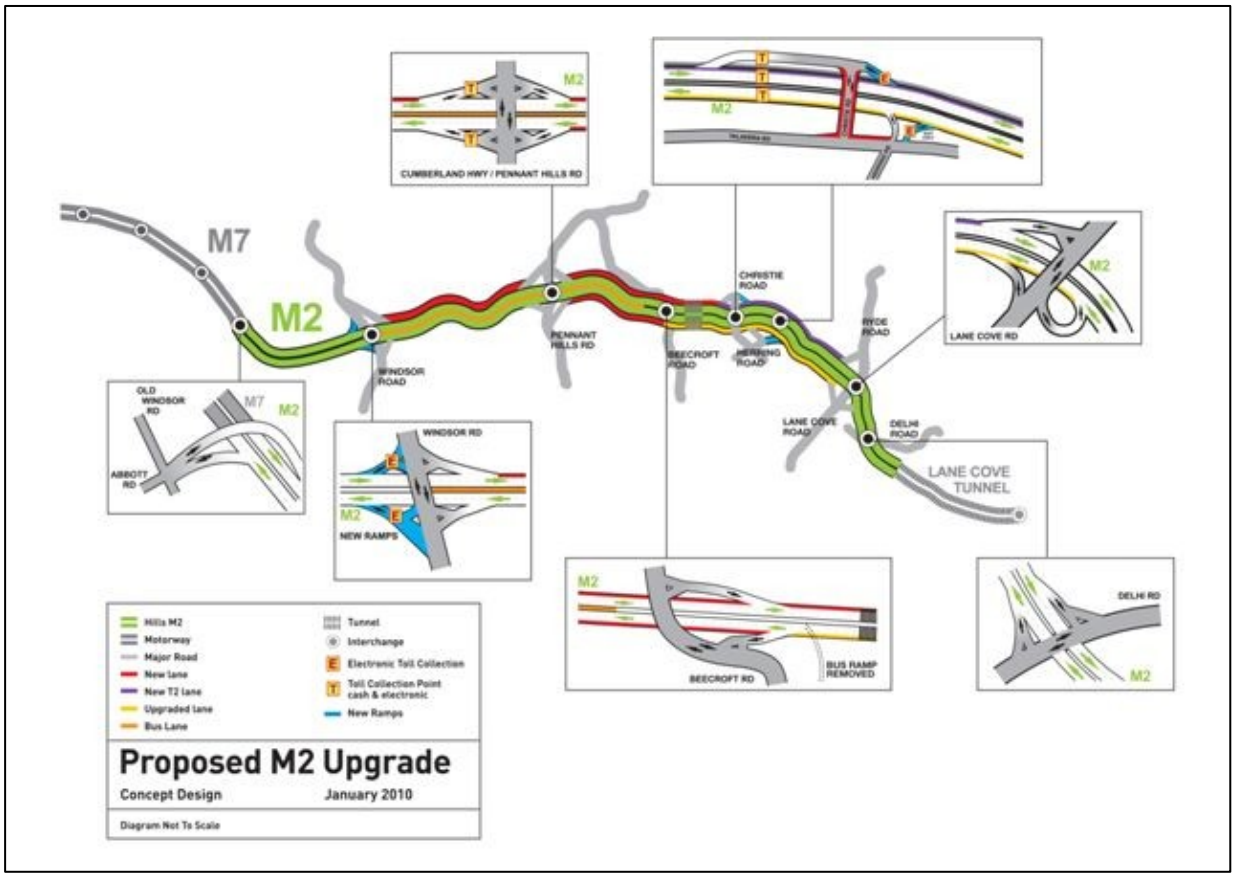

Figure 2 – M2 Upgrade Project

The proposed M2 Upgrade scope was developed to provide significantly improved travel conditions within the M2 whilst cognisant of capacity constraints at the eastern end of the motorway due to Lane Cove Tunnel. This will ensure that the Upgrade has minimal impacts on the greater network, particularly at Sydney Harbour crossings.

Basis of Assessing Current and Future Traffic Conditions in the M2 Corridor

Transurban's Strategic Traffic Model (TUSTM) was used to forecast traffic network volumes in the corridor, including on M2, with and without the proposed M2 Upgrade for years 2011 and 2021. Turning volume forecasts from TUSTM were also used to model intersection performance using the intersection analysis software packages SIDRA and SCATES.

TUSTM uses demand forecasts obtained from TPDC which are assigned using a 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 Improves Traffic Performance in the Corridor

Improved Levels of Service on M2

The overall level of peak period congestion will reduce in the corridor as a result of the M2 Upgrade compared with the current 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 Delhi 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 east facing 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 east facing 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 current 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 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.

Overall bus passengers will benefit significantly from the M2 Upgrade.

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.

Mitigation measures

Summary

The proposed M2 Upgrade provides additional capacity, where today's flows demonstrate it is needed; it will generate significant social, environmental and economic benefits. The upgrade of capacity and accessibility along its length will provide future network users (M2 and wider network users) with improved accessibility to a greater number of destinations and improved travel conditions during peak periods in the corridor. Without these improvements, traffic conditions in the corridor will deteriorate significantly and delays to users will increase; particularly in peak periods for travel to and from the central employment areas of Sydney.

Impacts during Construction

The construction of the M2 Upgrade will require the creation of work zones along the motorway that would alter the lane configuration and restrict the speed of vehicles. While motorway lane capacity would be maintained during peak periods there is expected to be some diversion from the motorway to other routes during off peak periods. The other routes have the capacity to handle the additional traffic in the off peak periods.

Management of the road works including layout of temporary concrete barriers, signage, speed limits, access points etc. would be detailed in Traffic Management Plans (TMPs). These would be developed by the contractor in consultation with key stakeholders such as RTA, emergency services and councils where applicable. TMPs would also provide details of how the changes to traffic arrangements are communicated to the road users and other impacted people including local residents.

A number of site compounds and laydown areas are required in close proximity to the motorway, vehicle movements to the site compounds and work zones would be from the motorway where possible and via

arterial and local roads in other cases. Working hours would be between 7.00 am and 6.00 pm Monday to Friday and 8.00 am and 1.00 pm on Saturday.

The existing bus lane would be maintained for travel in the direction of peak traffic by implementing a tidal flow arrangement between Windsor Road and near Kirkham Street/Murray Farm Road over-bridge. Due to the removal of the Beecroft Road bus ramps, bus trips that use these ramps would need to be re-routed. The re-routing would be determined by bus operators in conjunction with the Department of Transport and Infrastructure.

Due to the removal of the breakdown lane during construction to create work zones, an alternative off motorway route would be provided for cyclists. A preferred off motorway route was determined taking into account criteria such as the distance of the route, nature of the route (off-road, on-road) elevation to be overcome, slow points along the route and exposure to land uses that generate cyclist trips. Each of these aspects was discussed with representatives from Councils, RTA, Hills M2 and various cycling groups. The temporary arrangements would be further developed as part of detailed design in consultation with the relevant stakeholders. On completion of the widening works the breakdown lanes would be reinstated.

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.

The traffic volumes on the M2 have increased following the completion of the Sydney Orbital (the opening of Westlink M7 and Lane Cove Tunnel) over the period 2006 to 2007. This has resulted in higher congestion and deterioration of the level of service for M2 users.

To accommodate some of the increased pressure on the motorway and to coincide with opening of the Lane Cove Tunnel in March 2007 a third lane was introduced in the westbound direction between Lane Cove Road and Beecroft Road. This third lane was provided by using the shoulder of the motorway, removing the breakdown lane and prohibiting cyclists in that section. This involved remarking of the pavement to three narrower lanes with a lower speed limit.

As part of the interim widening, Hills M2 committed to investigate a permanent widening to restore the breakdown lane and the cycleway and has now proposed a general upgrade of the M2 Motorway. Following on from negotiation with the Roads and Traffic Authority (RTA) the scope of works of the M2 Upgrade was identified and is the subject of the Environmental Assessment of which this Traffic Impact Assessment forms a part.

Hills M2 and RTA have entered into an agreement to deliver the M2 Upgrade subject to receiving Project Approval.

Further information on the objectives and scope of the M2 Upgrade can be found in the main report of the Environmental Assessment (EA). This technical report is one of several supporting documents to the EA. It aims to:

- Establish existing traffic and transport conditions in the M2 environs;
- Assess the impacts of the M2 Upgrade on these conditions; and
- Propose suitable mitigation measures for minimising the extent of these impacts.

This report has a further 8 sections as follows:

- Sections 2 and 3 describe the existing traffic environment and performance of the transport network in the M2 corridor;
- Section 4 describes the traffic modelling undertaken to estimate and predict future changes in the traffic outlook in both a without and with M2 Upgrade project;
- Section 5 describes the predicted traffic conditions that will pertain in the "No M2 Upgrade" scenario i.e. without M2 Upgrade project;
- Section 6 briefly describes the M2 Upgrade Scope of Works;
- Section 7 describes and assesses changes or impacts on base conditions that will result from the M2 Upgrade project and describes mitigation measures to limit / accommodate any negative impacts;
- Section 8 deals with the traffic impacts of the construction period.

The Director-General of the Department of Planning has specified a number of requirements that the Environmental Assessment (EA) should address. Those requirements which relate to the operational traffic and transport assessment are set out below in Table 1, and Table 2 provides a cross reference to the relevant section(s) of this report which address these requirements.

Table 1 - Director General's Requirements (DGRs) – Operational Traffic and Transport, and Construction Traffic

DGRs
The Environmental Assessment must include an assessment of the operational impacts of the project, including: ▪ *traffic levels on the M2 Motorway and the impacts on the surrounding road network, including any impacts on the Lane Cove Tunnel, the M7 Westlink Motorway, and the surrounding local and regional road network.* ▪ *The assessment must also consider operational implications for public transport (particularly with respect to bus routes, interchanges and connections with the rail network), impacts on cyclists and cycle access, and any impacts on pedestrian access and safety (for those ancillary works around the Motorway corridor, as relevant).*
The Environmental Assessment must include consideration of, and a management framework for: • *Construction traffic including a considered approach to route identification and scheduling of transport movements, the number, frequency and size of construction related vehicles (both passenger, commercial and heavy vehicles), the nature of existing traffic on construction access routes (with consideration of peak traffic times and sensitive road users, including emergency vehicles and buses), and the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the project. The Environmental Assessment must also present a strategy for managing traffic impacts, with a particular focus placed on those activities identified as having the greatest potential for adverse traffic flow, capacity or safety implications, and a broader, more generic approach developed for day-to-day traffic management.*

Table 2 - DGRs Checklist

DGRs	*Section Addressed*
Impacts of traffic levels on the M2 Motorway	*7.2.1, 7.2.2, 7.2.3, 7.2.4 and 7.3*
Impacts on the surrounding road network	*7.1 ,7.2.5 and 7.4*
Impacts on the Lane Cove Tunnel	*7.2.5.3*
Impacts on M7 Westlink Motorway	*7.2.5.4*
Operational implications for public transport	*7.9*
Operational implications for bus routes	*7.9.2*
Operational implications for connections with rail network	*7.11.2*
Impacts on cyclists and cycle access	*7.8*
Impacts on pedestrians and pedestrian access	*7.5*
Impacts on road safety	*7.6*
Approach to route identification and scheduling of transport movements	*8.1.2, 8.1.3 and 8.3.2*
Number, frequency and size of construction related vehicles (both passenger, commercial and heavy vehicles)	*8.2.1*
The nature of existing traffic on construction access routes	*8.1.3*
Consideration of peak traffic times and sensitive road users, including emergency vehicles and buses	*8.1.2, 8.3.3, 8.4 and 8.5*
The need to close, divert or otherwise reconfigure elements of the road network associated with construction of the project	*8.1.2*
Strategy for managing traffic impacts	*8.3.1 and 8.6*

2.0 The Existing Transport Environment

This section outlines the existing transport environment within the study area. All data presented within this section representing the existing or base condition was sourced between 2006 and 2009.

2.1 Study Area

The study area of the assessment of traffic impacts is the M2 Motorway and M2 environs shown in Figure 3. This area is bounded by the following significant road network features.

- Windsor Rd, Showground Rd, Castle Hill Rd, Pennant Hills Rd and the Commenarra 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.

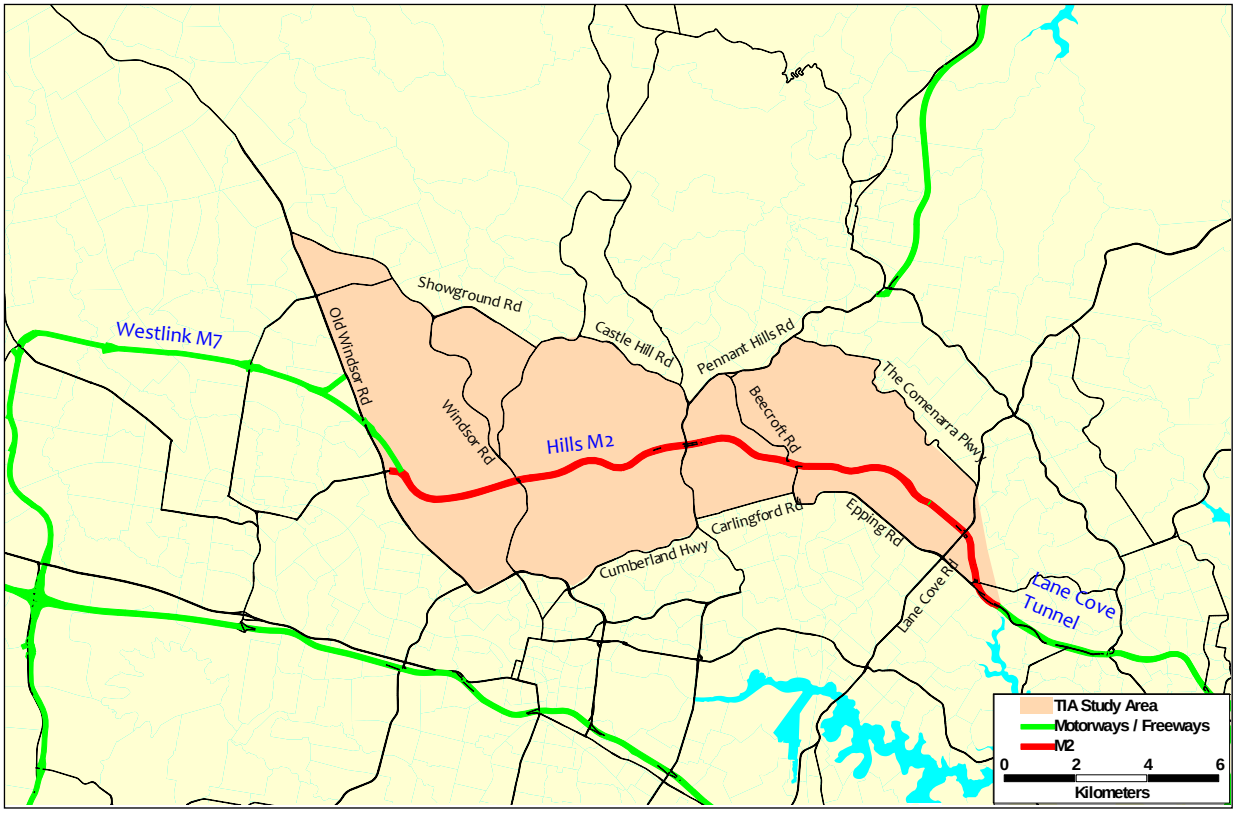

Figure 3 - Study Area

2.2 The Connecting Road Network

The M2 opened in 1997. Prior to this date, motor vehicle trips between the North West region of Sydney and North Sydney and the Sydney CBD would have used parallel routes that form the boundaries of the M2 study area defined above (Figure 1). Since 1997, the M2 has become the major traffic carrying corridor through the region, removing the majority of long distance traffic from the parallel routes. These parallel routes primarily service shorter length trips, and are also used as alternative routes for regional traffic for those drivers choosing to avoid the M2 toll.

Completion of the Sydney Orbital following the opening of the Westlink M7 (to the west of the M2) in December 2005 and the Lane Cove Tunnel (to the east of the M2) in March 2007 has increased M2's importance in the road hierarchy. The connecting Motorway network is shown in Figure 4.

M2 access and egress from and to the arterial road network is facilitated by M2 interchanges at the locations indicated in Figure 5. Key interchange characteristics include:

- The Pennant Hills Rd interchange is the only interchange where all movements are possible, that is vehicles travelling in either direction can enter and exit the motorway at this location;
- Windsor Road and Beecroft Road interchanges only have east-facing ramps meaning that motorway users can only travel to and from destinations to the east; and
- Herring Road / Christie Road, Lane Cove Road and Delhi Road interchanges only have west-facing ramps meaning that motorway users can only travel to and from destinations to the west.

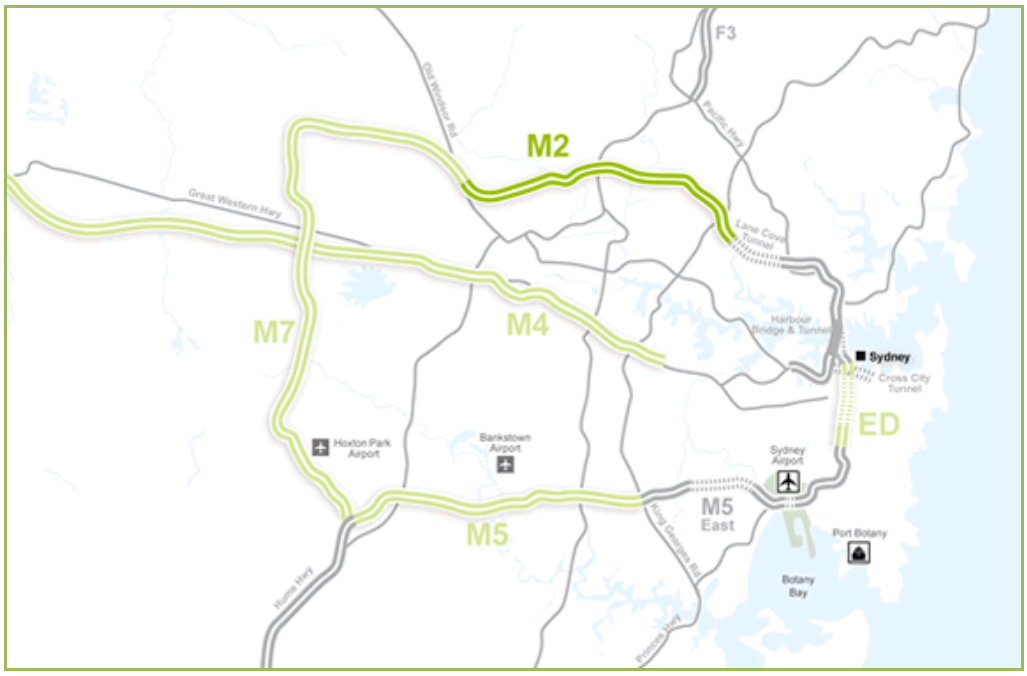

Figure 4 -Sydney Motorway Network

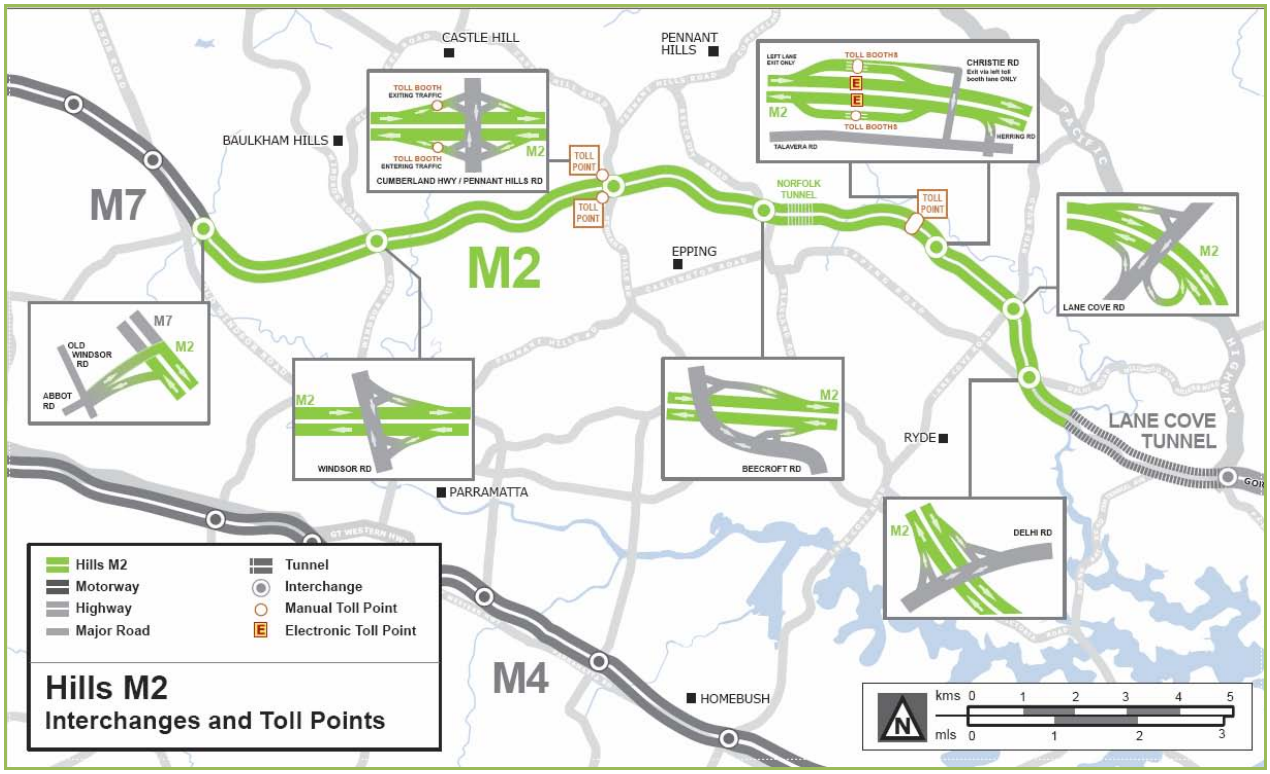

Figure 5 - M2 Access and Egress

2.3 Public Transport

2.3.1 Bus Services

The M2 is an important strategic bus corridor for services from Sydney's North West. Hillsbus is the main operator on the M2, carrying over 17,000 passengers each weekday[1]. In comparison, over 100,000 private vehicles use the M2 on an average day. These buses serve North West Sydney via the M2 to access Sydney CBD and North Sydney and to a lesser extent Lane Cove, Epping and Macquarie Park. The M2 is also used by Busways' Route 740.

M2 eastbound bus services can be grouped according to their exit point along the M2 Motorway as follows:

- M2 Express Routes - Routes 610, 610X, 612, 613, 613X, 614, 614X, 615, 615X, 616, 616X, 617X, 618, 620, 620X, 622, 642, 642X, 650X, 652X and 653 travel directly through and exit at the eastern end of the M2 and are known as the M2 Express Routes. A total of 230 eastbound services operate along these routes each weekday.
- Christie Rd off-ramp and Herring Rd on-ramp Routes - Routes 619, 621, and 651 exit via Christie Road Off Ramp and terminate at Macquarie Centre/Macquarie Park, or travel through to the CBD. These routes use the Herring Rd on-ramp in the westbound direction. A total of 57 eastbound services operate along these routes each weekday.
- Beecroft Rd Bus Ramp Routes - Routes 611 and 740 exit via the Beecroft Road bus only ramp and travel to Epping Station, Macquarie University and terminate at Macquarie Centre. A total of 23 eastbound services operate along these routes each weekday.

These service groupings, as well as the railway line and stations in the surrounding catchment, are illustrated in Figure 6. A detailed breakdown of services by time of day for each of these route groupings is included in Table 3 to Table 5. On weekdays, similar numbers of buses operate westbound.

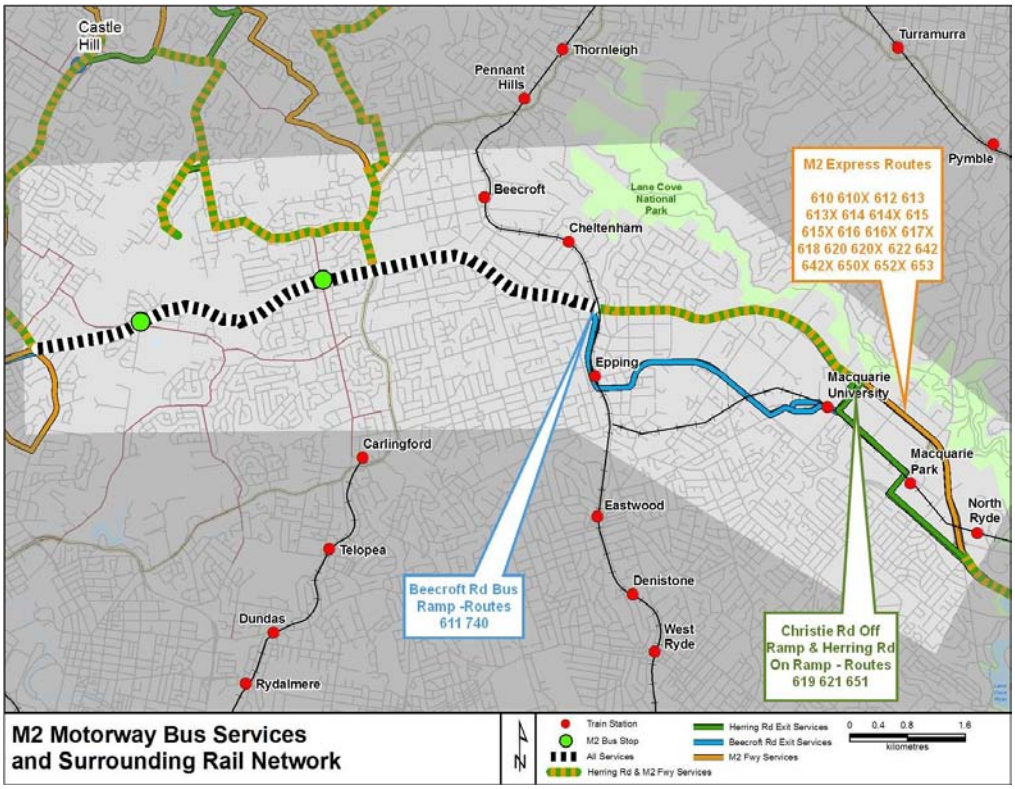

Figure 6 - M2 Bus Services and Surrounding Rail Network

[1] *Hillsbus,communications 2008. Assuming a bus-operating-day of 15 hours leads to peak flows of a bus every 4 minutes each with approximately 40 passengers.*

Table 3 - Bus Services which use the M2 Express Routes

Route	4AM-6AM	6AM-7AM	7AM-8AM	8AM-9AM	9AM-10AM	10AM-11AM	11AM-12PM	12PM-6PM	6PM - Midnight
610	3	4			4	2	2	17	7
610X		3	21	15					
612		3	9	7				2	
613		1	2						
613X		1	1						
614			3						
614X	1	2	2						
615		1	4					2	
615X		2	3						
616		1	2	1					
616X	1		5	5					
617X		1	5	5		1	1	2	
618								7	2
620		1			1				
620X		2	9	4					
622		1	3	2					
642		1	2	2	2				
642X		3	6	1		1		2	
650X		2	2	2					
652X		2	7	3					
653		2	3	1					
Total	**5**	**33**	**89**	**48**	**7**	**4**	**3**	**32**	**9**

Table 4 - Bus Services along the M2 Motorway which exit at Christie Road

Route	4AM-6AM	6AM-7AM	7AM-8AM	8AM-9AM	9AM-10AM	10AM-11 AM	11AM-12 PM	12PM-6PM	6PM - Midnight
619		2	2	2	2	2	2	10	2
621			2	2	1	1	1	8	2
651				1	2	1	1	9	2
Total	**0**	**2**	**4**	**5**	**5**	**4**	**4**	**27**	**6**

Table 5 - Bus Services along M2 which exit at Beecroft Road

Route	4AM-6AM	6AM-7AM	7AM-8AM	8AM-9AM	9AM-10AM	10AM-11 AM	11AM-12 PM	12PM-6PM	6PM - Midnight
611		1	2	3	2	1	1	6	
740		1	2	1	1			1	1
Total	**0**	**2**	**4**	**4**	**3**	**1**	**1**	**7**	**1**

The regional significance of the M2 on public transport operations is demonstrated by the extent of origins linked by bus routes that terminate in the vicinity of the M2 environs. These services generally terminate at the Macquarie Centre, linking Epping Interchange, Parramatta and Blacktown in the west, Mona Vale in the north, to the south via Ryde, Sydney CBD, and North Sydney and to a lesser extent Chatswood and Manly. These services are illustrated in Figure 7.

Figure 7 - Macquarie Park Bus Network (source: NSW Transport and Infrastructure)

Service levels and reliability of bus operations along these routes are dependent on traffic conditions on the M2 and on the surrounding local road network. Different bus operators provide the bus services on the M2 Motorway and in the M2 environs. The operator is based on the Sydney Metropolitan Contract Region from which the service originates. These regions are illustrated in Figure 8.

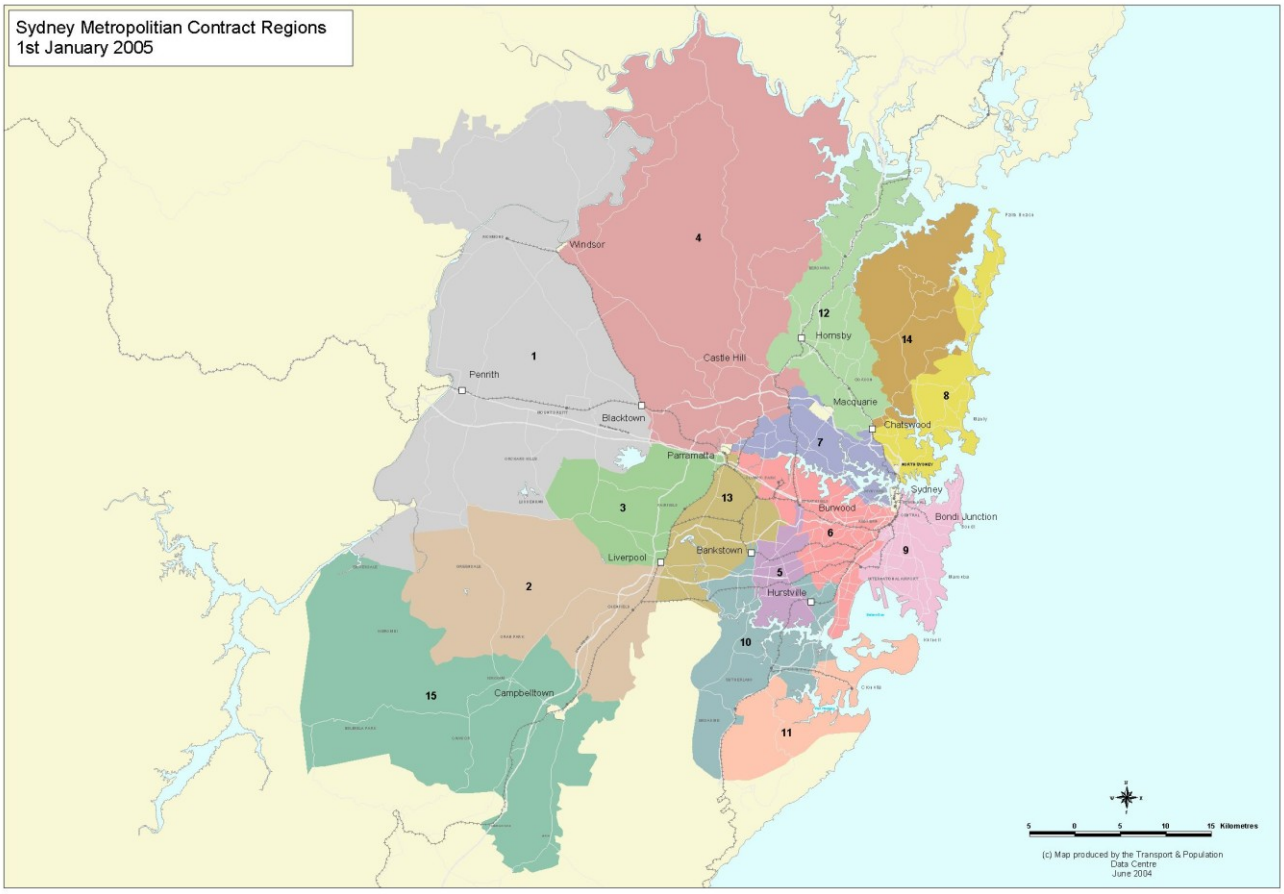

Figure 8 - Sydney Metropolitan Contract Regions (source: NSW Transport and Infrastructure)

2.3.2 Rail Services

Figure 8 shows rail lines within the vicinity of the M2 and estimated passenger loadings at nearby railway stations; with the exception of the recently opened Epping to Chatswood Rail Link (ECRL). The largest passenger flows are at:-

- Epping Railway Station - where passengers can connect to the Northern Line services and Newcastle and Central Coast Line services that stop at Epping Station.
- Chatswood Station – where passengers can connect with North Shore Line services.

ECRL connects these two stations and commenced operations on 26 February 2009. It provides rail access for the first time to the growing North Ryde/Macquarie Park area.

The ECRL originally ran as a 15 minute shuttle service in both directions between Epping and Chatswood. This service is now integrated with the CityRail network and the recently introduced new timetable. Patronage at the end of the initial fare free period (June 2009) was approximately 12,000 passengers per day.[2]

[2] *Website: http://www.transport.nsw.gov.au/news/releases/090604-ECRL-Survey.pdf*

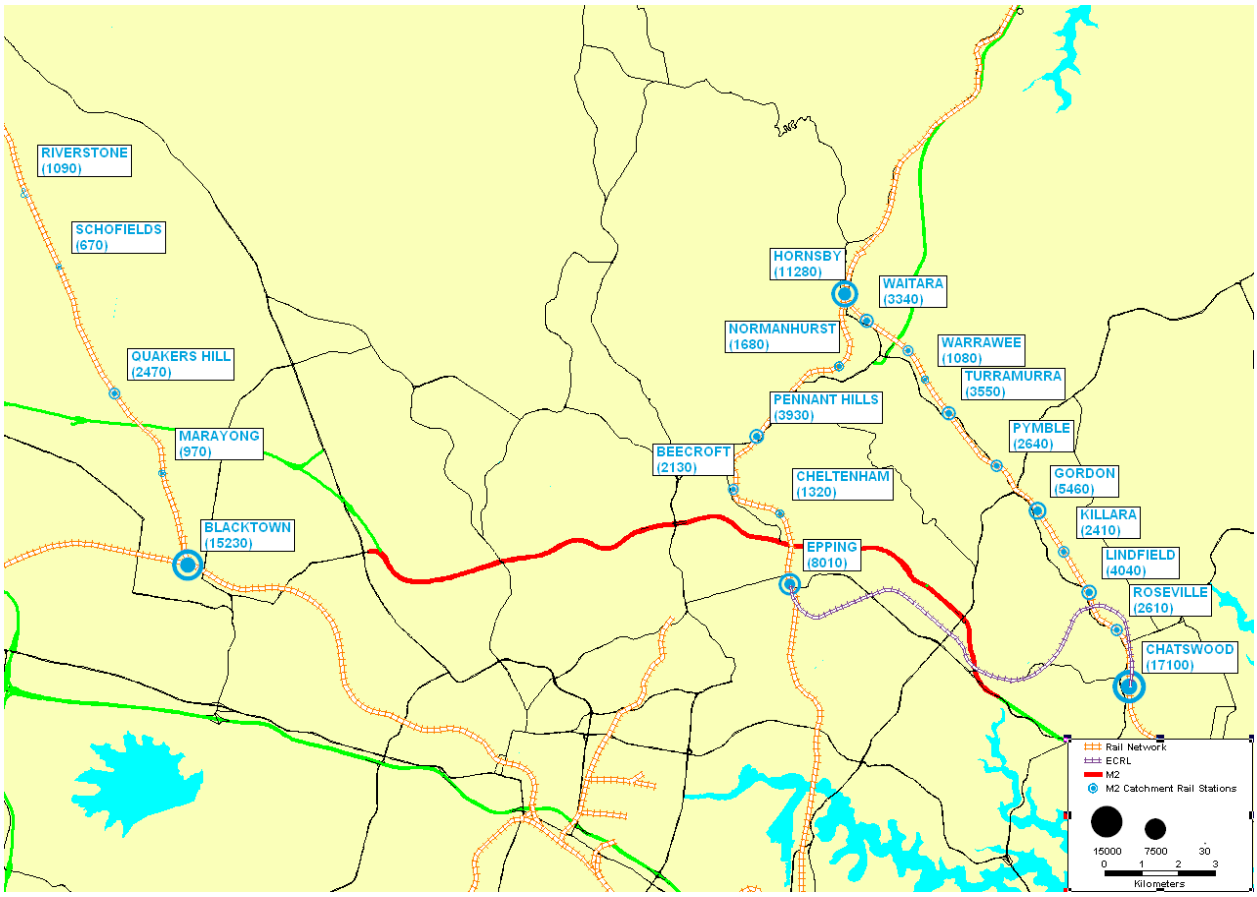

Figure 9 - Rail Station Passenger Boardings (source: CityRail 2005)

2.3.3 Existing Public Transport Infrastructure serving Bus and Rail Services

There is significant infrastructure for buses and rail in the M2 environs. This includes a number of rail stations in the M2 catchment serving the ECRL and the Northern Line..

Buses using the M2 benefit from significant bus priority infrastructure, including:

- Eight kilometres of two-way busway in the M2 Motorway median from Beecroft Road to Windsor Road
- Bus Only On & Off Ramps near Beecroft Road (west facing)
- Bus Only On & Off Ramps at Pennant Hills Road (east facing)
- Bus Only On & Off Ramps at Windsor Road (east facing)
- West of Windsor Road buses can use the breakdown lane to set down/pick up passengers

Bus stops are located on the M2 at Gooden Reserve (Model Farms), Cropley Drive (Baulkham Hills), Barclay Road (North Rocks), and Oakes Road (Carlingford North).

Work is currently underway for a bus waiting area on a section of the Warringah Motorway at Cammeray. The facility will provide a safe waiting area near the CBD for buses from the north west. Buses using the waiting area will be able to reach the CBD within 12 minutes. This will enable buses operating on M2 motorway services to better meet timetables for the evening peak.

The NSW Government has invested in a number of strategic corridors within the M2 environs including Castle Hill – City via Macquarie, Macquarie – City, Macquarie – Burwood, Parramatta – City via Macquarie. Bus priority measures are being implemented along these corridors to protect bus services from traffic congestion and achieve average peak period bus speeds of 20-25 km/h. Upgrades to Christie Road and Talavera Road are included in the scope of the M2 Upgrade.

A map of all Sydney Region Strategy Bus Corridors is illustrated in Figure 10.

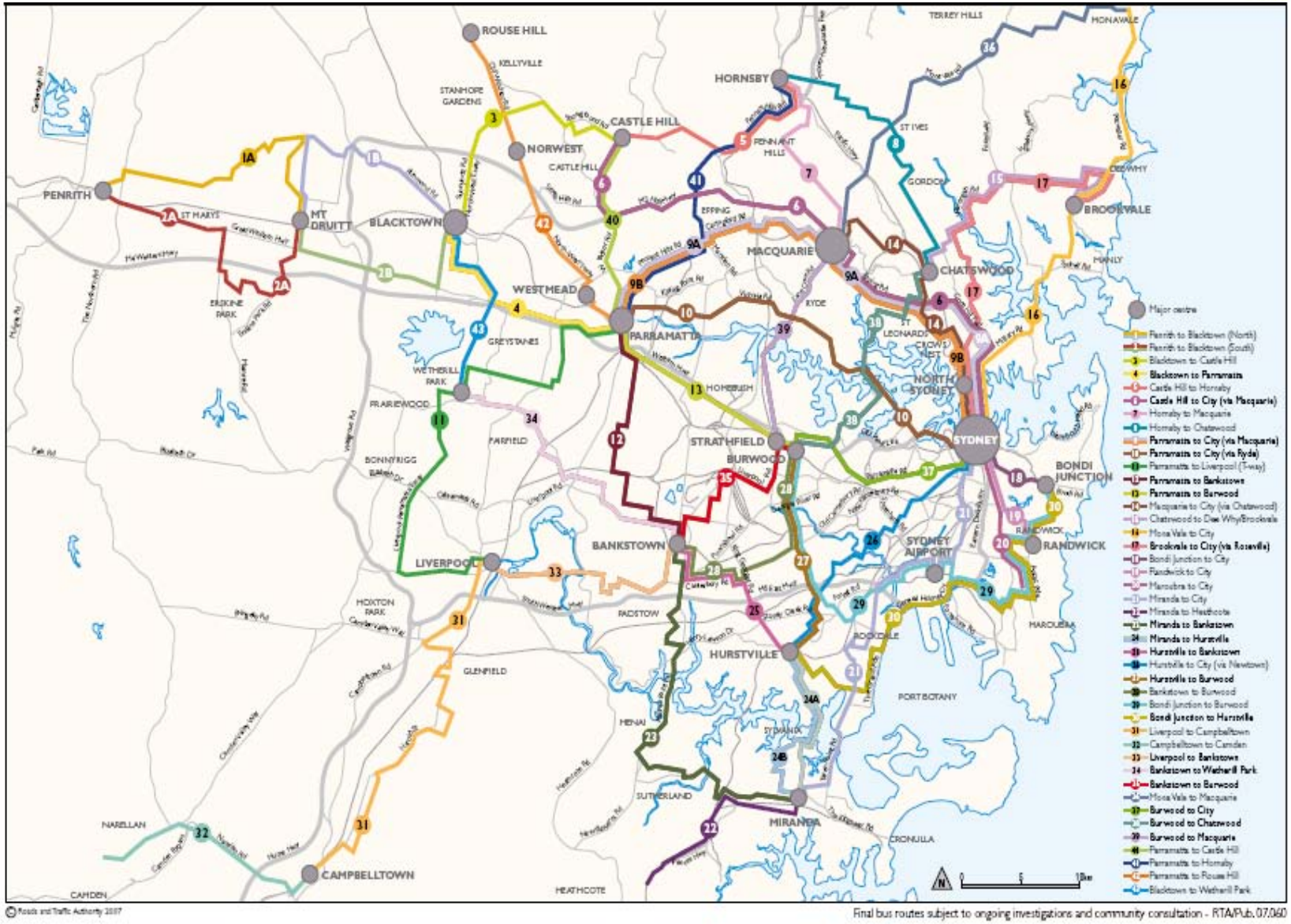

Figure 10 **- Sydney Region Strategic Bus Corridors (Source: NSW Transport and Infrastructure)**

2.3.4 Service Performance

Public transport mode share for journey to work (JTW) trips originating in the M2 environs is reasonably high. As illustrated by Figure 11, 15-30% of trip origins in the majority of the study area and within the M2 environs are on public transport. When considering the catchment of the majority of M2 users west of Pennant Hills Road, public transport JTW mode share is between 0-15%.

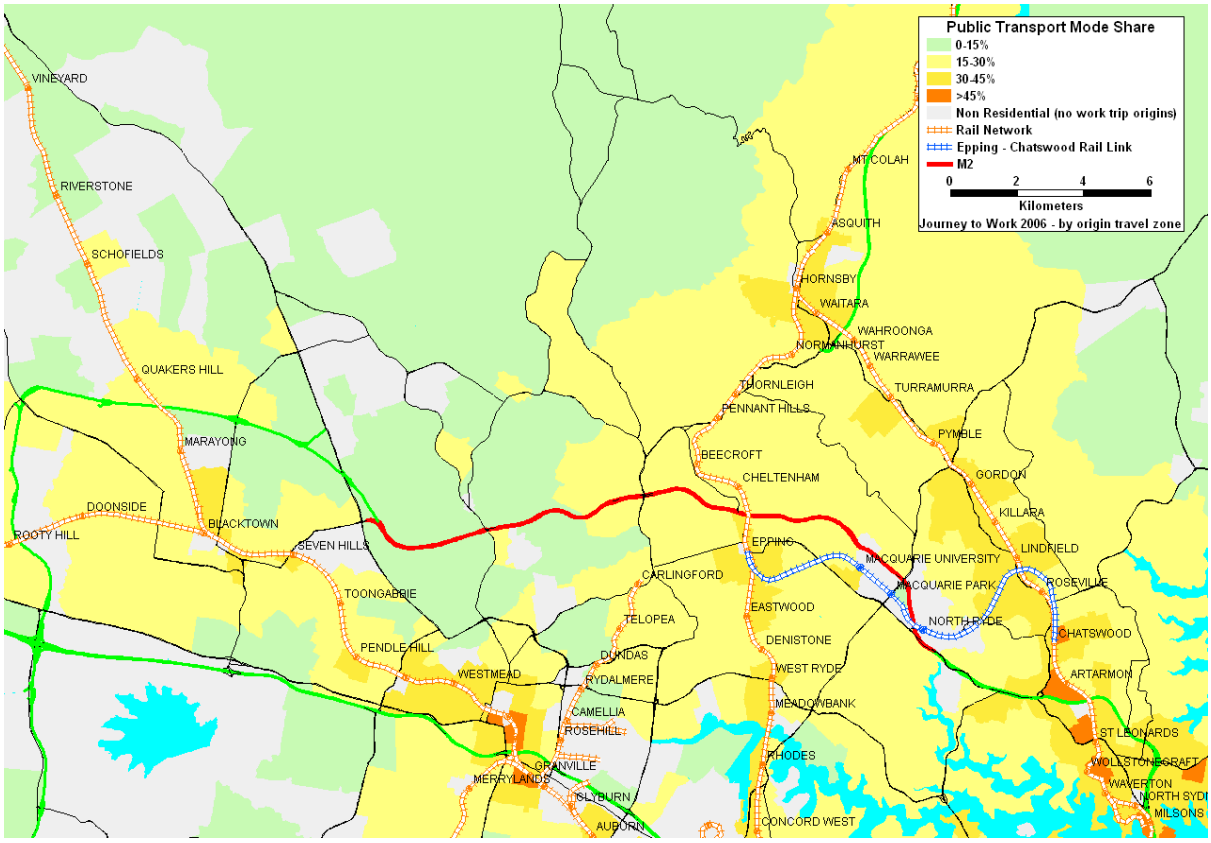

Figure 11 - Public Transport Mode Share Journey to Work by Origin (Source: 2006 Census)

Public transport mode share for JTW trips with a destination in the M2 environs is low as illustrated in Figure 12. New developments in the Macquarie Park area are required to have in place workplace plans to encourage public transport usage. An example of these measures include Optus putting in place a workplace travel plan when it centralised operations at its new headquarters in the area in 2007. This travel plan targets a 40%[3] public transport share by its employees. These requirements along with the commencement of operations of the new ECRL are expected to increase public transport mode share to the area.

[3] *Website: http://www.ryde.nsw.gov.au/WEB/SITE/RESOURCES/DOCUMENTS/Planning/MacquarieCorridor/MacquarieParkTraffic_Year2031Modelling.pdf*

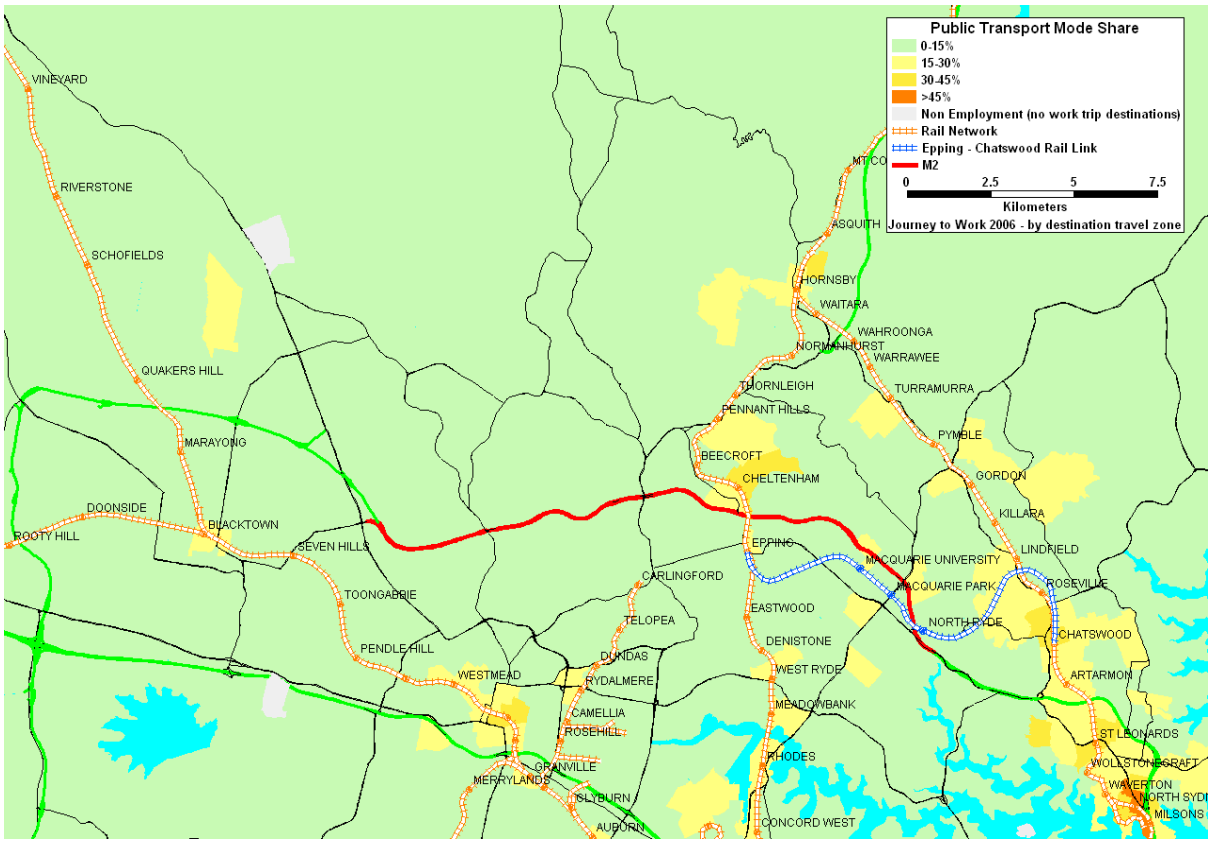

Figure 12 - Public Transport Mode Share Journey to Work by Destination (Source: 2006 Census)

No survey data are available to report existing bus delays in the area. However operator feedback suggests that bus priority on the M2 Motorway is protecting bus services from traffic congestion. However, in sections without bus priority, where traffic volumes exceed road capacity during the AM & PM peaks, buses are impacted by traffic congestion.

The introduction of the Epping-Chatswood Rail Line (ECRL) has created new public transport options for trips within Epping/Chatswood corridor.

2.4 Traffic Flows within Study Area

This section discusses traffic flows within the Study Area (both on the M2 itself and surrounding road network) – the focus is on Workday traffic and peak periods of the workday, when traffic volumes and hence impacts of the M2 Upgrade will be greatest.

2.4.1 M2 Workday Volumes

Average Workday volumes are an average of Monday to Friday daily volumes. Average Annual Daily Traffic (AADT) volumes are average daily volumes including Saturdays and Sundays. As weekend daily volumes are usually lower than workday volumes, AADT volumes are generally lower than average Weekday volumes. The M2 is currently used (average in June Quarter 2009) by 103,000 vehicle trips per workday; of which some 76,000 use the section of the M2 that includes the main toll point between Christie Road and Herring Road. The remainder (27,000) use only the section of M2 west of Pennant Hills[4].

[4] *Data collected via M2 Tolling System*

2.4.2 Growth in Average Annual Daily Traffic (AADT) Volumes

During the last 10 years, Average Annual Daily Traffic (AADT) traffic volumes along M2 have increased from 60,000 vehicles per day (vpd) to over 95,000 vpd, representing an average increase of 3,500 vehicles per year. During this period, a number of network events have impacted M2 traffic and growth.

These events include:

- Completion of M7 created an important infrastructure corridor linking the M4 and Hume Highway to M2. This resulted in a significant increase in traffic volumes (particularly trucks) west of Pennant Hills toll Plaza.
- Completion of Lane Cove Tunnel (LCT) created a motorway connection between M2 and the Gore Hill Freeway as the final missing link in the Sydney Orbital, with a consequent moderate uplift in M2 main plaza traffic. Interim westbound widening was completed in anticipation of LCT opening, and provided additional capacity resulting in a small uplift in PM peak westbound travel along the M2.

2.4.3 M2 Workday Peak Hour Traffic Flows

The M2 peak hour Workday traffic is over 4,800 vehicles per hour in the westbound direction and over 4,200 vehicles per hour in the eastbound direction.

Figure 13 indicates the historic hourly profile of total M2 Workday trips recorded at the MTP and Pennant Hills Plaza. Important points to note are:

- The completion of M7 in late 2005 resulted in uplift in peak and daily traffic, particularly at the western end of the motorway.
- The AM peak hour has been constrained at just under 8,000 vehicles since the completion of M7 and has not grown in 3 years.
- The completion of interim 3rd lane widening and the opening of the LCT in 2007 resulted in an uplift in PM peak traffic of approximately 800 vehicles per hour.
- While the peak period traffic – especially the AM – has remained relatively constant over the past 3 years due to capacity constraint, the motorway workday daily traffic has continued to grow, which is a result of peak spreading and growth in the inter-peak period.

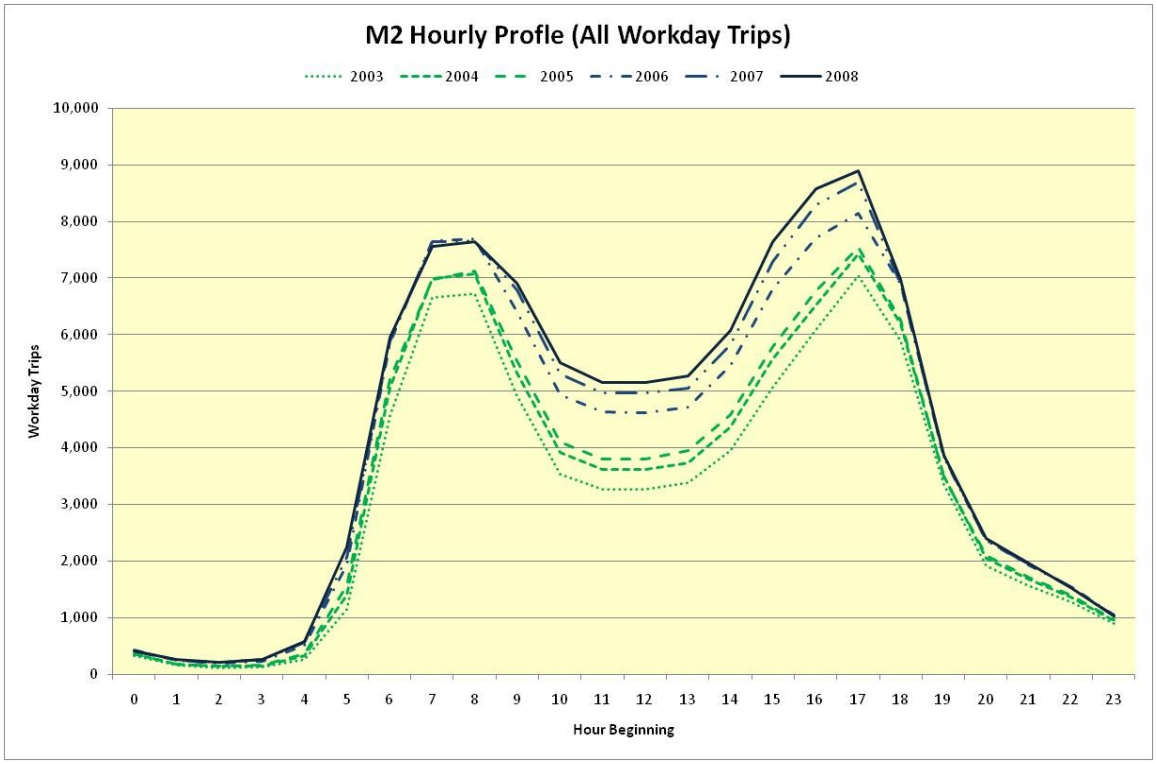

Figure 13 - M2 Historic Hourly Profile

2.4.4 M2 Sectional Volumes (Workday and Peak Periods)

Table 6 shows a breakdown of M2 sectional daily volumes along with the AM and PM peaks.

The AM peak hour referenced in this section and all subsequent sections of the report which details M2 sectional volumes is defined as 55% of the 2 hour period between 7-9AM. The PM peak hour is defined as 50% of the 2 hour period between 5-7pm.

During the AM peak, the eastbound (inbound) direction is busiest. At the beginning of the motorway, between Old Windsor Road and Windsor Road, M2 carries 2,250 vehicles. Further east, M2 is busier, with a peak of 4,200 vehicles travelling through the tunnel before the Main Toll Plaza.

During the PM peak, the westbound (outbound) direction is busiest, with a peak of 4,500 vehicles between Herring Road and Beecroft Road.

Across the day the busiest section, both in the east and westbound direction, is between Windsor Road and Pennant Hills.

Highest directional peak flows are at the Main Toll Point whilst overall highest daily flows are in the section west of Pennant Hills. This reflects the higher proportions of trucks in the traffic composition (with a through business day activity) in the section west of Pennant Hills (refer Section 2.4.5).

Table 6 - M2 Workday Daily Sectional Flows (2009)

Eastbound From	To	AM Peak Hour	PM Peak Hour	Daily
Old Windsor Road	Windsor Road	2,250	2,250	30,300
Windsor Road	Pennant Hills Road	3,150	2,800	39,000
Pennant Hills Road	Beecroft Road	3,400	2,100	33,950
Beecroft Road	Christie Road	4,200	2,300	38,050
Christie Road	Lane Cove Road	3,550	2,100	34,450
Lane Cove Road	Delhi Road	2,750	1,450	25,450
Delhi Road	Epping Road	1,900	1,050	17,350

Westbound From	To	AM Peak Hour	PM Peak Hour	Daily
Epping Road	Delhi Road	850	1,950	17,400
Delhi Road	Lane Cove Road	1,400	2,900	26,750
Lane Cove Road	Herring Road	1,950	3,750	35,550
Herring Road	Beecroft Road	2,150	4,500	39,650
Beecroft Road	Pennant Hills Road	2,000	4,100	36,800
Pennant Hills Road	Windsor Road	2,650	4,050	42,550
Windsor Road	Old Windsor Road	2,050	2,950	32,750

Total Traffic		AM Peak Hour	PM Peak Hour	Daily
Old Windsor Road	Windsor Road	4,300	5,200	63,050
Windsor Road	Pennant Hills Road	5,800	6,850	81,550
Pennant Hills Road	Beecroft Road	5,400	6,200	70,750
Beecroft Road	Christie Road	6,350	6,800	77,700
Christie Road	Lane Cove Road	5,500	5,850	70,000
Lane Cove Road	Delhi Road	4,150	4,350	52,200
Delhi Road	Epping Road	2,750	3,000	34,750

2.4.5 M2 Workday Traffic Composition

Completion of M7 in late 2005 created a key linkage for freight transport between the Hume Highway to the south and the F3 Freeway (F3) to the North with consequent significant growth in warehousing and distribution facilities along the M7 corridor. As a result, heavy vehicle (HV) traffic has grown significantly on the M2, particularly west of the Pennant Hills Road ramps.

Table 7 below shows daily heavy vehicle percentages (Toll Class 4[5]) since 2003. Prior to M7 truck percentage grew from 4.2% to 5.9%p.a. Post M7, truck percentage has grown to 7.7%p.a. and remained relatively constant to 2009.

Table 7 - M2 Historic Heavy Vehicle (HV) Class 4 Proportions of Workday Daily Traffic – All Toll Locations

Year	% Class 4
2003	4.2%
2004	5.4%
2005	5.9%
2006	7.3%
2007	7.7%
2008	7.7%
2009	7.2%

Completion of M7 also resulted in Pennant Hills Road Ramps Class 4 traffic doubling as shown in Figure 14. Prior to M7, Class 4 workday average was 2,000 vehicles, whereas after completion of M7 Class 4 workday average increased to over 4,000 vehicles.

This increase in traffic is primarily due to diversion of trips from the Cumberland Highway- Pennant Hills Road route between Hume Highway and F3 to the M7 route. Such diversion clearly demonstrates the benefits to the freight industry of tolled motorway facilities. Local communities also benefit from lower truck usage of the arterial network.

The proportion of class 4 traffic at the Main Toll Point has remained relatively constant since 2003 with an average of 4.3% of heavy goods vehicles.

[5] *Toll Class 4 includes two axle vehicles less more 2.8 metres in height and three axle vehicles more than 2 metres in height*

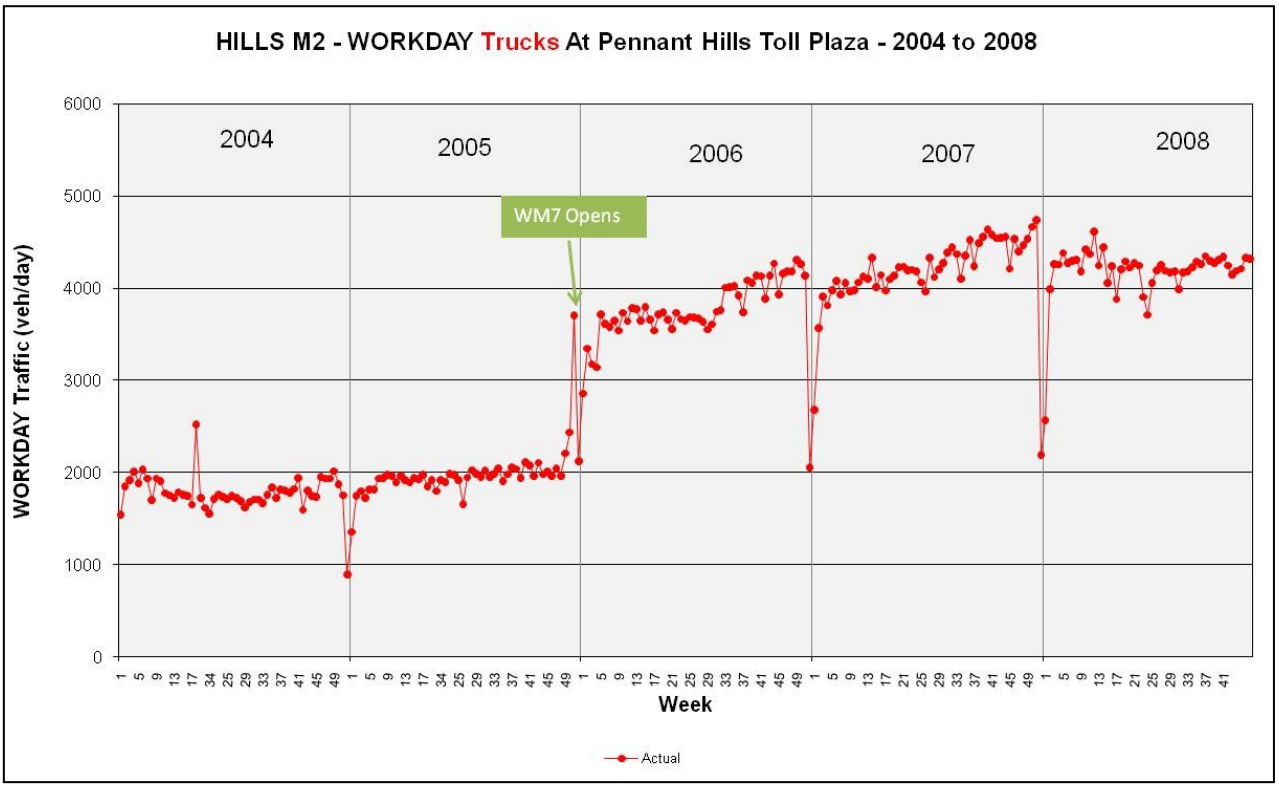

Figure 14 - Historic Heavy Vehicle (HV) Class 4 Workday Traffic (Pennant Hills)

2.4.6 Workday Traffic on Local / Access Roads

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 M2 Upgrade, 4 screenlines were defined as indicated in Figure 15. These are as follows:

- Western Screenline (N-S): the western screenline runs north to south between Norwest Boulevard and Station Road crossing the M2 at the interface with M7
- Windsor Road Screenline (N-S): The Windsor road screenline runs north to south between Castle Hill Road and Church St crossing the M2 between Windsor Road and Pennant Hills Road interchanges.
- Main Plaza Screenline (N-S): The Main Plaza screenline runs north to south between The Comenarra Parkway to Epping Road crossing the M2 at the Main Plaza
- Northern Screenline (E-W): The Northern Screenline runs east to west between Windsor Road and Ryde Road

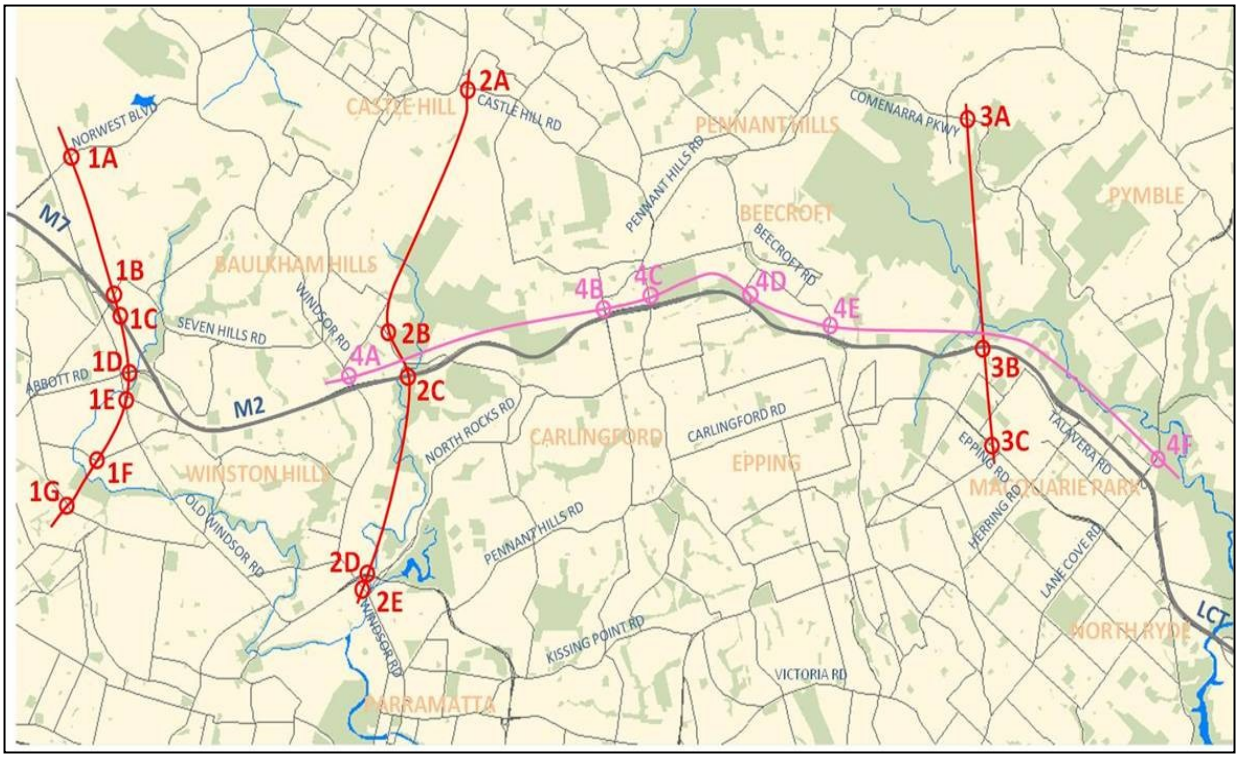

Figure 15 - Study Area Screenlines

Weekday morning peak hour and daily traffic on roads crossing these screenlines in each direction, and aggregate flows along screenlines are presented in Table 72 to Table 74. Information on individual roads is of interest in relation to the number of traffic lanes and comparative volumes both during the peak (vehicles per lane per hour) and total vehicles across the day. Information on screenline aggregate traffic is of interest when comparing traffic along the various corridors in the Study Area.

Table 8 gives the screenline traffic demands for the base year three north-south screenlines shown in Figure 15 with the traffic on M2/M7 shown as a percentage of the total demands. Demands in the study area build progressively from west to east as the route moves towards central Sydney. The largest screenline crossing is 238,200 vehicles per day, with AM and PM peaks each accounting for between 7% and 8% of the daily flow.

Table 8 - Daily Screenline Summary and M2 Capture

	Total Flow	M2 Flow	M2 Capture
Screenline 1	210,800	40,800	30%
Screenline 2	238,200	81,550	34%
Screenline 3	135,200	77,700	57%

2.5 Cycle Facilities

2.5.1 Hills M2 Original Layout

When the Hills M2 Motorway was originally opened in 1997, cyclists were allowed to use a 2.5m wide lane on the outer sides of the carriageway, which was used as a breakdown lane for motor vehicles. A typical cross section of the motorway is indicated as Figure 16 and shows the arrangements with 2 x 3.5m general traffic lanes each way for motor vehicles and the 2.5m shoulder. Some sections of the motorway also include a median bus lane in each direction (not shown here).

Designated cyclist cross-over points were line marked at the entry and exit ramps.

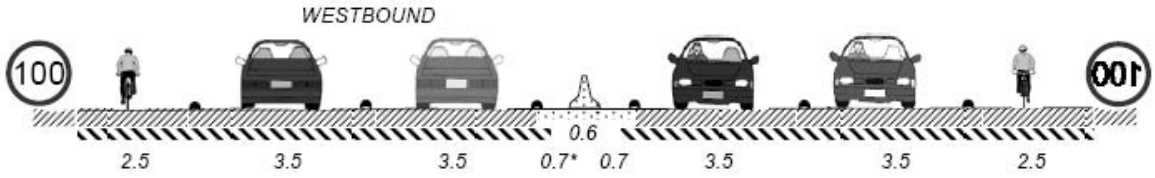

Figure 16 - As Constructed Lane Configuration

2.5.2 Hills M2 Current Layout

In March 2007, Hills M2 constructed an interim third lane westbound which included:

- the removal of the westbound carriageway shoulder (breakdown and cyclists lane) and replacement of line marking between Lane Cove and Beecroft Roads to create three lanes, consisting of two 3.1m wide and one 3.0m lane;
- The westbound speed limit was reduced from the prevailing 80km/h to 70 km/h along the new line marked sections. No change was made to the prevailing 100km/h eastbound speed limit;
- the establishment of an interim cycle detour via the local road system from North Ryde to Epping

The cross-section resulting from these works is shown in Figure 17

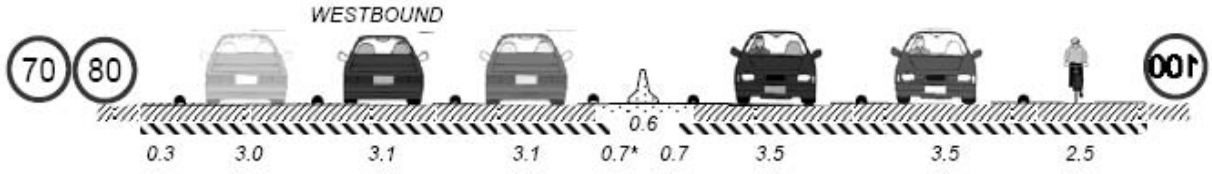

Figure 17 - Interim Lane Widening Lane Configuration

Westbound cyclists detour from the M2 approximately 80 metres from the Lane Cove Road interchange through a gap in the guardrail and travel along a cycle path, which connects to the cul-de-sac at the eastern end of Talavera Road. The route then crosses Lane Cove Road and continues along Talavera Road to Khartoum Rd, where a shared use path extends through to Culloden Road. From there, the detour continues onto Vimiera Road, across Epping Road to access the Pembroke Road cycle bridge over Terry's Creek. Continuing up Pembroke Road, cyclists then cross Epping Road again and travel northwest along Essex Street and Chester Street through the Beecroft Road bus underpass to connect onto the M2.

The section of motorway where the third lane was constructed, and the interim cycle detour route that was developed is shown in Figure 18.

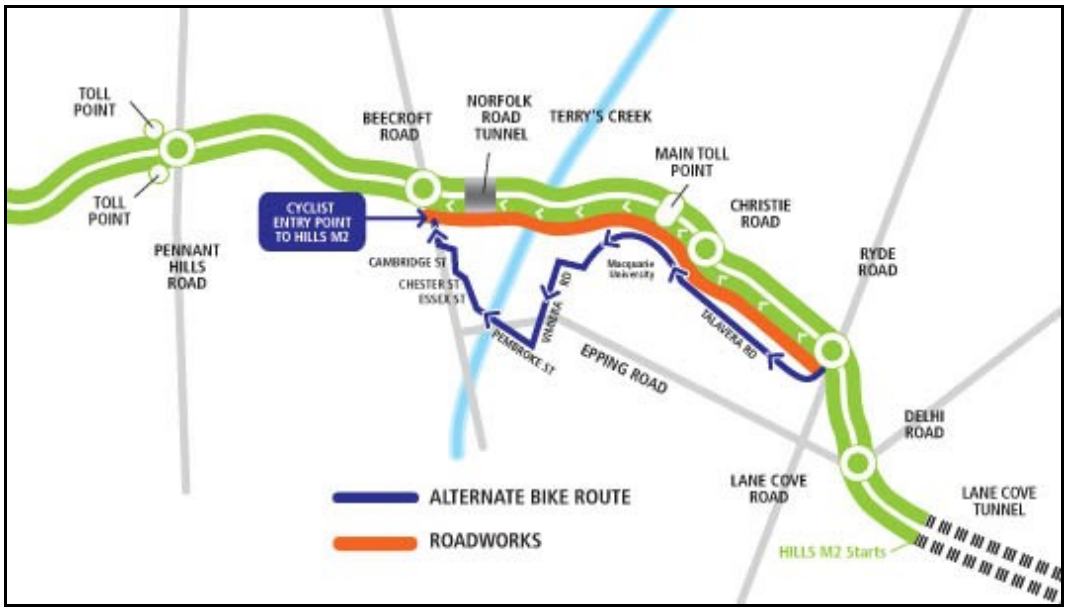

Figure 18 - Hills M2 Interim Cycle Detour

Other recent additions to the Sydney cycle network in the Hills M2 area include:

- a 7.5km shared cycle and pedestrian path from Wicks Road, North Ryde to Merrenburn Avenue, Naremburn constructed as part of the Lane Cove Tunnel project in 2006/07; and
- a shared cycle and pedestrian path of approximately 40km length, constructed as part of Westlink M7 project in 2004/5.

2.5.3 Existing local area cycle facilities in M2 study area

Local Councils in the M2 study area (City of Ryde, Parramatta City, The Hills Shire and Hornsby Shire) have implemented cycle plans, with varying degrees of progress. These local cycling networks could be utilised as cyclist detours during the M2 Upgrade construction works. Local cycle facilities are presented in Table 9.

Table 9 - Local Cycle Facilities

ROUTE	FACILITIES	POTENTIAL CYCLIST HAZARDS
Delhi Rd to Beecroft Rd (westbound)	▪ Epping Rd Shared User Path (SUP) from Lane Cove ends at the Wicks Rd intersection, North Ryde ▪ Cyclists are permitted to travel on M2 from Delhi Rd to Lane Cove Rd ▪ M2 interim 3rd lane detour route starts at Lane Cove Rd/Talavera Rd and continues past Macquarie Centre and Macquarie University (MQ) through to Vimera Rd, crossing Epping Rd twice before rejoining the M2 at the Beecroft Rd interchange	▪ Conflict with traffic on fragmented transfer from Epping Road SUP to M2 detour ▪ Major intersections at Epping Rd, Lane Cove Rd, Herring Rd ▪ Conflict with parked cars around MQ in Talavera and Vimera Rd ▪ Conflict with pedestrians as cyclists forced to use sections of the footpath rather than compete with cars ▪ Private driveways and multiple Epping Rd crossings along M2 interim 3rd lane detour route ▪ Use of Beecroft Rd bus underpass ramp not ideal
Beecroft Rd to Delhi Rd (eastbound)	▪ M2 breakdown lane accessible through to Delhi Rd ▪ M2 interim 3rd lane detour route which is currently marked for westbound only, could be used in both directions from Epping to Macquarie Park ▪ City of Ryde cycle route north/south in the peripheral area runs from West	▪ Tunnel lighting and uneven road surface on M2 ▪ Cross over point at Christie Road exit/Main Toll Plaza for through cyclist traffic not clearly marked or sign posted for motorists ▪ Existing interim detour route could be modified, however all existing hazards would be exacerbated by additional cycle traffic

ROUTE	FACILITIES	POTENTIAL CYCLIST HAZARDS
	Ryde along Vimera Rd under the M2 through Lane Cove National Park to South Turramurra	▪
Beecroft Rd to Pennant Hills Rd (westbound & eastbound)	▪ M2 breakdown lane accessible both directions ▪ Cyclists are known to use Kent St overbridge adjacent to Epping Heights School and cycle through Beecroft /Cheltenham Reserves ▪ Hornsby Shire cycleway alternate parallel to M2 along Copeland Rd (north) or Murray Farm Rd (south)	▪ Cyclists signage and line markings on local roads would need to be upgraded if utilised for detours ▪ Multiple intersections ▪ Hilly terrain on local streets in Epping, Beecroft and Carlingford
Pennant Hills Rd to Windsor Rd (eastbound & westbound)	▪ M2 breakdown lane is accessible both directions ▪ Unsealed walking tracks and mountain bike trails are utilised by recreational cyclists in Darling Mills/Bidjigal Reserve	▪ Fragmented network - lack of dedicated alternative east/west cyclist facilities in this area ▪ Cyclists signage and line markings on local roads would need to be upgraded if utilised for detours ▪ Multiple intersections ▪ Hilly terrain on local streets in Baulkham Hills, West Pennant Hills and North Rocks
Windsor Rd to Abbott Rd (eastbound & westbound)	▪ M2 breakdown lane is accessible both directions ▪ The Hills Shire has a sealed shared user path (SUP) from Old Windsor Rd, under the Abbott Rd ramps through several public reserves to Seven Hills Rd	▪ Conflict with buses and passengers on M2, as breakdown lane is shared with bus stops at Cropley Drive & Gooden Reserve ▪ Poor interface with M7 SUP encourages cyclists to cycle onto M7's breakdown lane ▪ Fragmented network - lack of dedicated alternative east/west cyclist facilities in this area ▪ Cyclists signage and line markings on local roads would need to be upgraded if utilised for detours ▪ Multiple intersections

2.6 Pedestrians

Pedestrian access is restricted to several points along the motorway that facilitate safe crossing of the M2 study area. The locations of these crossing points and the impacts on these from the M2 Upgrade are discussed in Section 7.5.

2.7 Summary

The M2 is a key link within the transport network, both as part of the Sydney orbital network and as a radial connection for private, public transport and commercial travel between the north-west and inner sectors of Sydney. It also caters for some cycle trips however pedestrians access is banned due to safety issues.

Increased travel demands and network changes have resulted in strong traffic growth on M2 with the result that it carries a large proportion of the study area's traffic demands, particularly at its eastern end. The M2 is strategically important in the study area as it caters for a large proportion of longer distance trips.

3.0 Existing Road Network Performance

Section 2 described the existing traffic demand patterns and behaviours. In this section, demands are combined with the network capacity to assess current network performance.

This assessment uses the following indicators:

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

3.1 Definition of Level of Service

3.1.1 Uninterrupted Flow (Motorways)

For uninterrupted flow on multi-lane roads, such as M2, 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 LoS[6]:

- **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 Hills M2 are based on the procedures in the US Transport and Research Board 2000 Highway and Capacity Manual.

[6] *AustRoads (2009), "Guide to Traffic Management, Part 3 - Traffic Studies and Analysis", Sydney*

3.1.2 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 LoS[7]:

- **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 in 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 intersection dealy 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.

3.2 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") 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 10 below lists theoretical hourly lane capacity by road type for LoS E. These theoretical capacities represent ideal conditions. In practice, higher traffic throughputs can be observed and local conditions such as narrow lanes, inadequate shoulders, parking and property access can also reduce these capacities.

Table 10 - 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

[7] *AustRoads (2009), op. cit.*

3.2.1 Hills M2 Level of Service

M2 provides the principal road connection between the Northwest suburbs of Sydney and the Lower North Shore/Sydney CBD. It also provides the principal transport connection for bus services.

Over time, M2 has become increasingly busy and congested. Table 11 provides existing AM and PM peak hour traffic flows, and associated level of service for each direction and section of the M2. During peak periods, the LoS of sections of M2 downstream of on-ramps generally falls below the midblock LoS due to relatively high merging volumes. Hence, traffic conditions along the M2 can deteriorate rapidly and cause delays for users. The LoS values shown in Table 11 reflect two analytical themes: where an on-ramp is present along a link, the LoS associated with the merge area has been adopted as the worst case, based on HCM[8] methodology; where a link is uninterrupted, the LoS is based on flows and capacities on the mainline between interchanges. An indication of this deterioration is provided in Section 3.3 "Travel Speeds and Travel Times".

Table 11 – Observed M2 Level of Service and Hourly Capacity

Eastbound From	To	Lanes	Capacity (veh/hr)	AM Peak Hour Veh (1)	PM Peak Hour Veh (1)	LoS (2) AM	LoS (2) PM
Old Windsor Road	Windsor Road	2	4,000	2,250	2,250	C+	B+
Windsor Road	Pennant Hills Road	2	4,000	3,150	2,800	D+	B+
Pennant Hills Road	Beecroft Road	2	4,000	3,400	2,100	D+	B+
Beecroft Road	Christie Road	2	4,000	4,200	2,300	F+	B+
Christie Road	Lane Cove Road	2	4,000	3,550	2,100	D	C
Lane Cove Road	Delhi Road	2	4,000	2,750	1,450	C	B
Delhi Road	Epping Road	2	4,000	1,900	1,050	B	A

Westbound From	To	Lanes	Capacity (veh/hr)	AM Peak Hour Veh (1)	PM Peak Hour Veh (1)	LoS (2) AM	LoS (2) PM
Epping Road	Delhi Road	2	4,000	850	1,950	A	C
Delhi Road	Lane Cove Road	2	4,000	1,400	2,900	B+	C+
Lane Cove Road	Herring Road (3)	3*	5,200*	1,950	3,750	B+	C+
Herring Road	Beecroft Road (3)	3*	5,200*	2,150	4,500	B+	D+
Beecroft Road	Pennant Hills Road	2	4,000	2,000	4,100	B	E
Pennant Hills Road	Windsor Road	2	4,000	2,650	4,050	C+	D+
Windsor Road	Old Windsor Road	2	4,000	2,050	2,950	B	C

Notes: (1) Vehicle volumes are June 2009 observed volumes.

(2) Level of service has been calculated using the AustRoad guidelines based on observed travel speeds. LoS marked with + refer to HCM freeway ramp merge analysis (See Appendix C).

(3) Westbound section between Lane Cove Road and Beecroft Road has three (narrow 3.1m) lanes hence increased capacity over the other 2 lanes segments.

In the AM peak, the dominant direction of travel is eastbound, catering for trips towards the business districts of Chatswood, North Sydney and Sydney CBD. The busiest section of the motorway is at the Main Plaza between Beecroft Road and Christie Road, with this section operating at a capacity corresponding to LoS E. However the merge analysis confirms this section's performance is constrained by the operation of the Beecroft Road on-ramp (with LoS F). This has a compounding effect with it not being uncommon to see similar poor LoS extended all the way back to the connection with M7, i.e.

[8] "§25 Ramps and Ramp Junctions", Highway Capacity Manual, TRB 2000

through the two sections between Windsor Road and Beecroft Road which are currently assessed as having LoS D, and the section between Old Windsor Road and Windsor Road which is currently assessed as LOS C.

Furthermore, in the morning peak, particularly in summer months, drivers of vehicles travelling through the tunnel suffer sun glare which can cause vehicles to slow suddenly with consequent flow breakdown and reduced sectional capacity.

In the PM peak, the dominant direction of travel is westbound with peaks of 4,500 vehicles per hour, some 300 vehicles per hour higher than the AM EB peak. Reasons for higher westbound peak traffic include the interim third lane widening between Lane Cove Road and Beecroft Road, where this section currently has three narrow lanes.

Furthermore, westbound traffic flow has always been slightly higher than eastbound because longer distance trips from the Sydney CBD do not pay a toll to use the Sydney Harbour Bridge or Tunnel.

In the PM peak, the westbound direction of the motorway operates at LoS C between Epping Road and Herring Road. Despite the three lanes between Lane Cove Road and Beecroft Road, effective capacity is reduced due to narrow lanes, lack of shoulders, and reduced speed, resulting in a LoS D between Herring Road and Beecroft Road. Further west from Beecroft Road the motorway operates near capacity equivalent to LoS E between Beecroft and Pennant Hills, and LoS D between Pennant Hills and Old Windsor Road.

3.2.2 Local Roads/Access

Vehicles on M2 can be separated into through-traffic, those that enter or exit M2 at M7 or LCT and travel the entire length of the motorway, and local traffic, those with trips ends in the study area.

This section assesses the current performance of local/access roads to the M2 at the screenline locations listed in Section 2. The majority of the data has been sourced for 2008/2009 from RTA count stations, SCATS intersection counts and travel time surveys. The LoS for these roads is defined in terms of average travel speed.

3.2.2.1 AM Peak Flows (Inbound)

Table 12 summarises inbound AM peak hour observed flows, and shows that a number of major arterial and arterial roads, along with M2, are at or approaching LoS F capacity levels.

At Screenline 1, the western end of the M2 Study area, Norwest Boulevard and Old Windsor Road are the most congested; both of these locations operate at LoS F.

At Screenline 2 further east, the flows and congestion across all roads begin to increase. Both James Ruse Road and Church St operate at LoS F.

At Screenline 3, Epping Road is at LoS F experiencing heavy congestion and slow travel times.

At Screenline 4, a number of M2 access points are nearing or at LoS F, with both Windsor Road and Ryde road suffering heavy congestion during the AM peak period.

Table 12 - AM Peak Performance of Local Roads in Study Area (Inbound/City bound)

SCL	DIR	Location	Type	Lanes	Hourly Vehicle Volume	LoS
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,200	F
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	1,250	B
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	950	A
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,850	F
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	700	C
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,000	C
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1,800	C
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	1,150	D
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	3,500	F
2E	EB	Church Street South of Briens Road	Major Arterial	3	2,250	F
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	500	D
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	2,500	F
4A	SB	Windsor Road North of M2	Major Arterial	2	2,750	E
4B	SB	Oakes Road North of M2	Sub-Arterial	1	1,150	C
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	3,550	F
4D	SB	Murray Farm Road @ M2	Collector	1	1,000	B
4E	SB	Beecroft Road North of M2	Major Arterial	2	2,100	C
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	4,000	F

Source: Various – including RTA, Local Council, Tolling and Data Collection

Notes: (1) Screenline 4A (Windsor Road) LoS services based on intersection LoS with M2

3.2.2.2 AM Peak Flows (Outbound)

Table 13 below summarises AM peak flows across the Study Area in the outbound direction. Unlike the inbound or city bound direction, which is the dominate movement in the AM peak, traffic flows in the outbound direction are significantly lower and generally sufficient capacity at each location in the Study Area.

Table 13 - AM Peak Performance of Local Roads in Study Area (Outbound)

SCL	DIR	Location	Type	Lanes	Hourly Vehicle Volume	LoS
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	850	A
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	900	B
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	750	A
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	1950	C
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	400	B
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	1000	C
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1900	C
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	550	D
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	1550	E
2E	WB	Church Street South of Briens Road	Major Arterial	3	900	E
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	900	C

SCL	DIR	Location	Type	Lanes	Hourly Vehicle Volume	LoS
3C	WB	Epping Road West of Vimiera Road	Major Arterial	2	850	E
4A	NB	Windsor Road North of M2	Major Arterial	3	1550	A
4B	NB	Oakes Road North of M2	Sub-Arterial	1	750	B
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	2150	B
4D	NB	Murray Farm Road @ M2	Collector	1	400	A
4E	NB	Beecroft Road North of M2	Major Arterial	2	850	B
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	3150	C

Source: Various – including RTA, Local Council, Tolling and Data Collection

Notes: (1) Screenline 4A (Windsor Road) LoS services based on intersection LoS with M2

3.2.2.3 PM Peak Flows (Inbound)

Table 14 below summarises PM peak traffic in the inbound direction. As with the AM outbound traffic, during the PM peak, the inbound direction is the non dominant direction of traffic flow, and hence the network provides sufficient capacity with flows at the majority of all crossing points well LoS D or better.

Table 14 - PM Peak Performance of Local Roads in Study Area (Inbound/City bound)

SCL	DIR	Location	Type	Lanes	Hourly Vehicle Volume	LoS
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1050	B
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	900	B
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	850	A
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,250	C
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	450	B
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,000	B
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1,800	D
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	500	A
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	1,800	B
2E	EB	Church Street South of Briens Road	Major Arterial	3	1,100	E
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	950	C
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	1,050	D
4A	SB	Windsor Road North of M2	Major Arterial	2	1,650	D*
4B	SB	Oakes Road North of M2	Sub-Arterial	1	650	C
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	2,400	D
4D	SB	Murray Farm Road @ M2	Collector	1	400	A
4E	SB	Beecroft Road North of M2	Major Arterial	2	950	B
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,750	D

Source: Various – including RTA, Local Council, Tolling and Data Collection

Notes: (1) Screenline 4A (Windsor Road) LoS services based on intersection LoS with M2

3.2.2.4 PM Peak Flows (Outbound)

Table 15 below summarise PM peak outbound flows across the Study Area screenlines. During the PM peak, the outbound direction is the dominant movement of traffic, which is reflected below with a number of local/access roads and the M2 at LoS D or worse.

At Screenline 1, Old Windsor Road is the busiest with LoS C.

At Screenline 3, Epping Road experiences heavy congestion and operates at LoS F.

Table 15 - PM Peak Performance of Local Roads in Study Area (Outbound)

SCL	DIR	Location	Type	Lanes	Hourly Vehicle Volume	LoS
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,900	B
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	1,150	B
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	1,000	A
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,600	C
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	550	B
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	950	B
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	2,050	C
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	1,150	D
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	2,300	C
2E	WB	Church Street South of Briens Road	Major Arterial	3	2,050	D
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	450	D
3C	WB	Epping Road West of Vimiera Road	Major Arterial	2	1,950	F
4A	NB	Windsor Road North of M2	Major Arterial	3	2,550	A*
4B	NB	Oakes Road North of M2	Sub-Arterial	1	1,350	C
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	3,200	D
4D	NB	Murray Farm Road @ M2	Collector	1	500	A
4E	NB	Beecroft Road North of M2	Major Arterial	2	1,600	B
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,650	B

Source: Various – including RTA, Local Council, Tolling and Data Collection

Notes: (1) Screenline 4A (Windsor Road) LoS services based on intersection LoS with M2

3.3 Travel Speeds and Travel Times

Travel speeds and travel times in the study area are compared and discussed in this section.

Figure 19 shows the routes chosen for this comparison. The comparison is from Lane Cove River to exit of the M2 onto Old Windsor Road. The green line represents the M2 route that was surveyed and the red line represents the next best alternative to M2.

Table 16 shows average travel times for the AM and PM peaks on the Hills M2 motorway and the local network alternatives. Congestion within the M2 study area is particularly bad during the AM peak period, as reflected by the high travel times and low average speeds.

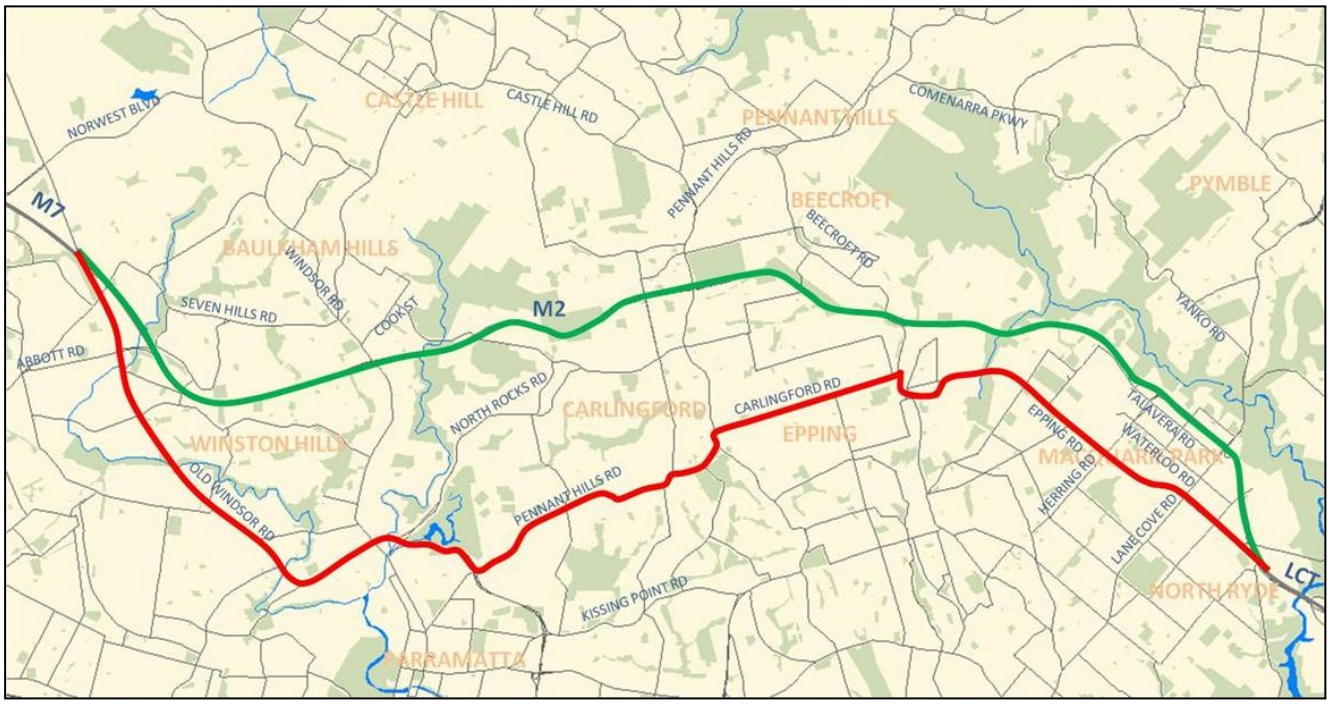

Figure 19 - Travel Time Comparison Routes

Table 16 - M2 and Surrounds Travel Time and Speeds (August 2009)

Route	Peak Period /Direction	Travel Time (minutes)	Average Speed (km/hr)
M2	AM-IB	34	37
Alternative	AM-IB	45	30
M2	PM-OB	27	45
Alternative	PM-OB	46	29

Morning peak congestion points on the motorway are west of and at Norfolk tunnel. Average speeds in these sections can drop below 20 km/h and are the result of insufficient capacity to accommodate traffic entering the motorway at Beecroft Road. The insufficient merge capacity at this location, coupled with conditions within the Norfolk tunnel result in flow break down, leading to poor travel speeds and queuing which can extend to M7.

Whilst westbound travel times during the PM peak are relatively high compared to other times of the day, the congestion on both the M2 motorway and the alternative local network is not as extreme as the AM peak. Average westbound speeds on the M2 during the PM peak are substantially higher than the

eastbound speeds in the AM peak; interim westbound widening is likely to be a contributing factor to the relative difference in peak direction performance of the M2 motorway.

3.3.1 Intersection Operation

The performance of intersections uses a Level of Service (LoS) indicator. Grades A to F are once again used, so as to provide some tie-in with the link indicators and the Level of service (LoS) criteria specified by the NSW RTA's guidelines[9] is shown in Table 17.

Two different traffic engineering software packages were used to estimate LoS for the intersections within the Study Area. The SCATES intersection analysis program has been used to assess the operation of closely spaced co-ordinated traffic signals, and SIDRA 3.2 has been used to assess isolated traffic signals.

Table 18 gives estimates of the current performance of major intersections within the study area and the associated software package used for the assessment.

Key input data for the intersection models were:

- Classified intersection counts and pedestrian movements, dated 2007 for Macquarie Park intersections (post LCT) and August 2006 for Windsor Rd and Pennant Hills Rd intersections only.
- SCATS intersection counts dated October 2009.
- Intersection geometry cross referenced from a variety of sources including aerial photographs, RTA detailed design diagrams and site inspections.
- Phase times and movement descriptions, specified by historical SCATS data, sourced from the RTA.

Table 17 : Intersection performance measures

Intersection Level of service (LoS)	Average Delay per vehicle (sec/veh) including geometric delay	Conditions for signalised intersections
A	0 – 14.5	Good operation
B	14.5 – 28.5	Acceptable delays & spare capacity
C	28.5 – 42.5	Satisfactory
D	42.5 – 56.5	Operating near capacity
E	56.5 – 70.5	At capacity
F	> 70.5	Extra capacity required

Source: NSW RTA Guide to Traffic Generating Development, Oct 2002.

Figure 20 indicates the locations of the intersections which were modelled as part of this impact assessment. The intersections were selected at locations where the M2 Upgrade is expected to impact the traffic volumes and operations of the intersections.

[9] *NSW RTA Guide to Traffic Generating Development, Oct 2002.*

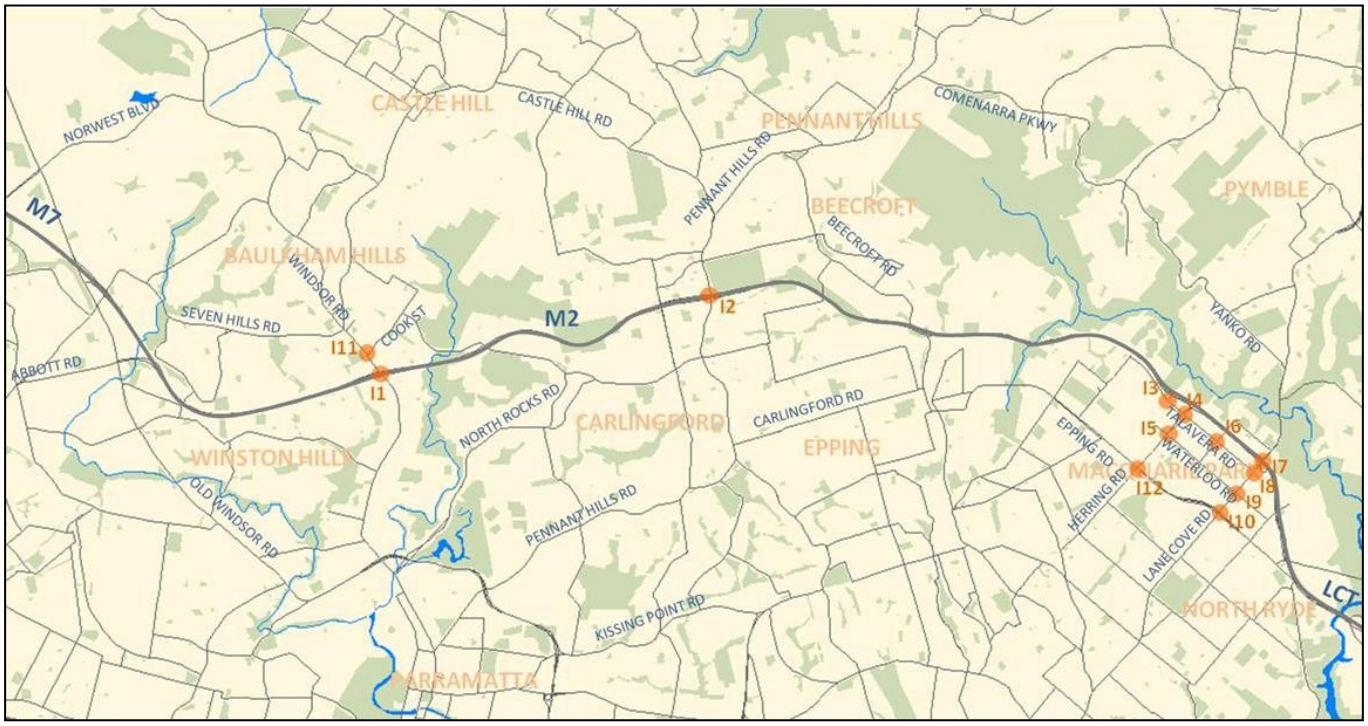

Figure 20 - Locations of Intersections assessed

Table 18 below summarises the current intersection performance within the Study Area. Intersections shaded above the solid green line are those directly impacted by M2 traffic flows while intersections below the solid green line are within the study and are influenced by travel patterns along M2.

The average delay represents the average delays that all vehicles experience within the AM and PM peak hour which is modelled. The degree of saturation (DOS) is the calculated ratio between the demand flow rate and the capacity for each movement. When the maximum DOS for any movement in the intersection is above 95%, then the intersection is regarded as over-saturated or operating above its practical capacity. This means that it will take more than one cycle of the signals to progress through the intersection. DOS values above 1.0 typically indicate higher congestion and delays with conditions more sensitive to small changes in demand.

Table 18 - Existing Intersection Performance

Intersection	LoS AM peak			LoS PM peak			Assessment Software
	LOS	Average Delay (s)	DOS	LOS	Average Delay (s)	DOS	
I1 - Windsor Road - M2 ramps	B	27	1.00	B	26	1.00	SIDRA
I2 - Pennant Hills Rd - M2 ramps	B	27	0.82	D	43	0.96	SIDRA
I3 - Christie Rd - Talavera Rd	C	42	0.98	A	8	0.55	SCATES
I4 - Herring Rd - Talavera Rd	B	26	0.68	B	18	0.83	SCATES
I7 - Lane Cove Rd - M2 ramps	A	8	0.80	A	7	0.81	SCATES
I5 - Herring Rd - Waterloo Rd	C	38	0.86	C	34	0.71	SIDRA
I6 - Khartoum Rd - Talavera Rd	B	28	>1.0	B	26	0.96	SCATES
I8 - Lane Cove Rd - Talavera Rd	B	25	>1.0	F	90	>1.0	SCATES
I9 - Lane Cove Rd - Waterloo Rd	F	107	>1.0	D	56	>1.0	SCATES
I10 - Lane Cove Rd - Epping Rd	E	65	>1.0	F	78	1.80	SCATES
I11 - Windsor Rd - Cook Rd	F	243	>1.0	C	36	0.96	SIDRA
I12 - Herring Rd - Epping Rd	E	57	1.00	D	52	0.90	SIDRA

In the AM Peak the only intersection operating at LoS F is Lane Cove Road and Waterloo Road, and is due to high proportion of turning traffic from Lane Cove Road accessing Macquarie Park via Waterloo Road. In the PM peak the intersections Lane Cove Road/Talavera Road and Lane Cove Road/Epping Road are operating at LoS F. Similarly to the intersection of Lane Cove Road/Waterloo Road during the morning peak, the poor performance of Lane Cove Road/Talavera Road during the evening peak is attributable to high volumes of traffic leaving the Macquarie Park area via Talavera Road. The performance of Lane Cove Road/Epping Road reflects intersection of two heavily trafficked major arterial roads in the network.

3.4 Road Safety

Table 19 summarises accident statistics on the M2 over the six-year period 2003 to 2008. It includes a breakdown of accidents by severity.

Table 19 - M2 Accidents by Type (2003-2008)

Severity	2003	2004	2005	2006	2007	2008	Total
Fatal	0	0	0	0	1	0	**1**
Injury	36	22	40	33	45	31	**176**
Non-casualty (tow away)	55	60	70	63	81	52	**329**
Grand Total	**91**	**82**	**110**	**96**	**127**	**83**	**506**

Source: Transurban and RTA

The following Table 20 compares 2008 accident rates observed on the M2 Motorway to the aggregate accident rates on all NSW roads in the same period. This shows that compared to state-wide average accident rates there is a favourable risk profile associated with travel on the M2 Motorway.

The difference between the M2 and state-wide average is greater for fatal and injury accident rates (less than a third of the overall rates) compared to the non-casualty rates (less than half the overall rate). This may be attributable to safety benefits of motorways associated with grade separated interchanges and physical separation between opposing traffic streams.

Table 20 - 2008 Accident Rates, M2 Motorway vs NSW Average (accidents per 100 million Vehicle Kilometre Travelled)

Severity	NSW Overall	M2 Motorway
Fatal	0.5	0.0
Injury	28.5	6.7
Non-casualty (tow-away)	36.1	11.3
Total	65.1	18.0

Source: Based on RTA and Transurban data

A more detailed analysis at the M2 accident data was carried out to establish the temporal and spatial distribution of the accidents along the motorway during the five year period for which data was summarised above.

Distribution of accidents by hour of the day is indicated in Figure 21. The two peaks that are observed in the chart demonstrate the significance of congestion as a contributing factor to accidents on the motorway. The proportion of accidents occurring during the most congested periods of the day, the morning peak period (6am to 9am) and afternoon peak period (4pm to 7pm) combine to account for 60 per cent of all accidents on the motorway. This is far in excess of the proportion of daily traffic in such periods indicating a higher accident per vehicle kilometre in the peak periods.

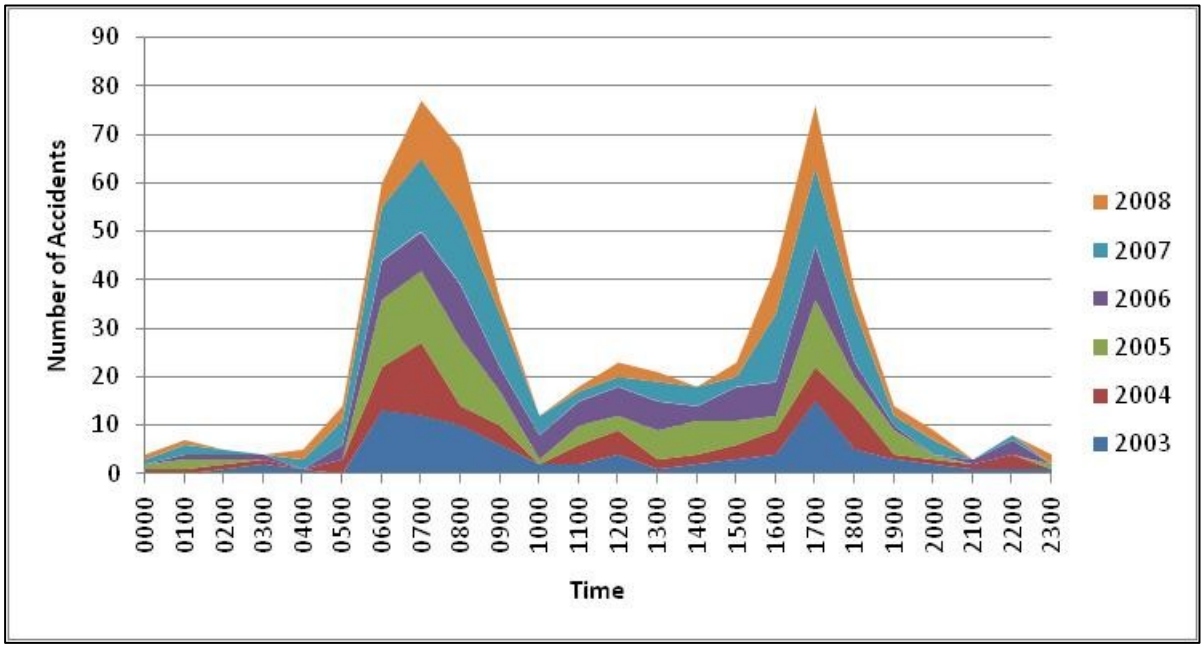

Figure 21 - M2 Accidents by Time of Day

Figure 22 below identifies areas where there were significant concentrations of accidents over the five year analysis period.

Table 21 describes the characteristics of each section and suggests possible reasons why accident occurrences tend to be particularly high in these sections. 57% of accidents during the analysis period occurred within the identified sections.

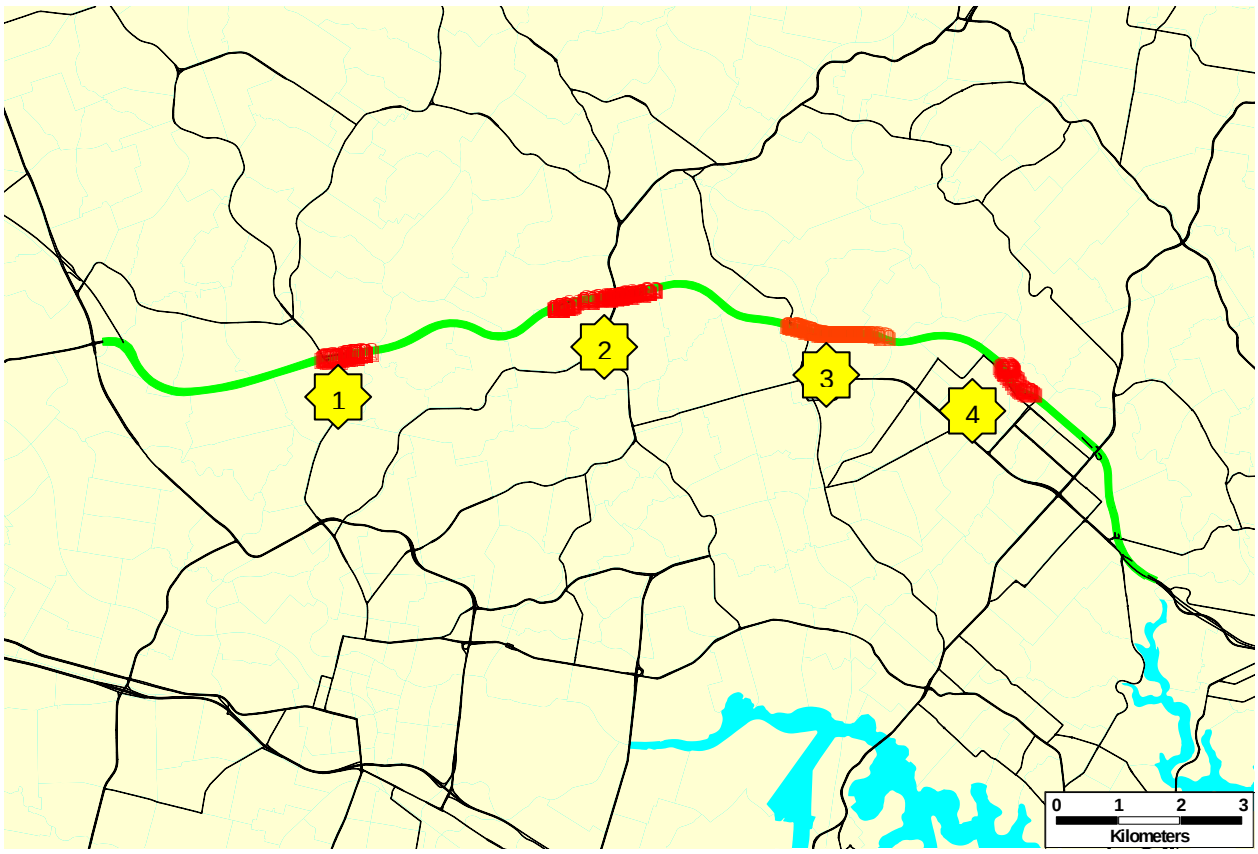

Figure 22 - M2 Accidents Concentrations

Table 21 - M2 Accident Hot Spots

Hot Spot ID	Location	Section Length (km)	# Accidents (2003-2007)	Comments
1	East of Windsor Rd Overpass	0.6	31	High merge volumes from the eastbound on-ramp.
2	Pennant Hills Rd Interchange	1.6	95	Highest traffic interchange
3	Norfolk Tunnel and approaches	1.5	119	Highest peak traffic section. Sun glare issues (particularly during the morning peak eastbound and evening peak westbound).
4	Main Toll Plaza	0.6	44	Accidents analysis period included prior to February 2006 when there were cash booths on the main line. The "Express Lanes" project resulted in cash lanes being moved to the left hand side of the toll plaza. Still many driver decisions required in this area including lane choice related to payment method and of the Herring Rd entry and Christie Rd exits.

Overall, there appears to be significant increase (50%) in M2 accidents during peak periods between 2006 and 2008 (M7 opened in December 2005 and LCT opened in March 2007), above the increase growth in traffic over this period.

3.5 Summary

With the completion of the M7 then LCT traffic demands within the Study Area have increased significantly, which has led to:

- low travel speeds along M2 and its alternative;
- Increased HGV proportions along M2 west of Pennant Hills Road
- poor levels of services, both on the Motorway and local roads.
- increase in vehicular accidents along M2 (particularly during peak periods)

Overall, traffic and transport services in the Study Area are substandard at peak periods and will worsen as demand grows. Improvements to M2 will be needed to improve or at least maintain the current level of service.

Given the existing conditions any further growth in traffic and peak congestion on the M2 will result in peak spreading with yet higher congestion levels in the shoulder hours and greater use of local roads to support long distance movements. Such increases will lead to further degradation of the traffic environment within the Study Area.

4.0 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 with and without the Proposed M2 Upgrade.

This chapter describes the TUSTM modelling process that underlies the prediction of future base traffic conditions and the change that will result from an M2 Upgrade.

4.1 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.

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; 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 which in turn affects 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 Data Centre (TDC).

4.2 Traffic Modelling Process – An Overview

TUSTM was developed in early 2005 by Transurban's Traffic Services Group (TSG) 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 in Appendix A.

4.3 Traffic Modelling Assumptions

4.3.1 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 69Table 69 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.

Table 68 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.

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.

4.3.1.1 North West Growth Centre

Population and employment is addressed in detail in the Strategic Needs Sections of the Environmental Assessment Report. In summary, as well as population and employment growth in the M2 environs, significant growth is planned for the North West Growth Centre which covers parts of the Blacktown, Baulkham Hills and Hawkesbury Local Government Areas (LGAs). The North West Growth Centre as illustrated in Figure 23 is approximately 10,000 hectares and is planned to accommodate around 66,000 new homes in the next 30 or so years.

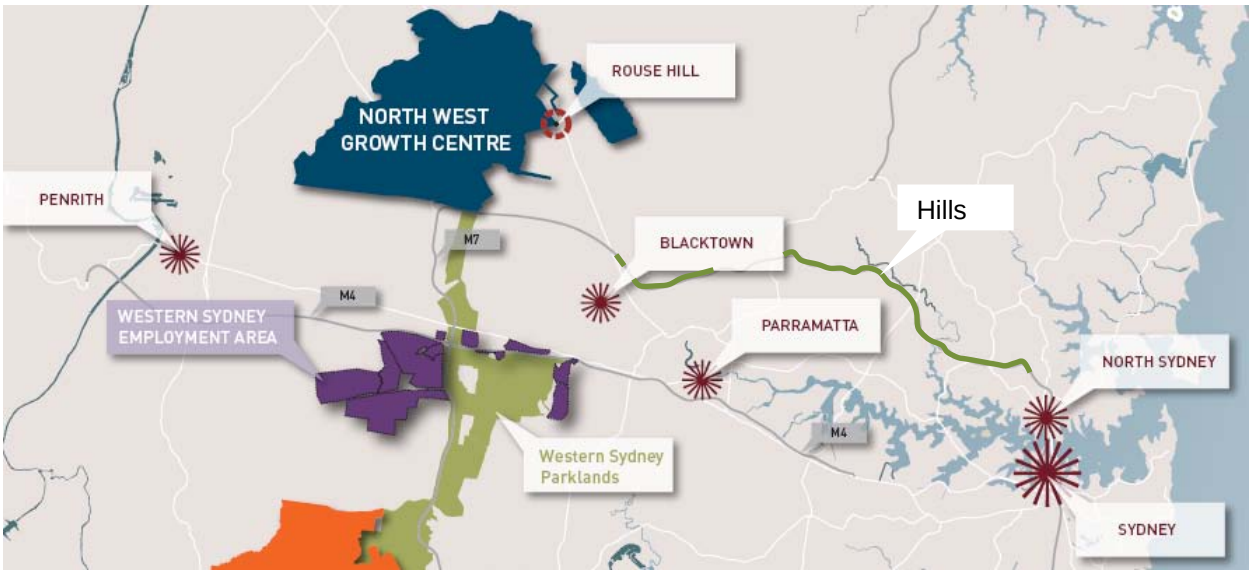

Figure 23 - Proposed North-West Growth Centre

Source: Department of Planning "Guide to Western Sydney Employment Area (August 2009)

4.3.2 M2 Upgrade Toll Assumptions

The future nominal M2 Tolls used for modelling the M2 Upgrade are detailed below in Table 22.

Table 22 - TUSTM Toll Assumptions (M2 Upgrade)

Toll Location	Nominal $	
	2011	2021
Main Plaza Cars	5.50	8.11
Main Plaza Trucks	15.10	24.20
Pennant Hills Road Cars	2.75	3.85
Pennant Hills Road Trucks	7.70	12.10
Windsor Road Ramps Cars	1.79	2.86
Windsor Road Ramps Trucks	5.35	8.57
Herring Road Ramps Cars	2.52	4.04
Herring Road Ramps Trucks	7.55	12.11

These tolls are consistent with the In-Principal Agreement which was reached between Hills M2 and RTA on 13 October 2009. However, it should be noted that for modelling purposes the opening year is considered to be 2011, and in accordance with the In-Principal agreement a toll increase of 8% has been applied. Hence, the modelled tolls for 2011 will not reflect the actual tolls for this period as the M2 Upgrade project will not be completed until September 2012.

4.3.3 TUSTM Network Assumptions

The baseline road network adopted for TUSTM was the situation as it existed in 2006. The process for forecasting future growth and impacts in regards to the M2 Upgrade project is discussed below.

4.3.4 Forecasting Future Growth and Impacts for the M2 Upgrade Project

For the future do nothing examined in this report, the following methodology and network changes where assumed:

Step 1: Updated 2006 Network

- The 2006 base network was updated to include:
  - Lane Cove Tunnel
  - Windsor Road Upgrade Works
- The updated 2006 network was then re-run with 2006 demands and validated.

Step 2: Determine "Do nothing" growth 2006-2011

- Generate 2011 road network with the following changes to the updated 2006 network:
  - Removal of M4 Toll
  - No other road projects were included. This was due to uncertainty around future timing and to ensure impacts forecast within the Study Area are those specifically relating to the M2 Upgrade Project
- Compare 2006 and 2011 model results and determine forecast per anum (p.a.) growth between 2006 and 2011
- Apply forecast growth to observed 2009 traffic conditions in Study Area

Step 3: Determine "Do nothing" growth 2011-2021

- Generate 2021 road network with the following changes to the updated 2011 network:
  - No other road projects were included. This was due to uncertainty around future timing and to ensure impacts forecast within the Study Area are those specifically relating to the M2 Upgrade Project
- Compare 2011 and 2021 model results and determine forecast p.a. growth between 2011 and 2021
- Apply forecast growth to observed forecast 2011 traffic conditions in Study Area

Step 4: Determine M2 Upgrade Impacts

- Recode the 2011 and 2021 networks as detailed in Steps 2 and 3 to include the M2 Upgrade scope;
- Run the 2011 and 2021 M2 Upgrade Scope models;
- Compare 2011 and 2021 model results with and without the project; and
- Apply the forecast change marginally to the 2011 and 2021 do nothing traffic scenario.

4.3.4.1 Potential Impacts from an F3-M2 connection

The F3 to Sydney Orbital link is identified as an AusLink strategic investment project, which requires Federal and NSW Government support. The Federal Government is committed in principle to delivering a new link for the National Highway route between the F3 and Westlink M7.

The NSW Government is not currently engaged with the project nor is there any State funding allocated to the corridor for either upgrading existing roads or developing new roads.

The preferred route option for the F3 to M2, option "Purple" (Figure 24), is a tunnel from the end of the F3 at Wahroonga following Pennant Hills Road and linking to the M2 with a westbound connection.

The completion of the F3-M2 Link 'purple' with west facing connections will increase future demand on M2 between M7 and Pennant Hills. A quantative assessment of forecast demand from TUSTM has been included as section 7.5. However, the impact and mitigation of such demand has not been addressed in this report and will need to be addressed in detail by the F3-M2 Link Project as and when it goes ahead.

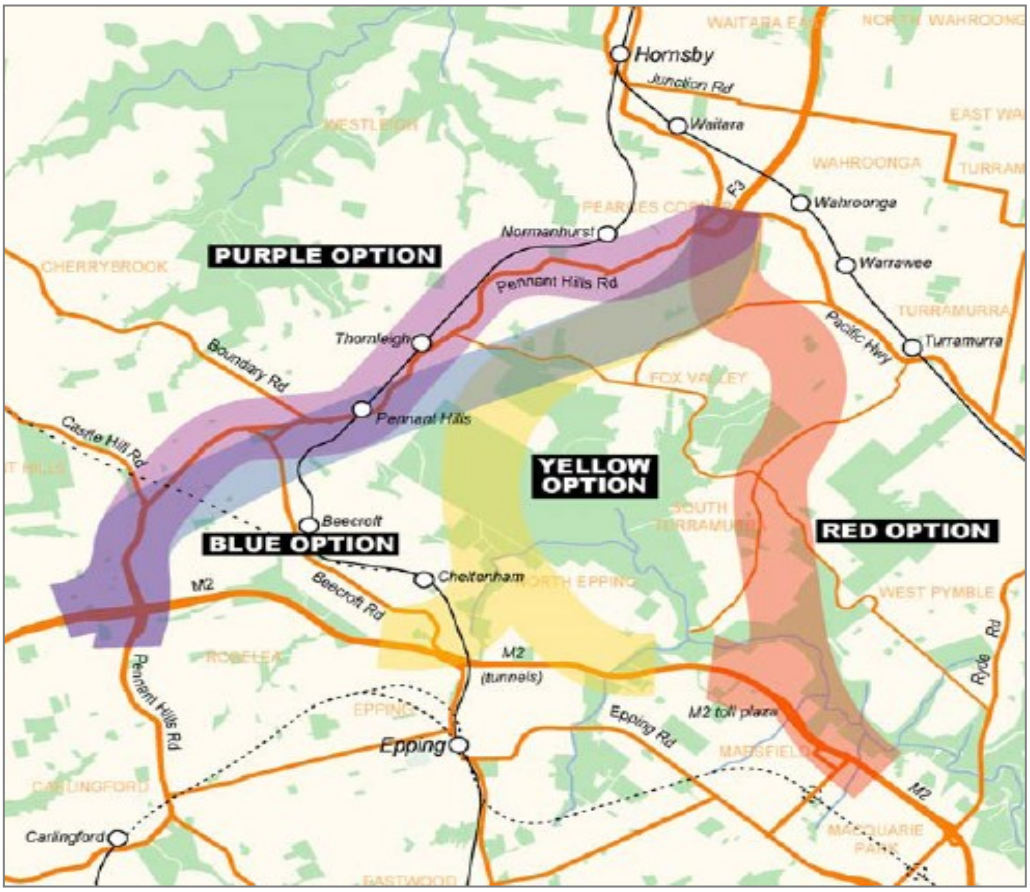

Figure 24 - F3M2 Link Route Options

4.3.5 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 M2, as a result of the proposed upgrade is considered insignificant for the following reasons:

- In the case of the M2 Upgrade, travel time improvements will occur primarily in the morning and evening peak periods with travel times during other hours of the day improving only marginally if at all; and
- The proposed toll at the new access ramps, and increased toll upon opening will act as a deterrent to discretionary travel.

Similarly, the east facing access at Herring/Christie Road (Macquarie Park) is likely to cause only small (if at all) mode shift from rail (ECRL):

- Private vehicle travel to/from Macquarie Park is most heavily influence by parking costs and availability, and this is not going to change as a result of the M2 Upgrade; and
- The proposed toll at the new access ramps will provide travel time benefits for private vehicle travelling to/from Macquarie Park, however the proposed toll will act as a deterrent and will only increase the cost of private vehicles travelling to/from Macquarie Park, hence will not attract any trips from rail.

4.3.6 Future Demand, Flows and Capacity

Traffic counts and surveys of existing roads generally yield information about vehicle flows by time of day. However, the underlying demand for travel, which results in these flows, is difficult to measure. Extensive queuing, as a consequence of flow breakdown, is a clear indication that demand exceeds measured flows within a particular time period such as morning and evening peaks. Queues begin to dissipate as demand falls below peak flow rates. The difference between demand and actual flow is manifested as peak spreading. That is, a proportion of trips that seek to use the facility in the peak period are delayed until after the peak period (shoulder peak period), and/or a proportion of trips decide to "re-time" resulting in increased trips directly before or after the peak period.

In peak periods, flows will typically approach capacities corresponding to LoS E (practical capacity). Queuing will occur on the approaches to critical locations. Between peaks, when peak period queues have dissipated, flows will correspond to higher LoS and range between A and D.

The following diagram illustrates the difference between demand, flow and capacity as well as the queuing that occurs when demand exceeds practical capacity.

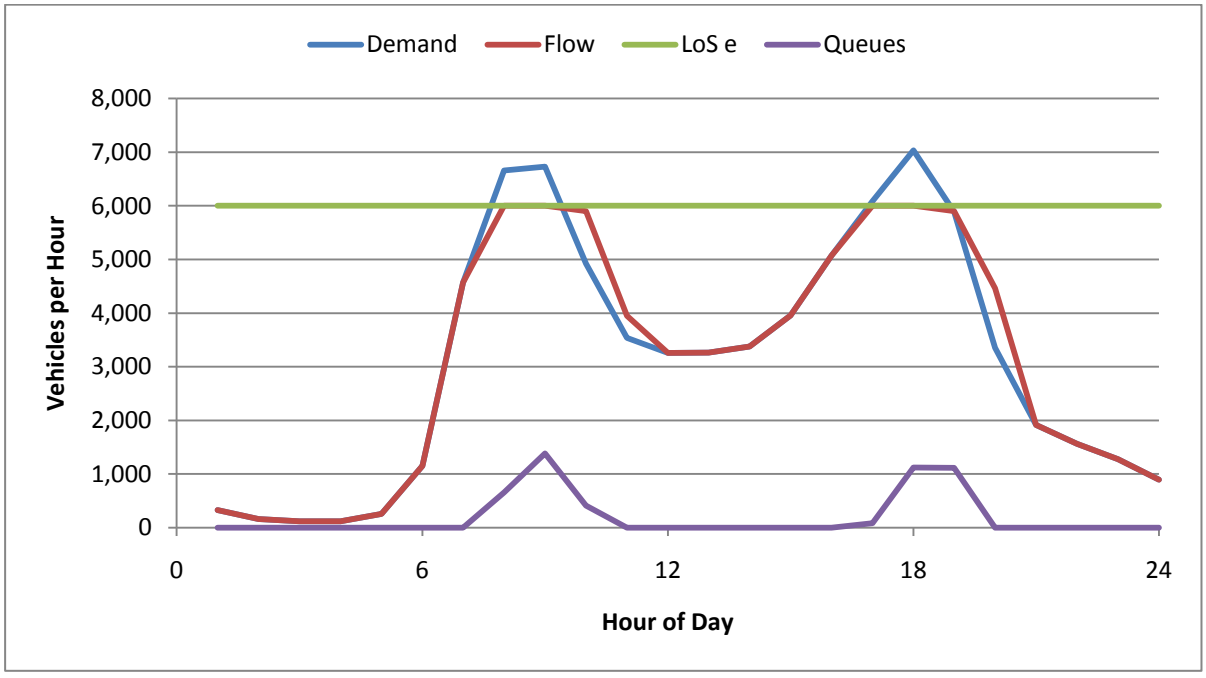

Figure 25 – Illustration of Demand, Flow, Capacity and Congestion

An appropriate design target is to achieve a practical capacity corresponding to LoS E or better during peak periods. However, traffic forecasts derived from strategic traffic models are generally estimating the demand for travel in a particular time period. Where demand exceeds practical flow rates, assessments of traffic performance can yield LoS F; indicating flow breakdown and rapid build-up of queues. In practice, a proportion of the forecast peak period trip demand will be delayed and serviced in the shoulder peak period.

In this report, analysis of the current situation is based on observed flows, which already account for the effects of demand exceeding practical capacity. However, analysis of future performance is based on trip demands with the potential for peak periods to yield flows that exceed practical capacity and hence yield a LoS F.

4.4 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 M2 upgrade.

5.0 Future Traffic Conditions without the "M2 Upgrade"

The current network performance was described in Section 3 and the traffic model and assumptions used to predict future conditions was the subject of Section 4. This chapter discusses the forecast of future traffic demands and the "changed" traffic conditions and network performance forecast to occur with no M2 Upgrade project. These forecast conditions represent a baseline by which the proposed M2 Upgrade can be assessed.

As with the assessment of current conditions, this "No M2 Upgrade" assessment for 2011 and 2021 uses the same indicators; which are as follows:

- 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 RTA
- Road Safety and Incidence of accidents.

5.1 Level of Service of Road Links

5.1.1 Hills M2 Motorway Conditions

Despite current sections of the M2 motorway displaying LoS E and being at or near capacity, the demand for M2 is expected to continue to grow. As previously discussed, the M2 provides the key transport linkage between the western suburbs and the business areas of Chatswood, North Sydney and Sydney CBD, and will continue to cater for this traffic as alternative routes via the local road network become increasingly congested.

5.1.1.1 AM PEAK

Table 23 below summarises the expected change in AM peak hour traffic in each of the M2 sections. By 2021, the eastbound sections between Windsor Road and Lane Cove Road are expected to operate at LoS E or LoS F where flow will breakdown and traffic queues will build quickly. As in Section 3.2.1, LoS have been calculated on mid-block flows, except where identified by $^{+}$ indicating LoS associated with on-ramp merging.

Table 23 - Forecast Future M2 Sectional Flows and LoS (AM Peak) – No M2 Upgrade

Eastbound Traffic		AM Peak Hour			Level of Service		
From	To	2009	2011	2021	2009	2011	2021
Old Windsor Road	Windsor Road	2,250	2,400	3,000	C	C	D
Windsor Road	Pennant Hills Road	3,150	3,350	4,200	D^{+}	D^{+}	F^{+}
Pennant Hills Road	Beecroft Road	3,400	3,600	4,350	D^{+}	D^{+}	F^{+}
Beecroft Road	Christie Road	4,200	4,450	5,250	F^{+}	F^{+}	F^{+}
Christie Road	Lane Cove Road	3,550	3,600	4,100	D	D	E
Lane Cove Road	Delhi Road	2,750	2,750	2,950	C	C	D
Delhi Road	Epping Road	1,900	1,900	1,900	B	B	B

Westbound Traffic		AM Peak Hour			Level of Service		
From	To	2009	2011	2021	2009	2011	2021
Epping Road	Delhi Road	850	950	1,250	A	A	B
Delhi Road	Lane Cove Road	1,400	1,550	1,950	B^{+}	B^{+}	B^{+}
Lane Cove Road	Herring Road	1,950	2,150	2,900	B^{+}	B^{+}	C^{+}
Herring Road	Beecroft Road	2,150	2,350	3,150	B^{+}	B^{+}	C^{+}
Beecroft Road	Pennant Hills Road	2,000	2,200	2,950	B	C	D

Pennant Hills Road	Windsor Road	2,650	2,900	3,550	C+	C+	D+
Windsor Road	Old Windsor Road	2,050	2,250	2,750	B	C	C

5.1.1.2 PM PEAK

Table 24 below summarises the expected change in PM peak hour traffic in each of the M2 sections. As shown, by 2021 the majority of the westbound sections will be operating at LoS D, with the sections west of Beecroft Road operating at LoS E or LoS F. The poor performance in the westbound direction, compared to the eastbound direction, reflects the higher westbound traffic flows along with the existing narrow lane widths with no emergency shoulder between Lane Cove Road and Beecroft Road.

Table 24 - Forecast Future M2 Sectional Flows and LoS (PM Peak) – No M2 Upgrade

Eastbound Traffic		PM Peak Hour			Level of Service		
From	To	2009	2011	2021	2009	2011	2021
Old Windsor Road	Windsor Road	2,250	2,350	2,900	C	C	D
Windsor Road	Pennant Hills Road	2,800	2,950	3,700	B+	C+	D+
Pennant Hills Road	Beecroft Road	2,100	2,250	2,900	B+	C+	C+
Beecroft Road	Christie Road	2,300	2,450	3,150	B+	C+	D+
Christie Road	Lane Cove Road	2,100	2,250	2,900	C	C	D
Lane Cove Road	Delhi Road	1,450	1,600	2,150	B	B	D
Delhi Road	Epping Road	1,050	1,200	1,800	A	B	C

Westbound Traffic		PM Peak Hour			Level of Service		
From	To	2009	2011	2021	2009	2011	2021
Epping Road	Delhi Road	1,950	2,050	2,350	C	C	D
Delhi Road	Lane Cove Road	2,900	3,000	3,400	C+	C+	D+
Lane Cove Road	Herring Road	3,750	3,900	4,400	C+	C+	D+
Herring Road	Beecroft Road	4,500	4,750	5,350	D+	D+	D+
Beecroft Road	Pennant Hills Road	4,100	4,300	4,500	E	F	F
Pennant Hills Road	Windsor Road	4,050	4,250	4,250	D+	F+	F+
Windsor Road	Old Windsor Road	2,950	3,150	3,100	C	D	D

5.1.1.3 Daily Traffic

Table 25 summarise the expected change in daily traffic in each of the M2 sections. As shown, the forecast average Compound Annual Growth Rate (CAGR) is between 1% and 3.4%.

Table 25 - Future M2 Sectional Flow (Daily)

Eastbound Traffic		Daily Flow			
From	To	2009	2011 Base	2021 Base	Average CAGR
Old Windsor Road	Windsor Road	30,300	31,800	37,550	1.8%
Windsor Road	Pennant Hills Road	39,000	41,200	49,750	2.0%
Pennant Hills Road	Beecroft Road	33,950	36,150	44,750	2.3%
Beecroft Road	Christie Road	38,050	40,350	49,250	2.2%
Christie Road	Lane Cove Road	34,450	36,250	42,900	1.8%
Lane Cove Road	Delhi Road	25,450	26,950	32,500	2.1%
Delhi Road	Epping Road	17,350	19,200	25,850	3.4%

Westbound Traffic		Daily Flow			
From	To	2009	2011 Base	2021 Base	Average CAGR
Epping Road	Delhi Road	17,400	18,750	24,300	2.8%
Delhi Road	Lane Cove Road	26,700	27,200	30,500	1.1%
Lane Cove Road	Herring Road	35,500	36,150	40,200	1.0%
Herring Road	Beecroft Road	39,650	40,800	47,250	1.5%
Beecroft Road	Pennant Hills Road	36,750	37,750	43,600	1.4%
Pennant Hills Road	Windsor Road	42,550	43,750	50,350	1.4%
Windsor Road	Old Windsor Road	32,750	33,300	37,350	1.1%

5.1.2 Local Roads/Access Roads

Changes to volumes on local roads i.e. non-motorway roads within Study Area are shown in Table 26, Table 27, Table 28 and Table 29.

5.1.2.1 AM Peak

Table 26 below summarises the expected change in AM peak hour traffic at each of the non-motorway sites across the project screenlines. By 2021, particularly in the inbound direction the majority of local roads will operate at LoS F and experience congestion and poor travel speeds.

Table 26 - Forecast Future Screenline Flows (AM Peak) - No M2 Upgrade

					Base AM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,200	1,250	1,400	F	F	F
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	1250	1,300	1,350	B	C	E
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	950	1,000	1,400	A	A	B
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2850	3,200	3,850	F	F	F
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	700	750	850	C	D	F
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1000	1,050	1,100	C	D	E
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1800	1,950	2,200	C	F	F
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	1150	1,250	1,400	D	F	F
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	3,500	3,550	3,600	F	F	F
2E	EB	Church Street South of Briens Road	Major Arterial	3	2250	2,400	2,700	F	F	F

					Base AM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	500	550	650	D	F	F
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	2500	2,800	3,450	F	F	F
4A	SB	Windsor Road North of M2	Major Arterial	2	2750	3,000	3,450	E*	E*	F*
4B	SB	Oakes Road North of M2	Sub-Arterial	1	1150	1,300	1,550	C	F	F
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	3550	3,600	3,650	F	F	F
4D	SB	Murray Farm Road @ M2	Collector	1	1000	1,150	1,400	B	D	F
4E	SB	Beecroft Road North of M2	Major Arterial	2	2100	2,200	2,400	C	E	F
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	4000	4,100	4,300	F	F	F

					Base AM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	850	1,000	1,350	A	B	B
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	900	1,100	1,450	B	F	F
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	750	850	1,200	A	A	B
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	1950	2,000	2,100	C	E	F
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	400	400	450	B	B	C
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	1000	1,050	1,100	C	D	E
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1900	1,950	2,000	C	C	D
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	550	650	800	D	F	F
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	1550	1,550	1,600	E	E	F
2E	WB	Church Street South of Briens Road	Major Arterial	3	900	950	1,050	E	F	F
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	900	950	1,050	C	E	F
3C	WB	Epping Road West of Vimiera Road	Major Arterial	2	850	950	1,150	E	F	F
4A	NB	Windsor Road North of M2	Major Arterial	3	1550	1,550	1,550	A*	A*	A*
4B	NB	Oakes Road North of M2	Sub-Arterial	1	750	800	850	B	C	E
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	2150	2,300	2,650	B	C	F
4D	NB	Murray Farm Road @ M2	Collector	1	400	400	450	A	A	A
4E	NB	Beecroft Road North of M2	Major Arterial	2	850	900	1,000	B	B	B
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	3150	3,300	3,600	C	C	F

5.1.2.2 PM Peak

Table 27 below summarises the expected change in PM peak hour traffic at each of the non-motorway sites across the project screenlines. By 2021, particularly in the outbound direction the majority of local roads will operate at LoS F and experience congestion and poor travel speeds.

Table 27 - Forecast Future Screenline Flows (PM Peak) - No M2 Upgrade

					Base PM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,050	1,150	1,350	B	B	E
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	900	950	1,000	B	B	C
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	850	950	1,400	A	A	A
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,250	2,450	2,800	C	F	F
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	450	500	550	B	B	C
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,000	1,050	1,100	B	B	C
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1,800	2,000	2,400	D	F	F
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	500	550	650	A	A	A
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	1,800	1,800	1,850	B	B	C
2E	EB	Church Street South of Briens Road	Major Arterial	3	1,100	1,150	1,300	E	F	F
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	950	950	950	C	C	C
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	1,050	1,100	1,200	D	F	F
4A	SB	Windsor Road North of M2	Major Arterial	2	1,650	1,800	2,050	D*	E*	E*
4B	SB	Oakes Road North of M2	Sub-Arterial	1	650	700	750	C	E	F
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	2,400	2,400	2,450	D	D	E
4D	SB	Murray Farm Road @ M2	Collector	1	400	400	400	A	A	A
4E	SB	Beecroft Road North of M2	Major Arterial	2	950	1,050	1,200	B	B	B
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,750	3,950	4,300	D	F	F

					Base PM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,900	2,050	2,400	B	B	F
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	1,150	1,300	1,550	B	C	F
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	1,000	1,050	1,300	A	A	B
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,600	2,800	3,250	C	F	F
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	550	600	650	B	C	D
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	950	950	1,000	B	B	C
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	2,050	2,350	2,900	C	F	F
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	1,150	1,250	1,400	D	F	F
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	2,300	2,300	2,350	C	C	E
2E	WB	Church Street South of Briens Road	Major Arterial	3	2,050	2,150	2,400	D	F	F
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	450	550	700	D	F	F
3C	WB	Epping Road West of Vimiera Road	Major	2	1,950	2,050	2,250	F	F	F

					Base PM Peak Hour			Level of Service		
SCL	Dir	Location	Type	Lanes	2009	2011	2021	2009	2011	2021
			Arterial							
4A	NB	Windsor Road North of M2	Major Arterial	3	2,550	2,550	2,600	A*	A*	A*
4B	NB	Oakes Road North of M2	Sub-Arterial	1	1,350	1,350	1,400	C	C	D
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	3,200	3,450	3,950	D	F	F
4D	NB	Murray Farm Road @ M2	Collector	1	500	550	600	A	A	A
4E	NB	Beecroft Road North of M2	Major Arterial	2	1,600	1,700	1,900	B	D	F
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,650	4,000	4,700	B	F	F

5.1.2.3 Daily Traffic

Changes in daily volumes on local roads within the Study Area are shown in Table 28 and Table 29.

Table 28 - Change in Local Road Daily Flows - Inbound Direction

			DAILY			
SCL	Dir	Location	2009	2011	2021	CAGR
1A	EB	Norwest Boulevard	13,800	14,400	16,500	1.5%
1B	EB	Seven Hills Road East of Merindah Road	11,000	11,250	12,150	0.8%
1D	EB	Abbot Road East of Old Windsor Road	10,250	11,050	14,350	2.8%
1E	EB	Old Windsor Road North of Gibbon Road	31,250	33,400	41,800	2.5%
1F	EB	Powers Road East of Station Road	6,150	6,400	7,200	1.3%
1G	EB	Station Road @ Mc Coy Park	11,600	11,750	12,200	0.4%
2A	EB	Castle Hill Road East of Old Northern Road	22,450	23,800	28,950	2.1%
2B	EB	Renown Road East of Cook Street	8,200	8,600	10,050	1.7%
2D	EB	James Ruse Road East of Windsor Road	28,300	28,450	29,050	0.2%
2E	EB	Church Street South of Briens Road	19,800	20,650	23,800	1.5%
3A	EB	The Comenarra Parkway East of Fox Valley Road	7,650	7,750	8,050	0.4%
3C	EB	Epping Road West of Vimiera Road	21,900	22,950	26,800	1.7%
4A	SB	Windsor Road North of M2	28,200	29,050	32,100	1.1%
4B	SB	Oakes Road North of M2	8,350	8,500	8,950	0.6%
4C	SB	Pennant Hills Road North of M2	38,350	38,850	40,450	0.4%
4D	SB	Murray Farm Road @ M2	4,700	4,700	4,750	0.1%
4E	SB	Beecroft Road North of M2	17,800	18,600	21,500	1.6%
4F	SB	Ryde Road South of Lady Game Drive	45,400	46,900	52,150	1.2%

Table 29 - Change in Local Road Daily Flows - Outbound Direction

			DAILY			
SCL	Dir	Location	2009	2011	2021	CAGR
1A	WB	Norwest Boulevard	15,850	16,750	20,150	2.0%
1B	WB	Seven Hills Road East of Merindah Road	11,100	11,500	12,950	1.3%
1D	WB	Abbot Road East of Old Windsor Road	12,000	12,000	12,000	0.0%
1E	WB	Old Windsor Road North of Gibbon Road	29,900	31,800	39,150	2.3%
1F	WB	Powers Road East of Station Road	5,200	5,300	5,750	0.8%
1G	WB	Station Road @ Mc Coy Park	11,900	12,100	12,700	0.5%
2A	WB	Castle Hill Road East of Old Northern Road	23,500	24,900	30,250	2.1%
2B	WB	Renown Road East of Cook Street	8,600	9,050	10,700	1.8%
2D	WB	James Ruse Road East of Windsor Road	25,000	25,150	25,650	0.2%
2E	WB	Church Street South of Briens Road	20,800	21,750	25,200	1.6%
3A	WB	The Comenarra Parkway East of Fox Valley Road	6,650	6,650	6,700	0.1%
3C	WB	Epping Road West of Vimiera Road	21,350	21,600	22,350	0.4%
4A	NB	Windsor Road North of M2	28,700	29,350	31,750	0.8%
4B	NB	Oakes Road North of M2	9,500	9,550	9,650	0.1%
4C	NB	Pennant Hills Road North of M2	38,700	40,850	48,800	2.0%
4D	NB	Murray Farm Road @ M2	3,650	3,750	4,200	1.2%
4E	NB	Beecroft Road North of M2	17,750	18,250	19,950	1.0%
4F	NB	Ryde Road South of Lady Game Drive	43,500	46,050	55,750	2.1%

5.2 Travel Speeds and Travel Times

This section outlines how current travel speeds and travel times are likely to change with “No M2 Upgrade” scenario.

5.2.1 M2 and Study Area

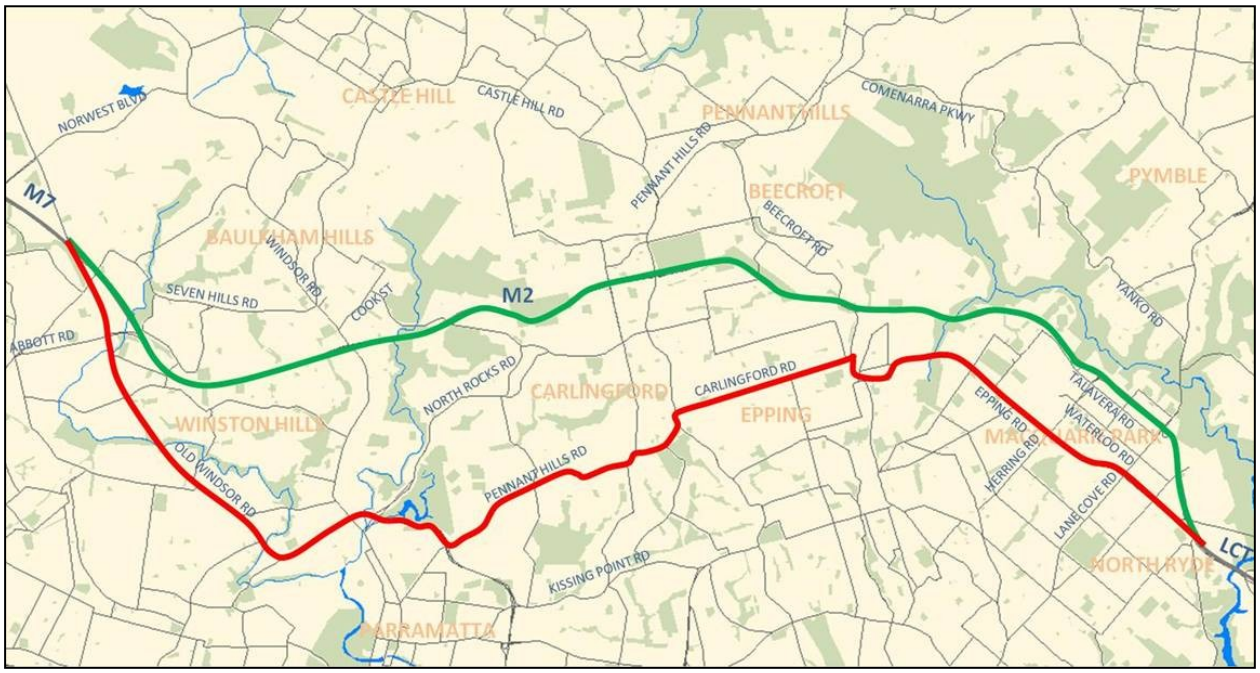

Figure 26 - Route used for travel time comparisons

Figure 26 shows the routes chosen for comparison of travel times and speeds. The route coloured green represents the M2 and the route coloured red is the alternative via the arterial road network.

Table 30 shows the forecast change in travel times for both the M2 and alternative, and Table 31 shows the forecast change in average speeds. The forecast increase in travel demand will reduce the traffic performance of the M2 study area, with travel times increasing for both the M2 and the alternative. By 2021 during the AM peak in the inbound direction, the M2 travel time is forecast to increase by 16 minutes and the alternative by 22 minutes. During the PM peak in the outbound direction, the M2 is forecast to increase by 9 minutes and the alternative by 6 minutes. The disproportionate change, when comparing directions, is because the capacity for westbound travel throughout the M2 study area has increased with the M2 interim widening implemented in 2007 between Lane Cove Road and Beecroft Road.

Table 30 - Future "No M2 Upgrade" scenario Travel Times (mins)

		Current	2011	Change	2011	2021	Change
M2	AM-IB	34	38	12%	38	50	32%
Alternative	AM-IB	45	59	31%	59	67	14%
M2	PM-OB	27	29	7%	29	36	24%
Alternative	PM-OB	46	48	4%	48	52	8%

Table 31 - Future "No M2 Upgrade" scenario Average Speeds (km/hr)

		2009	2011	Change	2011	2021	Change
M2	AM-IB	37	33	-11%	33	30	-9%
Alternative	AM-IB	30	21	-30%	21	18	-14%
M2	PM-OB	45	43	-4%	43	34	-21%
Alternative	PM-OB	29	28	-3%	28	26	-7%

5.2.2 Sydney Network

Table 32 below shows forecast network speeds by road classes and peak period under the "No M2 Upgrade" scenario. As shown, speeds across the network are expected to drop by 8% in the AM peak and 7% in the PM peak by 2011. Speeds are expected to drop by a further 19% in the AM peak and 17% in the PM peak by 2021 as the network continues to get congested, reducing average speeds by 6km/hr in both AM and PM peaks to 26 and 28km/hr respectively. In the future, the motorway network is forecast to have the largest reduction in peak speeds in both periods.

Table 32 - Future Network Speeds by Facility Type– No M2 Upgrade

Facility	Period	Base[10]	2011	Change	2011	2021	Change
Motorway	AM	49	43	-13%	43	33	-22%
Arterial	AM	46	42	-8%	42	36	-16%
Local / Sub Arterial	AM	26	25	-5%	25	21	-16%
Sydney Network	**AM**	**35**	**32**	**-8%**	**32**	**26**	**-19%**
Facility	**Period**	**Base**	**2011**	**Change**	**2011**	**2021**	**Change**
Motorway	PM	50	45	-10%	45	37	-19%
Arterial	PM	47	45	-5%	45	37	-17%
Local / Sub Arterial	PM	28	27	-5%	27	23	-14%
Sydney Network	**PM**	**37**	**34**	**-7%**	**34**	**28**	**-17%**

[10] Note "Base" in this instance refers to TUSTM base year – see section 4.

5.3 Intersection Performance (LoS) without M2 Upgrade

SIDRA intersection version 3.2 and SCATES was used to assess the intersection performance in 2011 and 2021 with no M2 Upgrade as was the case when intersection performances were evaluated under existing conditions (See Chapter 3). For the junctions assessed using SCATES the optimised cycle times are presented in this chapter. The optimised cycle times differ from the existing cycle times in response to the forecast change in traffic demand, which can lead to difference in results when compared with the existing cycle times.

The performances of the major intersections are shown in Table 33. Intersections shaded above the solid green line are those directly impacted by M2 traffic flows and intersections below the solid green line are within the study and are influenced by travel patterns along M2.

Table 33 - Intersection Performance – No M2 Upgrade

	2009 AM			2011 AM			2021 AM			2009 PM			2011 PM			2021 PM		
	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS
I1 - Windsor Road - M2 ramps	B	27	1.00	B	25	1.00	E	58	>1.0	B	26	1.00	B	28	1.00	C	31	1.00
I2 - Pennant Hills Rd - M2 ramps	B	27	0.82	C	29	0.87	E	65	>1.0	D	43	0.96	E	59	>1.0	F	>120	>1.0
I3 - Christie Rd - Talavera Rd	C	42	0.98	F	90	>1.0	F	>120	>1.0	A	8	0.55	A	6	0.57	A	12	0.75
I4 - Herring Rd - Talavera Rd	B	26	0.68	C	35	0.72	C	34	0.80	B	18	0.83	B	16	0.72	C	34	0.79
I7 - Lane Cove Rd - M2 ramps	A	8	0.80	A	11	0.86	C	29	>1.0	A	7	0.81	A	5	0.73	A	6	0.82
I5 - Herring Rd - Waterloo Rd	C	38	0.86	D	47	0.93	F	>120	>1.0	C	34	0.71	C	35	0.80	D	52	>1.0
I6 - Khartoum Rd - Talavera Rd	B	28	>1.0	C	41	0.62	C	37	0.72	B	26	0.96	A	14	0.82	E	57	0.95
I8 - Lane Cove Rd - Talavera Rd	B	25	>1.0	B	19	0.81	A	13	0.87	F	90	>1.0	F	84	>1.0	F	>120	>1.0
I9 - Lane Cove Rd - Waterloo Rd	F	107	>1.0	D	50	0.91	F	>120	>1.0	D	56	>1.0	E	61	0.94	F	113	>1.0
I10 - Lane Cove Rd - Epping Rd	E	65	>1.0	E	60	0.79	F	>120	0.96	F	78	>1.0	C	32	0.89	D	44	0.99
I11 – Windsor Rd / Cook Rd	F	>120	>1.0	F	>120	>1.0	F	>120	>1.0	C	36	0.96	D	45	1.00	F	95	>1.0
I12 - Herring Rd - Epping Rd	E	57	1.00	E	63	1.00	F	107	>1.0	D	52	0.90	D	57	0.94	E	67	>1.0

As shown above, as demands on the M2 motorway increase due to growth in Macquarie Park and the North West suburbs by 2021 a number of intersections will operate at LoS F resulting in significant network delays. In the AM peak the intersections of Christie/Talavera, Herring/Waterloo and Herrinng/Epping will all operate with LoS F. In the PM peak the intersections of M2/Pennant Hills and Lane Cove Road/Waterloo Road will operate with LoS F.

The intersections of Lane Cove Road/Waterloo Road and Lane Cove Road/Talavera Road show improvement in future years over the base condition, which may appear counter intuitive. However, as previously discussed, this is due to signal times being optimised as part of the SCATES modelling package for future forecast demands

5.4 Road Safety

Under the "No M2 Upgrade" scenario, the number of accidents on the M2 will continue to increase over time due to the increase in M2 traffic; drivers will also be faced with heavier merge volumes and accidents may become more prevalent as drivers have fewer opportunities to select suitable gaps to enter the mainline traffic stream.

Table 34 below summarises accident numbers on M2 in future years in absence of the M2 Upgrade. The analysis assumes that the accident rate and risk remains constant overtime, with changes in accident numbers reflecting changes in vehicle kilometres travelled along the motorway (VKT)[11].

Table 34 - Forecast Road Safety Performance Changes

		Average Annual Accidents			
Year	VKT (millions kilometres)	Fatal	Injury	Non-casualty (tow-away)	Total
2009	4.63	0	31	52	83
2011	4.83	0	32	54	87
2021	5.70	0	38	64	103

As shown above, keeping the current accident rates constant, it is forecast that the number of accidents will increase by 4 vehicles (4%) between 2011, and 19 vehicles (23%) by 2021. By keeping the accident rate constant this analysis is likely to be conservative, as it is reasonable to expect that M2 accident rate will increase in the future as the motorway becomes increasingly congested. The relationship between congestion and accident numbers is supported by the temporal analysis shown as Figure 21.

5.5 Future-base Public Transport Conditions

Public Transport patronage is expected to grow in the Study Area due to:

- Strong population and business growth in the north west; and
- Increasing perceived cost of private motoring as a result of increased traffic congestion and increasing oil prices

Historic monthly patronage on Hills Bus' M2 Motorway services is illustrated in Figure 27. Patronage grew at a Compound Annual Growth Rate (CAGR) of 35% pa from July 2005 to July 2008.

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

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

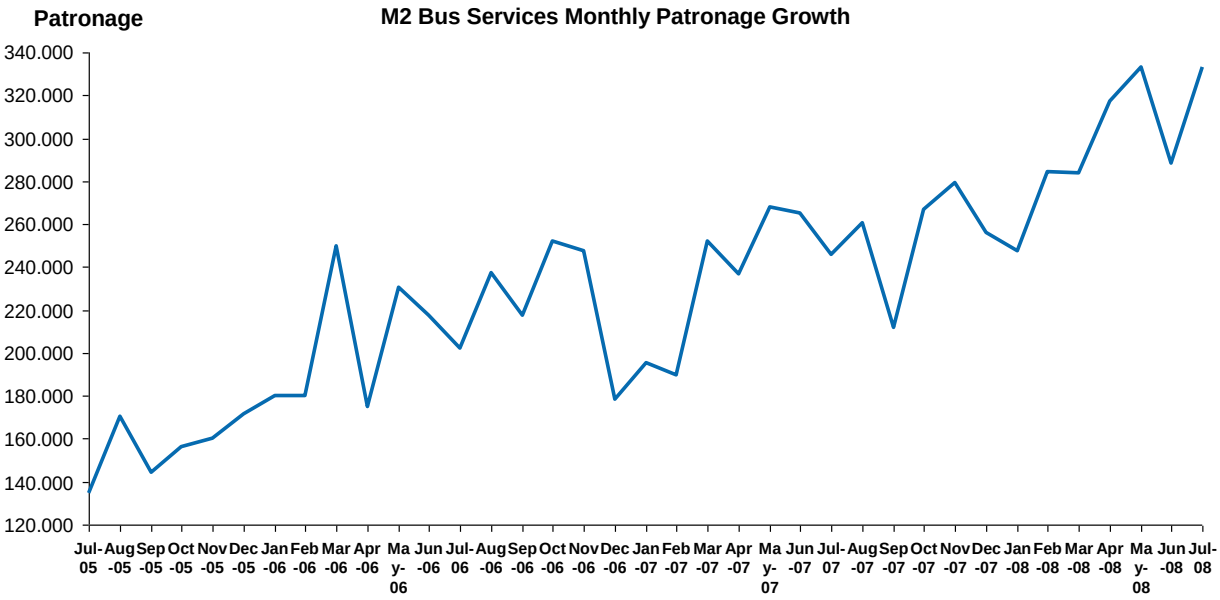

Figure 27 - Hills M2 Bus Service Patronage Growth

Growth in bus patronage and bus trips is expected to continue to remain high. Other key drivers of growth in bus patronage include:

- The M2 bus service provides the most direct and quickest public transport option for commuters travelling between the North West and the Sydney CBD; and
- High public transport Mode Share Targets for Macquarie Park.

5.5.1 Public Transport Alternatives

While not actively being pursued, a North West Rail Link (linking to ECRL) would provide a direct public transport alternative to the M2. However, as there are no current plans for such a project in the short to medium term to serve the North West, buses will continue as the key transport option for commuters in the region. Therefore, optimising the efficiency of the strategic bus corridors to this area will be particularly important.

5.5.2 High Public Transport Mode Share Targets

The NSW Government has set relatively high mode share targets for public transport to Sydney CBD of 75% by 2016[12] and for Macquarie Park of 40% by 2031[13]. The associated initiatives being implemented to achieve these targets, such as restricting parking availability, will continue to drive growth in public transport usage. The integration of the ECRL services is also expected to increase public transport mode share in the area.

Given that buses are at or near capacity during peak periods, a reasonable assumption is that additional public transport will need to include increased bus services on M2

5.5.3 Operational Impacts

There is currently trend for bus operators to utilize larger vehicles. State Transit is currently seeking tenders for 150 new articulated buses. Hillsbus has ordered 14.5m buses as well as testing double-decker buses. Forest Coach Lines is also purchasing more articulated buses.

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[12] *Website: http://www.nsw.gov.au/StatePlan/download.aspx?id=0399fa8a-77bd-457e-aa99-3842edb4725e*

[13] *Website:http://www.ryde.nsw.gov.au/WEB/SITE/RESOURCES/DOCUMENTS/Planning/MacquarieCorridor/MacquarieParkTraffic_Year2031Modelling.pdf*

Increasing congestion will impact bus services as well as motorists. Without the M2 Upgrade bus travel times are expected to increase significantly along with service unreliability. Modelling indicates that by 2021 bus travel times for AM peak eastbound trips will increase by 26% and for PM peak westbound trips by 28%[14].

5.6 Summary

Without the M2 Upgrade, the future traffic conditions along the M2 and within the Study Area can be characterised by further deterioration of the road network levels of service from already existing congested levels of peak operation. Link volumes are expected to grow, with a disproportionate amount of the increased travel to take place on high capacity facilities such as the M2. As a result, trip travel times are expected to increase throughout the M2 study area.

Intersection performance is expected to deteriorate from existing levels, with the worst effects at Windsor Road/M2 interchange, and Herring/Talavera Road. Even for those intersections with acceptable levels of services at present, delays are expected to increase.

Accidents along the M2 are expected to increase as a result of increased merging at on-ramps and substandard road geometry between Lane Cove Road and Beecroft Road.

The forecast deterioration of travel conditions within the M2 study area will impose additional transport costs on Sydney as a whole, with residents and businesses in the corridor likely to bear the costs more heavily than other community groups within the community. The above analysis indicates that the future peak hour conditions in 2011 and 2021 will be significantly worse than the existing unsatisfactory situation and will extend over longer periods of the day than at present.

[14] *Transurban Traffic Modelling 2009*