M2 Upgrade

VOLUME 2 – PART 1

ENVIRONMENTAL ASSESSMENT – TECHNICAL PAPERS

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M2 Upgrade Environmental Assessment

Volume 2 – Part 1: Technical Papers

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1. Traffic and transport assessment

Traffic and transport Impact Assessment (Transurban), 2010

2. Noise and vibration assessment

Noise and Vibration Assessment (Heggies Pty Ltd) 2010

3. Flora and fauna assessment

Flora and Fauna Assessment Report (AECOM Australia Pty Ltd) 2010






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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Hills M2

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.

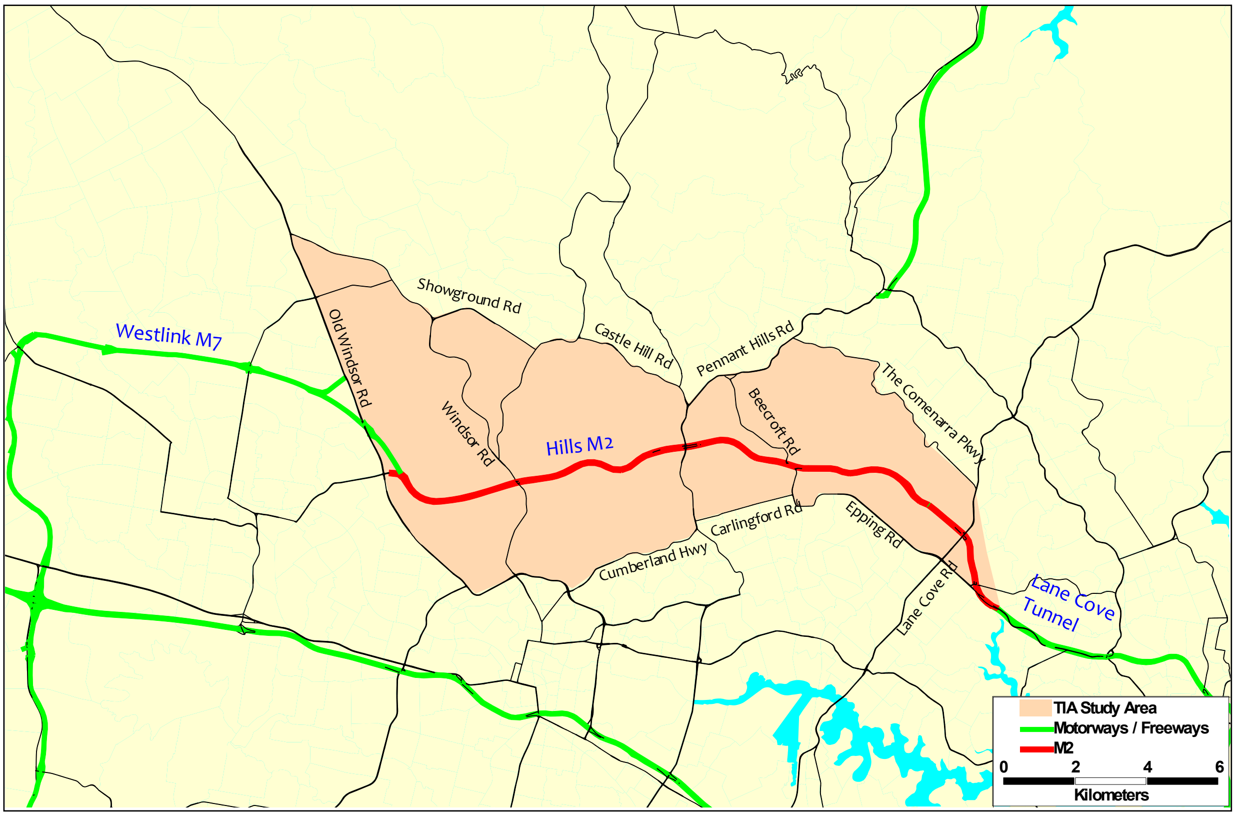

Figure 1 - Study Area

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.

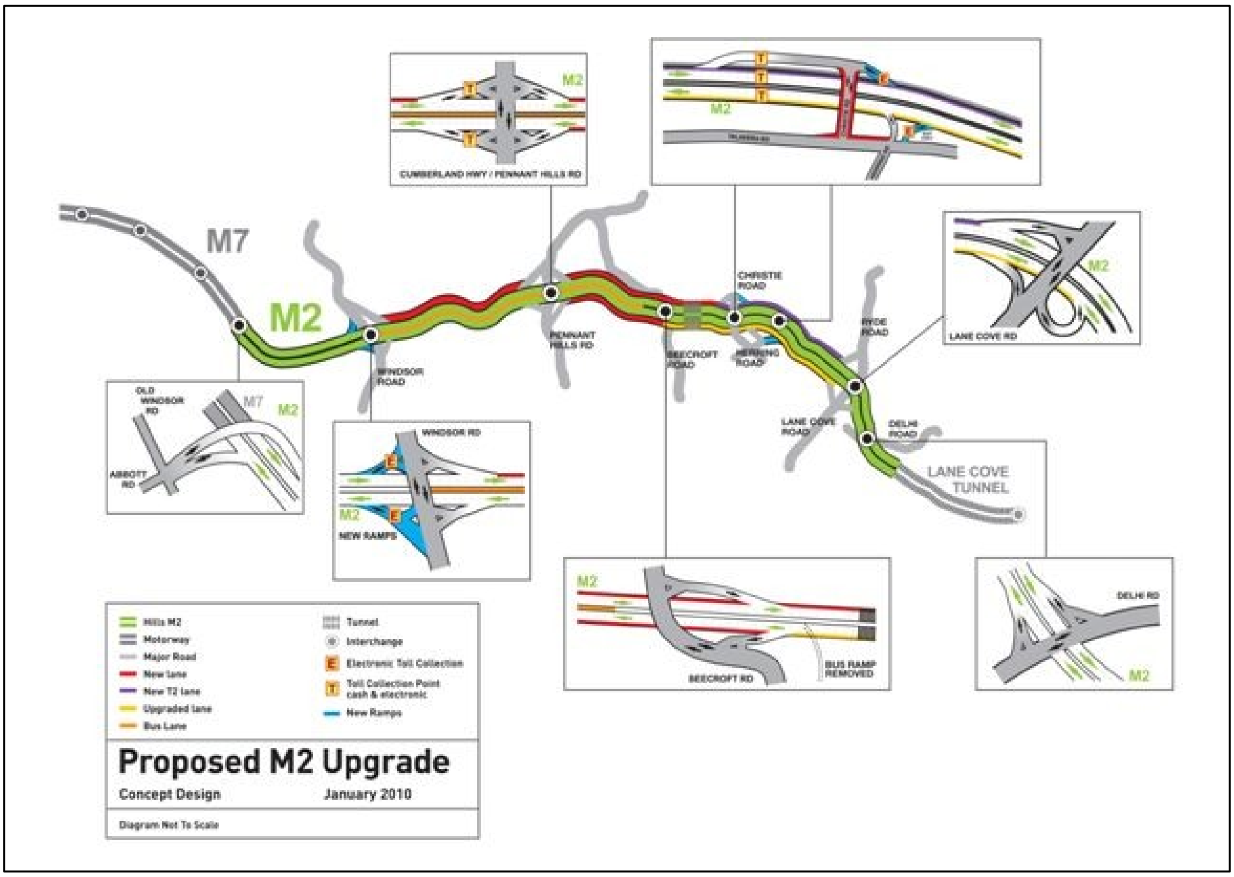

Figure 2 – M2 Upgrade Project

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.

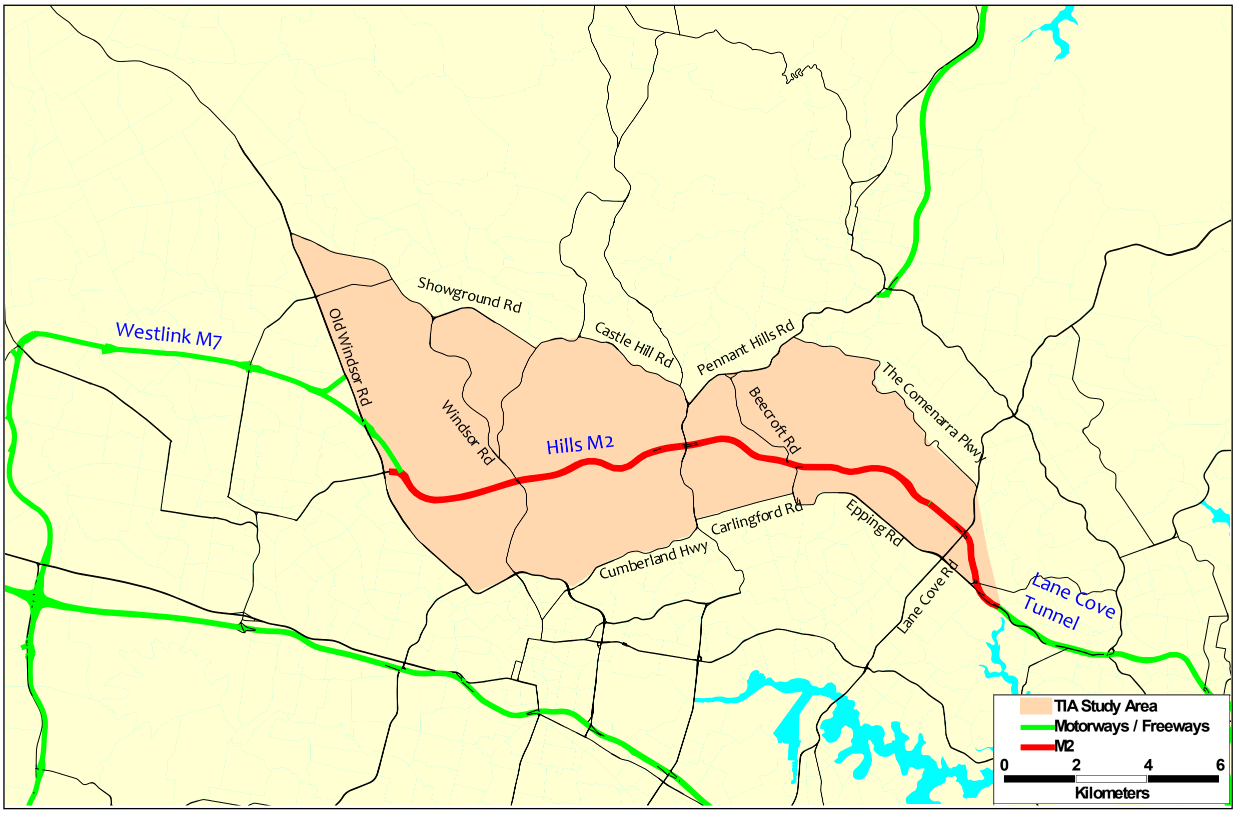

Figure 3 - Study Area

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.

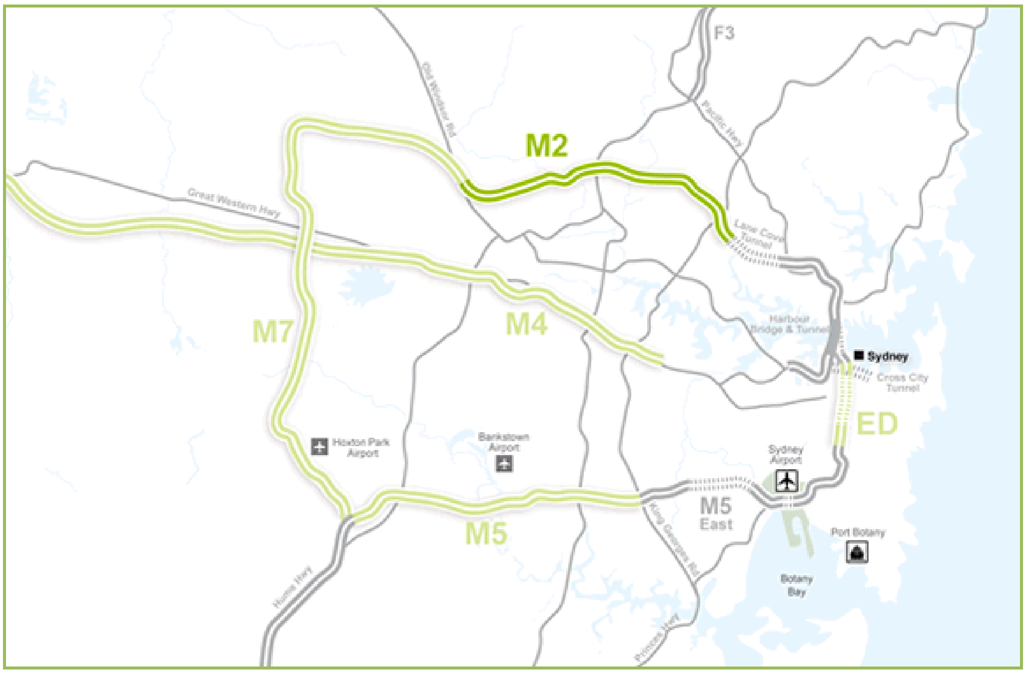

Figure 4 -Sydney Motorway Network

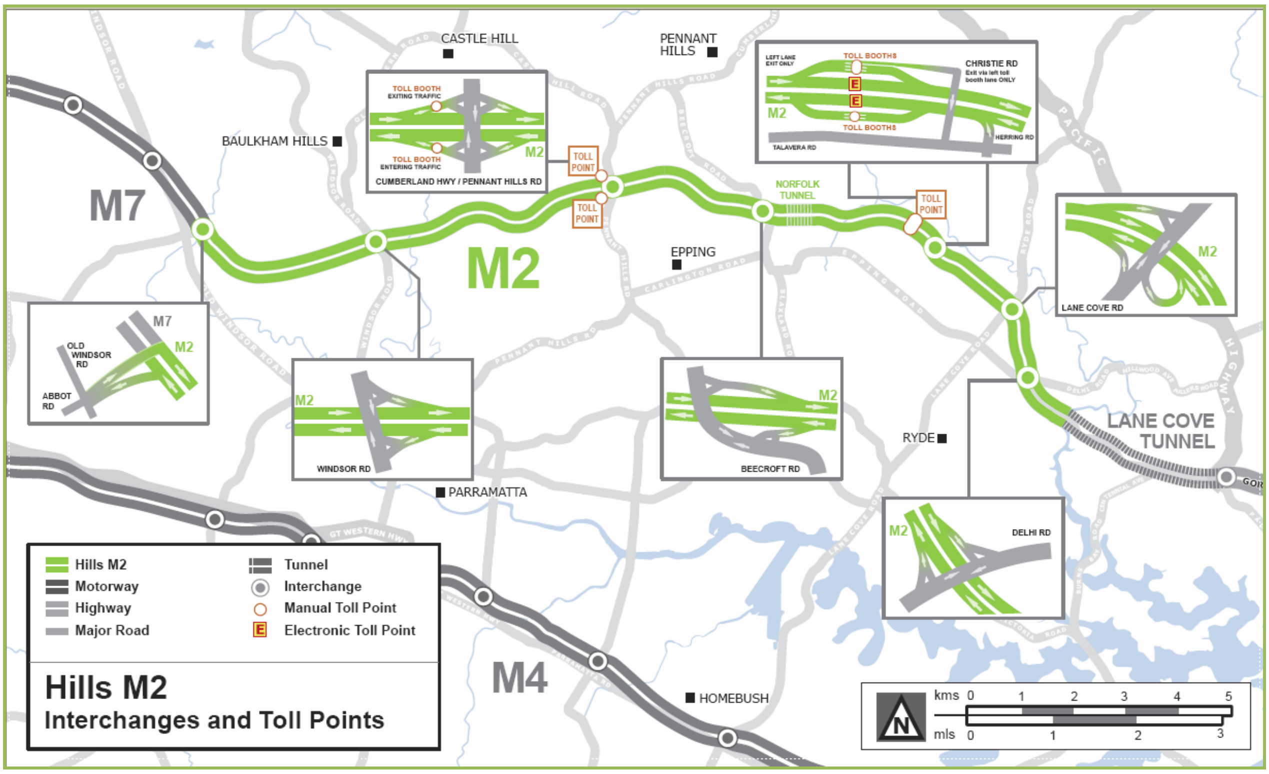

Figure 5 - M2 Access and Egress

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.

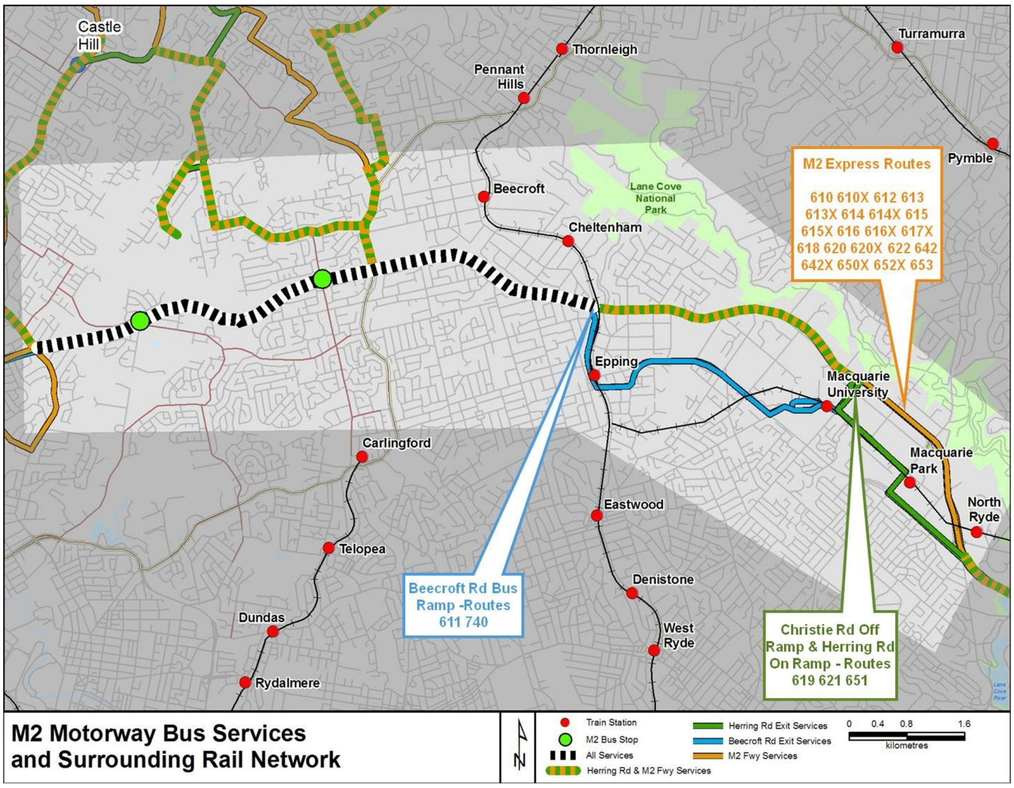

Figure 6 - M2 Bus Services and Surrounding Rail Network

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[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.

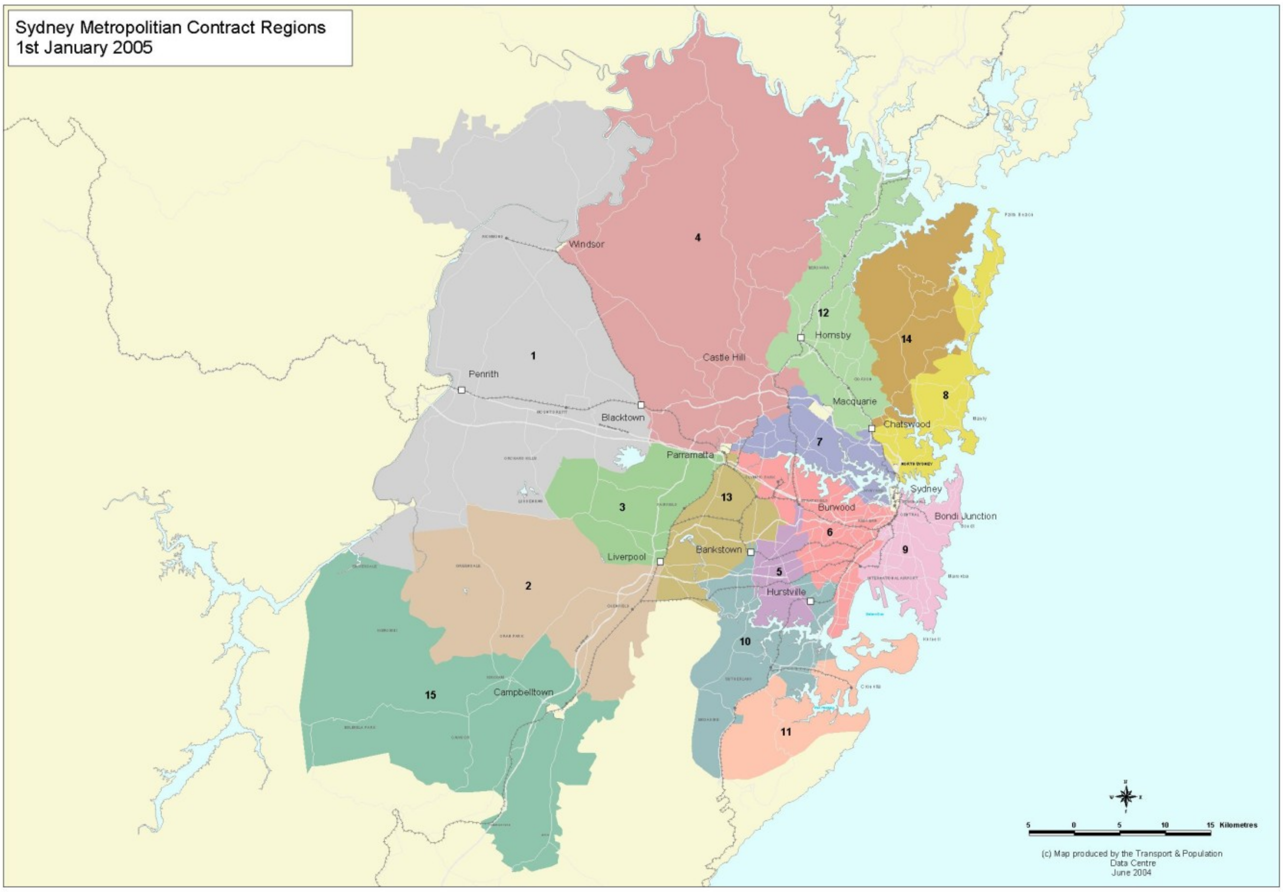

Figure 8 - Sydney Metropolitan Contract Regions (source: NSW Transport and Infrastructure)

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%.

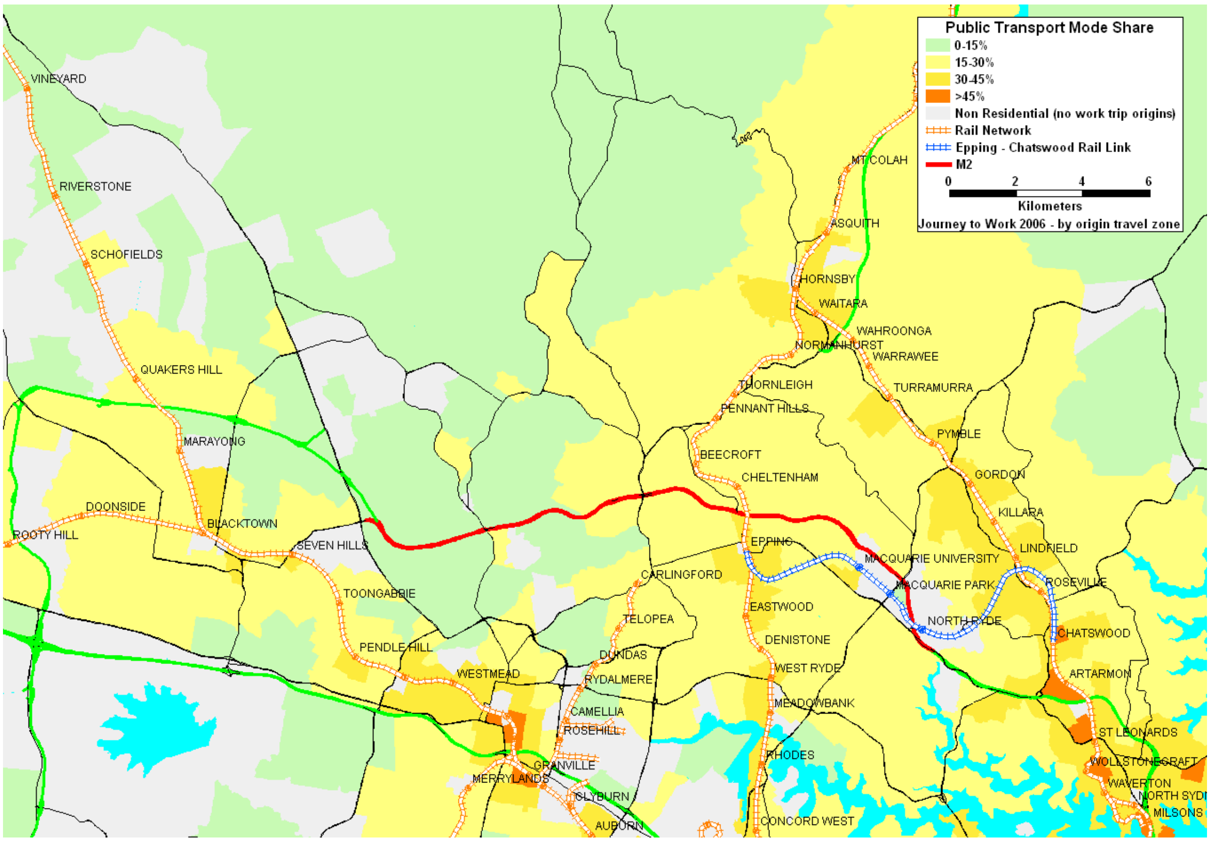

Figure 11 - Public Transport Mode Share Journey to Work by Origin (Source: 2006 Census)

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

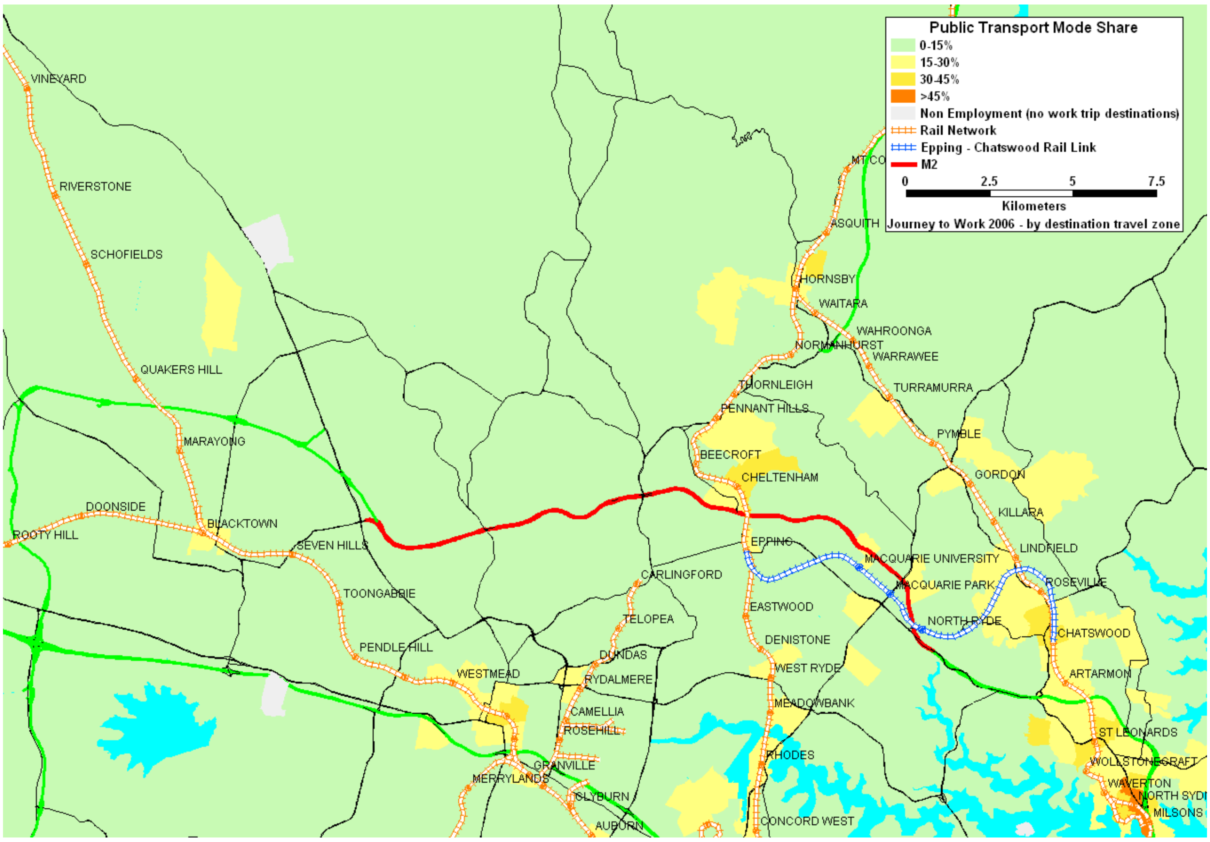

Figure 12 - Public Transport Mode Share Journey to Work by Destination (Source: 2006 Census)

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.

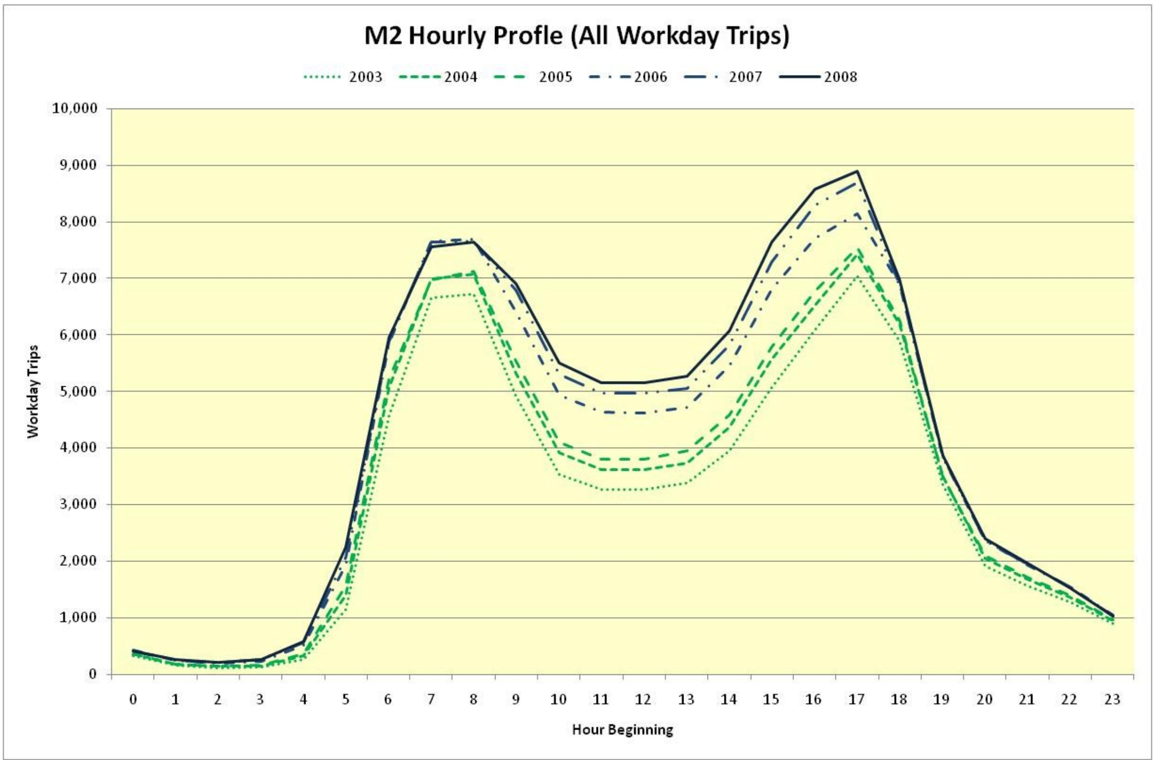

Figure 13 - M2 Historic Hourly Profile

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*

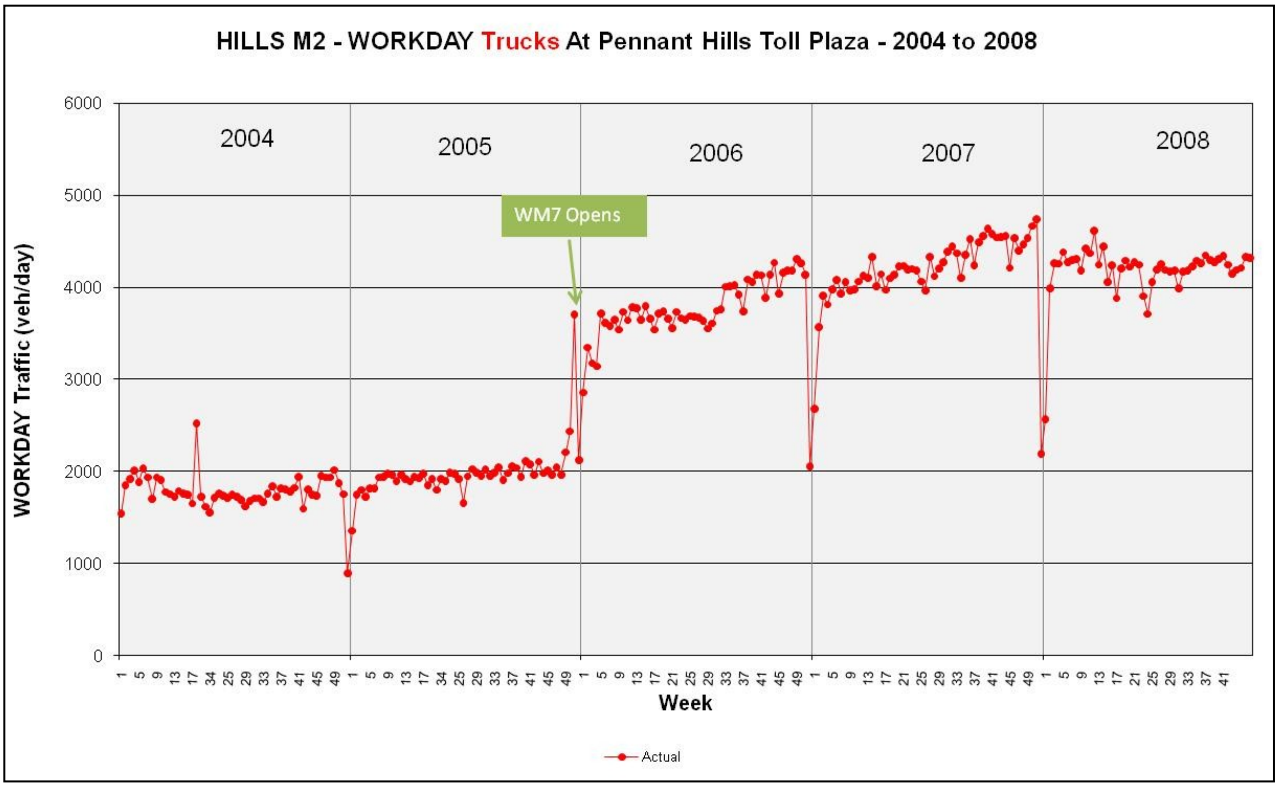

Figure 14 - Historic Heavy Vehicle (HV) Class 4 Workday Traffic (Pennant Hills)

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

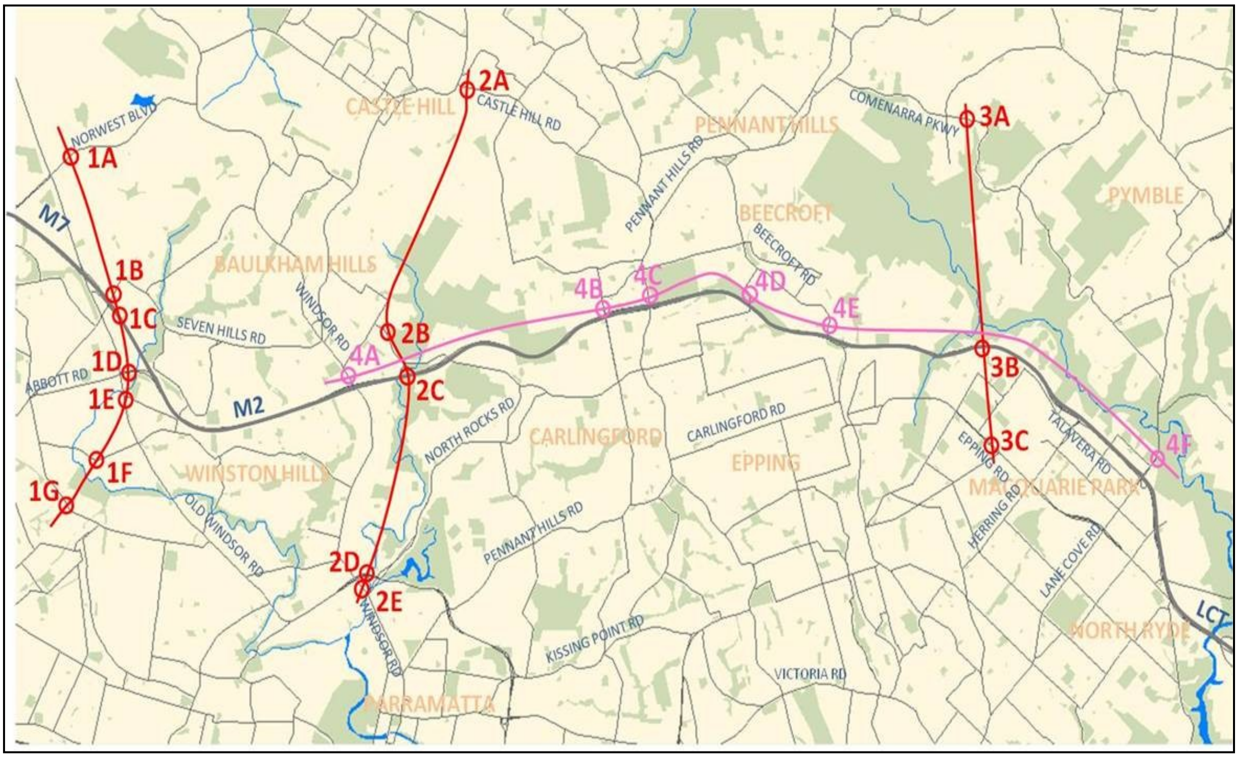

Figure 15 - Study Area Screenlines

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.

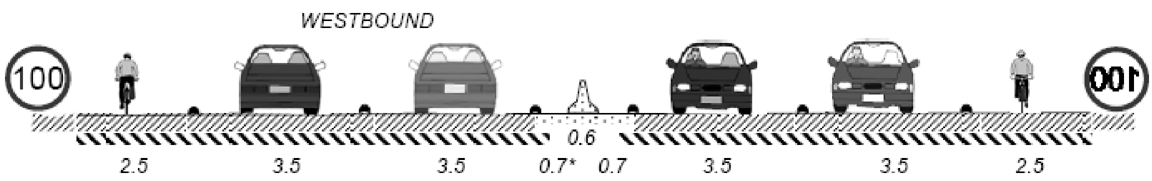

Figure 16 - As Constructed Lane Configuration

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

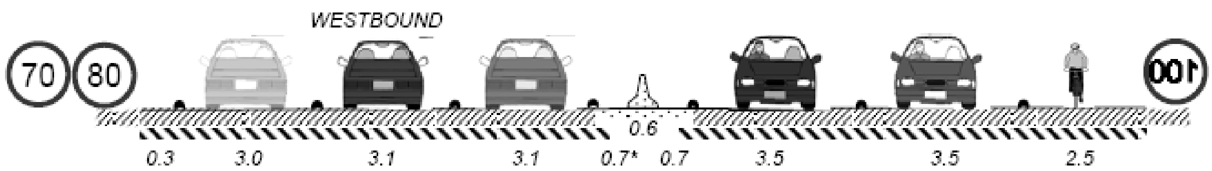

Figure 17 - Interim Lane Widening Lane Configuration

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.

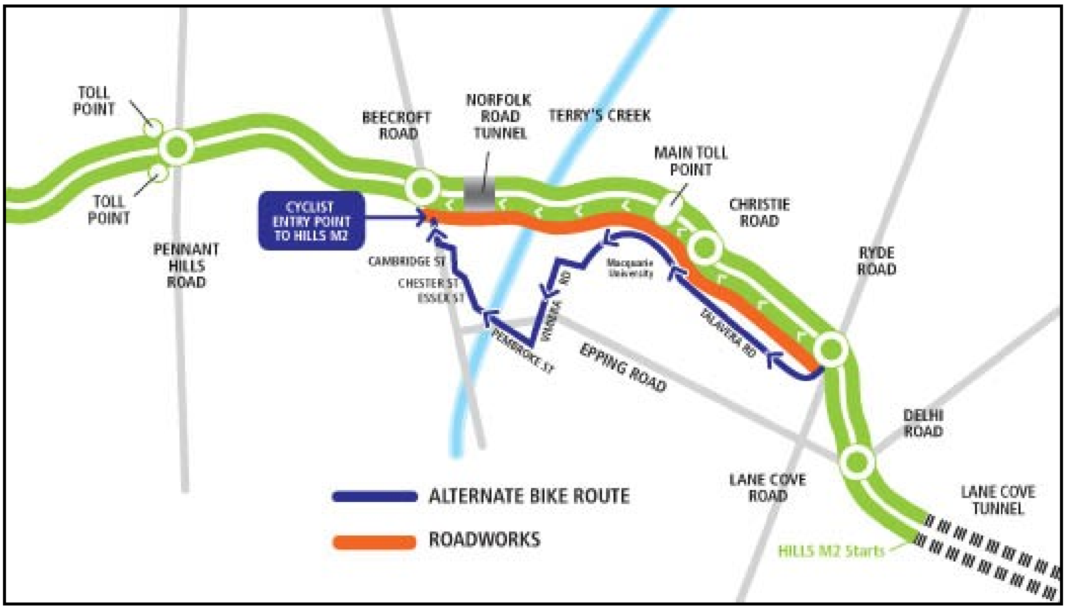

Figure 18 - Hills M2 Interim Cycle Detour

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.

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[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.

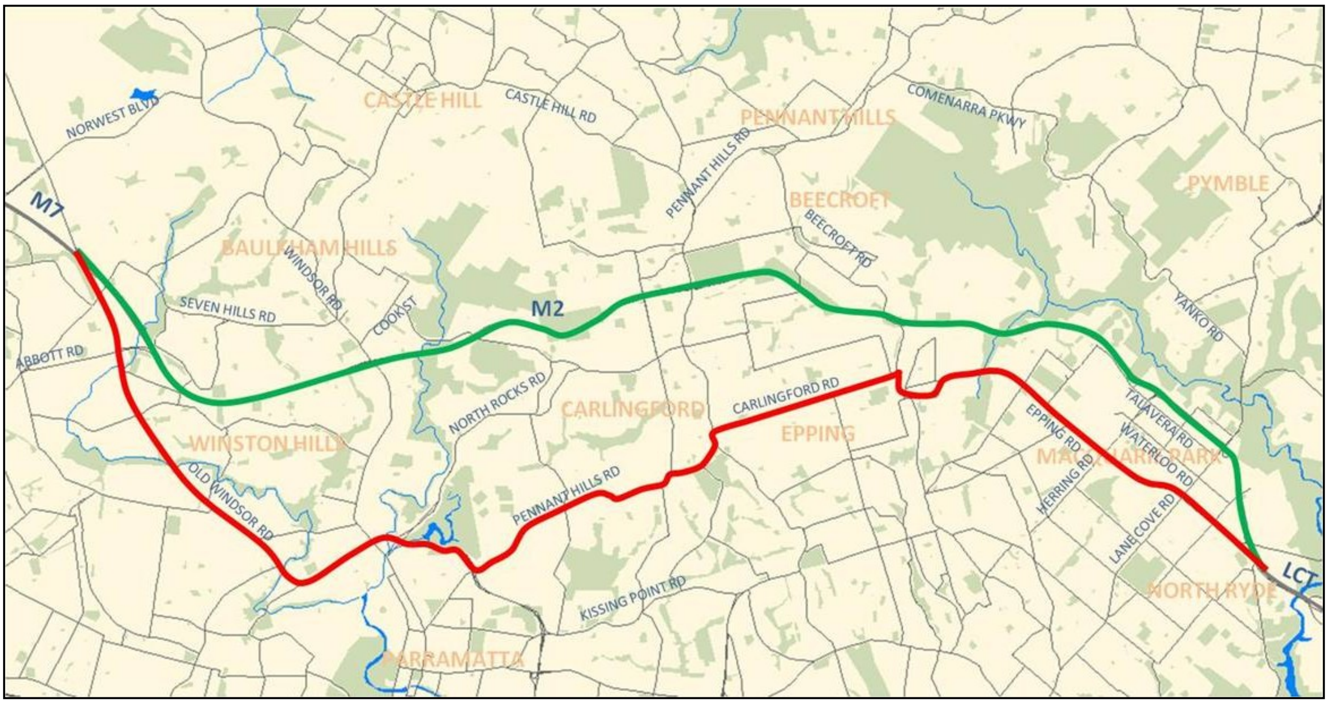

Figure 19 - Travel Time Comparison Routes

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.*

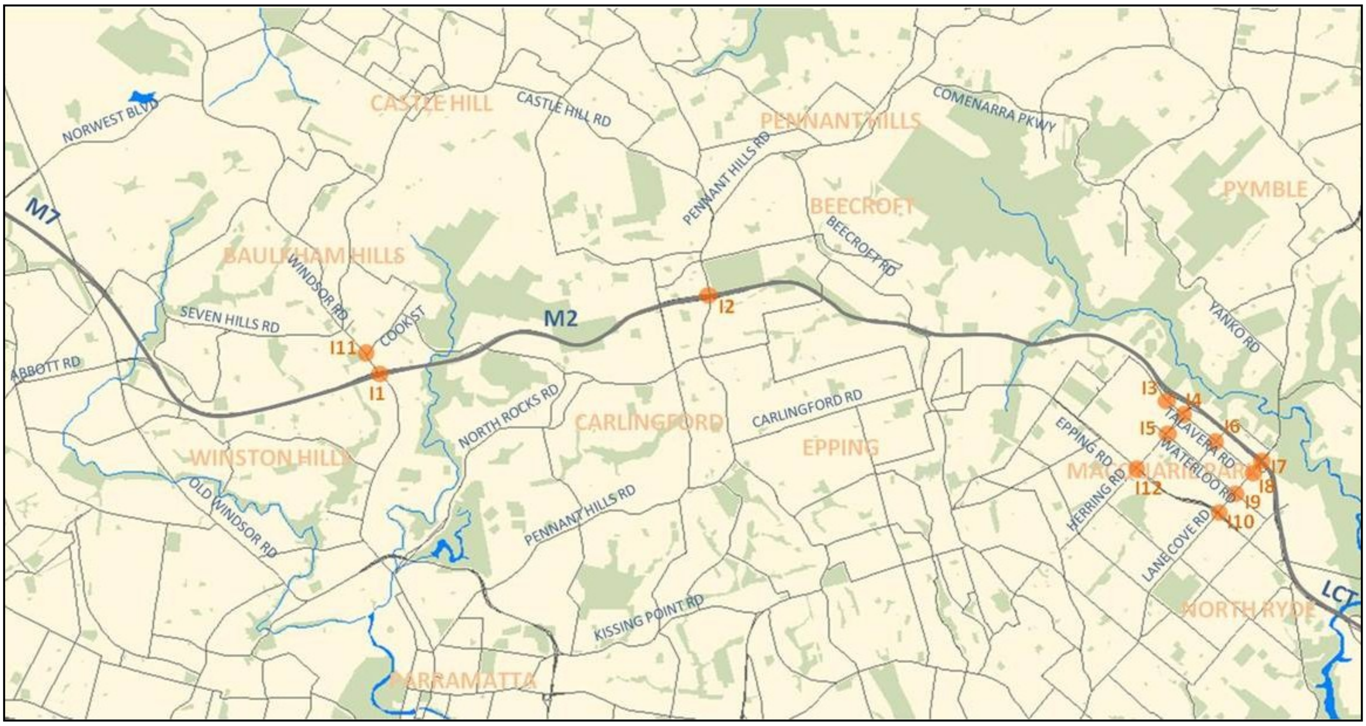

Figure 20 - Locations of Intersections assessed

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.

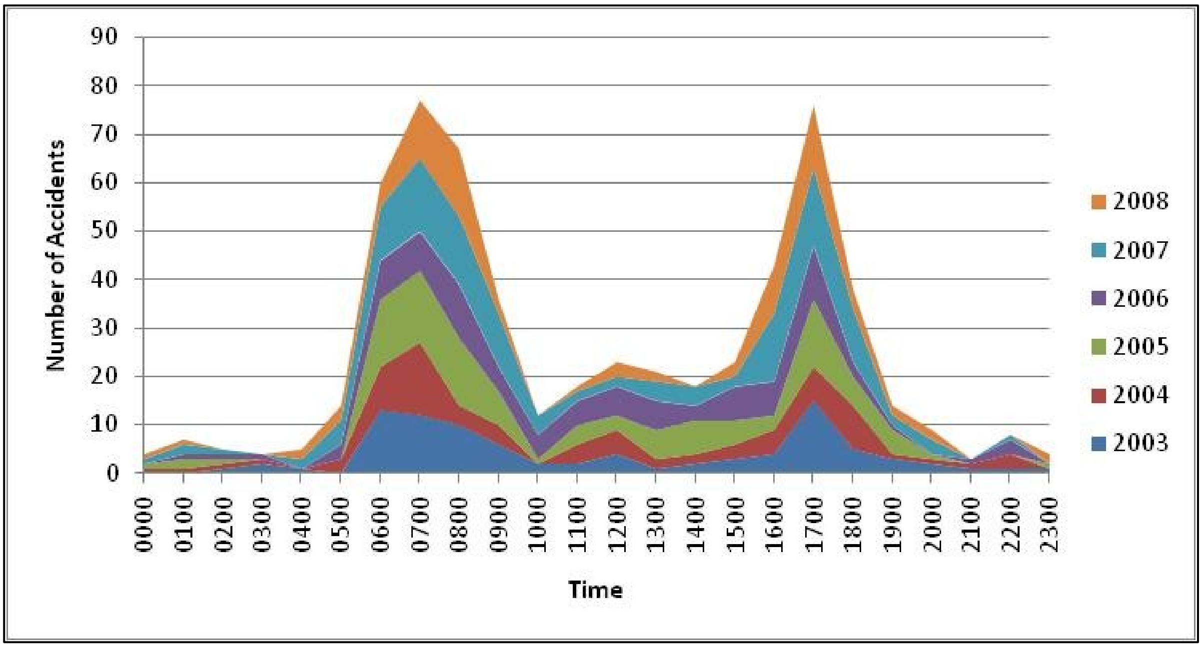

Figure 21 - M2 Accidents by Time of Day

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.

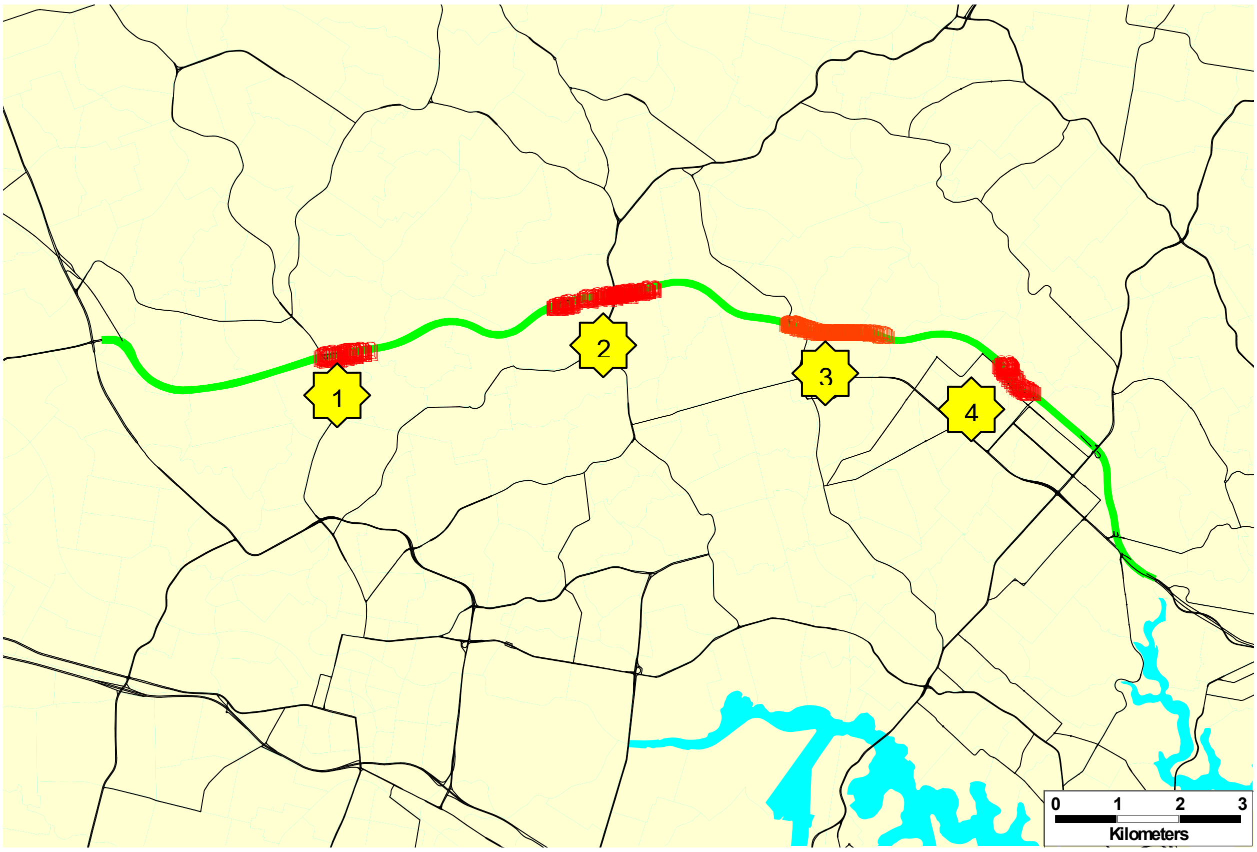

Figure 22 - M2 Accidents Concentrations

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.

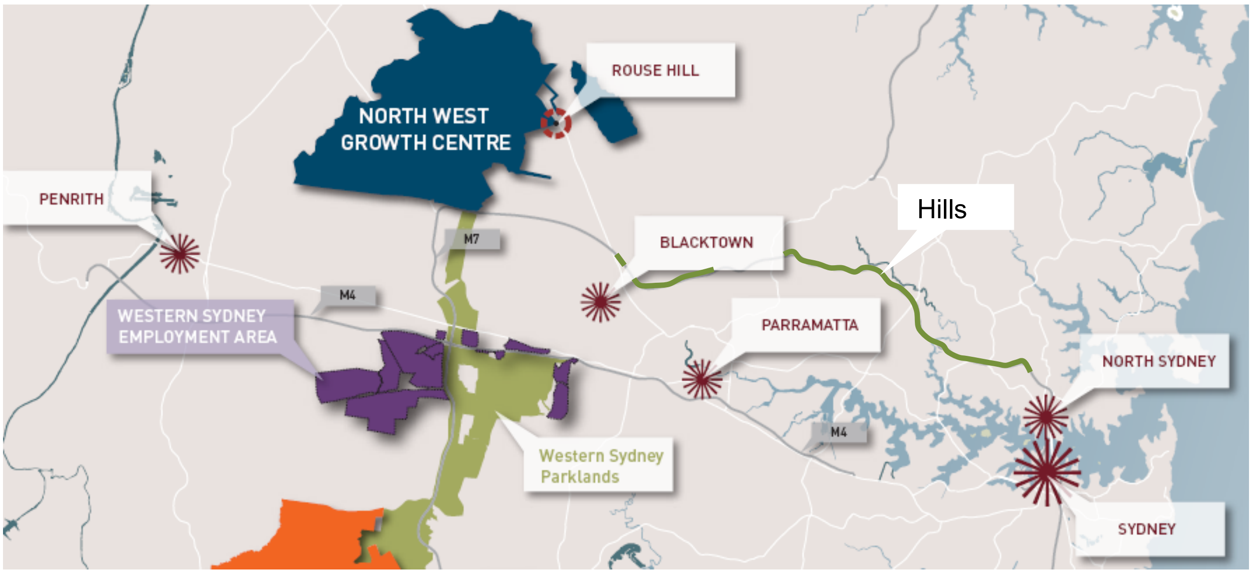

Figure 23 - Proposed North-West Growth Centre

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.

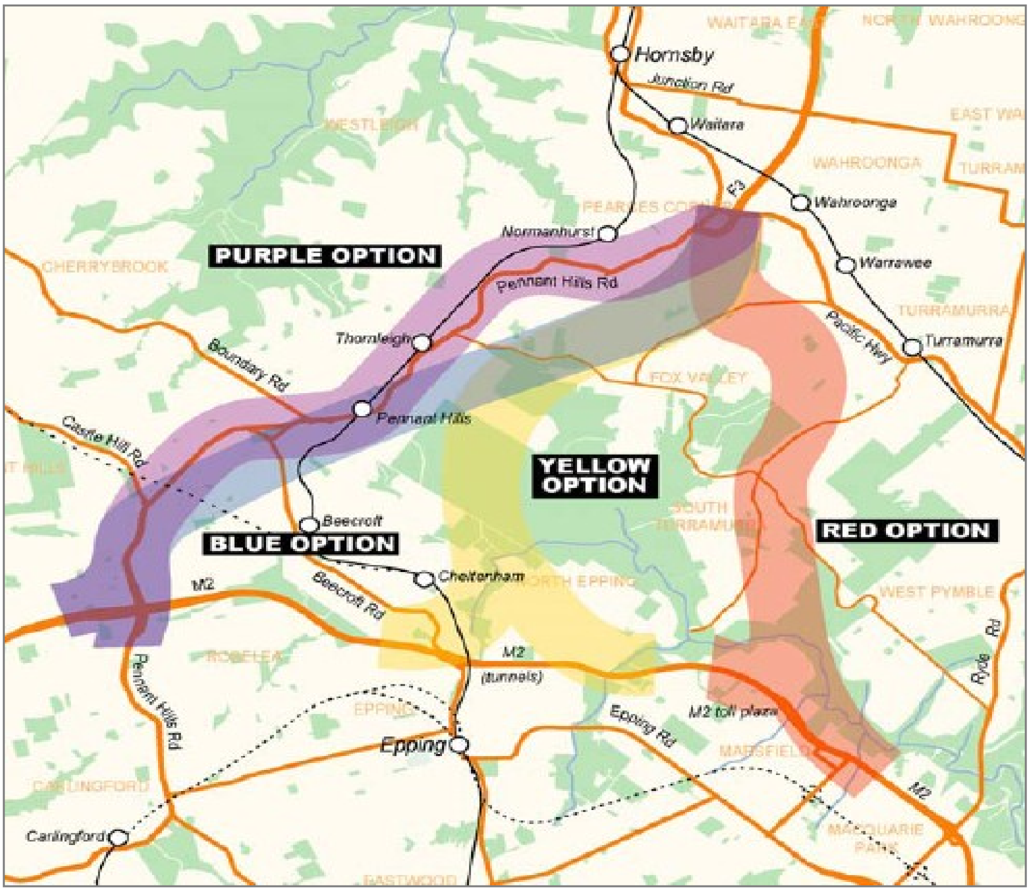

Figure 24 - F3M2 Link Route Options

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.

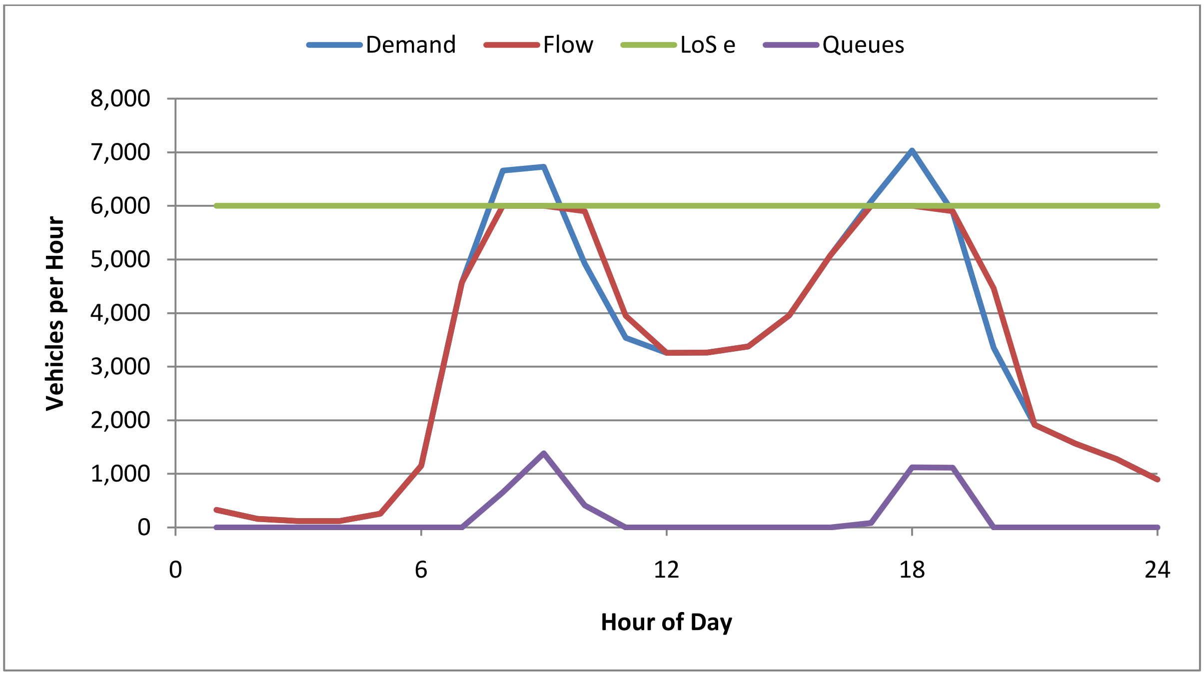

Figure 25 – Illustration of Demand, Flow, Capacity and Congestion

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

SCL	Dir	Location	Type	Lanes	Base PM Peak Hour 2009	2011	2021	Level of Service 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

SCL	Dir	Location	Type	Lanes	Base PM Peak Hour 2009	2011	2021	Level of Service 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

SCL	Dir	Location	Type	Lanes	Base PM Peak Hour 2009	2011	2021	Level of Service 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

SCL	Dir	Location	DAILY 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

SCL	Dir	Location	DAILY 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

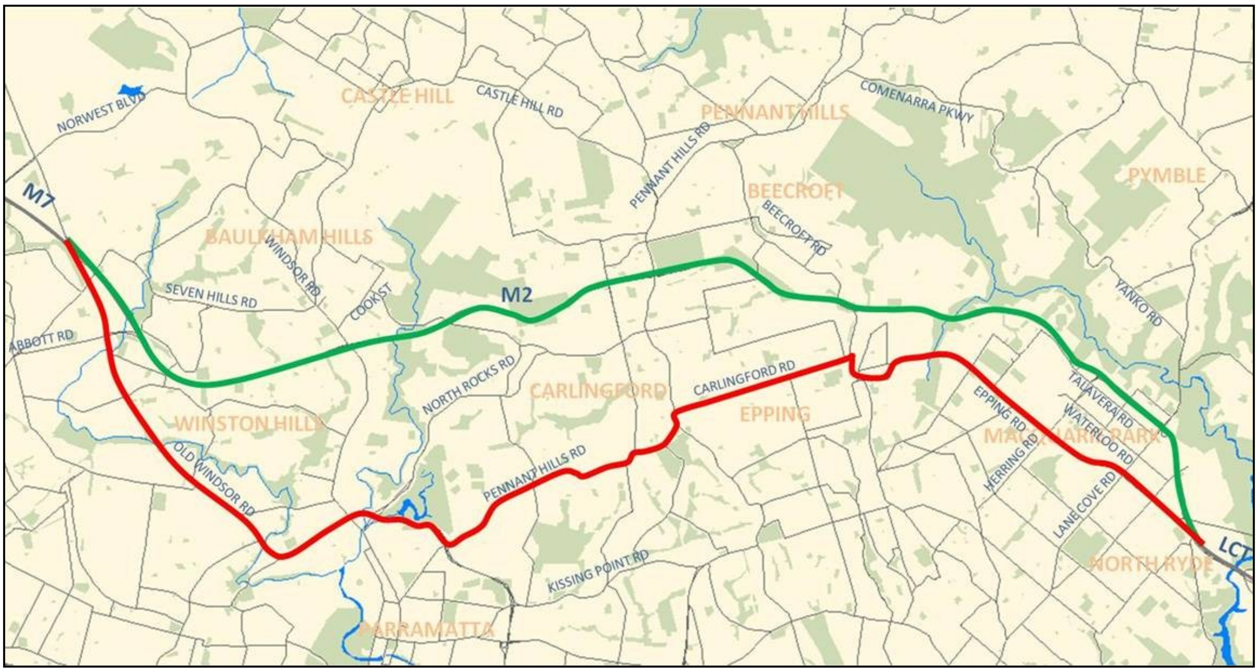

Figure 26 - Route used for travel time comparisons

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

Year	VKT (millions kilometres)	Average Annual Accidents			
		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.

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[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

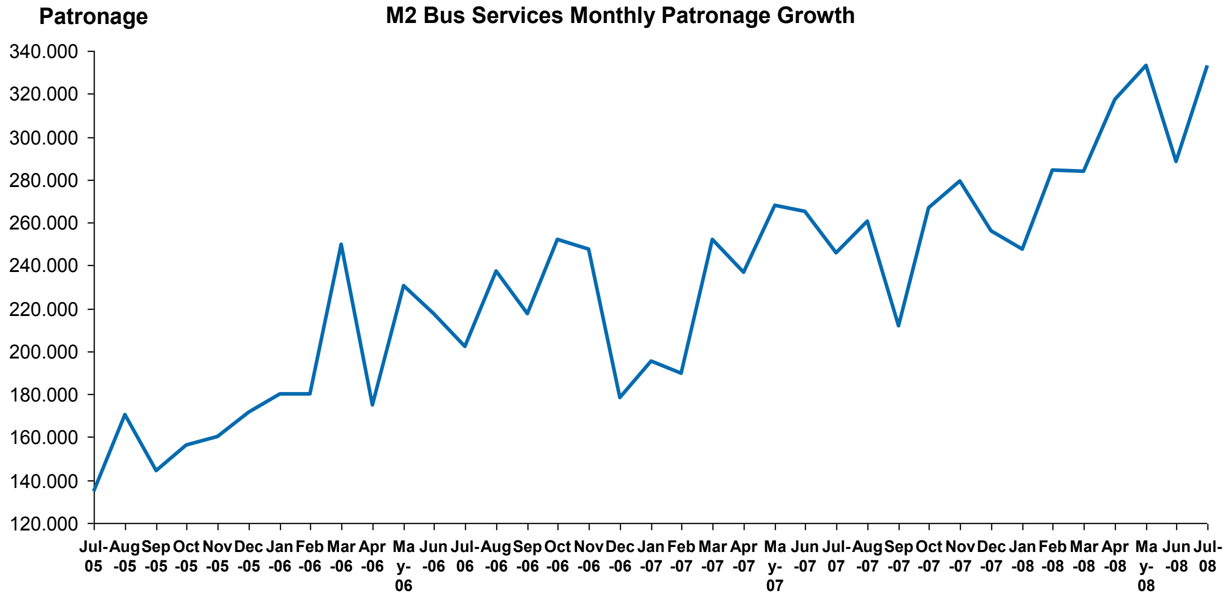

Figure 27 - Hills M2 Bus Service Patronage Growth

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.

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[14] *Transurban Traffic Modelling 2009*

6.0 The M2 Upgrade Project

The NSW Government and Transurban, the operator of the M2, have agreed in principle to investigate the economic, social, environmental and financial viability of a significant upgrade of the M2.

6.1 Background

Significant commercial and residential growth in Sydney's north-west has increased peak period congestion on the M2, affecting motorists, bus passengers and businesses. On a typical work day, the M2 is used by over 100,000 vehicles and 435 Hills bus services carry over 17,000 passengers.

An upgrade of M2 will provide relief from peak period congestion and ensure that this essential transport corridor can accommodate the predicted business and residential growth over the next 25 years. Current planning for Sydney's North-West includes the establishment of 140,000 new homes and 100,000 new jobs over the next 25 years.

A technical M2 Upgrade proposal was developed by Transurban and submitted to the NSW Roads and Traffic Authority (RTA) in December 2007. The project was developed in accordance with the NSW Working with Government Guidelines for Privately Financed Projects.

The M2 Upgrade project is expected to create at least 800 new construction and engineering jobs through the life of the project.

6.2 Project details

Transurban developed the "M2 Upgrade Project" to address increasing traffic congestion by widening and upgrading critical sections of M2. It will improve accessibility to major growth areas, provide for better traffic management and safety systems, as well as new cycling and bus facilities.

The M2 Upgrade Project scope reflects comments/suggestions received from a range of stakeholders, including motorists, cyclists, local bus companies, local councils, business and the broader community.

The proposed M2 Upgrade has been declared a Major Project for the purpose of seeking planning approval. It will be assessed under Part 3A of the Environmental Planning and Assessment Act 1979.

The M2 Upgrade will include:

- 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.

The project is illustrated below in Figure 28.

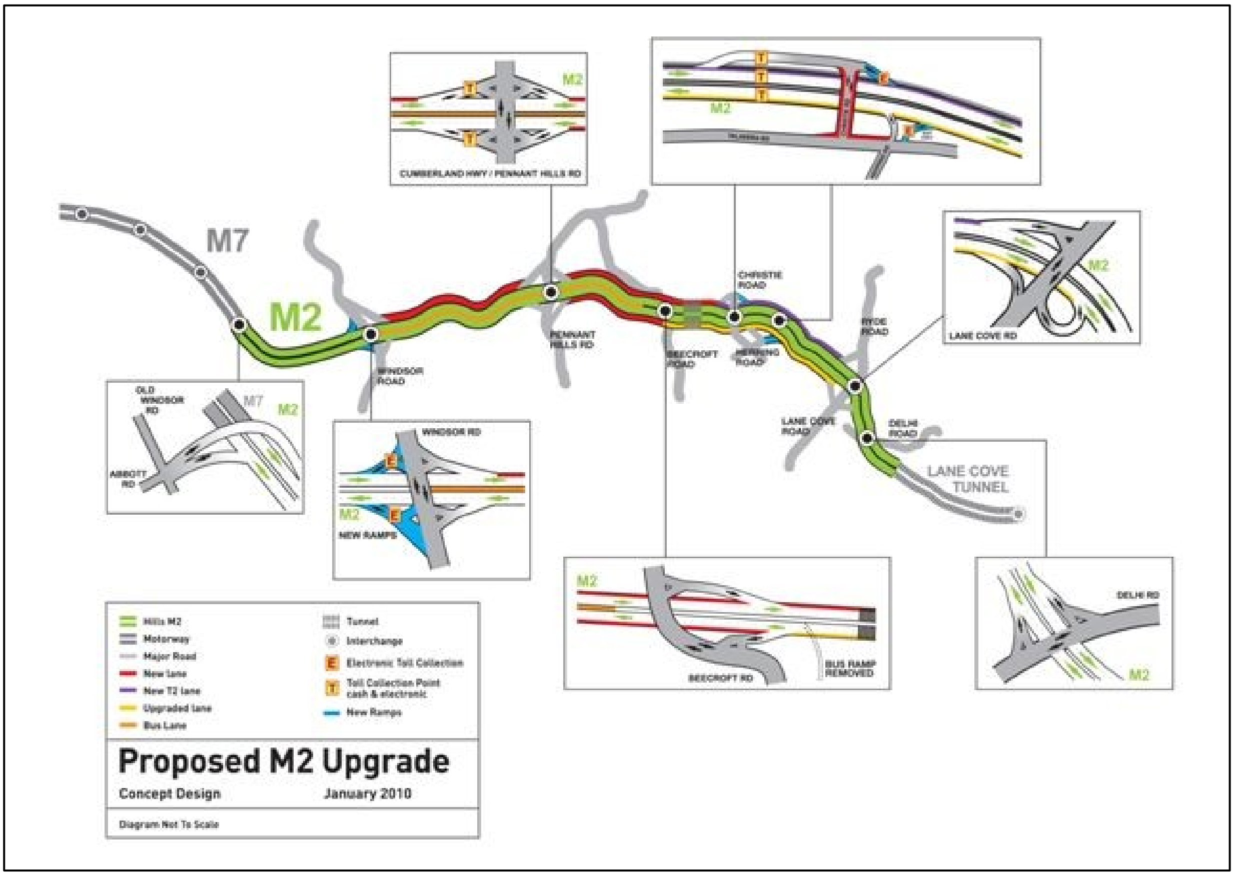


Figure 28 - M2 Upgrade Project

The proposed M2 Upgrade scope seeks to provide significantly improved travel conditions within the M2 whilst cognisant of capacity constraints at the eastern and western ends of the motorway (i.e. interface with Lane Cove Tunnel and Westlink M7). This will ensure that the widening has minimal impact on the greater network, particularly at the bridges and tunnels crossing Sydney Harbour.

Construction is expected to begin in September 2010 with a construction period of two years.

6.3 Project Objectives

The M2 provides connectivity and capacity for commuter, commercial, freight and road-based public transport. The proposed M2 Upgrade is significant to the Sydney Region as it will improve traffic flow and reduce bus travel times. The following are a summary of traffic objectives of the project:

- Support the NSW Government's State Plan, Metropolitan Strategy, Urban Transport Statement and State Infrastructure Strategy;
- Enhance the strategic road network in Sydney's north west to support economic growth;
- Connectivity between key traffic generators, residential, employment and educational precincts;

- Heavy and commercial vehicle growth to improve access and connectivity between key residential, employment and educational precincts in Sydney's north west;
- Improved safety through reduced accident rates for local and regional traffic;
- Improve travel times and network reliability by reducing congestion during peak periods for the benefit of local and regional traffic;
- Enhanced capacity of the corridor;
- Improve safety and amenity for all road users and surrounding communities;
- Improved incident management measures;
- Relieve traffic pressure on surrounding local traffic routes;
- Provide opportunities to improve land based public transport;
- Improved bus travel times and reliability;
- Improved public transport accessibility in the North West Corridor.

Section 7 of this report provides an operational impact assessment with regard to these objectives.

7.0 Operational Impact Assessment of M2 Upgrade

This section will address the DGRs relating to operation impacts of the M2 Upgrade, which are as follows:

DGRs – Operational Traffic and Transport
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 M2 Upgrade project objectives include reducing levels of congestion and improving accessibility. The upgrade will result in overall reduction in travel delay; however there may be parts of the network where the upgrade may result in increased traffic volumes and localised increases in delay.

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

- The Strategic Level changes – namely vehicle kilometres and vehicle hours resulting from the M2 Upgrade;
- 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
- Impacts on public transport.

This section presents two different future scenarios. The first future scenario being "No M2 Upgrade", which is presented as the "base" scenario. The second scenario being with the "M2 Upgrade Project", which is presented as the "M2 Upgrade" scenario.

7.1 Strategic Level Changes in Road Network Performance

The predicted change in travel demands on the Sydney network is shown in Table 35. The likely change in hours travelled in Table 36 and average vehicle speeds on the future network are shown by Table 37[15].

While the overall change in network vehicle kilometres travelled is small, there is an expected shift in travel from arterial and local roads (of between 0.2% - 0.5%) to travel on Motorways (0.6%) on the network. The majority of this predicted change will be within the M2 corridor, influenced by the M2 Upgrade.

There will be an overall significant reduction in vehicle hours travelled (Table 36), with up to 8.3% reduction on motorways as a result of the M2 Upgrade. Likewise, when travel speeds are compared with the "No M2 Upgrade" scenario (Table 37), the M2 Upgrade improves overall travel speed performance, including service levels for buses on the corridor.

[15] The annual figures below have been calculated using the following methodology:

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

Table 35 - Forecast Annual Road Network Vehicle Kilometres Travelled (VKT) (millions kilometres)

Facility	2011 Base	2011 M2 Upgrade	Impact	2021 Base	2021 M2 Upgrade	Impact
Motorway	8,697	8,749	0.6%	9,862	9,924	0.6%
Arterial	14,379	14,347	-0.2%	16,407	16,368	-0.2%
Local / Sub Arterial	7,302	7,280	-0.3%	8,668	8,628	-0.5%
Sydney Network	30,379	30,376	0.0%	34,936	34,920	0.0%

Table 36 - Future Annual Road Network Vehicle Hours Travelled (VHT) (million hours)

Facility	2011 Base	2011 M2 Upgrade	Impact	2021 Base	2021 M2 Upgrade	Impact
Motorway	113.0	112.51	-0.4%	156.89	143.82	-8.3%
Arterial	351.0	348.55	-0.7%	431.70	427.95	-0.9%
Local / Sub Arterial	209.9	209.05	-0.4%	276.62	274.30	-0.8%
Sydney Network	673.8	670.10	-0.6%	853.58	846.07	-0.9%

Table 37 - Future Annual Road Network Annual Average Vehicle Speeds (kilometres per hour)

Facility	2011 Base	2011 M2 Upgrade	Impact	2021 Base	2021 M2 Upgrade	Impact
Motorway	77.0	77.8	1.0%	62.9	69.0	9.8%
Arterial	41.0	41.2	0.5%	38.0	38.2	0.6%
Local / Sub Arterial	34.8	34.8	0.1%	31.3	31.5	0.4%
Sydney Network	45.1	45.3	0.5%	40.9	41.3	0.8%

7.2 Traffic Performance of Road Links

7.2.1 Hills M2 AM Peak Flow and Resultant Levels of Service

Table 38 shows the forecast change in AM peak flows on each section and direction of the M2. As in Section 5.1, LoS has been taken at the merge point of on-ramps if present. In the upgrade case where there is no required merge with the mainline traffic, LoS has been determined on the basis of capacity and demand. In the eastbound direction, AM peak flows on a widened M2 will increase west of Pennant Hills Road by 2011 (by up to 1,350 vehicles per hour compared with the "No M2 Upgrade" scenario. Westbound peak volumes will increase less (by up to 650 vehicles per hour).

While M2 peak volumes will increase, peak volumes on competing routes such as Epping Road and North Rocks Road will reduce. This is shown in Figure 31 which illustrates those links on the network which would benefit from the increased volumes on the M2 (shown in green in Figure 31)

The levels of service on a widened M2 during peak periods (AM and PM) will improve compared with the "No M2 Upgrade" scenario, as shown on Table 38.

The LoS F shown for the section between Beecroft Road and the Main Toll Plaza may not occur. The analysis indicates that the M2 Upgrade improves the eastbound Beecroft Road merge density, however the forecast performance of this section of the motorway currently reflects a conservative assumption with regard to uptake of the T2 lane based on surveys of vehicle occupancy undertaken under current conditions (without any incentive for car pooling).[16] However, the introduction of the T2 lane is designed to encourage car pooling. Such increases in car pooling and T2 occupancy rates would see an improvement in the forecast LoS F in this section. The operation of the T2 lane will be further investigated using micro simulation as part of detailed design.

Table 38 - Changes to M2 AM LoS

EASTBOUND DIRECTION					
From	**To**	**2011 Base**	**2011 M2 Upgrade**	**2021 Base**	**2021 M2 Upgrade**
Old Windsor Road	Windsor Road	C	**C**	D	**D**
Windsor Road	Pennant Hills Road	D+	C	F+	D
Pennant Hills Road	Beecroft Road	D+	D	F+	D
Beecroft Road	Christie Road	F+	D+	F+	F+
Christie Road	Lane Cove Road	D	C+	E	D+
Lane Cove Road	Delhi Road	C	**D**	D	**E**
Delhi Road	Epping Road	B	**C**	B	**C**

WESTBOUND DIRECTION					
From	**To**	**2011 Base**	**2011 M2 Upgrade**	**2021 Base**	**2021 M2 Upgrade**
Epping Road	Delhi Road	A	**B**	B	**C**
Delhi Road	Lane Cove Road	B+	**B+**	B+	**C+**
Lane Cove Road	Herring Road	B+	B+	C+	C+
Herring Road	Beecroft Road	B+	B+	C+	B+
Beecroft Road	Pennant Hills Road	C	B	D	C
Pennant Hills Road	Windsor Road	C+	**C+**	D+	**D+**
Windsor Road	Old Windsor Road	C	**C+**	C	**D+**

Note: **Items marked bold are not widened**
+ indicates LoS based on constraints at on-ramp merge point.

[16] Occupany surveys undetaken by AusTraffic on Friday April 11, 2008. Surveys indicated only 13% of AM peak EB traffic between Beecroft Road and Christie Road had 2 or more occupants.

7.2.2 Hills M2 PM Peak Flow and Resultant LoS

Table 39 shows the forecast change in PM peak flows on each section and direction of the M2.

The predicted traffic volumes on M2 will increase less in the afternoon peak periods compared with the morning peaks. The changes would be between 350 and 700 per hour eastbound and between 150-850 vehicles per hour westbound

The LoS F between Pennant Hills Road and Windsor Road occurs from high volumes of merging traffic from Pennant Hills Road. Under a no project scenario this section of motorway reaches LoS F by 2011. Under the M2 Upgrade scenario this section remain LoS F from 2011, however the merge density does not get any worse (refer Appendix C). This section of the motorway only reflects LoS F for the PM peak hour and operates at a better LoS for the remaining time periods.

Table 39 - Changes to M2 PM LoS

EASTBOUND DIRECTION					
From	To	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
Old Windsor Road	Windsor Road	C	**C**	D	**D**
Windsor Road	Pennant Hills Road	C+	C	D+	C
Pennant Hills Road	Beecroft Road	C+	B	C+	C
Beecroft Road	Christie Road	C+	B+	D+	C+
Christie Road	Lane Cove Road	C	B+	D	C+
Lane Cove Road	Delhi Road	B	**C**	D	**D**
Delhi Road	Epping Road	B	**B**	C	**C**

WESTBOUND DIRECTION					
From	To	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
Epping Road	Delhi Road	C	**C**	D	**D**
Delhi Road	Lane Cove Road	C+	D+	D+	D+
Lane Cove Road	Herring Road	C+	D+	D+	D+
Herring Road	Beecroft Road	D+	D+	D+	D+
Beecroft Road	Pennant Hills Road	F	D	F	D
Pennant Hills Road	Windsor Road	F+	**F+**	F+	**F+**
Windsor Road	Old Windsor Road	D	**D**	D	**D**

Note: **Items marked bold are not widened**
$^{+}$ indicates LoS based on constraints at on-ramp merge point.

7.2.3 Daily Impacts

Table 40 shows the forecast change in daily volumes on each section and direction of M2. While no direct LoS can be calculated from daily volumes, the table below is useful in demonstrating that the overall forecast impact is relatively moderate in a daily sense, with a maximum increase in the eastbound direction of 4,910 vehicles by 2021 in the section between Christie Road and Lane Cove Road. This increase can be attributed to increased volumes as a result of the eastbound widening and new trips to the M2 from the new Herring Road Ramps. The maximum daily increase in the westbound direction is 6,900 vehicles in same section.

Table 40 - Forecast Daily Impacts M2

EASTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	2011 Impact	2021 Base	2021 Upgrade	2021 Impact
Old Windsor Road	Windsor Road	31,800	33,950	2,150	37,550	40,050	2,500
Windsor Road	Pennant Hills Road	41,200	42,000	800	49,750	51,330	1,580
Pennant Hills Road	Beecroft Road	36,150	37,450	1,300	44,750	46,830	2,080
Beecroft Road	Christie Road	40,350	42,100	1,750	49,250	51,830	2,580
Christie Road	Lane Cove Road	36,250	40,070	3,820	42,900	47,810	4,910
Lane Cove Road	Delhi Road	26,950	30,670	3,720	32,500	37,310	4,810
Delhi Road	Epping Road	19,200	21,920	2,720	25,850	29,810	3,960

WESTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	2011 Impact	2021 Base	2021 Upgrade	2021 Impact
Epping Road	Delhi Road	18,750	21,450	2,700	24,300	27,800	3,500
Delhi Road	Lane Cove Road	27,200	31,600	4,400	30,500	35,250	4,750
Lane Cove Road	Herring Road	36,150	42,350	6,200	40,200	47,100	6,900
Herring Road	Beecroft Road	40,800	44,130	3,330	47,250	50,920	3,670
Beecroft Road	Pennant Hills Road	37,750	41,480	3,730	43,600	47,720	4,120
Pennant Hills Road	Windsor Road	43,750	45,280	1,530	50,350	52,020	1,670
Windsor Road	Old Windsor Road	33,300	38,280	4,980	37,350	42,715	5,365

7.2.4 New Access – Windsor Road Ramps

The proposed Windsor Road west facing ramps will significantly increase the accessibility of the Baulkham Hills area to the motorway network (travelling both in eastbound and westbound directions) and the employment hubs.

Figure 29 below shows forecast origins and destinations of vehicles using the west facing Windsor Road ramps at opening. The blue line represents traffic using the new west facing off-ramp, and the green line the new west facing on-ramp. A high proportion of vehicles using the ramps will be local trips accessing the suburbs within the Hills District. In particular, the suburbs of North Rocks, Baulkham Hills and Parramatta. The impact of the additional trips forecast for the Windsor Road interchange is addressed in section 7.4.3.

Table 41 below summarise forecast AM, PM peak hour ramp traffic. The dominant direction of travel in the AM peak is forecast to be eastbound and westbound during the PM peak.

Table 41 - Forecast New Ramp Traffic (Windsor Road)

Windsor Road Ramps	2011 AM Peak	2021 AM Peak	2011 PM Peak	2021 PM Peak	2011 Daily	2021 Daily
Eastbound Off-Ramp	420	450	230	250	3,800	4,120
Westbound On-Ramp	230	250	420	450	3,800	4,120

Figure 29 – Forecast Origins and Destinations of New West Facing Windsor Road Ramps traffic (Opening)

Using TUSTM the impact of the proposed ramps on the network traffic has been estimated. The development of the Project would lead to a redistribution of traffic on the road network. This redistribution results in a decrease in traffic on some roads and an increase on others. The project impact assessment identifies and quantifies both traffic increase and decrease of the network links.

The proposed ramps would remove traffic from the local road network. Figure 31 illustrates the change in volumes on links in 2021 compared with the "No M2 Upgrade" scenario. Seven Hills Road, Old Windsor Road, Power Road and Station Road are links that would have lower traffic as a result of introducing the Windsor Road West facing ramps. A summary of the forecast traffic impacts on key local roads is presented in Table 78, Table 79, Table 80 and Table 81

TUSTM forecasts that the proposed ramps would increase traffic on the western end of the M2 and Windsor Road, however there would be lower traffic on the northern sections of the Windsor Road north of Old Northern Road. Effects of increased traffic along Windsor Road and the performance of the modified Windsor Road/M2 junction are discussed in more detail in section 7.4.1.

7.2.5 New M2 Access – East Facing Herring/Christie Road Ramps

The proposed east facing Herring/Christie Road ramps will provide motorway access to Macquarie Park from the business districts of Chatswood, North Sydney and Sydney.

Figure 30 below shows forecast origins and destinations of vehicles using the new ramps at Herring Road (east facing exit ramp) and Christie Road (east facing entry ramp). The blue line represents traffic using the new east facing on-ramp, and the green line the new west facing off- ramp. The analysis shows that the majority of vehicles using the ramps will be local trips in the Macquarie Park and Macquarie University area. Trips from this local area using the new ramps extend to locations as far as the Sydney CBD and the suburbs surrounding the Sydney Airport via the interconnecting motorway system through LCT.

Table 42 below summarises forecast AM, PM peak hour ramp traffic. In the morning peak the dominant direction of travel is north-west bound, and caters for commuters travelling to Macquarie Park from the south east. In the evening peak the dominant direction of travel is reversed.

Table 42 - Forecast New Ramp Traffic (Christie/Herring)

Ramps	2011 AM Peak	2021 AM Peak	2011 PM Peak	2021 PM Peak	2011 Daily	2021 Daily
Macquarie Exit-Christie Road Eastbound On Ramp	150	200	300	350	2,320	2,680
Macquarie Exit-Herring Road Westbound Off Ramp	400	450	130	150	3,170	3,680

Figure 30 – Forecast Origins and Destinations of new East Facing Herring/Christine Road Ramp traffic (opening)

Using TUSTM the impact of the proposed ramps on the network traffic has been estimated. The development of the Project would lead to a redistribution of traffic on the road network. This redistribution results in a decrease in traffic on some roads and an increase on others. The project impact assessment identifies and quantifies both traffic increase and decrease of the network links.

The proposed ramps would remove traffic from local road network. Figure 31 illustrates the change in volumes on links in 2021 compared with the "No M2 Upgrade" scenario. Sections of Lane Cove Road, Waterloo Road and Talavera Road are the links that would have lower traffic as a result of introducing the new ramps. A summary of the forecast traffic impacts on key local roads is presented in Table 78, Table 79, Table 80 and Table 81.

TUSTM forecasts that the proposed ramps would increase traffic within the immediate vicinity of the new ramp along Talavera Road. Effects of increased traffic along Talavera Road and the performance of the widened and modified junction are discussed in more detail in section 7.4.1.

7.2.6 Effects on the surrounding road network

As previously discussed, Figure 31 illustrates the change in volumes on links in 2021 compared with the "No M2 Upgrade" scenario. Access roads to the M2 attract additional traffic in both the eastbound and westbound direction. As can be seen from Figure 31, the majority of the network in the corridor, including routes that compete with M2, such as Epping Road will benefit with significantly reduced traffic volumes from the M2 Upgrade. Individual forecast link volumes on local roads are shown in Table 78, Table 79, Table 80 and Table 81. The screenline reference refers to those shown on Figure 15.

7.2.6.1 AM Peak Conditions

Table 43 presents the forecast change in AM peak LoS on each of the local roads of the study area screenlines.

Table 43 - Changes in Local Road LoS (AM Peak)

SCL	DIR	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	F	F	F	F
1B	EB	Seven Hills Road East of Merindah Road	Arterial	C	B	E	B
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	A	A	B	C
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	F	F	F	F
1F	EB	Powers Road East of Station Road	Sub-Arterial	D	C	F	D
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	D	C	E	D
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	F	C	F	F
2B	EB	Renown Road East of Cook Street	Sub-Arterial	F	F	F	F
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	F	F	F	F
2E	EB	Church Street South of Briens Road	Major Arterial	F	F	F	F
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	F	F	F	F
3C	EB	Epping Road West of Vimiera Road	Major Arterial	F	F	F	F
4A	SB	Windsor Road North of M2	Major Arterial	E*	B*	F*	D*
4B	SB	Oakes Road North of M2	Sub-Arterial	F	F	F	F
4C	SB	Pennant Hills Road North of M2	Major Arterial	F	F	F	F
4D	SB	Murray Farm Road @ M2	Collector	D	D	F	F
4E	SB	Beecroft Road North of M2	Major Arterial	E	D	F	F
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	F	F	F	F

SCL	Dir	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	B	B	B	B
1B	WB	Seven Hills Road East of Merindah Road	Arterial	F	F	F	F
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	A	A	B	C
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	E	C	F	E
1F	WB	Powers Road East of Station Road	Sub-Arterial	B	B	C	C
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	D	C	E	D
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	C	C	D	B
2B	WB	Renown Road East of Cook Street	Sub-Arterial	F	F	F	F
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	E	E	F	F
2E	WB	Church Street South of Briens Road	Major Arterial	F	F	F	F
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	E	E	F	E
3C	WB	Epping Road West of Vimiera Road	Major Arterial	F	F	F	F
4A	NB	Windsor Road North of M2	Major Arterial	A*	C*	A*	C*
4B	NB	Oakes Road North of M2	Sub-Arterial	C	B	E	C
4C	NB	Pennant Hills Road North of M2	Major Arterial	C	B	F	E

SCL	DIR	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
4D	NB	Murray Farm Road @ M2	Collector	A	A	A	A
4E	NB	Beecroft Road North of M2	Major Arterial	B	B	B	B
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	C	C	F	F

As discussed in Section 7.2.1 and 7.2.2, the M2 Upgrade will improve LoS along the motorway, which will subsequently encourage transfer of traffic from the arterial network to the motorway and result in lower traffic and improved speeds on a number of key arterial roads. As shown in Table 43, during the AM peak it is forecast that Seven Hills Road, Powers Road, Station Road, Castle Hill Road, Old Windsor Road, Oaks Road and Pennant Hills Road will all benefit from reduced traffic volume and improved LoS and speeds. Furthermore, although Table 43 indicates that both Ryde Road and Norwest Boulevard do not show any improvement in LoS, both of these roads will benefit from reduced traffic volumes as a result of the project.

A key factor in route level of service is the efficiency of intersections. Section 7.4 presents an analysis of intersection performance.

7.2.6.2 PM Peak Conditions

Table 44 presents the forecast change in AM peak LoS on each of the local roads of the study area screenlines.

Table 44 - Changes in Local Road LoS (PM Peak)

SCL	DIR	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	B	B	E	D
1B	EB	Seven Hills Road East of Merindah Road	Arterial	B	B	C	B
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	A	A	A	C
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	F	C	F	F
1F	EB	Powers Road East of Station Road	Sub-Arterial	B	B	C	C
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	B	B	C	B
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	F	F	F	F
2B	EB	Renown Road East of Cook Street	Sub-Arterial	A	A	A	A
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	B	B	C	B
2E	EB	Church Street South of Briens Road	Major Arterial	F	F	F	F
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	C	C	C	B
3C	EB	Epping Road West of Vimiera Road	Major Arterial	F	F	F	F
4A	SB	Windsor Road North of M2	Major Arterial	E*	B*	E*	C*
4B	SB	Oakes Road North of M2	Sub-Arterial	E	C	F	E
4C	SB	Pennant Hills Road North of M2	Major Arterial	D	C	E	B
4D	SB	Murray Farm Road @ M2	Collector	A	A	A	A
4E	SB	Beecroft Road North of M2	Major Arterial	B	B	B	B
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	F	E	F	F

SCL	Dir	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	B	B	F	F
1B	WB	Seven Hills Road East of Merindah Road	Arterial	C	C	F	F
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	A	A	B	C

SCL	DIR	Location	Type	2011 Base	2011 M2 Upgrade	2021 Base	2021 M2 Upgrade
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	F	C	F	F
1F	WB	Powers Road East of Station Road	Sub-Arterial	C	B	D	B
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	B	B	C	C
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	F	F	F	B
2B	WB	Renown Road East of Cook Street	Sub-Arterial	F	F	F	F
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	C	C	E	C
2E	WB	Church Street South of Briens Road	Major Arterial	F	F	F	F
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	F	F	F	F
3C	WB	Epping Road West of Vimiera Road	Major Arterial	F	F	F	F
4A	NB	Windsor Road North of M2	Major Arterial	A*	C*	A*	C*
4B	NB	Oakes Road North of M2	Sub-Arterial	C	C	D	B
4C	NB	Pennant Hills Road North of M2	Major Arterial	F	E	F	F
4D	NB	Murray Farm Road @ M2	Collector	A	A	A	A
4E	NB	Beecroft Road North of M2	Major Arterial	D	C	F	F
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	F	E	F	F

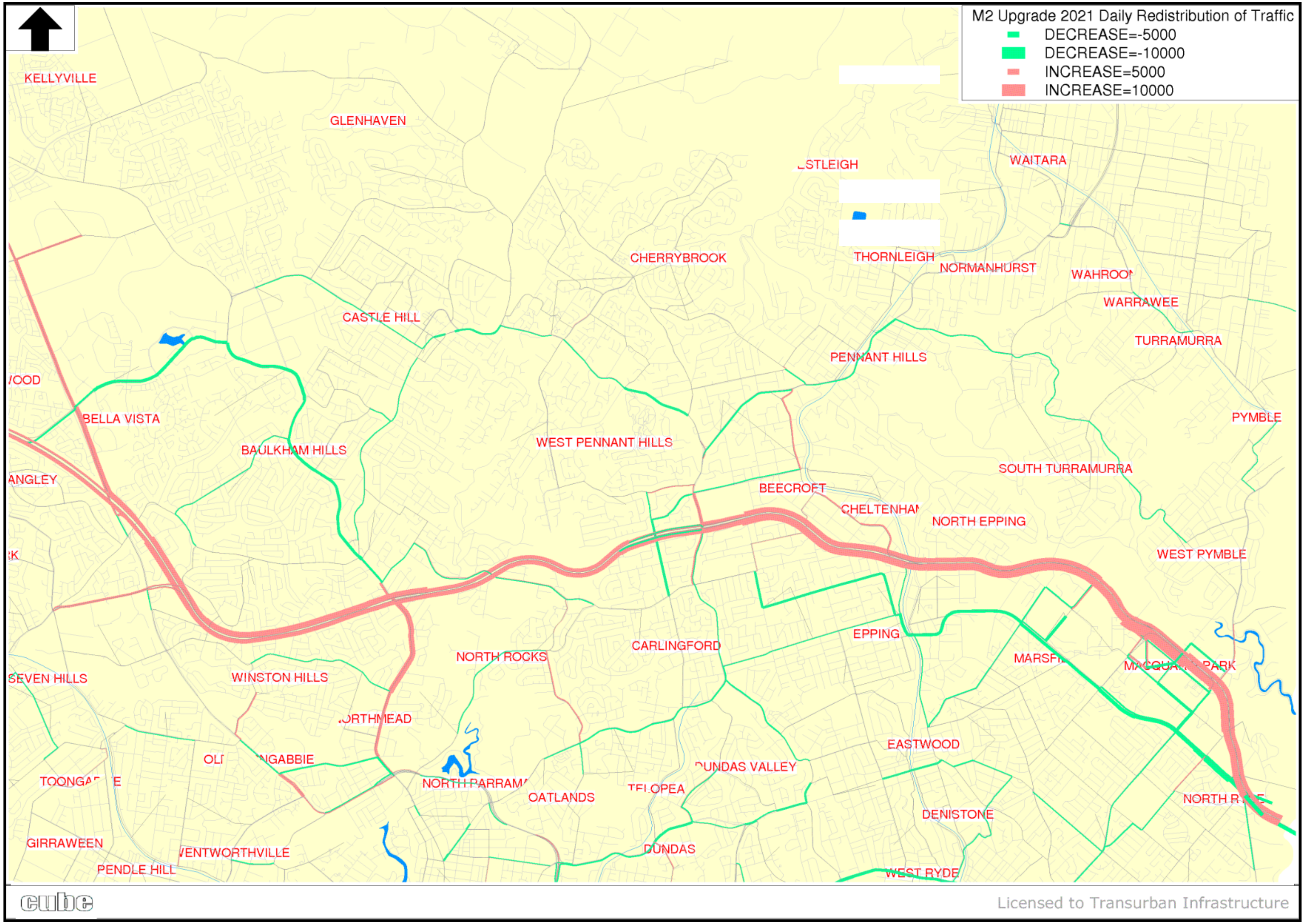
As shown in Table 44, during the PM peak it is forecast that Norwest Boulevard, Seven Hills Road, Powers Road, Station Road, Castle Hill Road, Old Windsor Road, Oaks Road, Ryde Road and Pennant Hills Road will all benefit from reduced traffic volume and improved LoS and speeds.

A key factor in route level of service is the efficiency of intersections. Section 7.4 presents an analysis of intersection performance.

7.2.6.3 Daily Conditions

Changes In daily flows are presented in Figure 31 below. Table 82 and Table 83 in Appendix B present the daily forecasts and associated impacts for both the 'Base' and 'Upgrade' scenarios for 2011 and 2021.

Figure 31 – Daily Project Flow Differences for 2021



7.2.6.4 Operational Impact on Lane Cove Tunnel

The operational impact of M2 Upgrade on LCT is discussed in this section, with particular attention to the conditions at the M2/LCT interface.

Table 45 below details the forecast AM and PM peak traffic flows at the western portal of the LCT. As shown the M2 Upgrade is expected to increase traffic through this section in both directions and both peak periods. Of particular importance is the EB section during the AM peak, which already displays signs of congestion at the merge between Epping Road and LCT. The M2 Upgrade is forecast to increase traffic through this section by up to 13% by 2021; however, despite this increase in peak hour volume as shown in Figure 32, the merge performance of this section will remain satisfactory. This is due to reduced traffic volume on Epping Road improving the operation of this merge, and confirms the objective of the Project to encourage longer distance travel along the motorway network.

Table 45 - LCT Western Portal, AM & PM Peak Traffic Flows

Peak Flows		2009	2011 Base	2011 M2 Upgrade	% Change	2021 Base	2021 M2 Upgrade	% Change
LCT	AM-IB	3,497	3,516	3,662	4%	3,713	4,182	13%
LCT	AM-OB	2,451	2,570	2,620	2%	3,488	3,568	2%
LCT	PM-IB	2,166	2,355	2,564	9%	3,360	3,708	10%
LCT	PM-OB	3,139	3,281	3,381	3%	3,700	3,800	3%

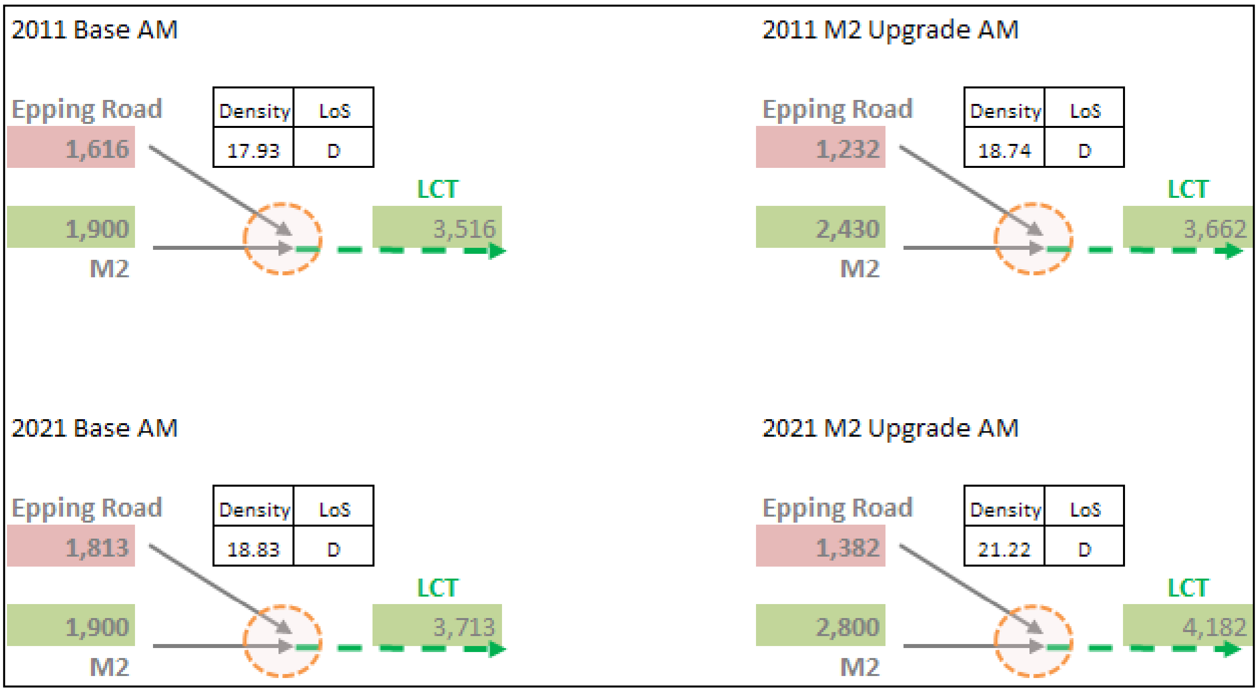


Figure 32 - Future Merge Performance of Epping Road / LCT

7.2.6.5 Operational Impact on M7

During the AM peak there is currently congestion and poor travel speeds eastbound at the M7/M2 interface which is caused by a lack of downstream capacity on M2, particularly at the Norfolk Tunnel (refer Section 3.3). The additional eastbound lane between Windsor Road and Terry's creek will resolve this issue by providing additional capacity and removing the merging conflict at Windsor and Pennant Hills Roads.

On opening of the M7, traffic at Pennant Hills plaza received a significant uplift and is demonstration that the M7 route via to M2 and off to Pennant Hills Road is attractive against the alternative "cross-city" route of Cumberland Highway and Pennant Hills Road with no use of M2. The widening of this eastbound section (Windsor Road to Pennant Hills Road) will again improve the M7 / M2 level of service and further entice transfer off the non-motorway route, providing uplift to M7.

The new west-facing ramps at Windsor Road provide new opportunity and accessibility between M2 and M7. Traffic at the new Windsor Road ramps, over and above that diverting from the Pennant Hills Road Plaza, will be new traffic to the M2 for its short section and will be coming from either the M7 (estimated to 80%) or Abbott Road (estimated to be 20%). However not all of the new trips between M7 and the new Windsor Road ramps will be new to M7 as many will be simply travelling further as their prior route may have been M7 and earlier exit/entry (e.g. Sunnyholt Road, Norwest Boulevard).

Section 7.2.6 summarises impacts and provides resultant V/C ratio at screenline 1C - WM7 East of Old Windsor Road.

7.3 Travel Times and Speeds

As link volumes increase, speeds reduce, LoS decreases and travel times increase. This section summarises forecast improvement in travel time and speeds for trips using the M2 and the new access points.

7.3.1 Long Distance M2 Travel Time Benefits

Table 46 summarises the modelled changes in travel time on the M2 and its route alternative in the AM and PM peak periods in 2011 and 2021. The start/end points are M2/Old Windsor Road and Epping Road/LCT.

Table 46 - M2 and Surrounds Travel Time Impacts

		2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
M2	AM-IB	38	23	-15	50	31	-19
Alternative	AM-IB	59	52	-7	67	62	-5
M2	PM-OB	29	22	-7	36	30	-6
Alternative	PM-OB	48	45	-3	52	50	-2

Figure 33 - Travel Time Analysis Routes

An overall 40% saving (19 minutes) in the AM peak is predicted for long-distance end to end trips using the upgraded M2 compared with the “No M2 Upgrade” scenario. In the PM peak, savings of up to 6 minutes are predicted. This can be compared to time savings on the alternative free-route of 5 minutes (AM peak) and 2 minute (PM peak) respectively.

7.3.2 Travel Time Benefits of New West Facing Windsor Road Ramps

The proposed ramps will provide an alternative route to the local arterial and sub-arterial road network, which would lead to travel time saving for trips between suburbs such as Blacktown, Seven Hills, Quakers Hill and southern parts of Baulkham Hills and northern Parramatta LGA’s. An example of a route where travel time savings would be experienced is shown below in Figure 34. The proposed M2/M7 route is highlighted green and the alternative route along Old Windsor Road and Seven Hills Road is highlighted red. The travel time savings indicated by TUSTM using new west facing ramps (green line) is 4 minutes in the peak directions in both the AM and PM peak periods.

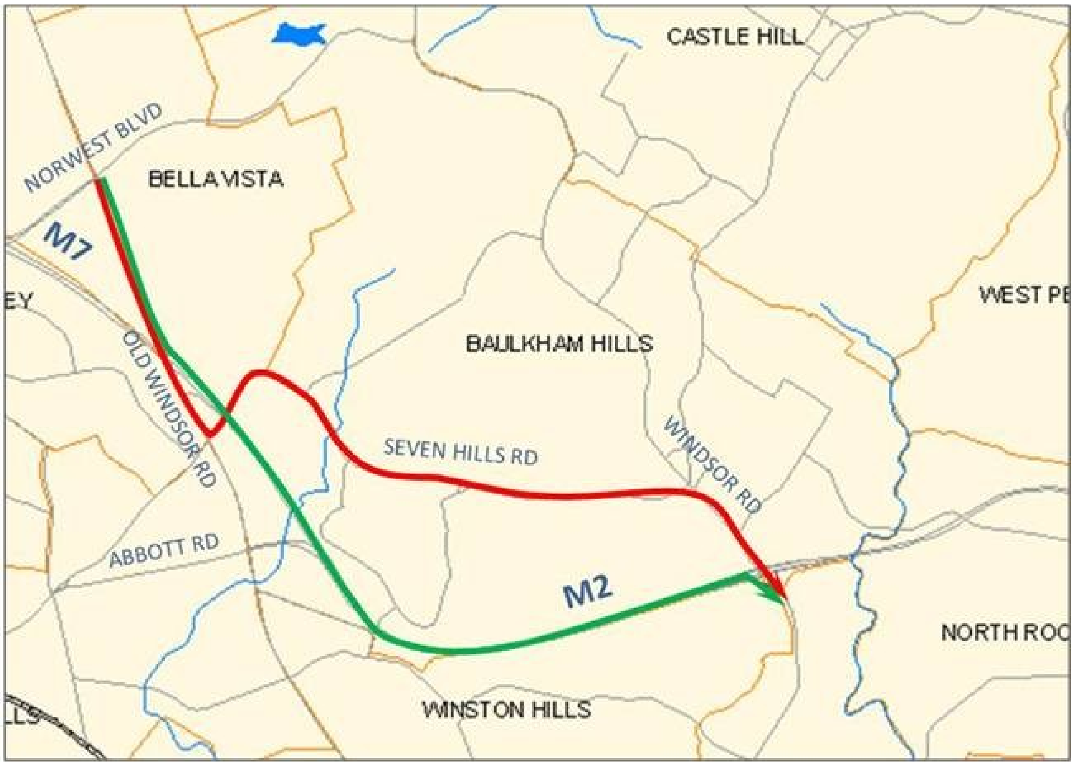


Figure 34 –Comparison of Travel Time between – New West Facing Windsor Road Ramps

7.3.3 Travel Time Benefits of New East Facing Herring/Christie Road Ramps

The proposed ramps will provide an alternative route to the local arterial and sub-arterial road network, which would lead to travel time saving for trips travelling to/from Macquarie Park and business areas of Chatswood, North Sydney, Sydney and suburbs such as Mossman, Neutral Bay and Cremorne . An example of a route where travel time savings would be experienced during the AM peak is shown below in Figure 35 and an example of travel time savings in the PM peak in Figure 36:

- the AM M2 route, which is from Lane Cove River to Macquarie Park using M2;
- the AM alternative route which from Lane Cove River to Macquarie Park using Epping Road and Herring Road;
- the PM M2 route which is from Macquarie Park to Lane Cove River using M2; and
- the PM alternative route which is from Macquarie Park to Lane Cove River using Talavera Road, Lane Cove Road and Epping Road.

For the AM peak northbound direction the travel time savings of the M2 route is forecast to be 3 minutes when compared to the alternative along Epping Road and Herring Road. For the PM southbound direction the travel time savings of the M2 route is forecast to be 5 minutes when compared with Talavera Road, Lane Cove Road and Epping Road.

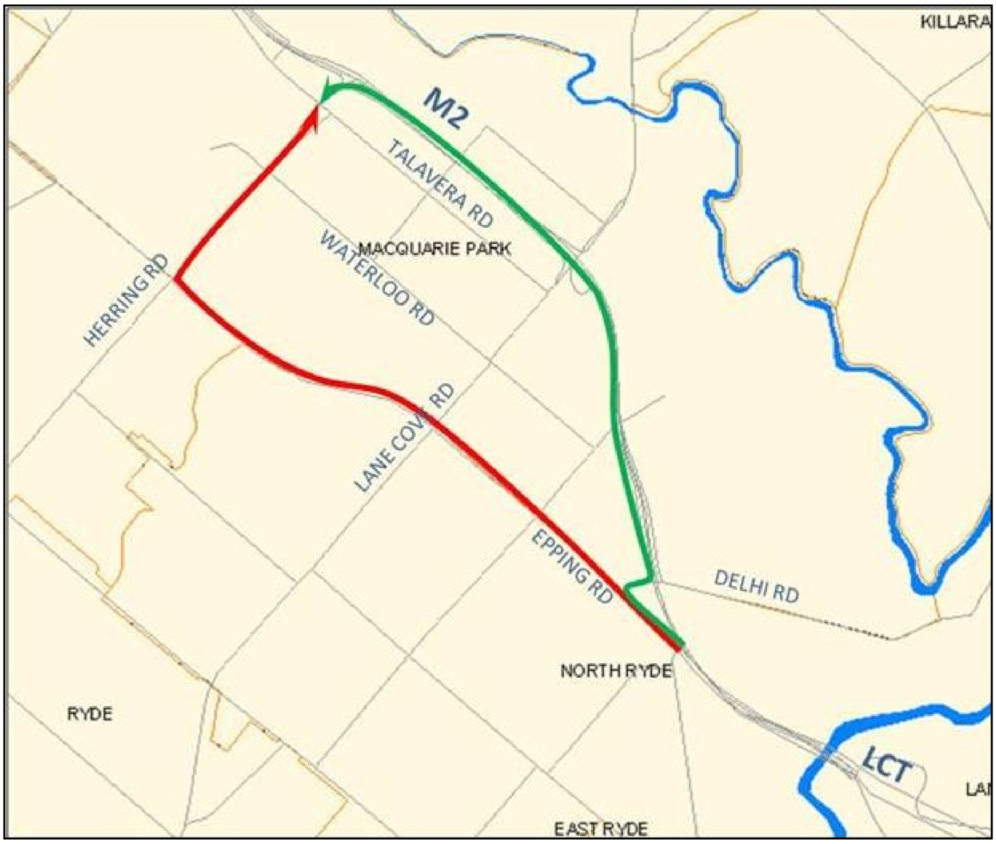


Figure 35 - Comparison of AM Peak Travel Time – New East Facing Herring Road Off Ramp

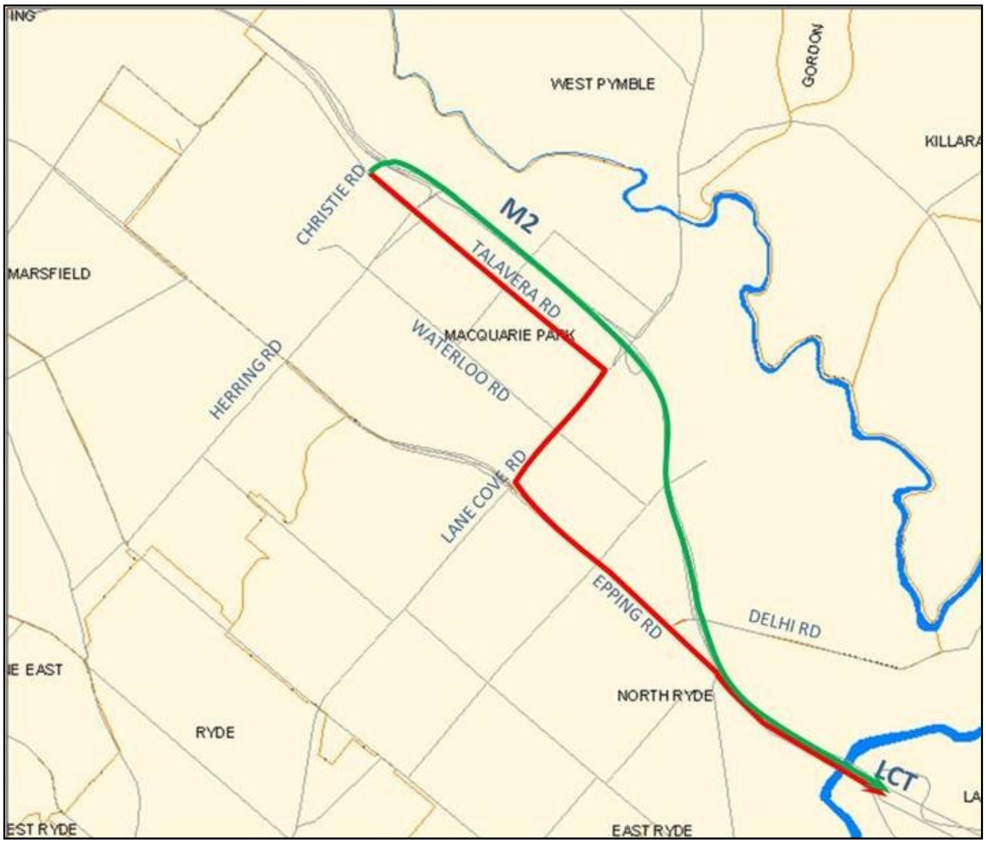


Figure 36 – Comparison of PM Peak Travel Time – New East Facing Christie Road On Ramp

7.4 Intersection Performance

Whilst operating conditions at a majority of intersections in the study area will not change significantly, new ramps on the M2 Motorway will significantly change operations at the Windsor Road, Herring Road, Talavera Road and Christie Road intersections.

7.4.1 Hills M2 Interchange modification and mitigation

As part of the M2 Upgrade, the following modifications are proposed to mitigate the effects of additional traffic using the intersections of Windsor Road/M2 (I1), Christie/Talavera (I3) and Herring/Talavera (I4):

7.4.1.1 Talavera Rd Intersections

- University Roundabout to Christie Road eastbound - increase from 1 to 2 lanes (starting just after roundabout), plus longer left turn lane;
- Christie Road to University Roundabout westbound - increase from 1 to 2 lanes (merging just prior to roundabout). Parking to be removed in both directions.
- Christie Road to Herring Road eastbound - same layout of 2 lanes and bus only right turn lane;
- Herring Road to Christie Road westbound - increase from 2 to 3 lanes (1 lane being a right turn lane to Christie Rd).
- Herring Road to Alma Road eastbound - same layout of 2 lanes plus 1 right turn lane;
- Alma Road to Herring Road westbound - increase from 1 to 2 through lanes, plus 1 additional right turn lane to M2 (from 1 to 2 lanes).

7.4.1.2 Christie Rd bridge and Intersection

- Northbound increase from 1 to 2 lanes, to accommodate a new right turn lane to the new ramp;
- Southbound increase from 2 to 3 lanes.

7.4.1.3 Windsor Rd Intersection

- Oakland Ave to M2 southbound - existing layout of 3 lanes and left turn to M2, plus two new right turn lanes to the new west-facing ramp;
- M2 to Oakland Ave northbound - same as existing layout of 3 lanes.
- M2 to Woodlands Street southbound - same as existing layout of 3 lanes merging to 2 lanes;
- Woodlands St to M2 northbound - increase from 2 to 3 lanes for 175m to the south, plus one new left turn lane to the new west-facing ramp and one additional right turn lane to the M2 (i.e. increase from 1 to 2 lanes).

Table 47: AM Peak Comparison of Intersection Performance with and without M2 Upgrade.

	2011 BASE			2011 M2 UPGRADE			2021 BASE			2021 M2 UPGRADE		
	AM			AM			AM			AM		
	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS	LOS	Average Delay	DOS
I1 - Windsor Road - M2 ramps	B	25	1.00	B	21	0.89	E	58	>1.0	C	29	1.00
I2 - Pennant Hills Rd - M2 ramps	C	29	0.87	B	28	0.84	E	65	>1.0	C	42	0.95
I3 - Christie Rd - Talavera Rd	F	90	>1.0	C	40	0.91	F	>120	>1.0	F	>120	>1.0
I4 - Herring Rd - Talavera Rd	C	35	0.72	E	57	0.92	C	34	0.80	F	92	>1.0
I7 - Lane Cove Rd - M2 ramps	A	12	0.82	A	12	0.89	D	49	>1.0	D	48	>1.0
I5 - Herring Rd - Waterloo Rd	D	47	0.93	D	46	0.94	F	>120	>1.0	F	>120	>1.0
I6 - Khartoum Rd - Talavera Rd	C	41	0.62	C	37	0.65	C	37	0.72	C	33	0.75
I8 - Lane Cove Rd - Talavera Rd	E	58	>1.0	B	20	0.82	D	56	>1.0	A	13	0.88
I9 - Lane Cove Rd - Waterloo Rd	F	>120	>1.0	D	48	0.91	F	>120	>1.0	F	106	>1.0
I10 - Lane Cove Rd - Epping Rd	F	96	>1.0	D	49	0.78	F	>120	0.96	F	71	0.82
I11 - Windsor Rd - Cook Rd	F	>120	>1.0	F	>120	>1.0	F	>120	>1.0	F	>120	>1.0
I12 - Herring Rd - Epping Rd	E	63	1.00	E	63	1.00	F	107	>1.0	F	90	>1.0

A critical finding of the above analysis is that the M2 Upgrade will contribute to improved performance of intersections on adjoining roads that are feeder routes to M2 as well as those serving local traffic.

The proposed access to Macquarie Park will provide direct freeway access for trips travelling from the business districts of Chatswood, North Sydney, and Sydney CBD and North Sydney suburbs. This will result in less traffic accessing Macquarie Park via the busy Lane Cove Road corridor and will reduce delay and improve intersection performance at the intersections of Lane Cove Road/Waterloo Road, Lane Cove Road/Talavera Road and Lane Cove Road/Epping Road.

The proposed modifications to the intersections of Christie Road/Talavera Road will provide additional capacity to this junction and reduce delay by 50 seconds from LoS F to LoS C in 2011, while still catering for the forecast increased traffic accessing Macquarie Park through this junction. For Herring Road/Talavera Road the dealy is forecast to increase by 22 seconds from LoS C to LoS E in 2011. While this reflects a slight increase in delay at Herring Road/Talavera Road, the combined delay at Herring Road/Talavera Road and Christie Road/Talavera Road will reduce in 2011 AM peak by a total of 28 seconds, from 125 to 97 seconds. By 2021 both Christie Road/Talavera Road and Herring Road/Talavera Road are forecast to operate at LoS F, the forecast LoS F for these junction does not reflect the improvement in junction performance as a result of the M2 Upgrade works. Appendix D provides more detailed results and shows a forecast reduction in delay from 495 to 190 seconds – a reduction of over 5 minutes during the AM peak for the Christie Road/Talavera Road intersection. Furthermore, the combined delay at Herring Road/Talavera Road and Christie Road/Talavera Road will reduce in 2021 AM peak by a total of 247 seconds (over 4 minutes), from 529 to 282 seconds. However, by 2021 the forecast increase in delay for Herring Road/Talavera Road during the AM peak is 58 seconds, which results in a change in LoS from C to F. This is due to the concept design providing insufficient capacity for the left turn movement from the proposed Herring Road ramp to Talavera Road eastbound. Further analysis has shown that if an additional flared left turn is provided for the movement from Herring Road to Talavera Road then the LoS for the intersection will improve from LoS F to LoS E. An improved design solution will be investigated as part of the detailed design phase of this project to ensure that the forecast LoS of this junction is acceptable.

The proposed modifications of the M2/Windsor Road interchange will cater for the additional forecast traffic and improve the LoS from the base situation from LOS E to LOS C during the AM Peak (2021).

Table 48 - PM Peak Comparison of Intersection Performance with and without M2 Upgrade

	2011 BASE			2011 M2 UPGRADE			2021 BASE			2021 M2 UPGRADE		
	LOS	PM Average Delay	DOS	LOS	PM Average Delay	DOS	LOS	PM Average Delay	DOS	LOS	PM Average Delay	DOS
I1 - Windsor Road - M2 ramps	B	28	1.00	B	19	0.70	C	31	1.00	B	21	0.83
I2 - Pennant Hills Rd - M2 ramps	E	59	>1.0	D	49	0.99	F	>120	>1.0	F	>120	>1.0
I3 - Christie Rd - Talavera Rd	A	6	0.57	A	5	0.56	A	12	0.75	A	9	0.58
I4 - Herring Rd - Talavera Rd	B	16	0.72	B	22	0.77	C	34	0.79	C	40	0.84
I7 - Lane Cove Rd - M2 ramps	A	6	0.79	A	6	0.75	A	9	0.91	A	9	0.83
I5 - Herring Rd - Waterloo Rd	C	35	0.8	C	36	0.85	D	52	>1.0	E	63	>1.0
I6 - Khartoum Rd - Talavera Rd	A	14	0.82	B	16	0.83	E	57	0.95	F	>120	>1.0
I8 - Lane Cove Rd - Talavera Rd	F	99	>1.0	F	109	>1.0	F	>120	>1.0	F	>120	>1.0
I9 - Lane Cove Rd - Waterloo Rd	E	66	>1.0	D	53	0.93	F	110	>1.0	E	57	0.97
I10 - Lane Cove Rd - Epping Rd	F	77	>1.0	C	31	0.88	F	86	0.99	C	37	0.94
I11 - Windsor Rd - Cook Rd	D	45	1	D	43	1.00	F	95	>1.0	F	>120	>1.0
I12 - Herring Rd - Epping Rd	D	57	0.94	D	56	0.94	E	67	>1.0	E	65	1.00

Similarly to the AM peak, during the PM peak there is forecast less traffic accessing Macquarie Park via the busy Lane Cove Road corridor and will reduce delay and improve intersection performance at the intersections of Lane Cove Road/Waterloo Road and Lane Cove Road/Epping Road.

The proposed modifications to Christie Road/Talavera Road and Herring Road/Talavera Road will ensure they junctions operate with satisfactory LoS while catering for the forecast increase in traffic accessing Macqaurie Park via these new ramps during the PM Peak. The intersection of Khartoum Road / Talavera Road is forecast to operate at LoS F as a result of the M2 Upgrade by 2021 during the PM peak, however, this delay and LoS could be reduced by further modification to the signal phases, and will be investigated further as part of detailed design.

The proposed modifications of the M2/Windsor Road interchange will cater for the additional forecast traffic and improve the LOS from the do nothing situation from LOS C to LOS B during the PM Peak (2021)

7.5 Impacts on M2 from Potential F3-M2 Connection

As discussed in section 4.3.4.1 the completion of the F3M2 Link 'purple' with west facing connections will increase future demand between M7 and Pennant Hills.

As shown below in Table 49 and Table 50 the F3-M2 'purple' connection is forecast to increase demands in both directions of the M2 west of Pennant Hills in both peaks. The largest increase is during the PM peak where the section westbound between Pennant Hills Road and Windsor Road is forecast to increase by 15% and the section between Windsor Road and Old Windsor Road by 19%. In order to adequately cater for these demands then widening of the M2 motorway between Pennant Hills and Old Windsor Road would be warranted, and would need to be considered as part of any future project appraisal.

Table 49 - Forecast increase in AM Peak Demand from F3M2 'purple' Connection

EASTBOUND DIRECTION				
From	To	2021 M2 Upgrade AM Peak	2021 Upgrade with F3M2 'Purple' Connection AM Peak	% Impact
Old Windsor Road	Windsor Road	3,400	3,700	9%
Windsor Road	Pennant Hills Road	4,800	5,100	6%

WESTBOUND DIRECTION				
From	To	2021 M2 Upgrade AM Peak	2021 Upgrade with F3M2 'Purple' Connection AM Peak	% Impact
Pennant Hills Road	Windsor Road	3,650	3,850	5%
Windsor Road	Old Windsor Road	3,050	3,250	7%

Table 50 - Forecast increase in PM Peak Demand from F3M2 'purple' Connection

EASTBOUND DIRECTION				
From	To	2021 M2 Upgrade PM Peak	2021 Upgrade with F3M2 'Purple' Connection PM Peak	% Impact
Old Windsor Road	Windsor Road	3,400	3,750	10%
Windsor Road	Pennant Hills Road	4,150	4,500	8%

WESTBOUND DIRECTION				
From	To	2021 M2 Upgrade PM Peak	2021 Upgrade with F3M2 'Purple' Connection PM Peak	% Impact
Pennant Hills Road	Windsor Road	4,300	4,950	15%
Windsor Road	Old Windsor Road	3,450	4,100	19%

7.6 Impacts on Pedestrians and Pedestrian Access

The M2 Upgrade will require some changes to existing pedestrian facilities. Table 51 summarises these changes. The majority of facilities will not change.

Table 51 – Changes to Pedestrian Facilities from the M2 Upgrade Project

Map ID	Location	Facility Type	M2 Upgrade Impacts
1	Old Windsor Rd	Traffic Signals	No change
2	Sierra Pl Reserve	Shared use path under M2	No change
3	Langdon Road	Road Bridge over M2	No change
4	Gooden Reserve footbridge (Intersection of Romulus Street and Junction Road)	Pedestrian Overpass	No change
5	Intersection of Ixion Street and Junction Road	Pedestrian Overpass	No change
6	Langdon Road	Road Bridge over M2	No change
7	Cropley Drive	Road Bridge over M2	No change
8	Watkins Road	Road Bridge over M2	No change
9	Windsor Road	Road Bridge over M2	Modifications to intersection would add crossings on the western side.
10	Barclay Road	Road Bridge over M2 (and pedestrian ramp to M2 bus stop)	No change
11	Yale Close	Pedestrian Underpass	No change
12	Oakes Road	Road Underpass (and pedestrian ramp to M2 bus stop)	No change
13	Pennant Hills Road	Road Bridge over M2	No change
14	Devlins Creek	Paths under M2 bridge	No change
15	Kirkham St / Murray Farm Road	Road Bridge	No change
16	Kent Street	Pedestrian Overpass	No change
17	Beecroft Road	Road Bridge over M2	No change
18	Constance Close	Road over M2 Road Tunnel	No change
19	Norfolk Road	Road over M2 Road Tunnel	No change
20	Sutherland Road	Pedestrian Underpass (and Emergency Vehicle use)	No change
21	Vimiera Road	Pedestrian Underpass	No change
22	Busaco Road	Road under M2	No change
23	Culloden Road	Road Bridge over M2	No change
24	Christie Road	Road Bridge over M2	Footpath may move to west side of bridge with signalised crossing of the ramp required. Intersection with Talavera would be modified with longer crossing on north link, 5 lanes not 3, with significant increase in traffic northbound on Christie Road bridge. Timing on signals will be modified.

Map ID	Location	Facility Type	M2 Upgrade Impacts
25	Herring Road/Talavera Road	At Grade	Crossing on north link of intersection would now have two-way traffic due to new off ramp. Timing on signals will be modified.
26	Khartoum Road	Road under M2	No change
27	Lane Cove Road	Road Bridge over M2	No change
28	Wicks Road	Road under M2	No change
29	Delhi Road	Road Bridge over M2	No change
30	Epping Road	Road Bridge over M2	No change

7.7 Impacts on Road Safety

Congestion effects related to speed are the most significant factor that contributes to accidents on the M2. The M2 Upgrade is designed to alleviate congestion with a consequent reduction expected in the accident rates.

The benefits in terms of accident reduction may not be limited to the M2 Motorway, as the reduction in congestion on parallel routes may also result in safer driving conditions on the arterial road network.

Table 52 indicates how the M2 Upgrade may improve accidents in the current hotspots.

Table 52 – Road Safety Improvements from the M2 Upgrade Project

Hot Spot ID	Location	M2 Upgrade Impacts
1	East of Windsor Rd Overpass	-Eastbound widening between the Windsor Rd on-ramp and Pennant Hills Rd off ramp will remove the need for traffic entering from Windsor Road to merge with heavy mainline volumes from Westlink M7 and Abbott Road. -This interchange is expected to operate more safely and smoothly as a result of traffic entering from Windsor Road not having to merge with heavy volumes on the mainline. -Alleviation of queues on Windsor Road from the eastbound Windsor Road merge may reduce the numbers of nose to tail accidents.
2	Pennant Hills Rd Interchange	-Eastbound widening east of Pennant Hills Road will remove the need for traffic entering from Pennant Hills Road to merge with heavy mainline volumes. -This interchange is expected to operate more safely and smoothly as a result of traffic entering from Pennant Hills Road not having to merge with heavy volumes on the mainline.
3	Norfolk Tunnel and approaches	-Sun glare issues will remain, however the M2 Upgrade will result in a significant reduction in traffic densities within and on approach to the tunnel during peak periods. This coincides with the times that sun glare is at its worst and may help to reduce accidents in this section. -Tunnel widening will result in wider lanes in the westbound directions and reinstatement of the breakdown lane. This will allow vehicles to get out of the mainline traffic flow in the event of an accident or breakdown and could help reduce the risk of secondary accidents. -Replacement of the existing tunnel lighting system with a new system and installation of a tunnel wall lining will combine to increase the brightness in the tunnel. This should allow drivers to better adapt to tunnel lighting conditions upon entering and is expected to result in a reduction in accidents. -Enhancements to communications and surveillance systems and egress arrangements to improve tunnel safety in the event of an emergency.
4	Main Toll Plaza	-The “Express Lanes” project resulted in cash lanes being moved to the left hand side of the toll plaza. This has already improved road safety at this location. -The M2 Upgrade should further improve the safety of this location with adjustments to the lane configurations at this location designed to accommodate 100 kph design speed.
5	Mainline carriageway	The emergency bays within the widened sections will be reconfigured to allow easier entry and exit.

7.8 Impacts on Cyclists

The Upgrade project restores the westbound breakdown lane between Lane Cove Road and Beecroft Road, which was reconfigured as a temporary third westbound lane in 2007 and necessitated the exclusion of cyclists from this section. In order to allow cyclists to rejoin the motorway from the current detour route, a temporary access point was provided at the Beecroft Road westbound exit. However, cyclists will be allowed to return to use the breakdown lane instead of the off motorway detour route that was provided; providing a shorter and more direct route for cyclists travelling westbound through this section. Furthermore, the proposed west facing Windsor Road and east facing Herring/Christie Road ramps will provide new access points for cyclists. In particular, the new east facing ramps at Herring/Christie Road will provide improved accessibility between Macquarie University and North Sydney and Sydney CBD.

7.9 Commercial Vehicle Movements

The completion of Westlink M7, linked to the M2, has created a key route for freight vehicle travel between the Hume Highway to the south and the F3 to the North. This has generated significant growth in warehousing and distribution facilities along the M7 corridor.

Heavy vehicle traffic has grown significantly along M2 west of the Pennant Hills Road ramps. This increase in traffic would primarily be from diversion off the toll-free Cumberland Highway through to

Pennant Hills Road and the F3. The increase in traffic that pays both M7 and Hills M2 Pennant Hills toll demonstrates the willingness for trucks to pay higher tolls provided travel time savings are available.

The completion of the M2 Upgrade will significantly improve travel conditions for M2 commercial vehicles and will continue to provide high levels of service for trucks. The M2 Upgrade will reduce travel times compared to the "No M2 Upgrade" scenario thereby reducing truck volumes and consequent truck noise and emission impacts on the local road network.

7.10 Emergency Service Vehicles

The reinstatement of a shoulder westbound between Lane Cove Road and Beecroft road will provide better access for emergency service vehicles in response to an accident or incident along the motorway within the reconfigured section.

7.11 Public Transport

The main benefits to bus services are:

- Reduced traffic congestion pinch points on the M2 as results of increased capacity; and
- changes to bus access arrangements.

7.11.1 Increased Road Capacity

The additional capacity on the M2 will facilitate continued growth in bus use by improving bus travel times and service reliability. Improvements for buses will result from reducing delays at and on approach to existing pinch points where buses are not protected by bus lanes. Key improvement areas for buses are:

- The provision of a T2 lane eastbound between Terrys Creek and Lane Cove Road will provide an additional eastbound road capacity and also provide buses with priority through a section currently congested during the AM Peak. This will assist eastbound services.
- Widening of the M2 Motorway from Beecroft Road to Lane Cove Road with an additional lane in each direction in this section of the M2 Motorway where buses currently use the general traffic lanes, is expected to benefit both buses and cars. An additional traffic lane in each direction will reduce traffic congestion for motorists and buses through this section providing improved bus travel times and reliability eastbound and westbound. The current M2 Motorway configuration includes three lanes in the westbound direction, but to achieve this, narrower lanes are required and this necessitates reduced speed limits. In addition, the configuration drops from three to two lanes beyond Beecroft Rd, resulting in queues forming back and delaying westbound buses during the PM peak. The M2 Upgrade will allow the westbound speed limit to be restored to 100km/h and resolve the delays from queuing caused by the lane drop.
- An additional eastbound traffic lane will be provided on the M2 Motorway between Windsor Road and Pennant Hills Road. In this section buses use the median bus lanes and are protected from traffic congestion. However the additional eastbound lane is expected to reduce upstream traffic queuing west of Windsor Road which currently delays bus services.
- Christie Road Changes – as part of the new access ramps, additional lanes are proposed on the Christie Road Bridge and Talavera Road. These changes will result in a higher level of service at the Talavera Road / Christie Road intersection than would occur without the proposed M2 upgrade. The higher levels of service will lead to a reduction in travel times for bus services exiting the M2 Motorway to access the Macquarie Centre.

The increased road capacity will provide bus travel time savings of up to 5 minutes as well as improving service reliability. A summary of the travel times during the AM and PM peaks is illustrated in Table 53.

Table 53 - Forecast Improvement to Bus Travel Times along Hills M2 (1)

		2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
M2	AM-IB	16	12	-4	18	13	-5
M2	AM-OB	12	12	0	12	12	0
Alternative Route	AM	31	29	-2	32	32	0
M2	PM-IB	12	12	0	13	12	-1
M2	PM-OB	25	20	-5	26	22	-4
Alternative Route	PM	51	52	1	55	53	-2

Notes: (1) Modelled travel time assumes no stopping

(2) Alternate Route (Figure 26) - Old Windsor, Pennant Hills Rd, Carlingford Rd, Epping Rd

Reduced traffic congestion on the M2 may also attract motorists who use the alternate surrounding road network, for example, motorists who are avoiding congestion on the M2. Any reduction in traffic volumes on the surrounding road network (e.g. Epping Road) will also improve bus operations in those locations. See Figure 6 for bus routes that would benefit.

7.11.2 Effects of Access Change

The removal of bus only ramps from the M2 to and from Beecroft Road will require bus services, Routes 611 and 740, to be rerouted. This will result in reduced access to Epping Railway Station.

Bus only ramps were planned with an expectation of strong demand for commuters to transfer from bus to rail at Epping Railway Station. Bus services were expected to feed the railway. Historic patronage data show that this transfer is small compared with strong growth for direct city services.

Routes 611 and 740 also connect Epping Railway Station to Macquarie University and Macquarie Centre. With the opening of the new Epping to Chatswood Rail Link this movement is less important as these trips can now be made by rail. Other bus services would also continue to make this movement from Epping Railway through the University and Shopping Centre.

Routes 611 and 740 can be rerouted to exit the M2 via Christie Road off-ramp and provide more direct and faster access to the university and Macquarie Shopping Centre. Hillsbus are also considering extending Route 611 into Macquarie Business Park. The new route and extended service would be more attractive for workers in the area than the existing arrangement.

The resulting bus services using the Christie Road off-ramp by time of day are illustrated in Table 54.

Weekday bus trip numbers would increase from the existing 57 to 80 per workday. These figures are based on services currently exiting via the Beecroft Road bus ramp switching to the Christie Road exit.

Table 54 - Christie Road Bus Services after the M2 Upgrade

	4AM-6AM	6AM-7AM	7AM-8AM	8AM-9AM	9AM-10AM	10AM-11 AM	11AM-12 PM	12PM-6PM	6PM - Midnight
Total		**4**	**8**	**9**	**8**	**5**	**5**	**34**	**7**

The additional services using the Christie Road ramp will benefit from proposed widening in this section with an additional lane proposed northbound and southbound on the over-bridge.

The removal of the Beecroft Road bus ramp would only require a change in trip schedule for those that use the 740 and 611 bus services to access Epping either as their destination or to connect with other services; particularly those on the Northern railway line.

Those continuing to Macquarie Park on these services would benefit from shorter travel times as a result of using the Christie Road exit from the M2.

Those departing at Epping do have other options available to them. Table 55 presents several example trips that could currently use the 611 or 740 services and depart at Epping or connect to another public transport services to reach their destination before 8.30am.

Some of the example trips indicate longer travel times and /or more transfers for the alternative, while others indicate that the alternative would require less travel time. One of the example trips with a shorter travel time is between Stanhope Gardens and Rhodes. Although one additional train is required, the travel time for the option that utilises the North-West T-Way is 17 minutes faster than using the 740 bus to connect to the Northern line at Epping.

The North-West T-Way is a bus rapid transit line that includes a Parramatta to Rouse Hill section (opened in 2006) and a Blacktown to Parklea section (opened in 2007). The example above indicates that the North-West T-Way has added some level of redundancy to the Beecroft Road bus ramp. Residents in the North-West whom once relied on M2 bus services to destinations along the Northern line can now use the T-Way to connect to the CityRail network at stations on the Western line including Blacktown, Parramatta and Westmead.

Table 55 - Alternatives Route Comparison for Beecroft Road Bus Ramp Users

Example Trip	Route Details	
	Beecroft Bus Ramp	Alternative
Castle Hill (Showground Rd) to Epping Station	2 buses (610x and 611) **Total Walking distance:** ~1.4km **Travel time (door to door):** 1 hour 4 minutes	2 buses (T70 and 633) and 1 train (Pennant Hills to Epping) **Total Walking distance**: ~200m walk **Travel time (door to door):** 59 minutes
North Rocks (Barclay Rd) to Pennant Hills Station	1 bus (611) and 1 train (Epping to Pennant Hills) **Total Walking distance:** ~300m **Travel time (door to door):** 36 minutes	2 buses (610x and 553) and 1 train (Beecroft to Pennant Hills) **Total Walking distance**: ~500m walk **Travel time (door to door):** 44 minutes
Stanhope Gardens (Stanhope Pkwy) to Rhodes Station	1 bus (740) 1 train (Epping to Rhodes) **Total Walking distance:** 600m walk **Travel time (door to door)**: 1hr 27 mins	1 bus (T74 - T-Way) and 2 trains (Blacktown to Strathfield, Strathfield to Rhodes) **Total Walking distance:** 500m walk **Travel time (door to door)**: 1hr 10 mins

Example Trip	Route Details	
	Beecroft Bus Ramp	Alternative
Baulkham Hills (Windsor Rd) to Eastwood Station	2 buses (610x and 611) 1 train **Total Walking distance:** 1200m walk **Travel time (door to door)**: 53 mins	1 bus (630) and 1 train (Epping to Eastwood) **Total Walking distance:** 900m walk **Travel time (door to door)**: 1hr 4 mins

7.12 Summary of Proposed M2 Upgrade Outcomes

The impact of the M2 Upgrade was analysed for the 2011 and 2021 forecast years. The outcomes predicted for the upgrade include:

- Improved levels of service – despite increased traffic volumes - on the M2 through the introduction of additional lanes (including new T2 Lane/Bus Lane eastbound between Terry's Creek and Lane Cove Road) and improved accessibility at Windsor Road and Christie/Herring Roads.
- Reduced congestion and intersection delay on the surrounding road network through diversion of more regional trips to the M2 and specific improvements at isolated intersections.
- Improved safety through reduction of congestion on both the M2 and surrounding network roads.
- Benefits to bus operators and passengers through improvement of access and travel times to Macquarie Park in lieu of the underutilised Beecroft Road ramps.
- Additional pedestrian accessibility via the additional crossing at the proposed Windsor Road ramps.
- An improvement in network traffic efficiency resulting in overall vehicle operating costs associated with reduced travel times.

In summary, the proposed M2 Upgrade provides additional capacity where today's flows demonstrate it is needed and is forecast to generate significant social, environmental and economic benefits. The upgrade of capacity and accessibility along its length would 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.

The Upgrade would accommodate the expected travel growth in the corridor over the next 10 years and result in corridor levels of service that are better than the "No M2 Upgrade" scenario .

8.0 Construction Impacts

8.1 Construction Site and Access

8.1.1 Work Sites

The M2 Upgrade work site extends around 14.5 km along the motorway between the Watkins Road overbridge west of Windsor Road and Lane Cove Road. The project has been divided into a series of Work Zones that are split into Work Sites for the purpose of planning and staging. The proposed work zones with work sites are generally as per Table 56;

Table 56 Proposed Work Zones with Work Sites

Work Zone	Work Site
Precinct 1 – Abbott Road to Windsor Road	New Windsor Road Ramps including Windsor Road widening
Precinct 2 – Windsor Road to Pennant Hills Road	Windsor Road to Barclay Road Barclay Road to Pennant Hills Road
Precinct 3– Pennant Hills Road to Beecroft Road	Pennant Hills Road East Bound Off Ramp Pennant Hills Road to Beecroft Road
Precinct 4 – Norfolk Tunnel (including approaches) to Terrys Creek	Norfolk Tunnel Portal Areas Norfolk Tunnel Norfolk Tunnel to Terry's Creek
Precinct 5 – Terrys Creek to Lane Cove Tunnel	Terry's Creek to Busaco Rd Western approach to the Main Toll Plaza Main Toll Plaza Eastern approach to the Main Toll Plaza Herring Road to Lane Cove Road Talavera Road (off M2)

These work sites would be serviced by a series of main compounds and laydown areas (ancillary sites) which are shown on the construction footprint drawings provided in Section 7.2.2 of the EA Report. Table 57 lists the main compounds that are expected to be set up along with the access points for each. The final list of sites would be determined in mid 2010.

Table 57 Main Compounds with Proposed Access

Precinct	Compound Name	Proposed Access
1	Windsor Road North	Entry / Exit off Torrs Street, straight onto Windsor Road
1	Windsor Road South	Entry / Exit off Windsor Road
2	Darling Mills Creek	Entry / Exit (Bridge Construction Traffic Only) off existing Windsor Road Ramps (in same direction as traffic flow)
2	Barclay Road	Entry / Exit off Perry Street, opposite Golf Club
2	Yale Close (Royal Institute for Deaf & Blind – Private Land)	Entry / Exit off Baden Powell Place & Barclay Road
3	Devlins Creek	Entry / Exit (Bridge Construction Traffic Only) off Allerton Road
4	Barombah Road	Entry / Exit off Barombah Road
4	Beecroft Road Compound (Tunnel Compound)	Left in / Left out off E/B carriageway of M2, through existing Noise Wall, alternative access off Sutherland Road
4	Terrys Creek / Somerset Street	Entry / Exit off (Bridge Construction Traffic Only) off Somerset Street
5	Vimiera Road	Left in / Left out off W/B carriageway of M2, with suitable ramps constructed, alternative access off Vimiera Road

Precinct	Compound Name	Proposed Access
5	Busaco Road	Entry / Exit off (Bridge Construction Traffic Only) Talavera Road
5	Toll Plaza	Entry 50m from EB Toll Plaza. Exit onto EB carriageway
5	Christie Rd Compound	Entry / Exit off Talavera Road
5	Macquarie Park Site	Left in / Left out (only) onto E/B carriageway of M2
5	TIDC Compound	Left in / left out off Delhi Road W/B on-Ramp, as well as Entry / Exit off Wicks Road
5	North Ryde Station Compound	Access from traffic lights on Delhi Road

8.1.2 Working Hours and Arrangements

Standard working hours for the sites would be between 7.00 am and 6.00 pm Monday to Friday and 8.00 am and 1.00 pm on Saturday. For sites accessed from the motorway, the start and finish time may be scheduled depending on the location of the site relative to the peak traffic flows but an earlier start time and later finish time could be sought. This is to minimise any impact of work vehicles entering sites during peak periods e.g. a delayed start for eastbound areas to avoid the morning peak.

Traffic Management Plans (TMPs) would be developed by the contractor to allow safe work sites to be created along the motorway and local roads i.e. non-motorway roads. These work sites would be protected by temporary concrete barriers while maintaining the lane capacity on the road by changes to the width and realignment of the lanes. The TMPs would consider the convenience and safety of all road users, including public transport, pedestrians and cyclists.

In some cases, works may have to be carried out at night or on weekends if the impacts on traffic flow by daytime lane occupancies are considered unacceptable by the M2 Motorway or RTA. Restrictions on lane occupancies on the motorway are governed by the volume of traffic. Night works on the motorway would commence after the evening peak once the traffic volumes are confirmed by the M2 Motorway Control Room (MCR) using real time data from the vehicle detection loops that are located at 500 m intervals along the motorway.

Night works on the motorway are expected to include:

- works within the median;
- the installation and removal of temporary concrete barriers;
- changing line markings;
- bridge and carriageway works; and
- cross drainage works.

The access points in and out of the work sites would be designed to minimise the potential for disruption to the general traffic caused by turning movements by construction vehicles.

8.1.2.1 Lane Capacity and Occupancies

Functionality of the M2 Motorway would be maintained throughout the construction phase of the project. To ensure that motorway traffic flow is sustained where practicable, the following objectives have been developed as a benchmark:

- Two lanes would be maintained for morning peak flow in the eastbound direction.
- Three lanes would be maintained for afternoon peak flow in the westbound direction (between Lane Cove Road and west of Beecroft Road).

- One dedicated bus lane would be maintained for bus use by tidal flow in the peak direction (between Windsor Road and Pennant Hills Road, and between Pennant Hills Road and Kent Street footbridge. The other bus lane would be taken for use as a general traffic lane during traffic management operations.
- Alternative cycle provision adopted on local roads during construction.

An initial schedule of motorway and local road lane occupancies has been developed and is generally as per Table 58. These hours of lane occupancies would vary depending on the direction relative to peak flow, volume and at weekends. The hours would be determined by M2 MCR or RTA Transport Management Centre (TMC) and are based on historical and/or live data and also take into consideration special events, holiday periods and late night shopping.

Table 58 Motorway and Local Lane Occupancies

Motorway Lane Occupancies	Proposed volume restriction	Lane Occupancy period (indicative)
1 of 2	1400 vph	Night time Saturday afternoon – Sunday
2 of 3	1400 vph	Night time
1 of 3	2800 vph	Off peak day time
Local Road Lane Occupancies		**Lane Occupancy period (indicative)**
1 of 2 1 of 3		Off peak day time Night time Saturday afternoon – Sunday
2 of 3		Night time

8.1.2.2 Norfolk Tunnel

The widening of the Norfolk tunnel is critical to the completion of the project. This would require a continuous implementation of night works and 24 hour operations during the two year construction period. TMPs will be developed to allow closure of one tunnel and maintain traffic flows by running contraflow in the other tunnel at various times. This is in line with existing maintenance practice by the M2 Motorway.

During normal weekday operations the tunnel will maintain two lanes in each direction in the morning and daytime periods. Due to the current Interim Widening arrangement for the westbound carriageway from Lane Cove Road to Beecroft Road a third lane will be made available for the evening peak period.

To achieve this, the expected sequence of lane utilisation would be in accordance with Table 4.

Initially works would be concentrated on the eastbound tunnel then the westbound tunnel would be widened to provide three 3.5 metre wide lanes plus a breakdown lane in both directions.

Table 59 Norfolk Tunnel Lane Utilisation

Stage	Works	Duration	Proposed Lane Utilisation Eastbound	Proposed Lane Utilisation Westbound
1	**Eastbound Tunnel** Surveys, Installation of Traffic Management, Adjustment of portal transition areas Service relocation Installing rockbolts in tunnel Installation of new service trench Installation of barrier within tunnel and at each portal. .	6 Months	**Daytime** 2 lanes **Night time** Closure	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** Contraflow
2	**Eastbound Tunnel** Widening of the tunnel using roadheader Drainage and pavement construction. **Westbound Tunnel** Service relocation Installing rockbolts in tunnel Installation of new service trench	4 Months	**Daytime** 2 lanes **Night time** Contraflow	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** Closure
3	**Eastbound Tunnel** Drainage and pavement construction. Services reinstallation	3 Months	**Daytime** 2 lanes **Night time** Closure	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** Contraflow
4	**Westbound Tunnel** Service relocation Installing rockbolts in tunnel Installation of new service trench Installation of barrier within tunnel and at each portal.	5 Months	**Daytime** 2 lanes **Night time** Contraflow	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** Closure
5	**Westbound Tunnel** Widening of the tunnel using roadheader Drainage and pavement construction	4 Months	**Daytime** 2 lanes **Night time** 2 lanes	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** 2 lanes
6	**Westbound Tunnel** Drainage and pavement construction. Services reinstallation	2 Months	**Daytime** 2 lanes **Night time** Contraflow	**Daytime** 2 lanes with 3 lanes in pm peak **Night time** Closure

8.1.2.3 Other Arrangements

Long term contraflow arrangements would be considered as part of the traffic management schemes where appropriate and where it would benefit the road users and construction planning. Contraflow traffic management allows a carriageway to be fully closed by running traffic in both directions on the other carriageway. This, in conjunction with tidal flow or other innovations, would be reviewed by the Traffic and Transport Liaison Group (TTLG) proposed in Section 8.3.1.

8.1.3 Construction Site Access

Worksites would be accessed via both non-motorway roads and the motorway. Where possible, depending on safety and traffic constraints a motorway access point would be provided to reduce the number of site vehicles using local roads. Route selection will consider the characteristics of the road, nature of traffic using the road, restrictions on use, bus routes, schools etc. Access to worksites for delivery trucks and staff along the project is generally summarised by the following table;

Table 60 Construction Site Vehicle Access

Worksite	Vehicle Access
Motorway sites	Left in and left out directly from the motorway with some local road access if necessary
Compounds	As per Table 57
Laydown areas	Left in and left out directly from the motorway with some local road access if necessary
Local road work sites (Predominantly bridge sites)	In and out via local roads
Truck Call-up areas	Left in and left out, directly from the motorway

Table 61 lists the local roads that would be used to provide direct access to work sites and ancillary sites. Estimates of the number of vehicle movements related to each site are provided in Table 61.

The local roads are classified into groups which have general traffic characteristics as follows:

1. Major Arterial: main function is to form the principle routes for the movement of goods and people.Major arterials are divided roads and contain occasional at-grade intersections resulting in interrupted flow.
2. Arterial: main function is to form the principle routes for the movement of goods and people. Arterial roads are not divided roads and contain occasional at-grade intersections resulting in interrupted flow.
3. Sub-Arterial: arterial roads which supplement the major arterial and arterial network in providing through traffic movement to an individually determined limit that is sensitive to roadway characteristics and abutting land uses.
4. Collector: important local roads whose function is to distribute traffic between the arterial roads and the local road system, and to provide access to abutting property
5. Residential Streets: Those roads or streets not having significant through traffic function, whose function is to provide access to abutting property.

The likely level of traffic on these roads will vary along the M2 corridor and time of day.

Table 61 Local Road Access to Work and Ancillary Sites

Work Zone	Non motorway roads used for access	Road Characteristics
Precinct 1 – Abbott Road to Windsor Road	Junction Road	Residential
	Torrs Street	Residential
	Craig Avenue	Residential
	Watkins Road	Residential
	Cropley Drive	Collector
	Windsor Road	Major Arterial
Precinct 2 – Windsor Road to Pennant Hills Road	Windsor Road	Major Arterial
	Cook Street	Collector
	Petrina Crescent	Residential
	Russell Street	Residential
	Dremeday Street	Residential
	Renown Road	Sub-Arterial
	Perry Street	Residential
	Barclay Road	Sub-Arterial
	North Rocks Road	Sub-Arterial

Work Zone	Non motorway roads used for access	Road Characteristics
	Baden Powell Place	Residential
	Carlton Road	Residential
	Morton Avenue	Residential
	Carmen Drive	Residential
	Oakes Road	Collector
	Coral Tree Drive	Residential
	Pennant Hills Road	Major Arterial
Precinct 3– Pennant Hills Road to Beecroft Road	Pennant Hills Road	Major Arterial
	Lamorna Avenue	Residential
	Orchard Road	Residential
	Allerton Road	Residential
	Kirkham Street	Collector
	Murray Farm Road	Collector
	Meadow Close	Residential
	Midson Road	Residential
	Ray Road	Collector
	Kent Street	Residential
	Kandy Avenue	Residential
	Barombah Road	Residential
	Beecroft Road	Major Arterial
	Cheltenham Road	Collector
	Sutherland Rd	Residential
Precinct 4 – Norfolk Tunnel (including approaches) to Terrys Creek	Somerset Street	Residential
	Norfolk Road	Collector
	Grayson Road	Residential
	Devon Street	Residential
	Pembroke Street	Collector
Precinct 5 – Terrys Creek to Lane Cove Tunnel	Somerset Street	Residential
	Crimea Road	Residential
	Vimiera Road	Collector /Residential
	Busaco Rd	Residential
	Talavera Road	Collector
	Culloden Road	Collector
	Christie Road	Residential
	Alma Road	Commercial
	Khartoum Road	Residential
	Lane Cove Road	Major Arterial
	Wicks Road	Commercial
	Epping Rd	Major Arterial
	Delhi Rd	Major Arterial

8.1.4 Construction Workforce Parking

It is anticipated that the total on-site staff and workforce would consist of up to 500 people over the duration of the construction period. Construction staff would have limited parking available at the compounds and worksites. There is also the possibility of providing temporary parking areas in locations where space and suitable access is available (a large area of land immediately south of the North Ryde station has been identified as a potential employee car park, from where Works buses could ferry staff & field operatives). Light Vehicle Works buses (15 – 20 seaters) would be used to ferry the workforce from the Main Compound area to the various work sites. The workforce would be advised on suitable parking arrangements as part of the compulsory project induction.

It is expected that a portion of the workforce would use public transport to commute to and from the work sites. Public transport and a reduction in general site vehicle movements would be promoted via the use of shuttle services from designated points collecting personnel and transporting them to site. This would minimise the number of staff using local roads for parking. The shuttle vehicles would operate at the beginning and end of each shift to get the workforce to and from the worksites. An on-demand service would then operate during the shift. The collection and delivery points for the shuttle service would vary as activities and worksites change during the length and time of the project.

Bus services along the M2 are detailed in Section 2.3.1. Bus stops that may be used by staff and workforce to access work compounds are located on the M2 at Cropley Drive (Baulkham Hills) and Barclay Road (North Rocks). The M2 bus stops at Gooden Reserve (Model Farms) and Oakes Road (Carlingford North) are likely to be too far from compounds or worksites to be used. Off the motorway there are bus stops on Windsor Road, Beecroft Road, Macquarie Park and Lane Cove Road near to the motorway compounds and worksites.

Section 2.3.2 provides the train services in the vicinity of the M2 motorway. The recently opened stations at North Ryde (Delhi Road), Macquarie Park (Lane Cove Road) and Macquarie University (Herring Road) will be suitable for staff and workforce and would be within 15 minute walking distance of compounds and worksites.

8.2 Proposed Construction Activity

8.2.1 Vehicle Movements

The M2 upgrade project involves cut and fill operations along the full length of the works. The majority of the excavation work is between the Norfolk tunnel and Windsor Road and is generally hard sandstone with low productivity rates. The excavated sandstone or other material would be transported to one of the main compound areas at the eastern end of the motorway at the TIDC or Macquarie Park compounds for stockpiling and processing (crushing etc.). The processed material would be used as select sub grade and fill for retaining walls, however it is anticipated that approximately 70,000 m^3 of surplus spoil is to be transported off site. This would require 160 – 200 truck movements on an average work day along the full length of the project during the early and mid phases when the majority of the bulk earthwork is carried out. The specific destination for these movements has not yet been determined and may potentially be used on other projects.

Possible locations for this excess material are Moorebank, Eastern Creek or the Port Botany Expansion. Transport routes would be along motorways or arterial roads where appropriate and would be detailed in the Spoil Management Plan.

Other activities such as paving, concrete placing, installation of traffic barriers and drainage would generate truck movements to and from the work sites. Table 62 and Table 63 below provide the total number of truck movements per worksite along with an estimate of the average daily movements. A vehicle movement is considered to be the trip to or from the site. The figures are based on an average working week as described in 8.1.2.

A combination of truck types e.g. tipper truck, semi trailer, truck and dog will be used on the project depending on access and productivity at each worksite or compound. For the purpose of determining vehicle movements in Table 56 and Table 57 Light Vehicles are classified as 3.5 tonnes or less and may be commercial or passenger use. All others are classified as Heavy Vehicles.

Table 62 Worksite Vehicle Movements

Description	Average Daily Heavy Vehicle Movements	Average Daily Light Vehicle Movements
EB Off Ramp Windsor Road	30	200
WB On Ramp Windsor Road	25	170
Windsor Road to Barclay Road EB	40	300
Barclay Road to Pennant Hills Road WB	50	360
Pennant Hills Road EB Off Ramp	10	80
Pennant Hills Road to Beecroft Road EB & WB	35	240
Beecroft Road to Eastern Portal	20	150
Tunnel	20	130
Eastern Portal to Terry's Creek	20	140
Terry's Creek to Busaco Road	40	270
Busaco Road to Toll Plaza	20	150
Toll Plaza	10	50
Toll Plaza to Herring Road	25	180
Herring Road to Lane Cove Road	60	420

Table 63 Compound Vehicle Movements

Compound Name	Average Daily Heavy Vehicle Movements	Average Daily Light Vehicle Movements
Windsor Road North	20	90
Windsor Road South	20	90
Darling Mills Creek (on/off M2)	25	40
Barclay Road (Not intended to be in constant use)	25	30
Yale Close	25	40
Devlins Creek (Allerton Road) (Not intended to be in constant use)	25	40
Barombah Road	30	40
Tunnel Compound	25	50
Terrys Creek (Somerset Street)	30	40
Vimiera Road (Not intended to be in constant use)	40	60
Busaco Road (Not intended to be in constant use)	25	70
Toll Plaza (on/off M2)	25	40
Christie Road (Talavera Road)	20	50
Macquarie Park Site (on/off M2)	65	125
TIDC Compound	190	800
North Ryde Station Compound	30	580

The main compounds located at the eastern end of the corridor will have the largest volume of vehicle movements associated with them. These are located in the commercial and industrial areas of North Ryde with immediate access to the M2 and major arterial roads. Due to the early start times associated with construction work there would be negligible impacts on the surrounding network in the peak periods

8.2.2 Night Works

Night works vehicle movements on the motorway would include:

- general light vehicles including staff and workforce;
- floats;
- tipper trucks;
- truck and dog;
- flatbed crane trucks;
- concrete trucks; and
- asphalting.

Around 180 truck and light vehicle movements per night, each in up to three locations across the project would be expected. The locations of the worksites will vary from week to week. These truck movements are included in the figures for total movements in Table 61 above. Due to the reduced volume of traffic at night on the motorway and the road network there is no impact expected on the operation of these roads.

Construction vehicle movements for the tunnel works include those listed above along with specialist equipment such as elevated work platforms, road header for rock excavation, drill rigs and shotcreting plant. During the excavation phase there would be up to:

- two spoil truck movements per hour;
- four shotcrete deliveries per day;.
- daily delivery of rock bolts;
- daily delivery of reinforcing fibres; and
- approximately five miscellaneous other deliveries per day.

These are included in the figures for total movements in Table 63 above. Due to the low volume of construction traffic for tunnel works on the motorway and local network there is no impact expected on the operation of these roads.

The use of night works is dictated by the restrictions on lane occupancies as discussed in Section 8.1.2. These occupancies will be operated through Traffic Management Plans approved by the RTA with suitable detours provided to minimise impacts on the local road network. Appropriate communication strategies would be implemented to ensure that the road users and adjacent community are informed prior to any works that may affect local traffic conditions.

A more detailed construction methodology would be prepared in accordance with the detailed design prior to commencement of construction works and as part of the Construction Environmental Management Plan (CEMP).

8.2.3 Special Loads

Special load deliveries for the project are anticipated for items such as:

- large bridge beams;
- paving equipment;
- and plant equipment for the tunnelling works.

These movements would in general occur at night under escort to locations on the motorway. Oversized loads would be restricted by the routes and access hours allowed by RTA. Deliveries to sites on the motorway or non-motorway roads would have minimal impact to traffic due to the low volumes experienced during the permissible hours. Some deliveries on local roads would require stop & go procedures to facilitate access by oversized loads resulting in short term closures to assist movement and unloading.

There would also be some temporary local road closures during widening works at Christie Road and Khartoum Road bridges e.g. beam installation etc. and lengthening of the Kirkham Street/Murray Farm

Road and Barclay Road bridges. These closures will be operated through TMPs approved by the RTA and appropriate Councils with suitable detours provided to minimise impacts on the local road network. In some cases single-way traffic light controlled access would be required to ensure consistent safety of the workforce operating in close proximity to traffic.

8.3 Impact on Traffic Flows

8.3.1 M2 Motorway

The construction of this project would impact on the existing traffic flows along the M2 Motorway, arterial roads and various local roads in close proximity to the motorway corridor. Those non-motorway roads that would experience some additional traffic during the construction period are the same routes that are expected to experience longer term benefits from additional capacity after the M2 Upgrade. These are identified in Tables 52 to 55.

Control of traffic on the M2 motorway is carried out by the M2 MCR working closely with the RTA TMC. Traffic is monitored on a 24 hour basis using CCTV and real time flow data from vehicle detection loops every 500 m along the carriageways. The M2 MCR has responsibility for providing permission to implement Traffic Control Plans (TCP). On non-motorway roads this authority remains with RTA TMC.

For the construction phase of the project a series of Traffic Management Plans (TMPs) will be developed and approved by M2 MCR and RTA TMC. The TMPs provide the overall plan and staging for managing traffic through and around each work site. These will be based on the new AS 1742.3-2009 Traffic Control for Works on roads and reviewed by the Traffic and Transport Liaison Group (TTLG) or a dedicated working group. The TTLG would include relevant stakeholders such as NSW Police Force, State Transit Authority, affected Bus Operators, NSW Transport and Infrastructure, RTA, NSW Taxi Council and Local Councils.

8.3.1.1 Speed Limits

The motorway would in general have a reduced daytime speed of 80 km/hr with some areas east of the tunnel reduced to 60 km/hr for periods of time during construction operations, the latter due to the alignment. The restrictions are required to accommodate works in the median to remove the existing barrier, upgrade drainage, reinstate the pavement and barrier and safety critical activities. A minimum of two lanes are maintained during the weekday daytime periods with three lanes westbound for the PM peak from Lane Cove Road to Beecroft Road.

The 70 km/hr limit westbound from Terrys Creek to Beecroft Road would remain initially but would eventually reduce as the construction staging progresses. Due to the restricted space available at the tunnel the speed would drop to 60 km/hr for longer periods to meet the lane and shoulder width standards in AS 1742.3-2009. The reduction in speed limits represents up to 2.5 minutes additional travel time in non congested periods over the 14.5 km length of widening works.

Enforcement of speed limits by Police would continue as per normal operation of the M2 motorway with potential for increased surveillance after major traffic switches when users have settled into the new configurations. Other active measures such as radar speed signage (actual vehicle speeds displayed) would be considered as part of the development of TMPs.

8.3.1.2 Motorway Lane Capacity and Occupancies

As described in Section 8.1.2 the capacity of the M2 motorway during construction is not reduced in peak periods. During peak periods the current vehicle speeds are below the proposed construction zone speed limits so the average travel time in peak periods are likely to remain unchanged. The timing of lane occupancies (Section 8.1.2) is planned to minimise the impact on the general traffic flows. For motorway lane occupancies the volume of traffic must fall below the threshold level of 1400 vph to ensure adequate capacity is available to accommodate traffic demand. Monitoring of the motorway and worksites would be carried out using CCTV and mobile patrols to assist management of incidents and maintenance of the signs and devices.

8.3.1.3 Non Motorway Impact

Road users may choose to take an alternative route (diversion) due to the reduced benefit on the motorway because of lower speed limits and lane closures. Diversion is expected mainly in the off peak periods and particularly at night when up to 150 vehicles per hour would use the alternative routes along the full length of the M2 corridor. These alternative routes are free flowing and the additional vehicles would not create congestion due to the low volumes involved.

8.3.2 Construction Vehicle Movements

The majority of construction vehicles would access the work sites from the motorway where possible. Truck haulage would generally avoid peak periods in peak directions for productivity reasons and to limit the impact of truck movements in and out of worksites. Worksites and laydown areas are positioned along the motorway corridor so as to reduce the travel distance and time for all vehicles and the workforce.

Vehicle Management Plans (VMPs) would be developed to reduce the impact of construction vehicle movements on the motorway and non-motorway roads. Such methods include controlled access points, radio contact to drivers and off motorway truck staging. Staging sites for delivery and haulage trucks would be selected as appropriate for the capacity required and location relative to residences and other sensitive receivers. The staging sites would be agreed through the TTLG.

8.3.2.1 Impact due to local road access of work and ancillary sites

The estimated vehicle movements to worksites and compounds are provided in Table 62 and Table 63. While the preferred access is via the motorway there will be construction vehicles using the non-motorway roads. Table 61 lists the roads around the motorway that will be used to various degrees by construction related vehicles depending on the nature of the site. These are classified into groups: Residential; Collector; Sub-Arterial, Arterial and Major Arterial as described in Section 8.1.3.

Based on the existing volumes and mix of heavy vehicles it is expected that only the residential streets will have a noticeable increase in vehicle movements due to construction traffic accessing the work areas. Assessment of suitable routes and access points will be made as part of the Construction Environment Management Plan with TMPs developed to limit the impact as detailed in Section 8.6.

8.3.2.2 Selection of Construction Traffic Routes

Routes for construction vehicles to and from compounds and worksites will be developed in the context of minimising impacts on local streets and maximising use of arterial roads. The approach for development of the routes is to consider the following:

- Preference for the motorway network, arterial roads and other higher order roads;
- Restrictions on size and load of vehicles;
- Sensitive communities especially schools, hospitals, places of worship, businesses;
- Hours of operation of the sensitive communities;
- Access needs for residents, pedestrians, emergency services and buses;
- Out of hours impact on residential areas;
- Consultation with the TTLG, residents and sensitive communities; and
- Guidance from relevant documents and standards e.g. Guide to Traffic Control at Worksites (RTA).

8.3.3 Emergency Service Vehicle Movements

The M2 is used by emergency service vehicles for travel to and from call outs. Due to the potential delays in travel times during peak periods the emergency services will be regularly informed on the staging and progress of works. In off peak periods the travel time delays are related to the speed limit reduction and the impact on emergency services would be minimal.

The removal of the breakdown lane will restrict access to incidents on the motorway by emergency service vehicles. Management Plans for incidents would be developed in consultation with the emergency services, project construction team and the motorway operators taking into account the staging of construction activities, communications with M2 MCR and crossover facilities for contraflow access. Emergency service vehicles would also be able to use the tidal flow bus lane described in Section 8.5 to avoid congested lanes to access an incident. The existing relationship with the motorway operators will provide a good basis for communication and agreement on procedures.

8.3.4 Local Roads i.e. non-motorway

The local roads that are subject to project works are detailed in Table 64 along with a brief outline of the works involved. These works would require a series of lane occupancies in accordance with the parameters in Table 64 and would be detailed in TMPs. The works to lengthen the spans on Barclay Road and the Kirkham Street/Murray Farm Road would require the closure of the road for some activities. This would be subject to planning and agreement with the relevant stakeholders through the TTLG including identification of suitable detour routes and consideration of 'stop-go' restrictions, to keep the traffic on the same route, and minimise inconvenience. Appropriate communication strategies would be implemented to ensure that the users and adjacent community are informed prior to any works that may affect local traffic conditions.

Table 64 Works Affecting local roads

Location	Scope of Works
Windsor Road	Widening of road south of M2 intersection to near Woodlands Street. Tie-in works for the new ramps plus traffic signal adjustment at the interchange.
Barclay Road	Lengthening of bridge spans over M2.
Kirkham Street/Murray Farm Road	Lengthening of bridge spans over M2.
Somerset Street (east of Norfolk tunnel)	Realignment of kerbline and drainage near Gloucester Road.
Christie Road	Lengthening and widening of bridge spans over M2 and traffic signals adjustment at the interchange.
Talavera Road	Widening carriageway between Macquarie School of Management access and Alma Road and traffic signal adjustments at Christie and Herring Roads.

8.3.4.1 Residential and Business Access

The project works on Windsor Road, Somerset Street and Talavera Road will have some impact on the driveways to properties in order to make the necessary adjustments to complete the final design. Through the consultation phase prior to start of construction, property owners will have input to the agreed final design. Staging of the works would be included in the TMPs for each section.

8.3.5 Regional Traffic Flow Impacts (Spoil Haulage Routes)

Approximately 40% of all truck movements on site would be due to the excavation activities and the delivery of processed sandstone or quarry materials. Sandstone that is cut from the widening works would be taken to a stockpile area at the main compound for processing. From here it would be returned to site typically for retaining wall backfilling operations, embankments or Select Material Zone in the pavement construction. The main compound will have direct access and egress off the motorway and the truck movements associated with these works will be primarily only on the motorway.

Surplus spoil material would be transported to suitable reuse sites such as the developments at Moorebank, Eastern Creek and Port Botany expansion or appropriately licensed waste facilities. Haulage routes to these sites would use the Sydney Orbital Motorway and arterial roads at the destination in accordance with the operating licence of the facility. Further locations may arise for consideration during the construction phase. A Spoil Management Plan will be developed for the project. This plan would detail the routes to be used taking into consideration factors including time of day (peak or off-peak), time of month (school holidays), events occurring on the road network (accidents or special events) and/or EA restrictions.

8.4 Impacts on Pedestrians, Cyclists and Rail

8.4.1 Pedestrians

The only permitted pedestrian movements on the motorway are in the vicinity of the bus stops. Bus stops are located on the M2 at;

- Gooden Reserve (Model Farms),
- Cropley Drive (Baulkham Hills),
- Barclay Road (North Rocks),
- Oakes Road (Carlingford North).

Works on some of the overbridges to lengthen the spans and intersection reconfiguration would require temporary diversion of pedestrians. Access would be maintained although trips may be longer by up to one minute. These would be addressed in the TMPs that are developed for the planning and staging of the works. Table 65 outlines impact to pedestrians at bridges and intersections along the motorway due to the M2 Upgrade project.

Table 65 Works Impacting Pedestrians

Location	Facility Type	M2 Upgrade Impacts
Windsor Road	Bridge	During construction of the new ramps on the west side it is likely that all pedestrians would be diverted to the east footpath.
Barclay Road	Bridge (and pedestrian ramp to M2 bus stop)	During construction there would be one of two footpaths closed for the lengthening works at the northern end. Temporary road crossing may be used to facilitate access.
Devlins Creek (from Allerton Road to Welham Street and Austral Avenue)	Bridge	During construction some local detours for pedestrians would be required to avoid working areas. Access under the M2 from north to south would be restricted.
Kirkham Street/Murray Farm Road	Bridge	During construction there would be one of two footpaths closed for the lengthening works at the each end. Temporary road crossing may be used to facilitate access.
Beecroft Road	Bridge	During construction the footpath on the west side may be altered for the modifications to the central pier. Temporary road crossing may be used to facilitate access.
Christie Road	Bridge	During construction the footpath on the east side may be altered for the widening/lengthening works. Temporary road crossing may be used to facilitate access. Access to the council car park may be closed for some periods. An alternative car park at Talavera Road could be provided with pedestrian access across the bridge allowed.
Herring Road /Talavera Road	At Grade	During construction the footpath on the east side may be altered for the widening/lengthening works. Temporary road crossing may be used to facilitate access.
Khartoum Road	Underpass	During construction there would be one of two footpaths closed for the widening works at the each end. Temporary road crossing may be used to facilitate access

8.4.2 Cyclists

The breakdown lanes of the M2 Motorway are used primarily by commuter and training cyclists. Based on traffic counts in 2007 after the introduction of the Interim Widening between Lane Cove Road and Beecroft Road an estimated 250 cycle trips per day are made along the M2.

The project would affect cycle use from west of Windsor Road to east of Lane Cove Road due to the removal of the breakdown lane during construction. An alternative route would be provided using non-motorway roads that stay close to the alignment of the motorway where possible. A working group was established in November 2009 for the purpose of determining an acceptable alternative route. The alternative route should desirably have the following characteristics:

- A safe and unobstructed cycle route clear of islands and hazards such as speed humps and angle parking
- The avoidance of areas of traffic congestion leading to improved cyclist safety and decreased travel times
- Delivering cyclists to areas of local significance such as shopping centres and train stations
- Gradients of 5% or less are desirable for ease of use in accordance with the RTA's NSW Bicycle Guidelines – however this will be governed by local topography and may not be possible in all sections
- Addresses requirements of relevant standards, guidelines, codes and local and regional strategies regarding the cycle route
- Use of existing or proposed cycle routes

In February 2010 GTA consultants presented to the working group on route options and indicated its preferred option. Following feedback from Bike Groups, Council and RTA a preferred route was selected and is shown in Figure 37. A report *"M2 Upgrade. Alternative Cycle Route. Preferred Route Analysis Report"* was produced. The preferred route would be further developed in consultation with the relevant cycle user groups and councils during preparation of the Environmental Assessment and its impacts would be assessed. Suitable temporary detour signage and marking would be used along the route during the construction period of around two years. It is realised that the alternative route would be longer than a M2 route. Analysis on the preferred route identification process is detailed in the GTA report: "M2 Upgrade Alternative Cycleway Route. Preferred Route analysis Report (February 2010)". This report incorporates comments and suggestions from the Cycle Working Group members and relevant local councils, with detailed responses and action taken where appropriate.

The underpass at Vimiera Road is part of a north-south route used by pedestrians and cyclists between Macquarie Park and South Turramurra. The structure will be extended to allow widening of the embankment on the northern side. Short term closures will be required for some construction activities, probably overnight, with advance notification provided to minimise disruption to users. When works are being undertaken on this underpass during normal working hours, access will be maintained for the public by means of personal escort or dedicated exclusion zone through the works at all times.

8.4.3 Rail

The rail line crossing over the M2 east of Beecroft Road is not impacted by the construction works.

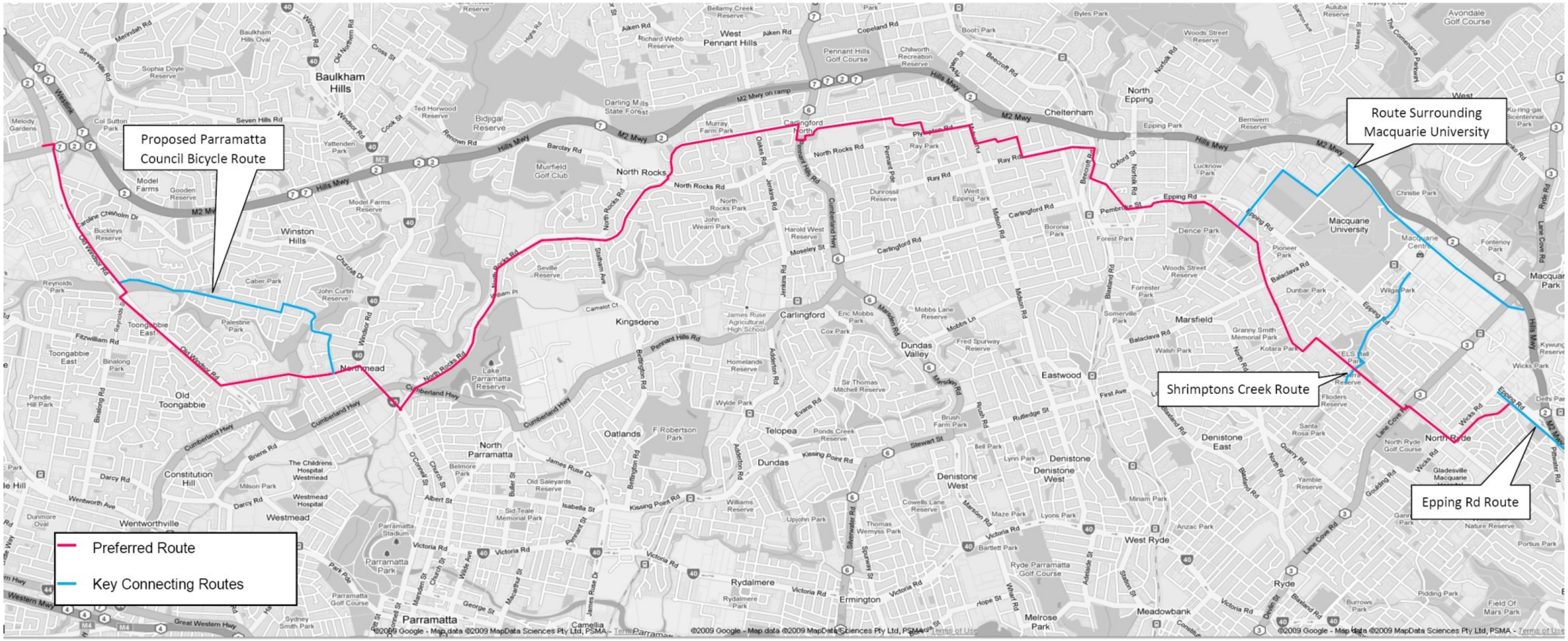


Figure 37 - Draft Cycle Detour under construction

8.5 Impacts on Bus Operation

Approximately 8 km of bus lanes are provided on the M2 between Windsor Road and Beecroft Road These run adjacent to the median and have dedicated access and egress ramps at Windsor Road (east facing), Pennant Hills Road (east facing) and Beecroft Road (west facing). East of Beecroft Road buses join the general traffic. During peak periods the bus lanes provide a congestion free journey with reliable travel times in this section.

In order to provide safe worksites for the widening activities it is proposed to create a tidal bus lane from Windsor Road to Pennant Hills Road and from Pennant Hills Road to a suitable merge point near the Kirkham Street/Murray Farm Road bridge. This tidal lane will allow buses travelling in the peak direction to travel as normal with access to the bus stops at Barclay Road and Oakes Road maintained. The contra-peak direction buses would use the general traffic lanes which are not congested. Bus routes would not be affected along this section. A detailed TMP would be developed to show how the tidal bus lane would operate including:

- Extent of the tidal lane;
- Signs and devices to advise bus drivers and road users of the operation;
- Timing and operational procedures for switching the direction of flow;
- Monitoring and incident management;
- Training requirement for all bus drivers; and
- Communication of arrangements via website etc.

The tidal flow bus lane would be further developed in consultation with the bus companies during preparation of the Environmental Assessment. A working group was established in November 2009 for this purpose and have agreed on the concept and basic arrangements. The tidal flow would operate:

- Eastbound from 4 am to 12 pm
- Westbound from 12 pm to 4 am.

The removal of the Beecroft Road bus ramps as detailed in Section 7.8.2 will require the permanent rerouting of some services, which will probably be via Christie Road. This change can be implemented at any stage during construction because the alternative route is available. The alternate route would be determined by bus operators in conjunction with the Department of Transport and Infrastructure. The timing of the demolition would be detailed in the project CEMP to minimise disruption to the general traffic on the motorway possibly during a holiday period.

As noted in Section 8.4.1 all four bus stops on the M2 motorway will not be impacted by the project works and will continue to operate in their existing configuration. Due to the implementation of tidal flow arrangements the express bus services travelling in peak direction will be required to stop at Barclay Road bus stop if there is a bus loading or unloading passengers. Bus stops on non motorway roads e.g. Windsor Road and Talavera Road will require a temporary relocation or closure during the works at that location. These changes will be detailed in the TMP and will be following consultation with the bus companies and user groups.

The reduction in speed limits in the construction zones represents up to 2.5 minutes additional travel time in non congested periods over the 14.5 km length of widening works. This would increase in congested periods as there are no bus lanes for 5.5 km from Beecroft Road to Lane Cove Road.

8.6 Traffic Management Measures during Construction

8.6.1 Traffic Management Plans

The Project Traffic Manager is responsible for the development of TMPs for all aspects of construction that will require temporary changes to the motorway and non-motorway road layout using barriers or lane occupancies. These would be in accordance with the Australian Road Rules, AS1742.3: Traffic control devices for works on s, the RTA's Traffic Control at Worksites Manual and any other relevant standard, guide or manual. Consultation with the relevant stakeholders is managed through the TTLG as described in Section 8.3.1.

TMPs provide the overall staging for the traffic management and the detail of how subplans are managed. The content of a TMP includes:

- Traffic Control Plans showing the detail of signs and devices required for each configuration;
- Vehicle Management Plans showing access to worksites, direction of travel etc.;
- Pedestrian Control Plans;
- Management strategy for vehicles e.g. public transport, temporary bus stop relocation, tidal bus lane operation; and
- Management strategy for access to properties, schools, business activities etc.

Communication of the proposed changes will vary depending on the nature and extent of the management scheme. The options and processes for advising users and the general public of the changes would be included in the Community and Stakeholder Consultation Plan and coordinated by the TTLG to include:

- Portable and permanent Variable Message Signs;
- M2 Upgrade and RTA web sites;
- Radio advertising; and
- Metropolitan and local newspaper advertising.

8.6.2 Strategy and Objectives

The Project Traffic Manager would ensure that road user delays are kept to an absolute minimum and maintain access for all road users.

8.6.2.1 Objectives

The objectives for managing the impact of the project construction activities on traffic are:

- Safety of all road users and pedestrians;
- Minimise disruption to road users and pedestrians;
- Ensure the M2 motorway and surrounding road network continue to function;
- Limit impacts on public transport (buses);
- Minimise changes to traffic operation;
- Minimise access disruptions to adjoining properties;
- Minimise construction activities on non-motorway roads and residential areas wherever possible; and
- Avoid heavy vehicle movements in peak traffic and out of hours.

8.6.2.2 Strategies

These objectives are achieved through the planning and consultation phases and implemented during the construction phase considering the following strategies:

- Potential road user delays are identified during the planning and consultation phases;
- During the design phase develop construction staging and temporary works that avoid conflicts with the existing road network, maximises separation between work areas and travel lanes;
- Existing road network capacity to be maintained;
- Existing road characteristics and environment especially residential streets, schools, business operations, clearways, parking, places of worship etc.
- Isolate work areas from general traffic using temporary safety barriers;

- Provide remote parking facilities for workforce with shuttle services to work areas
- Develop alternative work methods to minimise impacts (e.g. utilise more efficient plant / equipment, apply different design solution);
- Provision of CCTV coverage to observe traffic flow and incidents;
- Providing mechanism for the community to report incidents and delays, eg. 1800 phone number;
- Plan all lane occupancies with the aim to: minimise the actual work area, limit obstructions and restrictions, maximise the roads capacity, and avoid peak traffic flow periods;
- Analyse traffic volume data to: identify the capacity requirements of the , assess the potential impact on traffic flows, and identify the best time to minimise the inconvenience to road users;
- Clear and concise guidance and support amongst key stakeholders involved in the TTLG and its working groups; and
- Innovation in traffic management solutions including long term contra flow arrangements.

Appendix A Model Development and Assumptions

TUSTM was originally 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 below.

Traffic Forecasting Methodology

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

TUSTM General Characteristics

The general characteristics of the TUSTM are:

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

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

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

Assignment within TUSTM

Figure 38 describes the process of assignment in TUSTM.

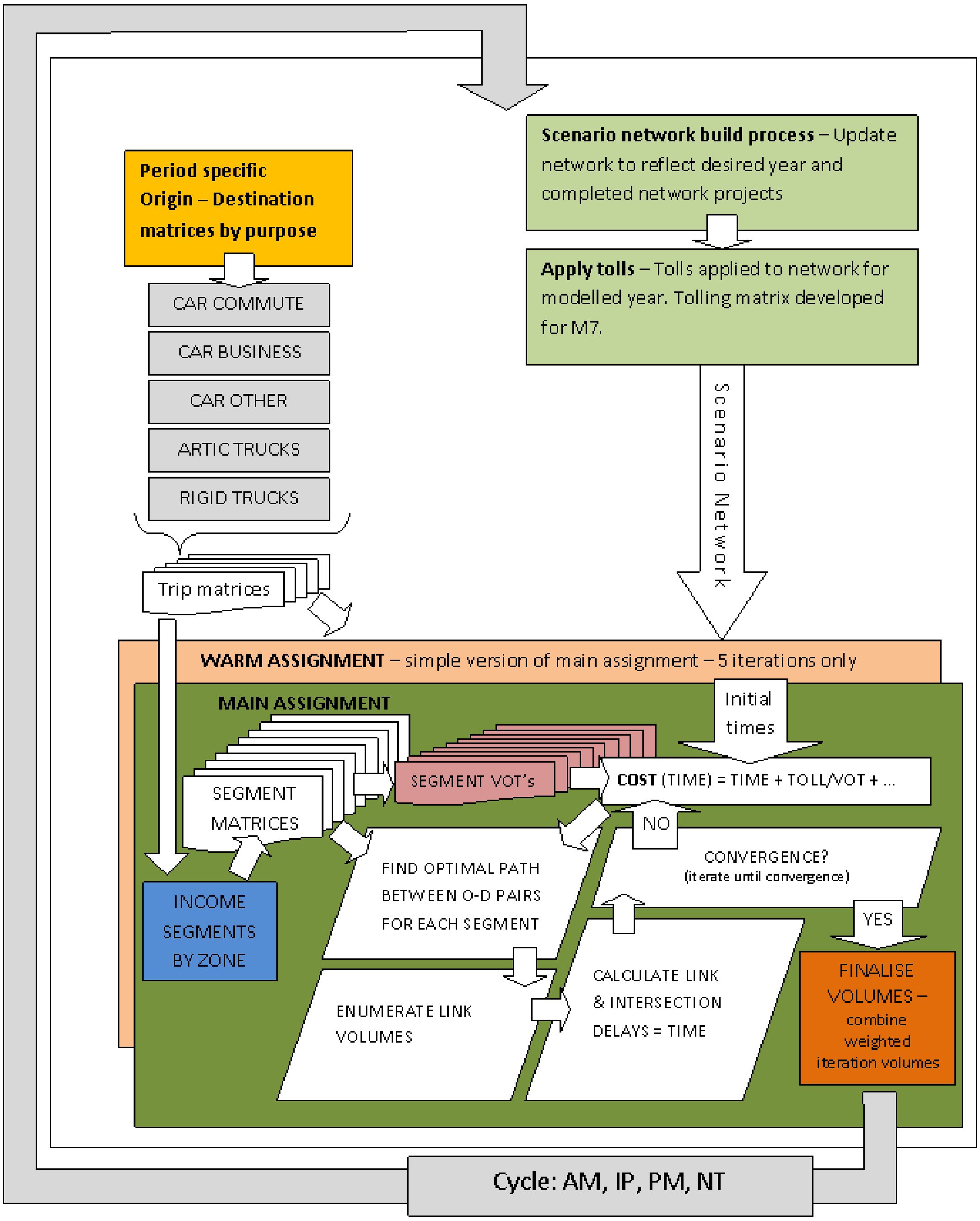


Figure 38 - Overview of TUSTM Assignment

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

Figure 39 shows the family income bands by statistical sub-division and indicates a reasonably wide range of family incomes across Sydney. Observations are:

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

This pattern will lead to differential values of times across the region and explains the presence of cashback[17] on the M4 and M5 motorways where the former Labour Government was looking to offer some relief to the less well-off families of the South and West.

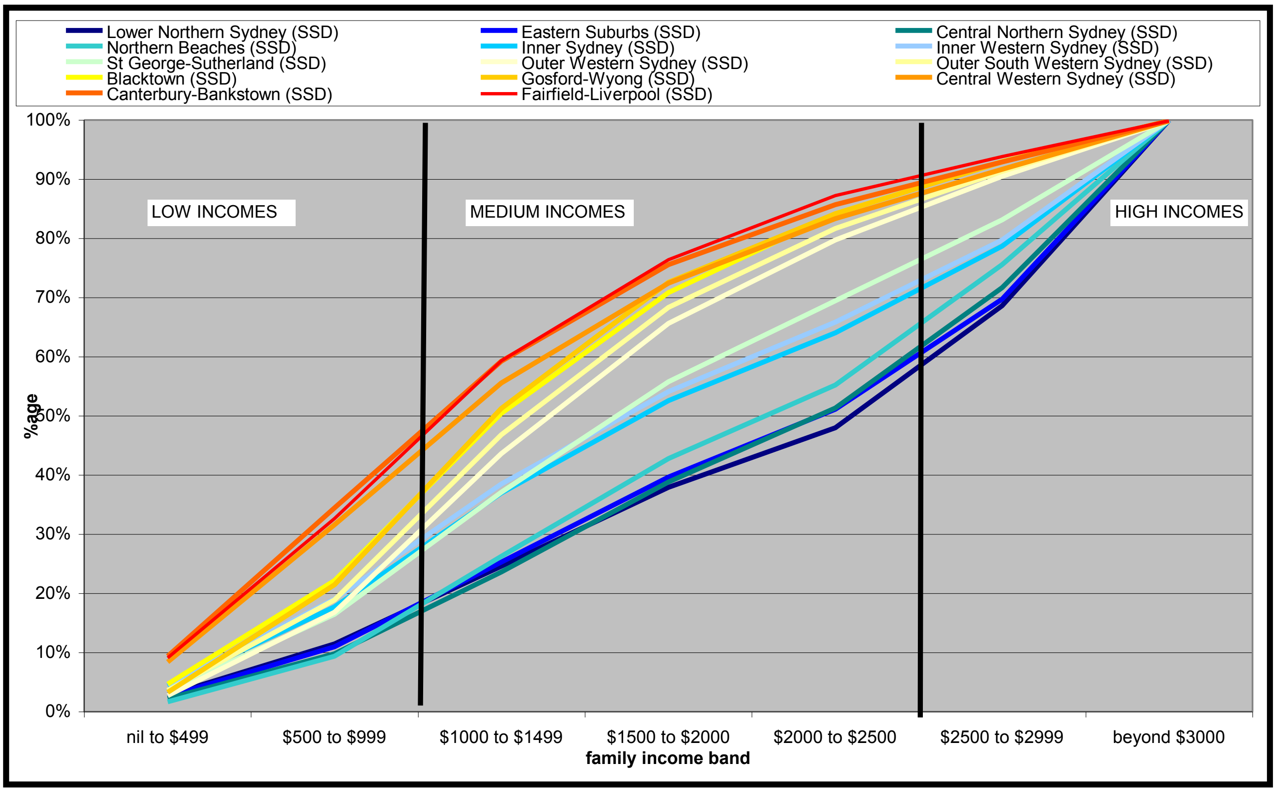


Figure 39 - Sydney Income Distribution

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

Road Network Representation

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

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

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

All links in the network have been adjusted to reflect:

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

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

Vehicle Type and Passenger Car Unit

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

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

A capacity of a motorway lane is often taken as 2,000 vehicles per hour per lane, however it will be dependent on the vehicle type mix and implies a higher PCU capacity. As noted in section 3.1 TUSTM adopts a PCU capacity of 2,200 PCUs per lane per hour for motorways which comprises of vehicle type mix of order:

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

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

Link Types within TUSTM

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

The link type is the key to describing the "base" hourly capacity per traffic lane available. The link types and the nominated base capacity are shown in Table 66.

Table 66 - TUSTM Hourly Lane Capacities

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

Table 66 above details theoretical hourly lane capacity based on the number physical lanes in the network. However, in practice the number of available lanes can vary by:

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

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

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

The above assumptions apply equally across all time periods.

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

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

▪ Therefore total PM and Off Peak capacity equivalent to 2.21 lanes

Modelling of Network Times and Delays

Travel times along each link comprise of:

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

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

Figure 40 shows speed-flow curves within TUSTM.

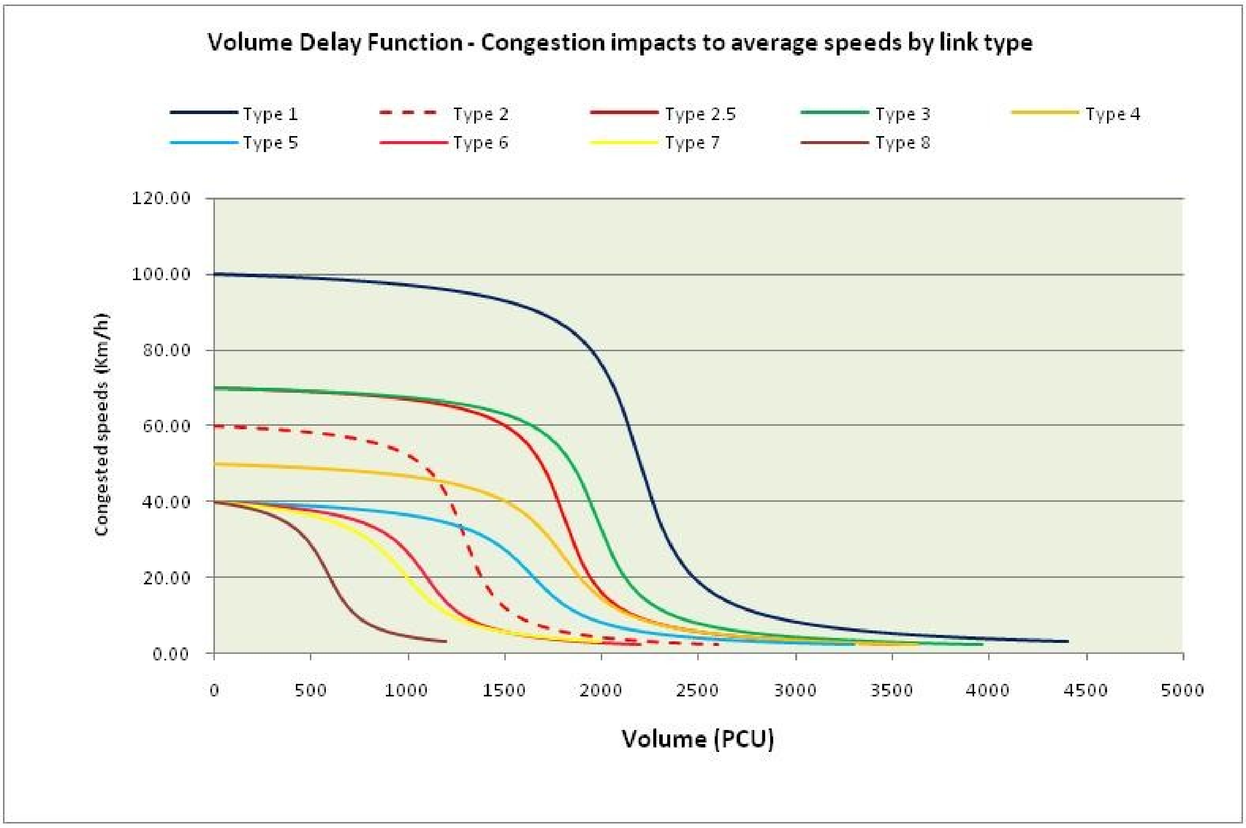


Figure 40 - TUSTM Volume Delay Functions

Base Year Model Calibration/Validation

Base Year Trip Tables

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

SKM estimated the 2006 trip tables from data and raw model outputs from the Sydney Traffic Model (STM) of The Transport and Population Data Centre (TDC), and utilised the earliest implementation of the

STM non-home based models; the lack of non-home based models in earlier STM releases has always been acknowledged as a weakness for the estimation of trip tables outside of the peak periods.

Network Audit

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

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

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

Validation Criteria

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

Screenline Validation

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

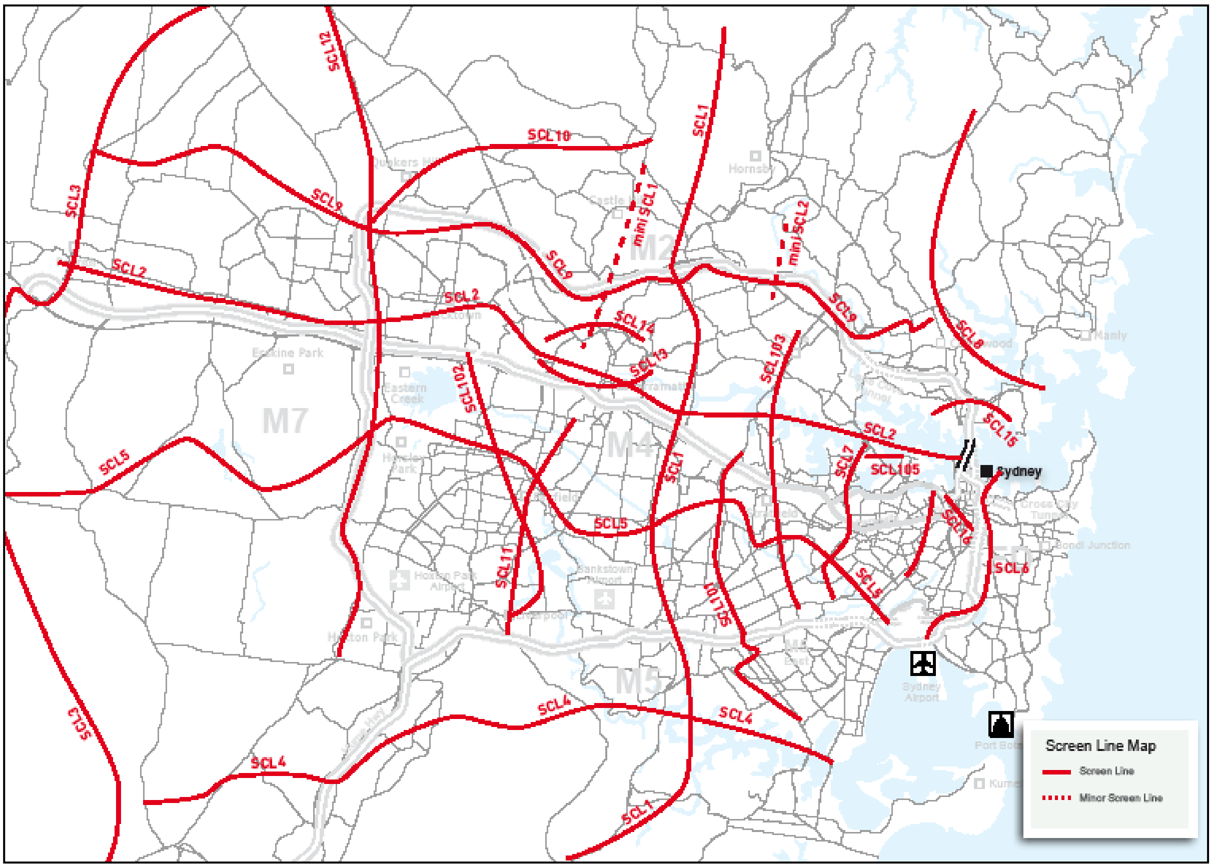


Figure 41 - Screenline Locations

Figure 41 above shows all screenline locations as maintained by RTA. The RTA continuously collects data at specific points along each screenline.

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

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

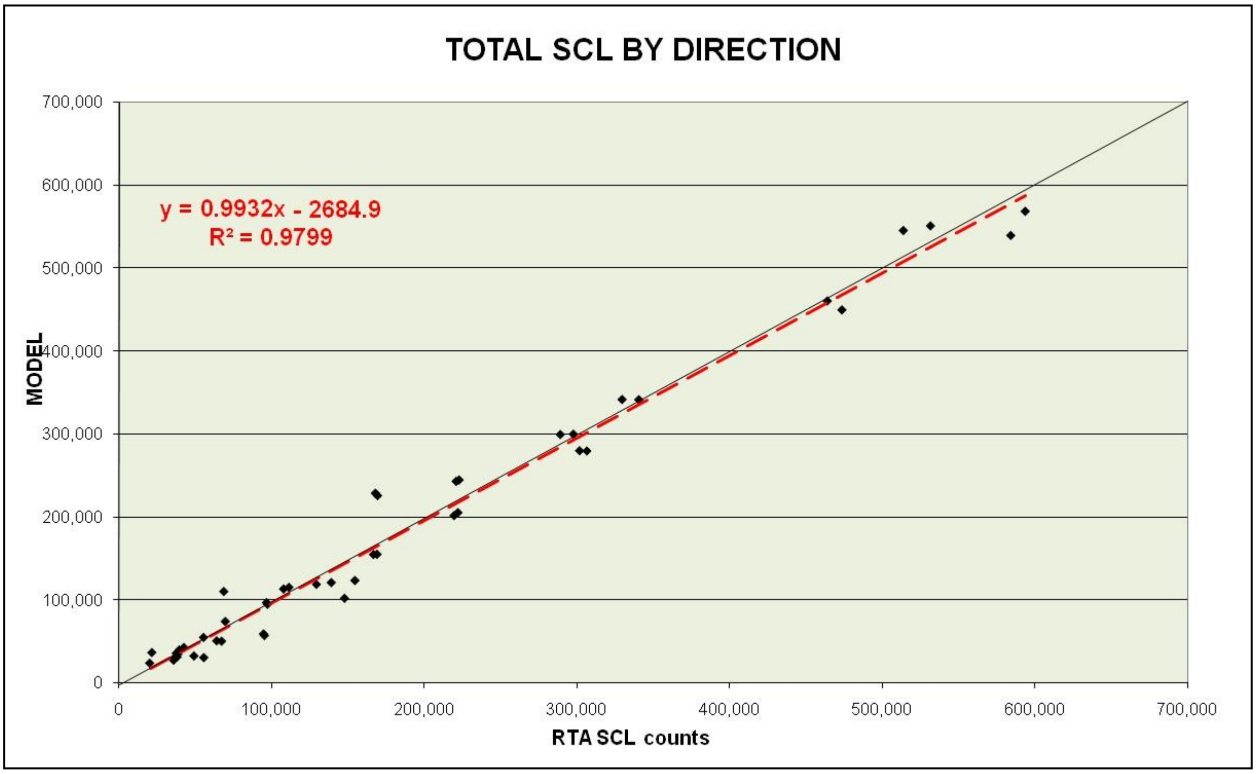


Figure 42 - Screenline Validation

Figure 42 represents scatter plot analysis for daily screenline totals by direction. It shows an excellent "goodness of fit" (0.98) and equally good slope (0.99), indicating that the assigned trip matrices are fit for purpose.

Toll Point Validation

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

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

$$V_1 = Modelled\ Flow\ (in\ Vehicles/Hour)$$

$$V_2 = Observed\ Flow\ (in\ Vehicles/Hour)$$

The GEH statistic is considered a useful measure of the performance of a model in a particular area. Examination of absolute or relative differences can provide misleading results over a wide range of volumes. A large percentage difference may relate to a small absolute difference on a lightly trafficked link, and a small percentage difference may relate to a large absolute difference for links with greater volumes. The GEH statistic is less sensitive to these variations and gives roughly the same result for both large and small volumes with the same degree of error.

Generally accepted GEH targets are:

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

Table 67 - Toll Point Validation

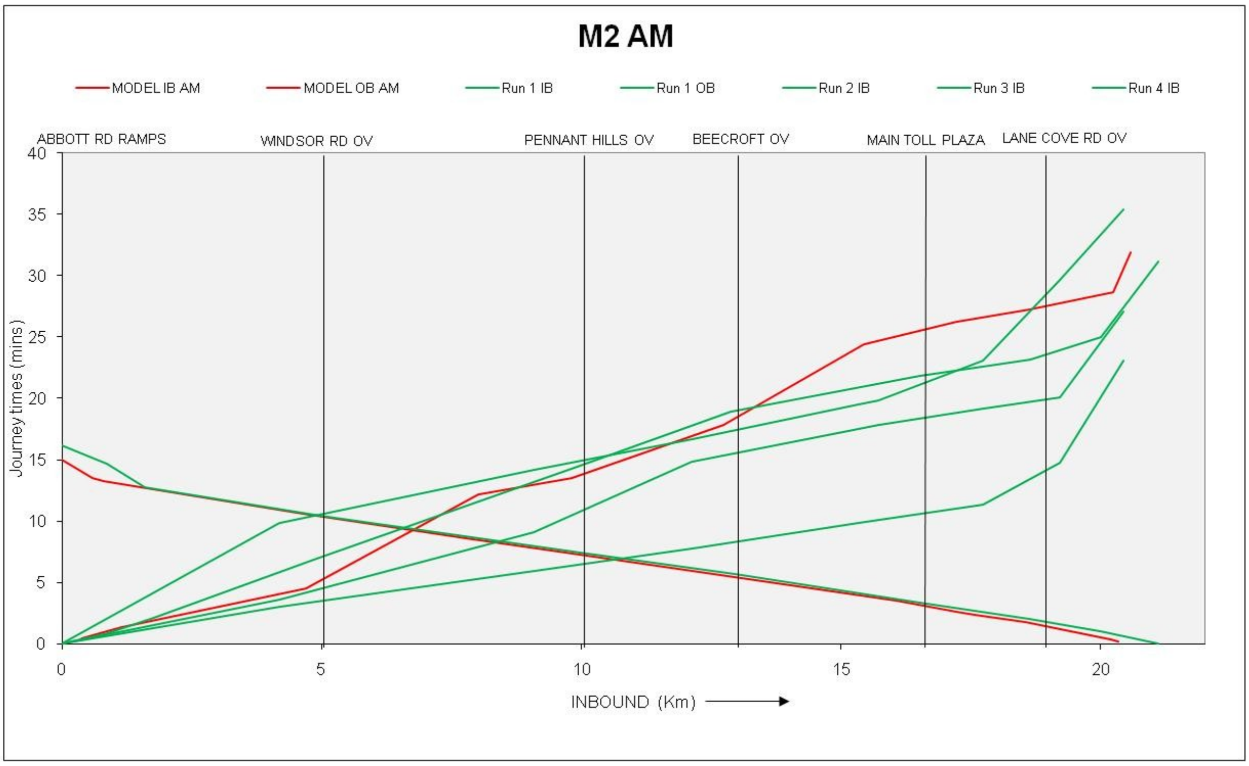
TOLL POINT	OBSERVED DAILY	MODEL DAILY	GEH
M2 Main	71,660	71,296	0.27
M2 Pennant Hills	24,567	19,896	6.40
M4	113,391	116,586	1.92
M5	114,404	115,836	0.86
ED	52,068	41,592	9.88
M7	119,858[18]	136,306	9.38

Table 67 is a comparison of modelled and observed daily toll point volumes. As seen, all locations are within the prescribed criteria.

Journey Times

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

The results presented in Figure 43, Figure 44, Figure 45 and Figure 46 show comparison of modelled and observed AM and PM peak travel times along the M2 and the alternative free route. As shown the modelled results is compares extremely well to observed travel times along both M2 and alternative in both periods and directions.



[18] *Observed data effected by ramp up*

Figure 43 - Modelled M2 AM Peak Travel Time

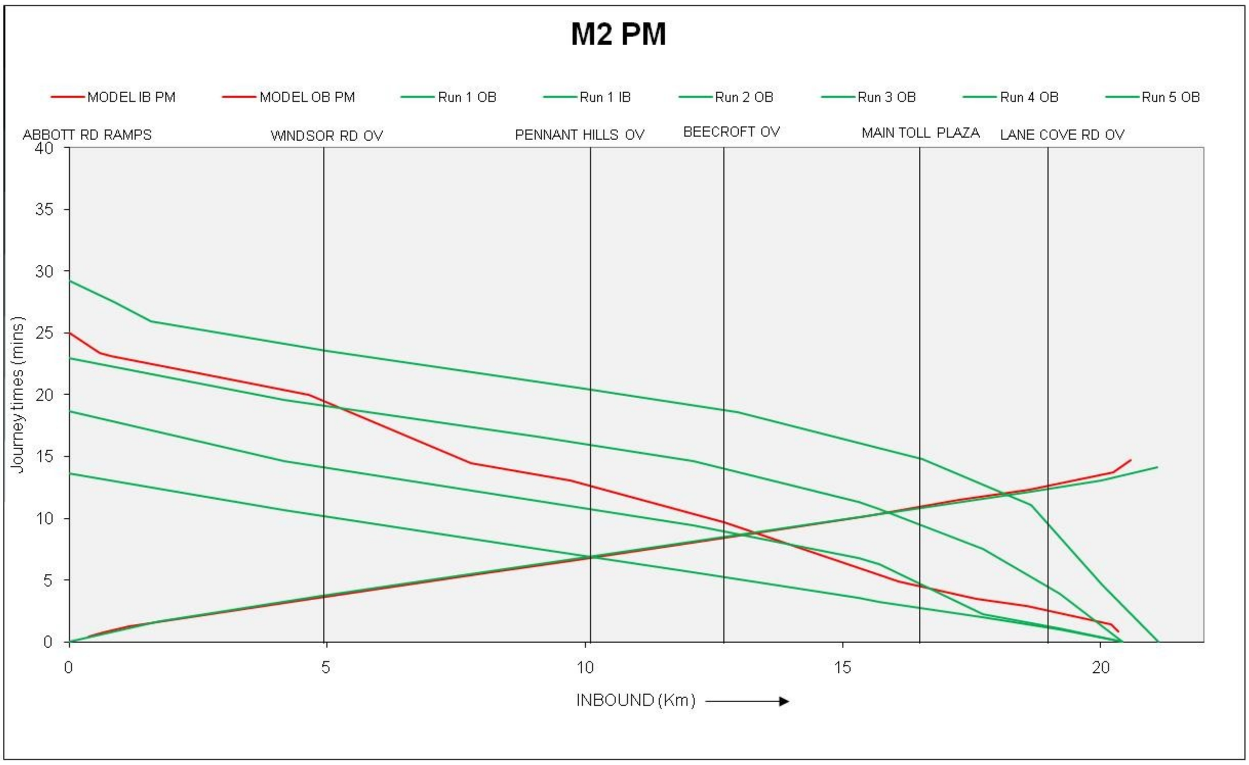


Figure 44 - Modelled M2 PM Peak Travel Time

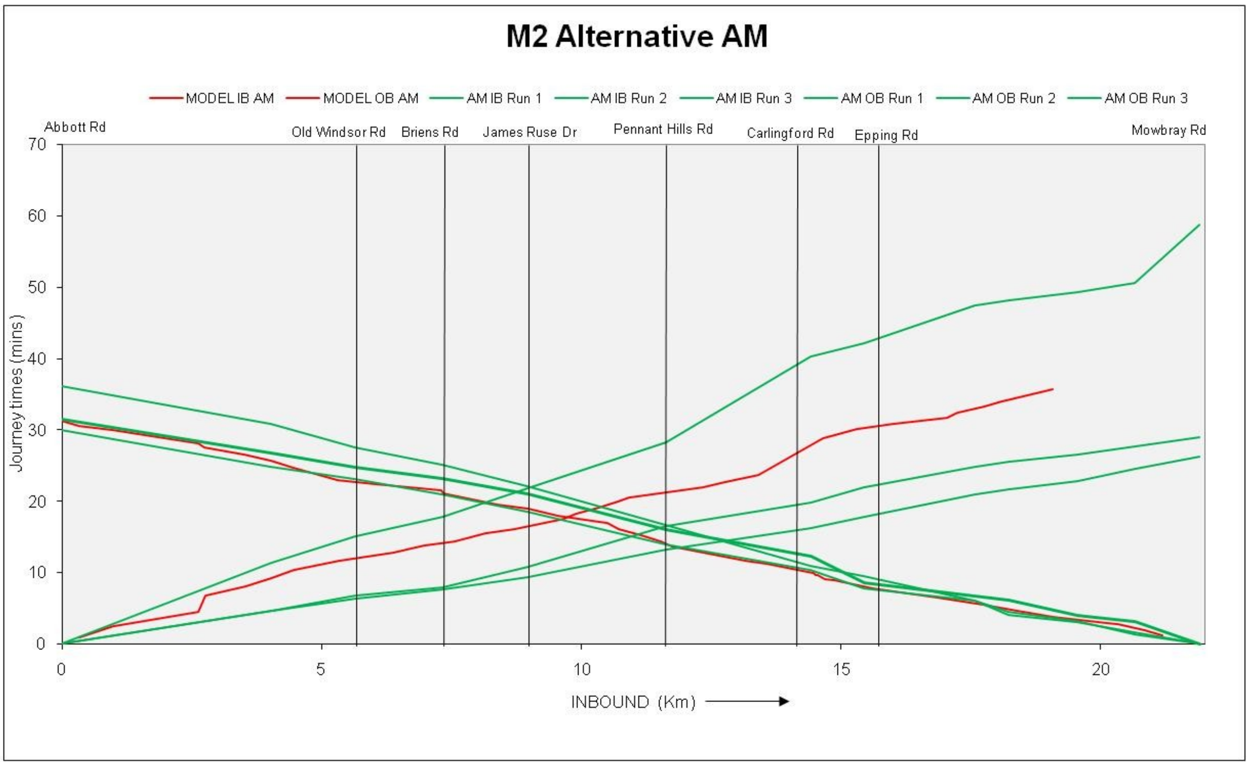


Figure 45 - Modelled M2 Alternative Travel Time

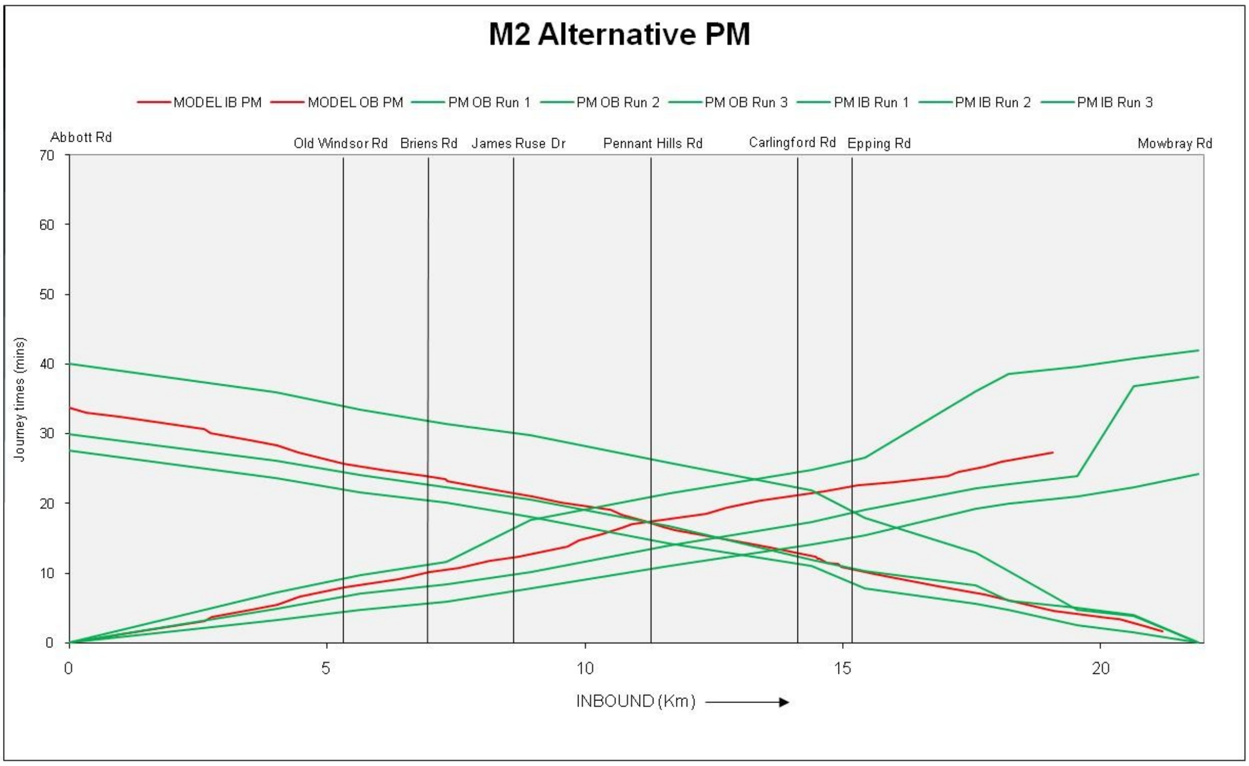


Figure 46 - Modelled M2 Alternative PM Peak Travel Time

Demographic Assumptions

Table 68 - TDC Forecast Population

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

Source: Based on the NSW Transport Planning Data Centre (TDC)

Table 69 - TDC Forecast Employment

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

Source: Based on the NSW Transport Planning Data Centre (TDC)

Values of Time

The values of time applied to tolls for conversion to equivalent travel minutes are given in Table 70. These values comprise a wide ranging review of survey and values applied in toll road forecasts around Australia and are hence of the right order.

Table 70 - Base Year 2006 Value of Time ($2006)

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

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

Users' willingness-to-pay can be expected to increase over time as disposable incomes increase (as indicated by the higher AWE growth above CPI growth). The relative difference between these factors has been reflected in the model by de-escalating the willingness-to-pay parameter by a rate that is the expected difference between AWE and CPI. Table 71 documents the AWE inflators and the resultant values of time applied in each year of the model.

Table 71 - Future Year VOT

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

Appendix B Detailed Model Outputs

Table 72 - EB and SB (Inbound) Flows at Screenlines (refer Fig 15)

SCL	DIR	Location	Lanes	AM Flow (veh/hour)	AM Flow (veh /lane / hour)		PM Flow (veh/hour)	PM Flow (veh /lane / hour)
1A	EB	Norwest Boulevard East of Old Windsor Road	2	1,200	600		1,050	525
1B	EB	Seven Hills Road East of Merindah Road	1	1,250	1,250		900	900
1C	EB	WM7 East of Old Windsor Road	2	1,300	650		1,400	700
1D	EB	Abbott Road East of Old Windsor Road	2	950	475		850	425
1E	EB	Old Windsor Road North of Gibbon Road	2	2,850	1,425		2,250	1,125
1F	EB	Powers Road East of Station Road	2	700	350		450	225
1G	EB	Station Road @ Mc Coy Park	1	1,000	1,000		1,000	1,000
		Screenline 1 Total		**9,300**			**8,000**	
2A	EB	Castle Hill Road East of Old Northern Road	2	1,800	900		1,800	900
2B	EB	Renown Road East of Cook Street	2	1,150	575		500	250
2C	EB	M2 @ Darling Creek	2	3,150	1,575		2,800	1,400
2D	EB	James Ruse Road East of Windsor Road	3	3,500	1,167		1,800	600
2E	EB	Church Street South of Briens Road	3	2,250	750		1,100	367
		Screenline 2 Total		**11,850**			**8,000**	
3A	EB	The Comenarra Parkway East of Fox Valley Road	1	500	500		950	950
3B	EB	M2 Main Plaza	2	4,200	2,100		2,300	1,150
3C	EB	Epping Road West of Vimiera Road	2	2,500	1,250		1,050	525
		Screenline 3 Total		**7,200**			**4,300**	
4A	SB	Windsor Road North of M2	2	2,750	1,375		1,650	825
4B	SB	Oakes Road North of M2	1	1,150	1,150		650	650
4C	SB	Pennant Hills Road North of M2	3	3,550	1,183		2,400	800
4D	SB	Murray Farm Road @ M2	1	1,000	1,000		400	400
4E	SB	Beecroft Road North of M2	2	2,100	1,050		950	475
4F	SB	Ryde Road South of Lady Game Drive	3	4,000	1,333		3,750	1,250
		Screenline 4 Total		**14,550**			**9,800**	

Table 73 - WB and SB (Outbound) Flows at Screenlines (refer Fig 15)

SCL	DIR	Location	Lanes	AM Flow (veh/hour)	AM Flow (veh /lane / hour)		PM Flow (veh/hour)	PM Flow (veh /lane / hour)
1A	WB	Norwest Boulevard East of Old Windsor Road	2	850	425		1900	950
1B	WB	Seven Hills Road East of Merindah Road	1	900	900		1150	1,150
1C	WB	WM7 East of Old Windsor Road	2	1,300	650		1,950	975
1D	WB	Abbott Road East of Old Windsor Road	2	750	375		1,000	500
1E	WB	Old Windsor Road North of Gibbon Road	2	1,950	975		2,600	1,300
1F	WB	Powers Road East of Station Road	2	400	200		550	275
1G	WB	Station Road @ Mc Coy Park	1	1,000	1,000		950	950
		Screenline 1 Total		**7,250**			**10,300**	
2A	WB	Castle Hill Road East of Old Northern Road	2	1,900	950		2,050	1,025
2B	WB	Renown Road East of Cook Street	2	550	275		1150	575
2C	WB	M2 @ Darling Creek	2	2,650	1,325		4,050	2,025
2D	WB	James Ruse Road East of Windsor Road	2	1,550	775		2,300	1,150
2E	WB	Church Street South of Briens Road	3	900	300		2050	683
		Screenline 2 Total		**7,550**			**11,600**	
3A	WB	The Comenarra Parkway East of Fox Valley Road	1	900	900		450	450
3B	WB	M2 Main Plaza	3	2,150	717		4,500	1,500
3C	WB	Epping Road West of Vimiera Road	2	850	425		1950	975
		Screenline 3 Total		**3,900**			**6,900**	
4A	NB	Windsor Road North of M2	3	1,550	517		2,550	850
4B	NB	Oakes Road North of M2	1	750	750		1350	1,350
4C	NB	Pennant Hills Road North of M2	3	2,150	717		3,200	1,067
4D	NB	Murray Farm Road @ M2	1	400	400		500	500
4E	NB	Beecroft Road North of M2	2	850	425		1600	800
4F	NB	Ryde Road South of Lady Game Drive	3	3,150	1,050		3,650	1,217
		Screenline 4 Total		**8,850**			**12,850**	

Table 74 - Daily Volume at Screenlines (refer Fig 15)

SCL	Dir	Location	OBSERVED AM Peak	OBSERVED PM Peak	OBSERVED DAILY
1A	EB	Norwest Boulevard East of Old Windsor Road	1,200	1,050	13,800
1A	WB	Norwest Boulevard East of Old Windsor Road	850	1,900	15,850
1B	EB	Seven Hills Road East of Merindah Road	1,250	900	11,000
1B	WB	Seven Hills Road East of Merindah Road	900	1,150	11,100
1C	EB	WM7 East of Old Windsor Road	1,300	1,400	20,050
1C	WB	WM7 East of Old Windsor Road	1,300	1,950	20,750
1D	EB	Abbott Road East of Old Windsor Road	950	850	10,250
1D	WB	Abbott Road East of Old Windsor Road	750	1,000	12,000
1E	EB	Old Windsor Road North of Gibbon Road	2,850	2,250	31,250
1E	WB	Old Windsor Road North of Gibbon Road	1,950	2,600	29,900
1F	EB	Powers Road East of Station Road	700	450	6,150
1F	WB	Powers Road East of Station Road	400	550	5,200
1G	EB	Station Road @ Mc Coy Park	1,000	1,000	11,600
1G	WB	Station Road @ Mc Coy Park	1,000	950	11,900
		Screenline 1 Total	**16,400**	**18,000**	**210,800**
2A	EB	Castle Hill Road East of Old Northern Road	1,800	1,800	22,450
2A	WB	Castle Hill Road East of Old Northern Road	1,900	2,050	23,500
2B	EB	Renown Road East of Cook Street	1,150	500	8,200
2B	WB	Renown Road East of Cook Street	550	1,150	8,600
2C	EB	M2 @ Darling Creek	3,150	2,800	39,000
2C	WB	M2 @ Darling Creek	2,650	4,050	42,550
2D	EB	James Ruse Road East of Windsor Road	3,500	1,800	28,300
2D	WB	James Ruse Road East of Windsor Road	1,550	2,300	25,000
2E	EB	Church Street South of Briens Road	2,250	1,100	19,800
2E	WB	Church Street South of Briens Road	900	2,050	20,800
		Screenline 2 Total	**19,400**	**19,600**	**238,200**
3A	EB	The Comenarra Parkway East of Fox Valley Road	500	950	7,650
3A	WB	The Comenarra Parkway East of Fox Valley Road	900	450	6,650
3B	EB	M2 Main Plaza	4,200	2,300	38,050
3B	WB	M2 Main Plaza	2,150	4,500	39,650
3C	EB	Epping Road West of Vimiera Road	2,500	1,050	21,900
3C	WB	Epping Road West of Vimiera Road	850	1,950	21,350
		Screenline 3 Total	**11,100**	**11,200**	**135,250**
4A	NB	Windsor Road North of M2	1,550	2,550	28,700
4A	SB	Windsor Road North of M2	2,750	1,650	28,200
4B	NB	Oakes Road North of M2	750	1,350	9,500
4B	SB	Oakes Road North of M2	1,150	650	8,350
4C	NB	Pennant Hills Road North of M2	2,150	3,200	38,700
4C	SB	Pennant Hills Road North of M2	3,550	2,400	38,350
4D	NB	Murray Farm Road @ M2	400	500	3,650
4D	SB	Murray Farm Road @ M2	1,000	400	4,700
4E	NB	Beecroft Road North of M2	850	1,600	17,750
4E	SB	Beecroft Road North of M2	2,100	950	17,800
4F	NB	Ryde Road South of Lady Game Drive	3,150	3,650	43,500
4F	SB	Ryde Road South of Lady Game Drive	4,000	3,750	45,400
		Screenline 4 Total	**23,400**	**22,650**	**284,600**

Table 75 - Local Roads/Access Future Peak Volumes

						2009 AM	2011 Base AM	2021 Base AM		2009 PM	2011 Base PM	2021 Base PM
SCL	Direction	Location	Type	Lanes	Capacity	Volume	Volume	Volume		Volume	Volume	Volume
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	3300	1,200	1,250	1,400		1,050	1,150	1,350
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	1650	1250	1,300	1,350		900	950	1,000
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	3600	450	500	900		900	1,000	1,450
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	3600	2850	3,200	3,850		2,250	2,450	2,800
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	3000	700	750	850		450	500	550
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1500	1000	1,050	1,100		1,000	1,050	1,100
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	3600	1800	1,950	2,200		1,800	2,000	2,400
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	3000	1150	1,250	1,400		500	550	650
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	5400	3,500	3,550	3,600		1,800	1,800	1,850
2E	EB	Church Street South of Briens Road	Major Arterial	3	5400	2250	2,400	2,700		1,100	1,150	1,300
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	1500	500	550	650		950	950	950
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	3600	2500	2,800	3,450		1,050	1,100	1,200
4A	SB	Windsor Road North of M2	Major Arterial	2	3600	2750	3,000	3,450		1,650	1,800	2,050
4B	SB	Oakes Road North of M2	Sub-Arterial	1	1500	1150	1,300	1,550		650	700	750
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	5400	3550	3,600	3,650		2,400	2,400	2,450
4D	SB	Murray Farm Road @ M2	Collector	1	1000	1000	1,150	1,400		400	400	400
4E	SB	Beecroft Road North of M2	Major Arterial	2	3600	2100	2,200	2,400		950	1,050	1,200
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	5400	4000	4,100	4,300		3,750	3,950	4,300

Table 76 - Impacts to M2 AM Peak Flows

EASTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
Old Windsor Road	Windsor Road	2,400	2,800	400	3,000	3,400	400
Windsor Road	Pennant Hills Road	3,350	3,830	480	4,200	4,800	600
Pennant Hills Road	Beecroft Road	3,600	4,430	830	4,350	5,400	1,050
Beecroft Road	Christie Road	4,450	5,380	930	5,250	6,400	1,150
Christie Road	Lane Cove Road	3,600	4,430	830	4,100	5,300	1,200
Lane Cove Road	Delhi Road	2,750	3,480	730	2,950	4,000	1,050
Delhi Road	Epping Road	1,900	2,430	530	1,900	2,800	900

WESTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
Epping Road	Delhi Road	950	1,250	300	1,250	1,650	400
Delhi Road	Lane Cove Road	1,550	1,950	400	1,950	2,450	500
Lane Cove Road	Herring Road	2,150	2,650	500	2,900	3,550	650
Herring Road	Beecroft Road	2,350	2,500	150	3,150	3,400	250
Beecroft Road	Pennant Hills Road	2,200	2,400	200	2,950	3,250	300
Pennant Hills Road	Windsor Road	2,900	2,950	50	3,550	3,650	100
Windsor Road	Old Windsor Road	2,250	2,480	230	2,750	3,050	300

Table 77 - Impacts to M2 PM Peak Flows

EASTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
Old Windsor Road	Windsor Road	2,350	2,750	400	2,900	3,400	500
Windsor Road	Pennant Hills Road	2,950	3,270	320	3,700	4,150	450
Pennant Hills Road	Beecroft Road	2,250	2,620	370	2,900	3,450	550
Beecroft Road	Christie Road	2,450	2,870	420	3,150	3,750	600
Christie Road	Lane Cove Road	2,250	2,920	670	2,900	3,800	900
Lane Cove Road	Delhi Road	1,600	2,170	570	2,150	2,950	800
Delhi Road	Epping Road	1,200	1,670	470	1,800	2,500	700

WESTBOUND DIRECTION From	To	2011 Base	2011 Upgrade	Change	2021 Base	2021 Upgrade	Change
Epping Road	Delhi Road	2,050	2,150	100	2,350	2,450	100
Delhi Road	Lane Cove Road	3,000	3,200	200	3,400	3,650	250
Lane Cove Road	Herring Road	3,900	4,350	450	4,400	5,000	600
Herring Road	Beecroft Road	4,750	5,170	420	5,350	6,000	650
Beecroft Road	Pennant Hills Road	4,300	4,670	370	4,500	5,100	600
Pennant Hills Road	Windsor Road	4,250	4,220	-30	4,250	4,300	50
Windsor Road	Old Windsor Road	3,150	3,440	290	3,100	3,450	350

Table 78 - Changes to Local Roads AM Flows – Inbound Direction

SCL	DIR	Location	Type	Lanes	2011 Base	2011 Upgrade	Impact	2021 Base	2021 Upgrade	Impact
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,250	1,200	-50	1,400	1,350	-50
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	1,300	1,200	-100	1,350	1,250	-100
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	1,000	1,050	50	1,400	1,450	50
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	3,200	3,050	-150	3,850	3,650	-200
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	750	700	-50	850	750	-100
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,050	1,000	-50	1,100	1,050	-50
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1,950	1,800	-150	2,200	1,950	-250
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	1,250	1,300	50	1,400	1,400	0
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	3,550	3,450	-100	3,600	3,400	-200
2E	EB	Church Street South of Briens Road	Major Arterial	3	2,400	2,400	0	2,700	2,750	50
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	550	550	0	650	600	-50
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	2,800	2,750	-50	3,450	3,400	-50
4A	SB	Windsor Road North of M2	Major Arterial	2	3,000	3,350	350	3,450	3,850	400
4B	SB	Oakes Road North of M2	Sub-Arterial	1	1,300	1,300	0	1,550	1,550	0
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	3,600	3,300	-300	3,650	3,350	-300
4D	SB	Murray Farm Road @ M2	Collector	1	1,150	1,150	0	1,400	1,350	-50
4E	SB	Beecroft Road North of M2	Major Arterial	2	2,200	2,150	-50	2,400	2,341	-59
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	4,100	4,100	0	4,300	4,290	-10

Table 79 - Changes to Local Roads AM Flows – Outbound Direction

SCL	DIR	Location	Type	Lanes	2011 Base	2011 Upgrade	Impact		2021 Base	2021 Upgrade	Impact
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,000	1,000	0		1,350	1,350	0
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	1,100	1,050	-50		1,450	1,400	-50
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	850	900	50		1,200	1,300	100
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,000	1,900	-100		2,100	2,000	-100
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	400	400	0		450	450	0
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,050	1,000	-50		1,100	1,050	-50
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	1,950	1,950	0		2,000	1,850	-150
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	650	650	0		800	800	0
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	1,550	1,550	0		1,600	1,600	0
2E	WB	Church Street South of Briens Road	Major Arterial	3	950	1,050	100		1,050	1,150	100
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	950	950	0		1,050	950	-100
3C	WB	Epping Road West of Vimiera Road	Major Arterial	2	950	950	0		1,150	1,150	0
4A	NB	Windsor Road North of M2	Major Arterial	3	1,550	1,750	200		1,550	1,850	300
4B	NB	Oakes Road North of M2	Sub-Arterial	1	800	750	-50		850	800	-50
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	2,300	2,100	-200		2,650	2,450	-200
4D	NB	Murray Farm Road @ M2	Collector	1	400	300	-100		450	350	-100
4E	NB	Beecroft Road North of M2	Major Arterial	2	900	900	0		1,000	967	-33
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,300	3,300	0		3,600	3,592	-8

Table 80 - Changes to Local Roads PM Flows – Inbound Direction

SCL	DIR	Location	Type	Lanes	2011 Base	2011 Upgrade	Impact		2021 Base	2021 Upgrade	Impact
1A	EB	Norwest Boulevard East of Old Windsor Road	Arterial	2	1,150	1,100	-50		1,350	1,300	-50
1B	EB	Seven Hills Road East of Merindah Road	Arterial	1	950	950	0		1,000	900	-100
1D	EB	Abbott Road East of Old Windsor Road	Major Arterial	2	950	1,000	50		1,400	1,500	100
1E	EB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,450	2,300	-150		2,800	2,600	-200
1F	EB	Powers Road East of Station Road	Sub-Arterial	2	500	500	0		550	550	0
1G	EB	Station Road @ Mc Coy Park	Sub-Arterial	1	1,050	1,050	0		1,100	1,050	-50
2A	EB	Castle Hill Road East of Old Northern Road	Major Arterial	2	2,000	2,000	0		2,400	2,350	-50
2B	EB	Renown Road East of Cook Street	Sub-Arterial	2	550	550	0		650	650	0
2D	EB	James Ruse Road East of Windsor Road	Major Arterial	3	1,800	1,750	-50		1,850	1,800	-50
2E	EB	Church Street South of Briens Road	Major Arterial	3	1,150	1,200	50		1,300	1,350	50
3A	EB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	950	950	0		950	900	-50
3C	EB	Epping Road West of Vimiera Road	Major Arterial	2	1,100	1,100	0		1,200	1,200	0
4A	SB	Windsor Road North of M2	Major Arterial	2	1,800	2,000	200		2,050	2,300	250
4B	SB	Oakes Road North of M2	Sub-Arterial	1	700	650	-50		750	700	-50
4C	SB	Pennant Hills Road North of M2	Major Arterial	3	2,400	2,300	-100		2,450	2,250	-200
4D	SB	Murray Farm Road @ M2	Collector	1	400	400	0		400	300	-100
4E	SB	Beecroft Road North of M2	Major Arterial	2	1,050	1,000	-50		1,200	1,150	-50
4F	SB	Ryde Road South of Lady Game Drive	Major Arterial	3	3,950	3,900	-50		4,300	4,250	-50

Table 81 - Changes to Local Roads PM Flows – Outbound Direction

SCL	DIR	Location	Type	Lanes	2011 Base	2011 Upgrade	Impact		2021 Base	2021 Upgrade	Impact
1A	WB	Norwest Boulevard East of Old Windsor Road	Arterial	2	2,050	2,000	-50		2,400	2,350	-50
1B	WB	Seven Hills Road East of Merindah Road	Arterial	1	1,300	1,250	-50		1,550	1,400	-150
1D	WB	Abbott Road East of Old Windsor Road	Major Arterial	2	1,300	1,350	50		1,550	1,600	50
1E	WB	Old Windsor Road North of Gibbon Road	Major Arterial	2	2,800	2,550	-250		3,250	3,000	-250
1F	WB	Powers Road East of Station Road	Sub-Arterial	2	600	550	-50		650	550	-100
1G	WB	Station Road @ Mc Coy Park	Sub-Arterial	1	950	950	0		1,000	1,000	0
2A	WB	Castle Hill Road East of Old Northern Road	Major Arterial	2	2,350	2,350	0		2,900	2,900	0
2B	WB	Renown Road East of Cook Street	Sub-Arterial	2	1,250	1,300	50		1,400	1,500	100
2D	WB	James Ruse Road East of Windsor Road	Major Arterial	2	2,300	2,250	-50		2,350	2,300	-50
2E	WB	Church Street South of Briens Road	Major Arterial	3	2,150	2,250	100		2,400	2,500	100
3A	WB	The Comenarra Parkway East of Fox Valley Road	Sub-Arterial	1	550	550	0		700	650	-50
3C	WB	Epping Road West of Vimiera Road	Major Arterial	2	2,050	2,050	0		2,250	2,250	0
4A	NB	Windsor Road North of M2	Major Arterial	2	2,550	2,750	200		2,600	2,800	200
4B	NB	Oakes Road North of M2	Sub-Arterial	1	1,350	1,350	0		1,400	1,250	-150
4C	NB	Pennant Hills Road North of M2	Major Arterial	3	3,450	3,300	-150		3,950	3,600	-350
4D	NB	Murray Farm Road @ M2	Collector	1	550	250	-300		600	300	-300
4E	NB	Beecroft Road North of M2	Major Arterial	2	1,700	1,650	-50		1,900	1,800	-100
4F	NB	Ryde Road South of Lady Game Drive	Major Arterial	3	4,000	3,950	-50		4,700	4,650	-50

Table 82 - Daily Impacts Local Roads EB

SCL	DIR	Location	2011 Base	2011 Upgrade	Impact	2021 Base	2021 Upgrade	Impact
1A	EB	Norwest Boulevard	14,400	14,000	-400	16,500	16,000	-500
1B	EB	Seven Hills Road East of Merindah Road	11,250	10,800	-450	12,150	11,250	-900
1D	EB	Abbot Road East of Old Windsor Road	11,050	11,700	650	14,350	15,200	850
1E	EB	Old Windsor Road North of Gibbon Road	33,400	31,600	-1,800	41,800	39,450	-2,350
1F	EB	Powers Road East of Station Road	6,400	6,300	-100	7,200	7,100	-100
1G	EB	Station Road @ Mc Coy Park	11,750	11,500	-250	12,200	11,800	-400
2A	EB	Castle Hill Road East of Old Northern Road	23,800	23,250	-550	28,950	28,350	-600
2B	EB	Renown Road East of Cook Street	8,600	8,600	0	10,050	10,250	200
2D	EB	James Ruse Road East of Windsor Road	28,450	27,650	-800	29,050	28,250	-800
2E	EB	Church Street South of Briens Road	20,650	21,150	500	23,800	24,400	600
3A	EB	The Comenarra Parkway East of Fox Valley Road	7,750	7,700	-50	8,050	7,700	-350
3C	EB	Epping Road West of Vimiera Road	22,950	22,700	-250	26,800	25,200	-1,600
4A	SB	Windsor Road North of M2	29,050	32,450	3,400	32,100	35,950	3,850
4B	SB	Oakes Road North of M2	8,500	8,250	-250	8,950	8,700	-250
4C	SB	Pennant Hills Road North of M2	38,850	38,850	0	40,450	40,550	100
4D	SB	Murray Farm Road @ M2	4,700	4,600	-100	4,750	4,100	-650
4E	SB	Beecroft Road North of M2	18,600	18,700	100	21,500	21,600	100
4F	SB	Ryde Road South of Lady Game Drive	46,900	46,500	-400	52,150	51,700	-450

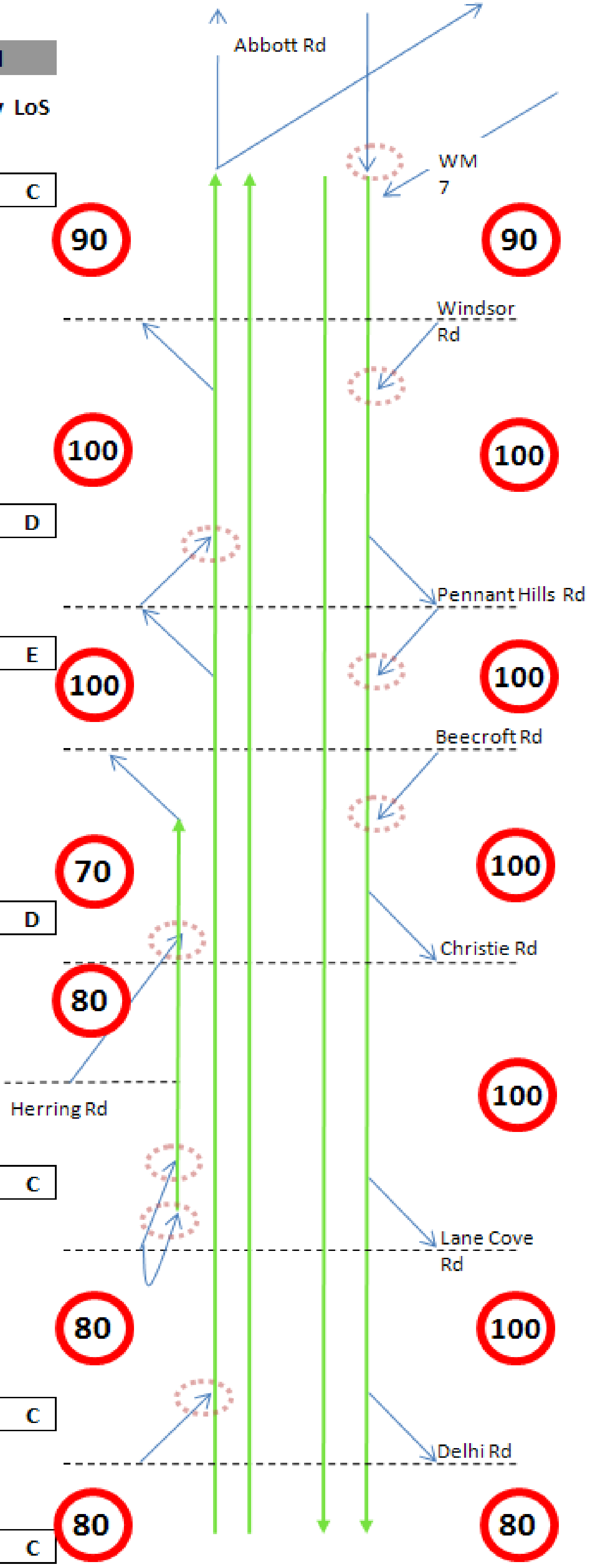
Table 83 - Daily Impacts Local Roads WB

SCL	DIR	Location	2011 Base	2011 Upgrade	Impact	2021 Base	2021 Upgrade	Impact
1A	WB	Norwest Boulevard	16,750	16,450	-300	20,150	19,800	-350
1B	WB	Seven Hills Road East of Merindah Road	11,500	11,000	-500	12,950	12,000	-950
1D	WB	Abbot Road East of Old Windsor Road	12,000	13,050	1,050	14,000	17,350	3,350
1E	WB	Old Windsor Road North of Gibbon Road	31,800	31,300	-500	39,150	38,550	-600
1F	WB	Powers Road East of Station Road	5,300	5,200	-100	5,750	5,650	-100
1G	WB	Station Road @ Mc Coy Park	12,100	11,850	-250	12,700	12,400	-300
2A	WB	Castle Hill Road East of Old Northern Road	24,900	24,700	-200	30,250	29,650	-600
2B	WB	Renown Road East of Cook Street	9,050	9,300	250	10,700	11,050	350
2D	WB	James Ruse Road East of Windsor Road	25,150	24,800	-350	25,650	25,300	-350
2E	WB	Church Street South of Briens Road	21,750	22,350	600	25,200	26,000	800
3A	WB	The Comenarra Parkway East of Fox Valley Road	6,650	6,450	-200	6,700	6,500	-200
3C	WB	Epping Road West of Vimiera Road	21,600	21,350	-250	22,350	20,850	-1,500
4A	NB	Windsor Road North of M2	29,350	32,700	3,350	31,750	35,950	4,200
4B	NB	Oakes Road North of M2	9,550	9,150	-400	9,650	8,850	-800
4C	NB	Pennant Hills Road North of M2	40,850	40,850	0	48,800	48,900	100
4D	NB	Murray Farm Road @ M2	3,750	3,350	-400	4,200	3,750	-450
4E	NB	Beecroft Road North of M2	18,250	18,350	100	19,950	20,150	200
4F	NB	Ryde Road South of Lady Game Drive	46,050	45,650	-400	55,750	55,300	-450

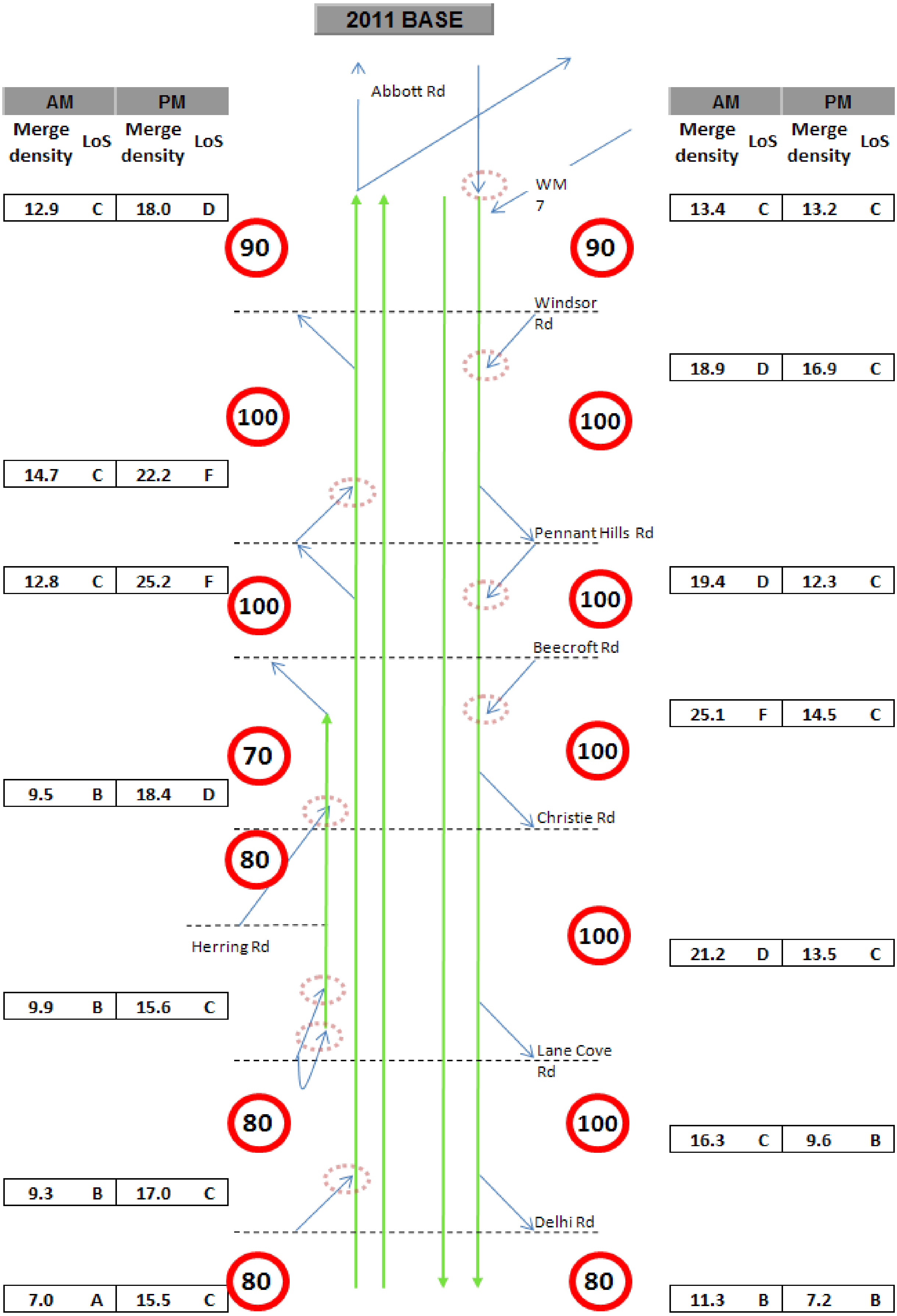
Appendix C HCM Motorway Merge and Segment Analyses

2009 BASE

AM		PM	
Density	LoS	Density	LoS
11.7	B	16.8	C
13.3	C	18.2	D
11.6	B	24.0	E
8.9	B	17.4	D
9.3	B	15.2	C
8.5	B	12.2	C
6.2	A	14.7	C

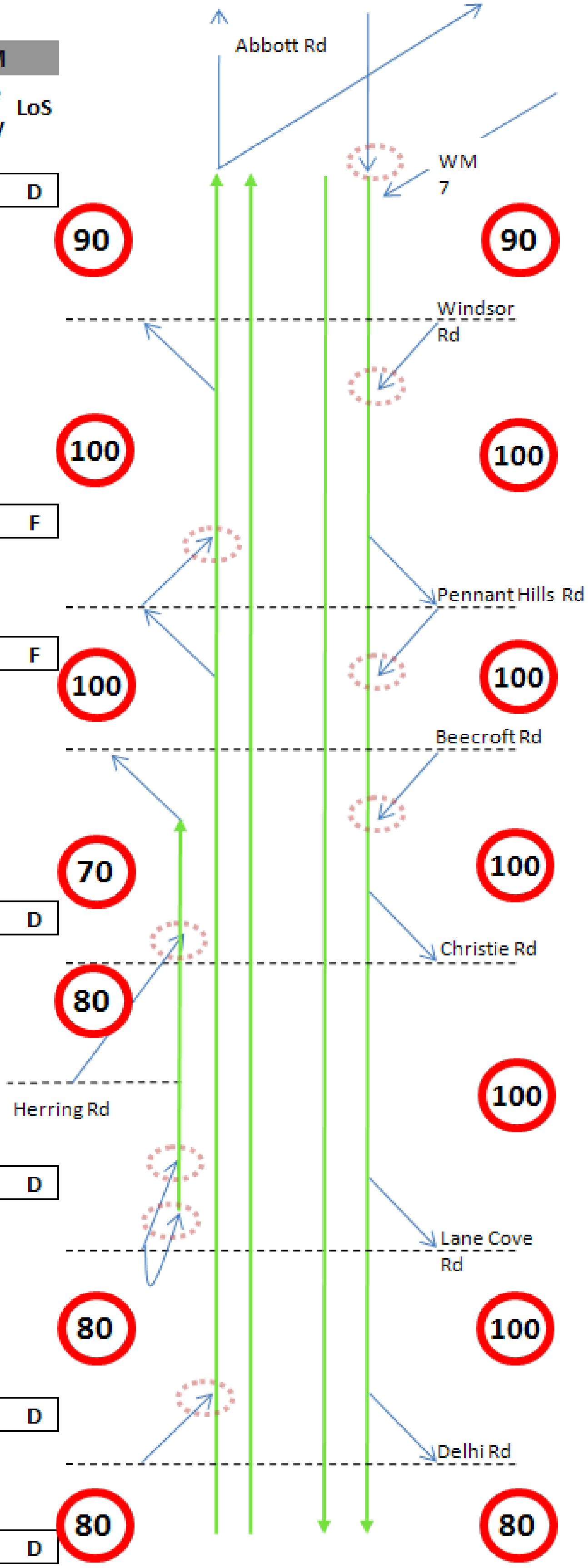


AM		PM	
Density	LoS	Density	LoS
12.6	C	9.5	B
17.8	D	11.0	B
18.4	D	10.1	B
23.7	F	9.1	B
21.0	D	12.6	C
16.3	C	8.7	B
11.3	B	6.3	A


2011 BASE
AM
PM
Merge density
LoS
Merge density
LoS
Abbott Rd
WM 7
Windsor Rd
Pennant Hills Rd
Beecroft Rd
Christie Rd
Herring Rd
Lane Cove Rd
Delhi Rd
12.9 C 18.0 D
14.7 C 22.2 F
12.8 C 25.2 F
9.5 B 18.4 D
9.9 B 15.6 C
9.3 B 17.0 C
7.0 A 15.5 C
13.4 C 13.2 C
18.9 D 16.9 C
19.4 D 12.3 C
25.1 F 14.5 C
21.2 D 13.5 C
16.3 C 9.6 B
11.3 B 7.2 B
90
100
100
70
80
80
80
90
100
100
100
100
100
80

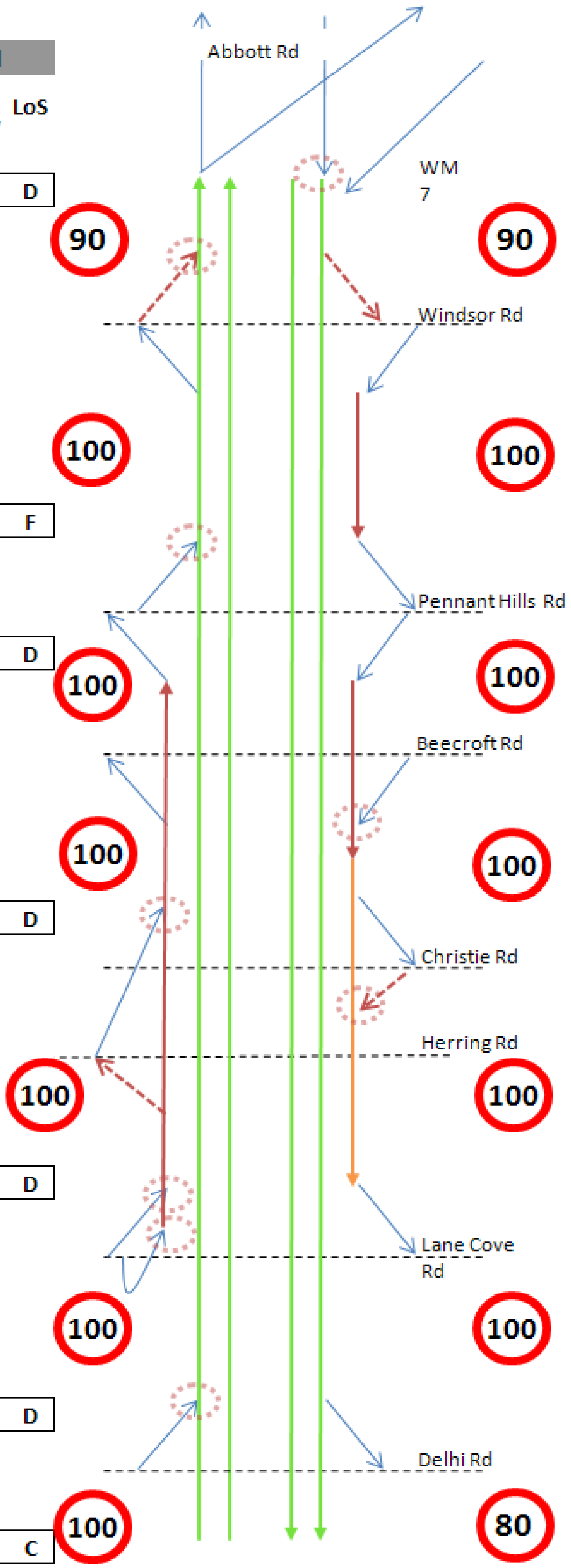
2021 BASE

AM Merge density	AM LoS	PM Merge density	PM LoS
15.7	C	19.7	D
18.2	D	22.2	F
17.1	D	29.9	F
12.2	C	20.5	D
12.4	C	17.2	D
11.4	B	19.1	D
9.2	B	18.5	D



AM Merge density	AM LoS	PM Merge density	PM LoS
16.6	C	16.0	C
23.5	F	20.9	D
23.4	F	15.8	C
29.4	F	18.3	D
24.2	E	22.8	D
17.5	D	17.8	D
11.3	B	15.0	C

2011 Upgrade

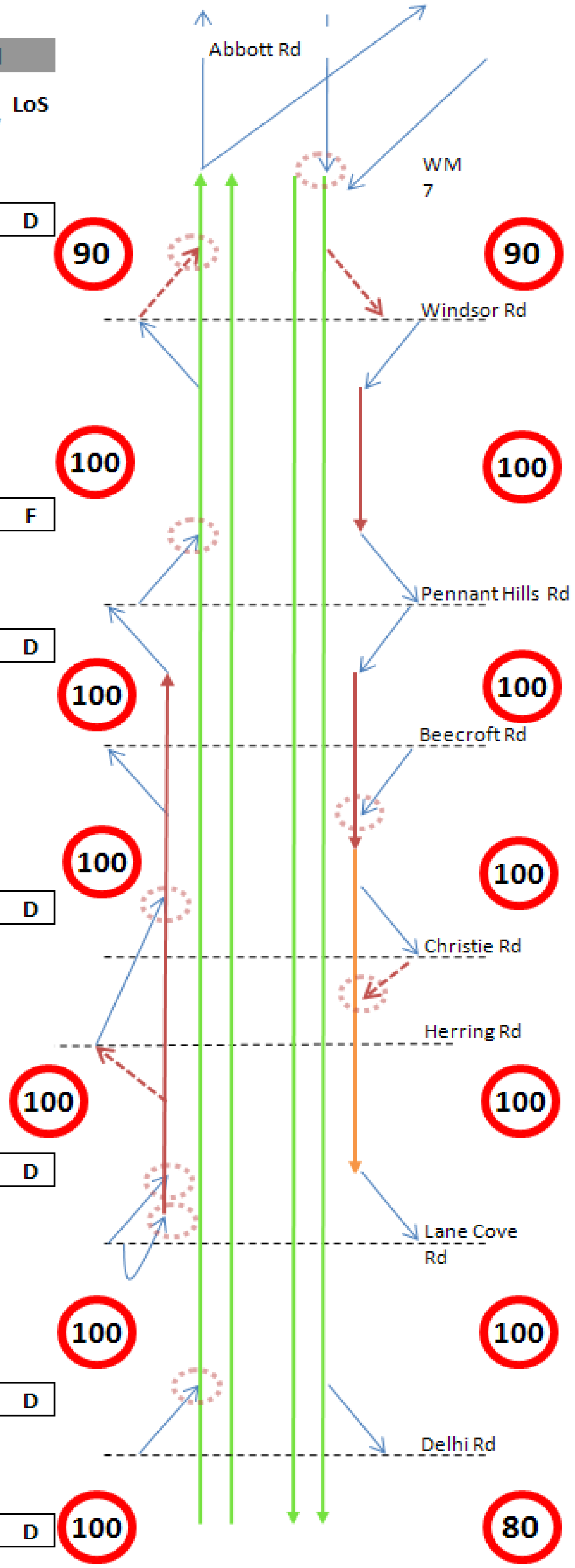


AM		PM	
Merge density	LoS	Merge density	LoS
14.6	C	19.8	D
15.0	C	22.1	F
9.3	B	18.3	D
8.9	B	18.6	D
11.6	B	17.2	D
11.4	B	18.0	D
9.2	B	16.2	C

AM		PM	
Merge density	LoS	Merge density	LoS
15.6	C	15.3	C
14.8	C	12.9	C
17.4	D	10.5	B
20.3	D	11.0	B
15.2	C	10.6	B
20.7	D	13.1	C
14.5	C	10.0	B

2021 Upgrade

AM Merge density	AM LoS	PM Merge density	PM LoS
17.8	D	19.9	D
18.8	D	22.6	F
12.6	C	19.9	D
12.0	B	21.4	D
14.4	C	19.4	D
14.1	C	20.4	D
12.1	C	18.5	D



AM Merge density	AM LoS	PM Merge density	PM LoS
18.7	D	18.7	D
18.5	D	16.3	C
23.7	F	13.9	C
18.1	D	13.5	C
23.8	E	17.8	D
16.7	C	15.0	C

Appendix D SCATES Intersection Analyses

SCATES Modelling of Lane Cove Road Intersections

Extent of Model

Four intersections were modelled along the Lane Cove Road corridor:

- TCS 195 Epping Road
- TCS 1012 Waterloo Road
- TCS 1799 Talavera Road
- TCS 3161 M2 Ramps.

Data Collection

Geometry, gradients and lane lengths were taken from TCS plans, and aerial photos. Percentage phase splits and cycle lengths set using IDM data supplied by Transurban. Offset data obtained from SCATS for AM and PM peaks. Standard SCATES lane saturation flows used (adjusted upwards on the left turn to the M2 on ramp to reflect through alignment).

Volumes supplied by Transurban in spreadsheet HALCROWSCATES_TALAVERA_LCR.xlsx for existing and future scenarios:

- Base (existing)
- 2011 status quo
- 2011 with upgrading
- 2021 status quo
- 2021 with upgrading.

Proportion heavy vehicles taken from SIDRA files of the intersections supplied by Transurban. No data was supplied for future proportions of heavy vehicles, so the existing proportions were applied to the future scenarios. There are no changes to the road network itself for the future scenarios, only to the volumes.

SCATES Results

Results were extracted for two scenarios – the first being using the existing phase splits and offsets for all future scenarios, and the second allowing SCATES to optimise the phase splits and offsets, within the existing cycle length.

Table 1 – Lane Cove Road Base Results

Intersection	AM Peak			PM Peak		
	Avg Delay	**LoS**	**X-value**	**Avg Delay**	**LoS**	**X-value**
Existing Timing						
Lane Cove Rd	65	E	1.09	78	F	1.80
Waterloo Rd	107	F	1.01	56	D	1.45
Talavera Rd	25	B	1.02	90	F	1.44
M2 Ramps	8	A	0.80	7	A	0.81
SCATES Optimised						
Lane Cove Rd	42	C	0.77	32	C	0.86
Waterloo Rd	44	D	0.88	57	E	0.97
Talavera Rd	19	B	0.81	70	E	1.01
M2 Ramps	9	A	0.83	5	A	0.72

Table 2 – Lane Cove Road 2011 Results No Upgrading

Intersection	AM Peak			PM Peak		
	Avg Delay	**LoS**	**X-value**	**Avg Delay**	**LoS**	**X-value**
Existing Timing						
Lane Cove Rd	96	F	>1.0	77	F	>1.0
Waterloo Rd	126	F	>1.0	66	E	>1.0
Talavera Rd	58	E	>1.0	99	F	>1.0
M2 Ramps	12	A	0.82	6	A	0.79
SCATES Optimised						
Lane Cove Rd	60	E	0.79	32	C	0.89
Waterloo Rd	50	D	0.91	61	E	0.94
Talavera Rd	19	B	0.81	84	F	>1.0
M2 Ramps	11	A	0.86	5	A	0.73

Table 3 – Lane Cove Road 2011 Results With Upgrading

Intersection	AM Peak			PM Peak		
	Avg Delay	**LoS**	**X-value**	**Avg Delay**	**LoS**	**X-value**
Existing Timing						
Lane Cove Rd	48	D	0.78	28	C	0.88
Waterloo Rd	44	D	0.91	65	E	0.93
Talavera Rd	55	D	0.82	112	F	>1.0
M2 Ramps	12	A	0.89	6	A	0.75
SCATES Optimised						
Lane Cove Rd	49	D	0.78	31	C	0.88
Waterloo Rd	48	D	0.91	53	D	0.93
Talavera Rd	20	B	0.82	109	F	>1.0
M2 Ramps	12	A	0.89	6	A	0.75

Table 4 – Lane Cove Road 2021 Results No Upgrading

Intersection	AM Peak			PM Peak		
	Avg Delay	LoS	X-value	Avg Delay	LoS	X-value
Existing Timing						
Lane Cove Rd	320	F	>1.0	86	F	>1.0
Waterloo Rd	178	F	>1.0	110	F	>1.0
Talavera Rd	56	D	>1.0	218	F	>1.0
M2 Ramps	49	D	>1.0	9	A	0.91
SCATES Optimised						
Lane Cove Rd	145	F	0.96	44	D	0.99
Waterloo Rd	136	F	>1.0	113	F	>1.0
Talavera Rd	13	A	0.87	195	F	>1.0
M2 Ramps	29	C	>1.0	6	A	0.82

Table 5 – Lane Cove Road 2021 Results With Upgrading

Intersection	AM Peak			PM Peak		
	Avg Delay	LoS	X-value	Avg Delay	LoS	X-value
Existing Timing						
Lane Cove Rd	122	F	>1.0	63	E	>1.0
Waterloo Rd	177	F	>1.0	65	E	>1.0
Talavera Rd	42	C	>1.0	228	F	>1.0
M2 Ramps	123	F	>1.0	26	B	>1.0
SCATES Optimised						
Lane Cove Rd	71	F	0.82	37	C	0.94
Waterloo Rd	106	F	>1.0	57	E	0.97
Talavera Rd	13	A	0.88	211	F	>1.0
M2 Ramps	48	D	>1.0	9	A	0.83

Notes:

The detailed results indicate that in many instances, the degree of saturation >1.0 occurs on a minor movement with low volumes while the majority of movements have acceptable degrees of saturation.

SCATES Modelling of Talavera Road Intersections

Extent of Model

Four intersections were modelled along the Talavera Road corridor:

- TCS 3170 Khartoum Road
- TCS 3299 Alma Road/Macquarie Centre access
- TCS 3162 Herring Road/M2 ramp
- TCS3167 Christie Road.

Data Collection

Geometry, gradients and lane lengths were taken from TCS plans, and aerial photos. Percentage phase splits and cycle lengths set using IDM data supplied by Transurban. SCATES optimised offset has been adopted. Standard SCATES lane saturation flows used.

Volumes supplied by Transurban in spreadsheet HALCROWSCATES_TALEVERA_LCR.xlsx for existing and future scenarios:

- Base (existing)
- 2011 status quo
- 2011 with upgrading
- 2021 status quo
- 2021 with upgrading.

Proportion heavy vehicles have been estimated from SIDRA files of the intersections supplied by Transurban. No data was supplied for future proportions of heavy vehicles, so the existing proportions were applied to the future scenarios.

Under the 2011/2021 with upgrade options, Herring Road/M2 ramp and Christie Road intersection layouts have been modified according to the concept designs provided by Transurban. All other intersections were analysed using the existing intersection layout.

SCATES Results

Results were extracted for two scenarios – the first being using the existing phase splits and offsets for all future scenarios, and the second allowing SCATES to optimise the phase splits and offsets, within the existing cycle length.

The results for Alma Road/Macquarie Centre access were not reported as phase split and cycle length information was not provided to calibrate the model.

Table 1 – Talavera Road Base Results

Intersection	AM Peak Hour LOS	AM Peak Hour Average Delay (S)	AM Peak Hour DOS	PM Peak Hour LOS	PM Peak Hour Average Delay (S)	PM Peak Hour DOS
Existing Timing						
I3 - Christie Rd - Talavera Rd	C	42	0.98	A	8	0.55
I4 - Herring Rd - Talavera Rd	B	26	0.68	B	18	0.83
I6 - Khartoum Rd - Talavera Rd	B	28	>1.0	B	26	0.96
SCATES Optimised						
I3 - Christie Rd - Talavera Rd	B	27	0.95	A	6	0.53
I4 - Herring Rd - Talavera Rd	D	45	0.62	A	12	0.66
I6 - Khartoum Rd - Talavera Rd	D	48	0.58	A	10	0.76

Table 2 – Talavera Road 2011 Results No Upgrading

Intersection	AM Peak Hour LOS	AM Peak Hour Average Delay (S)	AM Peak Hour DOS	PM Peak Hour LOS	PM Peak Hour Average Delay (S)	PM Peak Hour DOS
Existing Timing						
I3 - Christie Rd - Talavera Rd	F	98	>1.0	A	8	0.59
I4 - Herring Rd - Talavera Rd	C	31	0.72	B	17	0.94
I6 - Khartoum Rd - Talavera Rd	B	26	>1.0	C	38	>1.0
SCATES Optimised						
I3 - Christie Rd - Talavera Rd	F	90	>1.0	A	6	0.57
I4 - Herring Rd - Talavera Rd	C	35	0.67	B	16	0.72
I6 - Khartoum Rd - Talavera Rd	C	41	0.62	A	14	0.82

Table 3 – Talavera Road 2011 Results With Upgrading

Intersection	AM Peak Hour LOS	AM Peak Hour Average Delay (S)	AM Peak Hour DOS	PM Peak Hour LOS	PM Peak Hour Average Delay (S)	PM Peak Hour DOS
SCATES Optimised						
I3 - Christie Rd - Talavera Rd	C	40	0.91	A	5	0.56
I4 - Herring Rd - Talavera Rd	E	57	0.92	B	22	0.77
I6 - Khartoum Rd - Talavera Rd	C	37	0.65	B	16	0.83

Table 4 – Talavera Road 2021 Results No Upgrading

Intersection	AM Peak Hour			PM Peak Hour		
	LOS	Average Delay (S)	DOS	LOS	Average Delay (S)	DOS
Existing Timing						
I3 - Christie Rd - Talavera Rd	F	544	>1.0	A	9	0.77
I4 - Herring Rd - Talavera Rd	B	22	0.89	B	22	>1.0
I6 - Khartoum Rd - Talavera Rd	B	22	>1.0	F	110	>1.0
SCATES Optimised						
I3 - Christie Rd - Talavera Rd	F	495	>1.0	A	12	0.75
I4 - Herring Rd - Talavera Rd	C	34	0.80	C	34	0.79
I6 - Khartoum Rd - Talavera Rd	C	37	0.72	E	57	0.95

Table 5 – Talavera Road 2021 Results With Upgrading

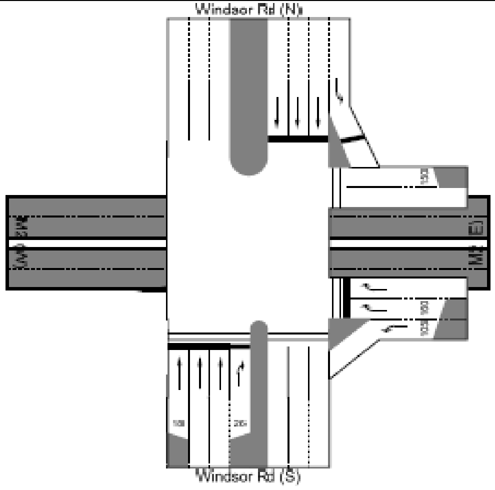
Intersection	AM Peak Hour			PM Peak Hour		
	LOS	Average Delay (S)	DOS	LOS	Average Delay (S)	DOS
SCATES Optimised						
I3 - Christie Rd - Talavera Rd	F	190	>1.0	A	9	0.58
I4 - Herring Rd - Talavera Rd	F	92	>1.0	C	40	0.84
I6 - Khartoum Rd - Talavera Rd	C	33	0.75	F	136	>1.0

NOTE: For 2011/2021 with upgrade scenarios, the phasing was modified at all intersections to reflect the change in intersection layouts and traffic volumes.

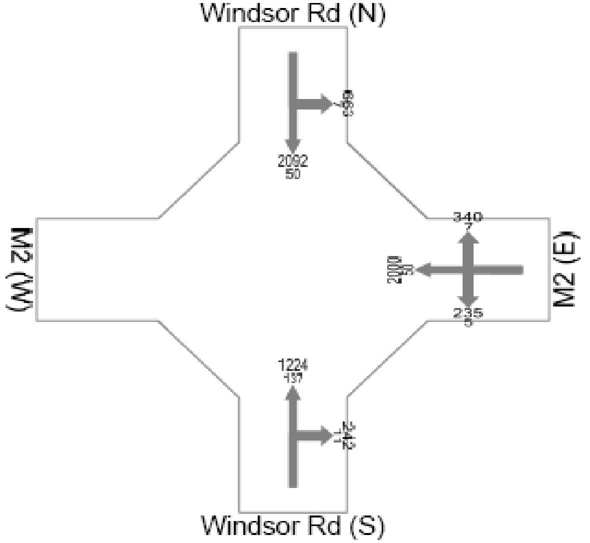
Appendix E SIDRA Intersection Analyses

Windsor Road / M2 Motorway 2009 Base (Existing) AM

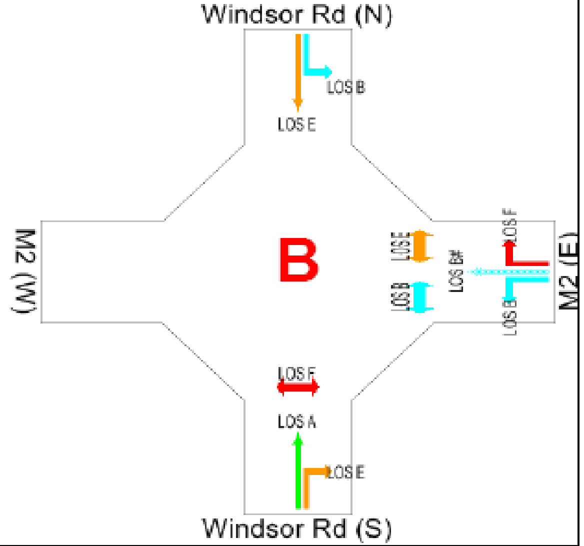
Layout



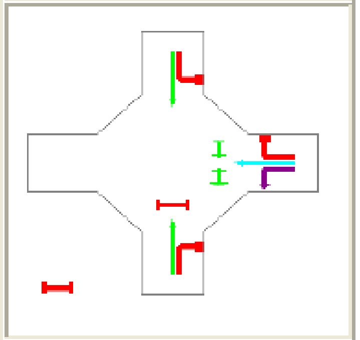
Volumes



Level of Service

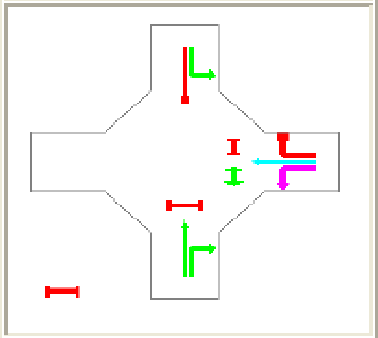


Phase A



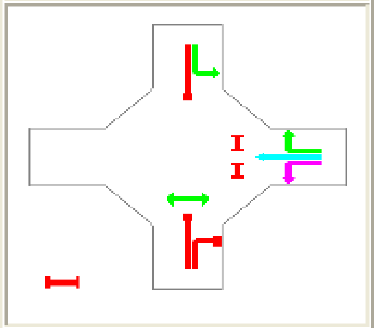
Green Time = **53** seconds
Phase Time = **60** seconds
Phase Split = **43** %

Phase B



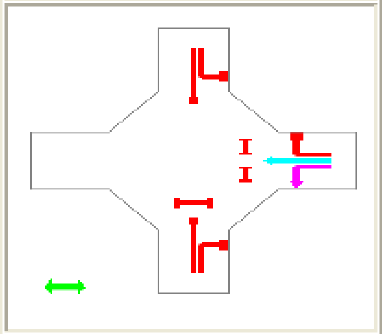
Green Time = **41** seconds
Phase Time = **48** seconds
Phase Split = **34** %

Phase C



Green Time = **20** seconds
Phase Time = **27** seconds
Phase Split = **19** %

Phase D (bus phase)

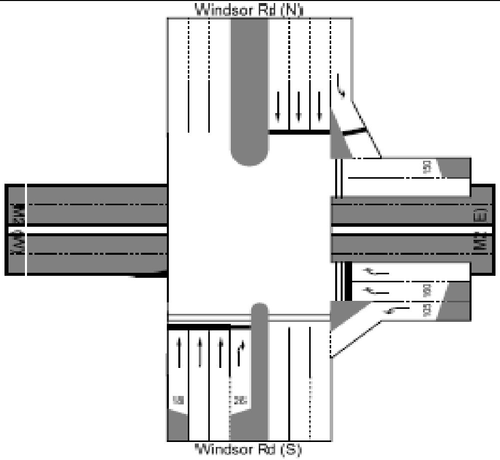
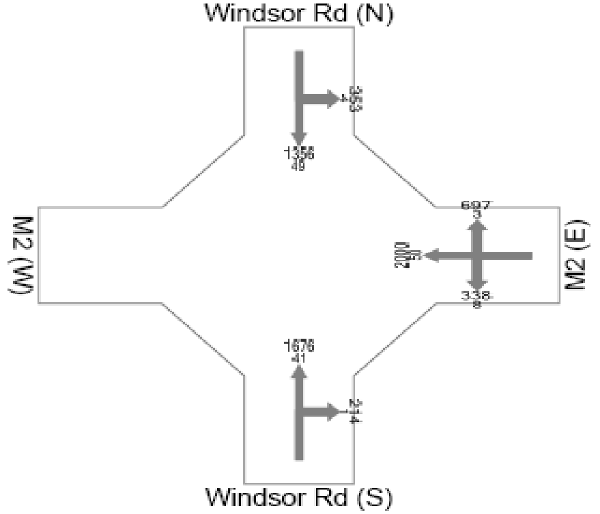
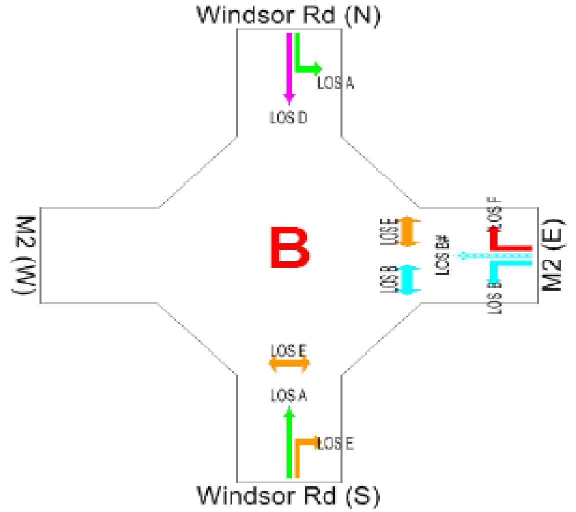


Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **4** %

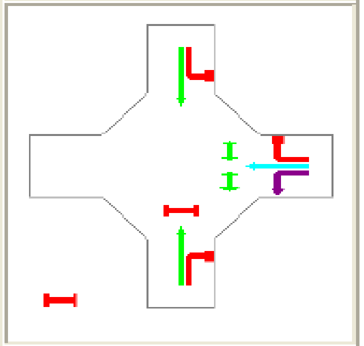
C = **140** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2009 Base (Existing) PM

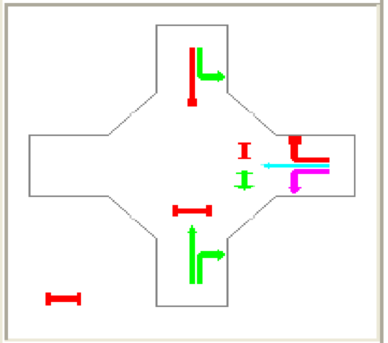
Layout	Volumes	Level of Service
		

Phase A



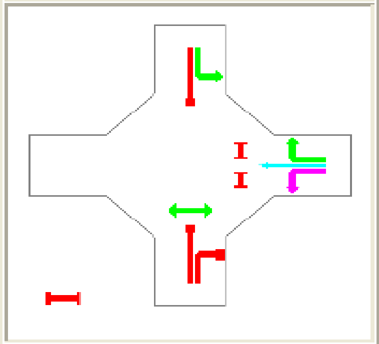
Green Time = **37** seconds
Phase Time = **44** seconds
Phase Split = **31** %

Phase B



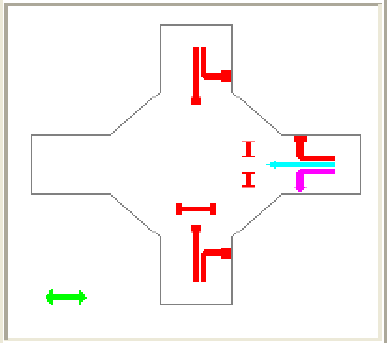
Green Time = **47** seconds
Phase Time = **54** seconds
Phase Split = **39** %

Phase C



Green Time = **28** seconds
Phase Time = **35** seconds
Phase Split = **25** %

Phase D (bus phase)



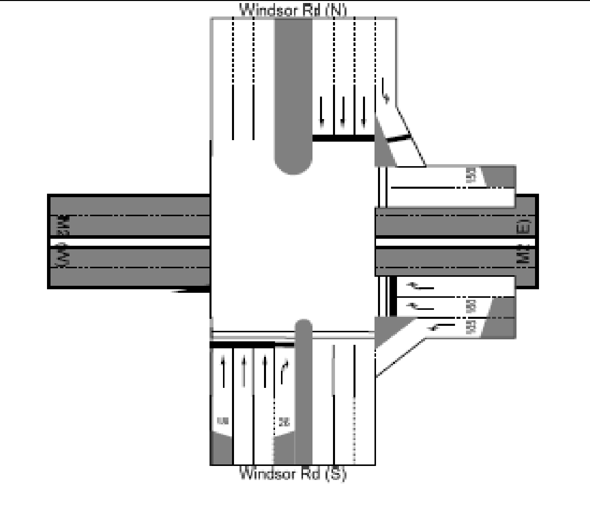
Green Time = **1** seconds
Phase Time = **7** seconds
Phase Split = **5** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

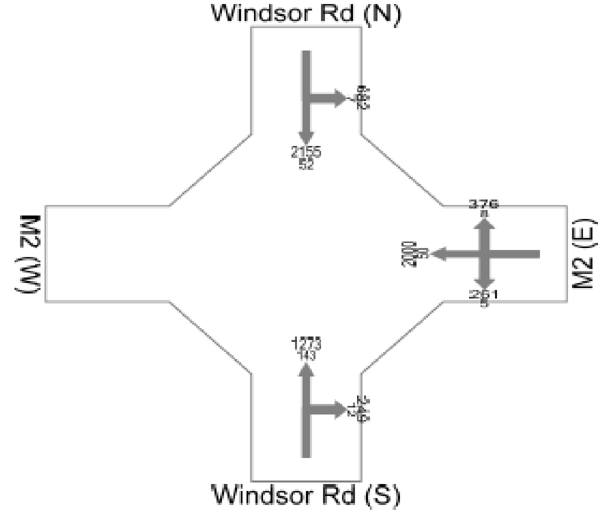
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2011 Status Quo AM

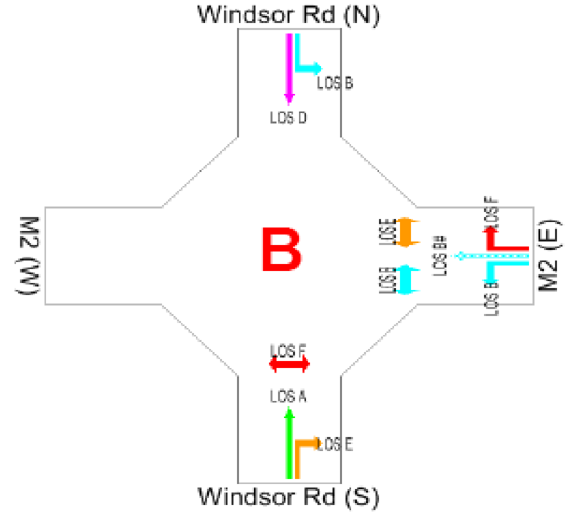
Layout



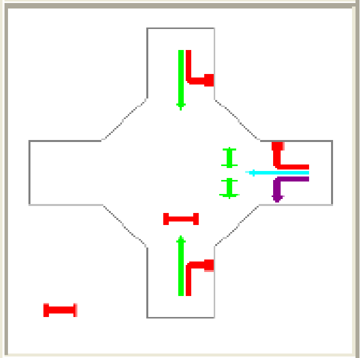
Volumes



Level of Service

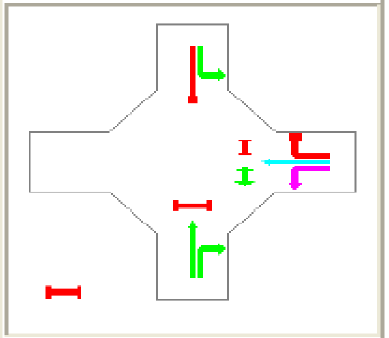


Phase A



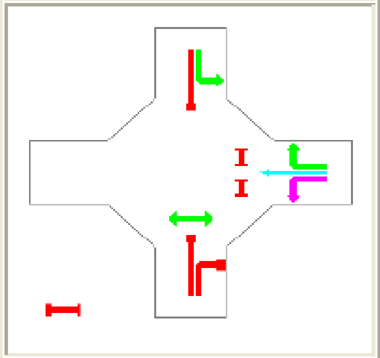
Green Time = **55** seconds
Phase Time = **62** seconds
Phase Split = **44** %

Phase B



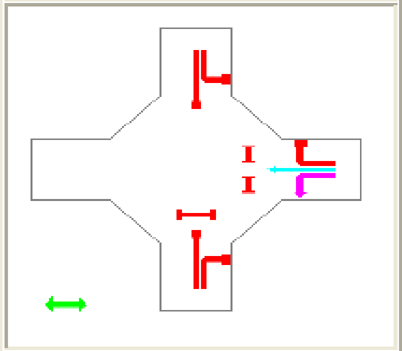
Green Time = **39** seconds
Phase Time = **46** seconds
Phase Split = **33** %

Phase C



Green Time = **20** seconds
Phase Time = **27** seconds
Phase Split = **19** %

Phase D (bus phase)



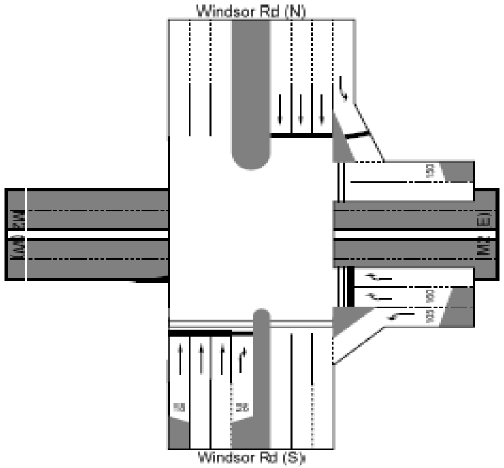
Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **4** %

C = **140** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

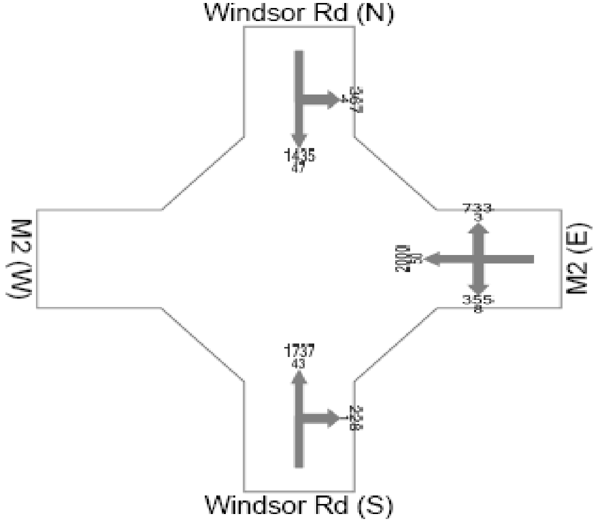
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2011 Status Quo PM

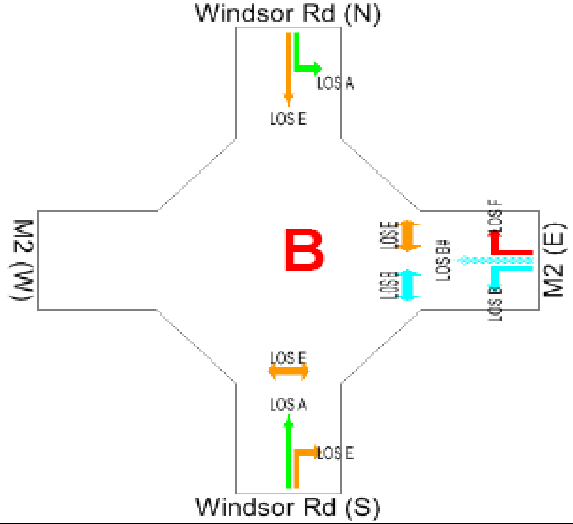
Layout



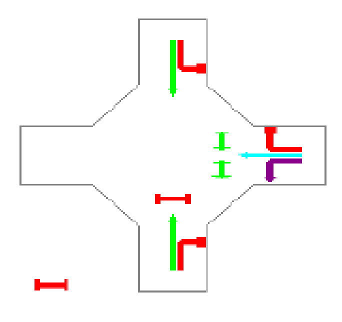
Volumes



Level of Service

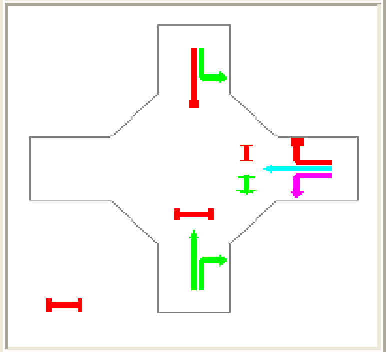


Phase A



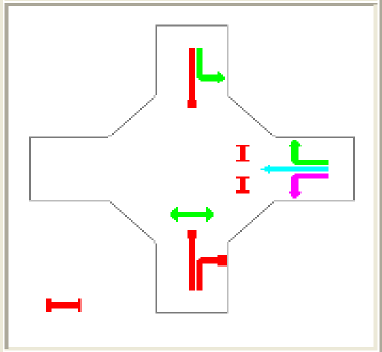
Green Time = **38** seconds
Phase Time = **45** seconds
Phase Split = **32** %

Phase B



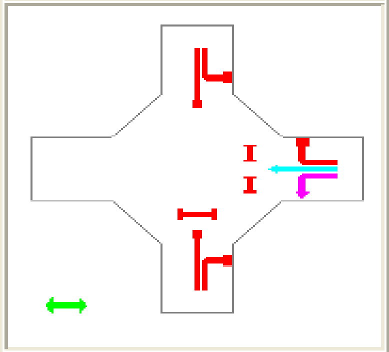
Green Time = **45** seconds
Phase Time = **52** seconds
Phase Split = **37** %

Phase C



Green Time = **29** seconds
Phase Time = **36** seconds
Phase Split = **26** %

Phase D (bus phase)

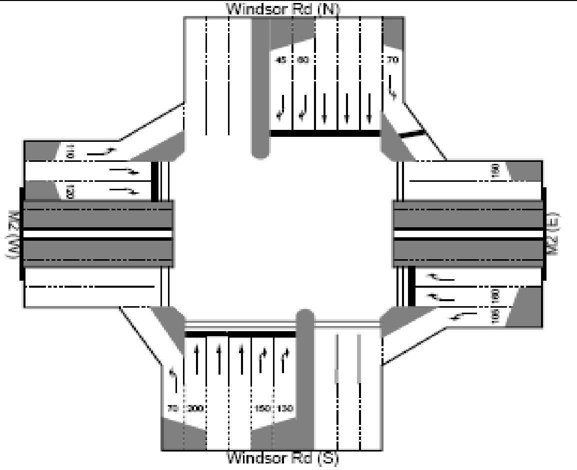
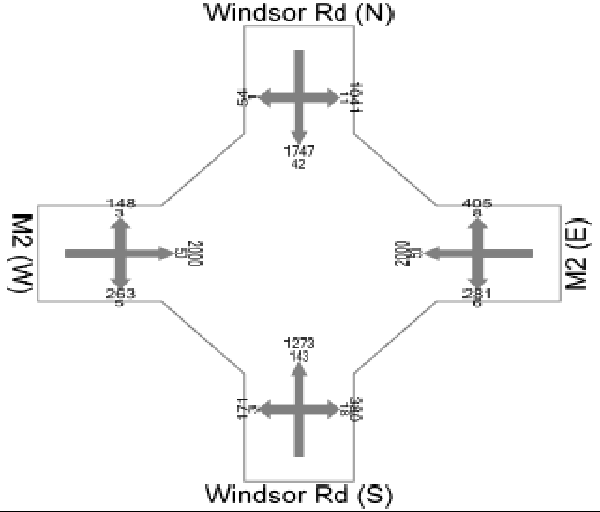
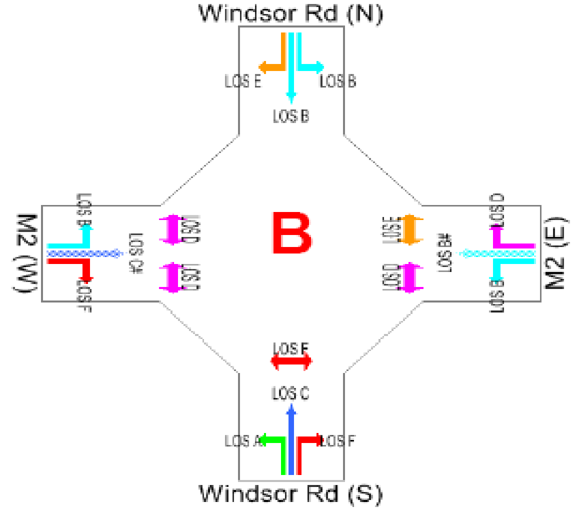


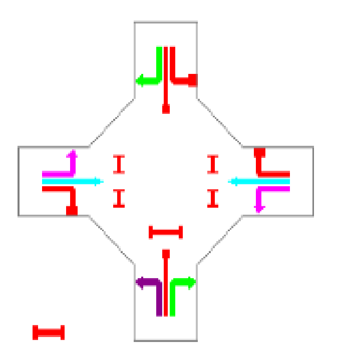
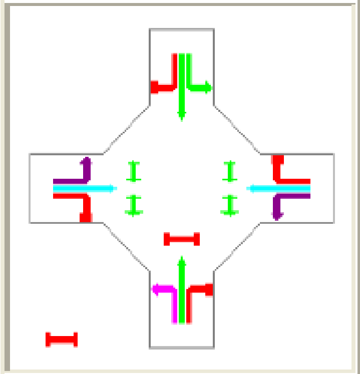
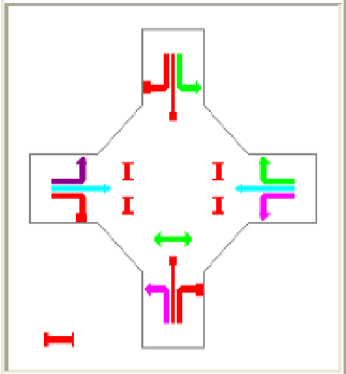
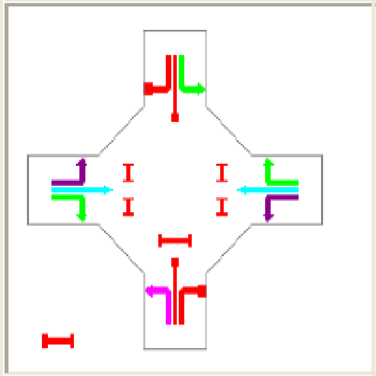
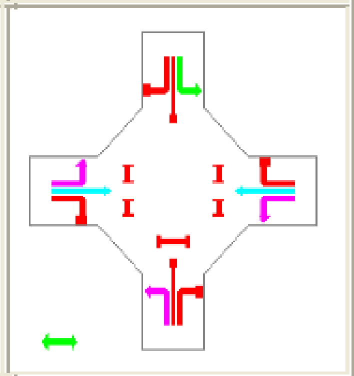
Green Time = **1** seconds
Phase Time = **7** seconds
Phase Split = **5** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2011 with Upgrade AM

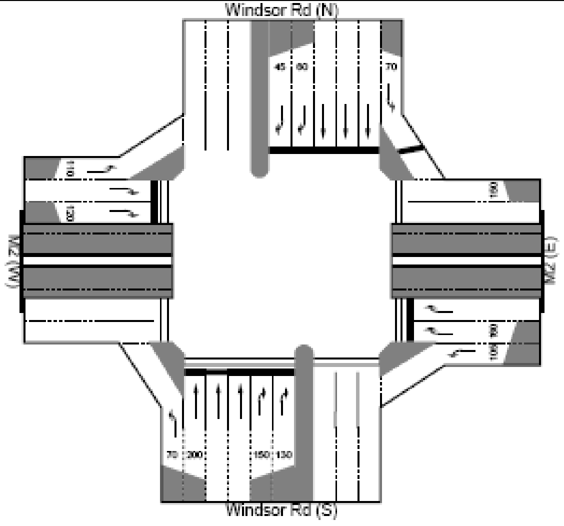
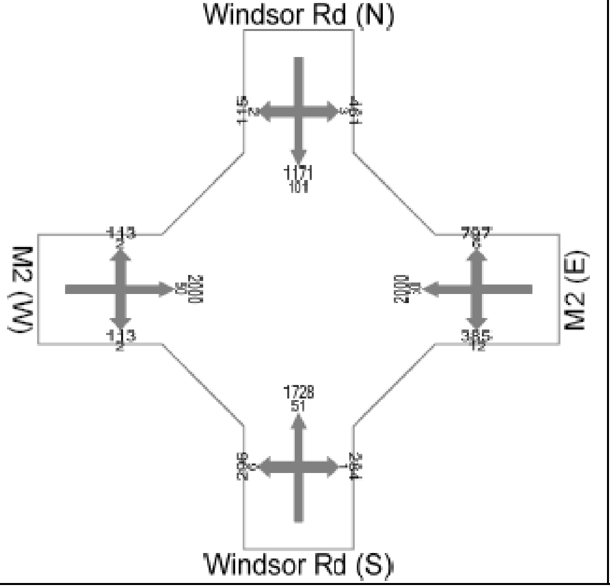
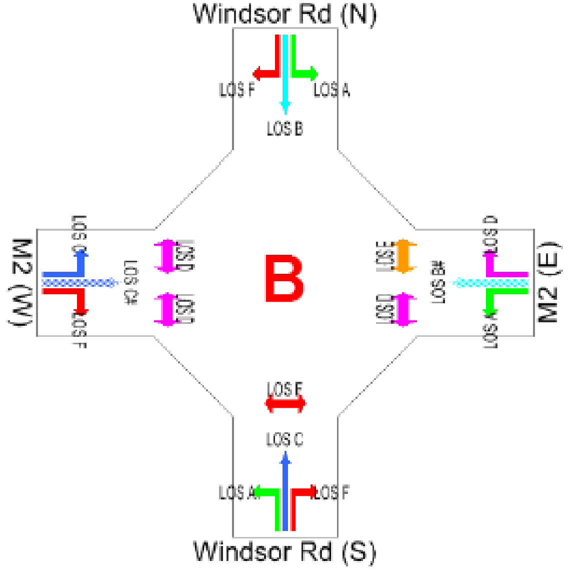
Layout	Volumes	Level of Service
		

Phase G	Phase A	Phase C1	Phase C	Phase D (bus phase)
				
Green Time = **21** seconds Phase Time = **27** seconds Phase Split = **18** %	Green Time = **58** seconds Phase Time = **65** seconds Phase Split = **43** %	Green Time = **24** seconds Phase Time = **31** seconds Phase Split = **21** %	Green Time = **15** seconds Phase Time = **22** seconds Phase Split = **15** %	Green Time = **1** seconds Phase Time = **5** seconds Phase Split = **3** %

C = **150** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

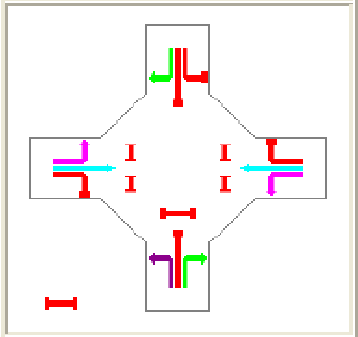
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2011 with Upgrade PM

Layout	Volumes	Level of Service
		

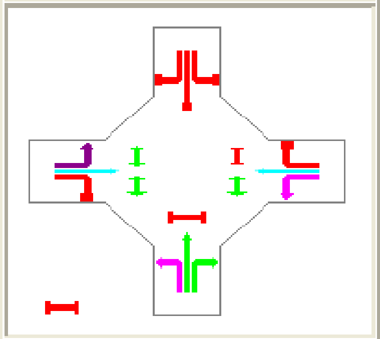
Windsor Road / M2 Motorway 2011 with Upgrade PM

Phase G



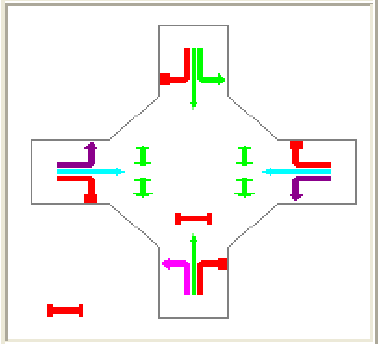
Green Time = **7** seconds
Phase Time = **13** seconds
Phase Split = **9** %

Phase A2



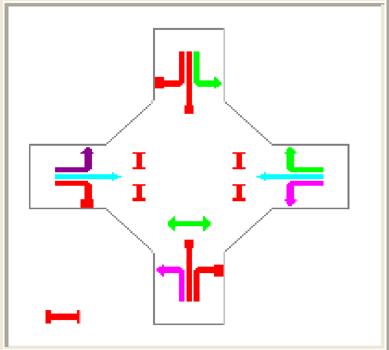
Green Time = **7** seconds
Phase Time = **14** seconds
Phase Split = **9** %

Phase A



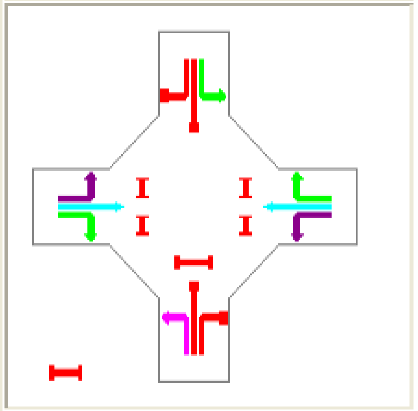
Green Time = **54** seconds
Phase Time = **61** seconds
Phase Split = **41** %

Phase C1



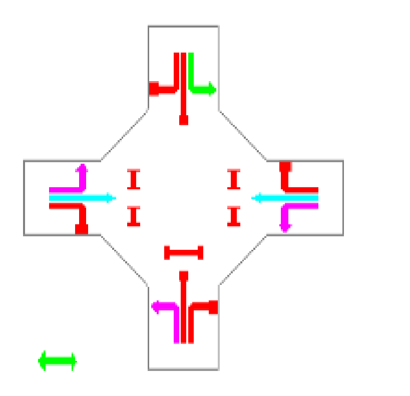
Green Time = **24** seconds
Phase Time = **31** seconds
Phase Split = **21** %

Phase C



Green Time = **19** seconds
Phase Time = **26** seconds
Phase Split = **17** %

Phase D (bus phase)



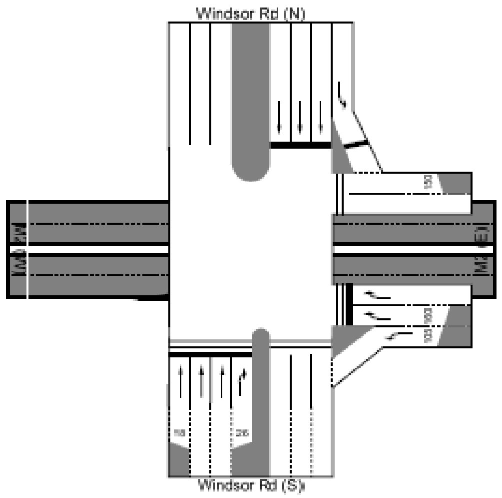
Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

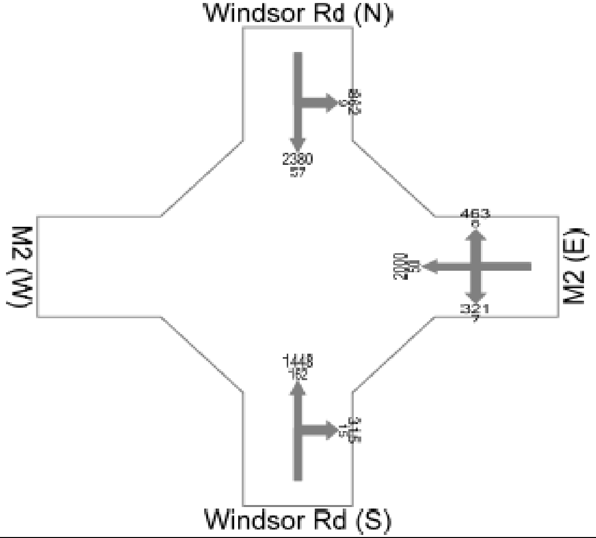
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2021 Status Quo AM

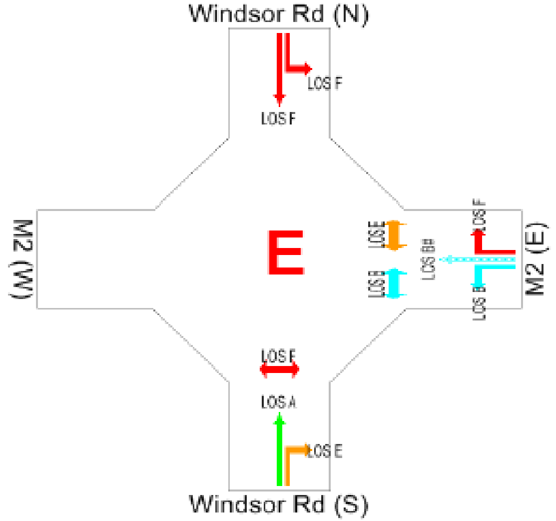
Layout



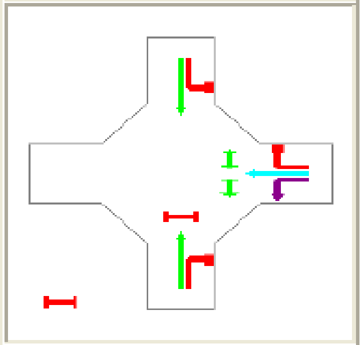
Volumes



Level of Service

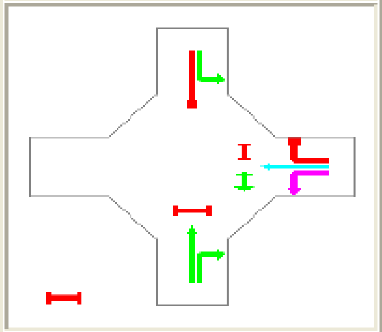


Phase A



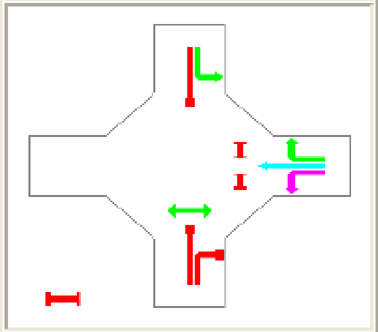
Green Time = **57** seconds
Phase Time = **64** seconds
Phase Split = **46** %

Phase B



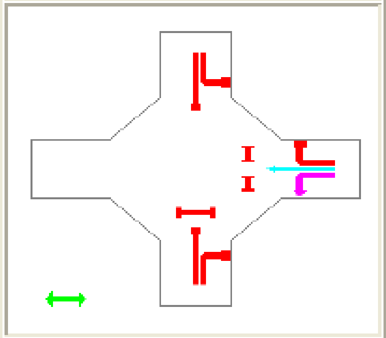
Green Time = **37** seconds
Phase Time = **44** seconds
Phase Split = **31** %

Phase C



Green Time = **20** seconds
Phase Time = **27** seconds
Phase Split = **19** %

Phase D (bus phase)



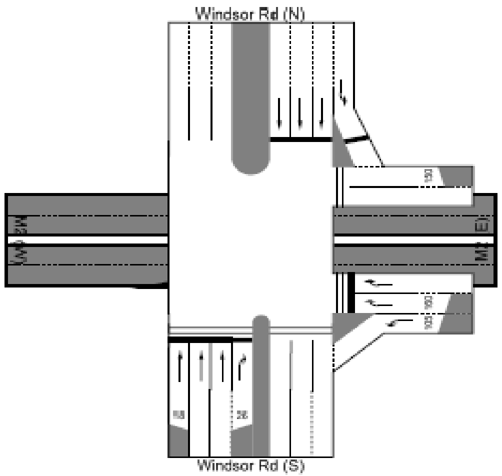
Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **4** %

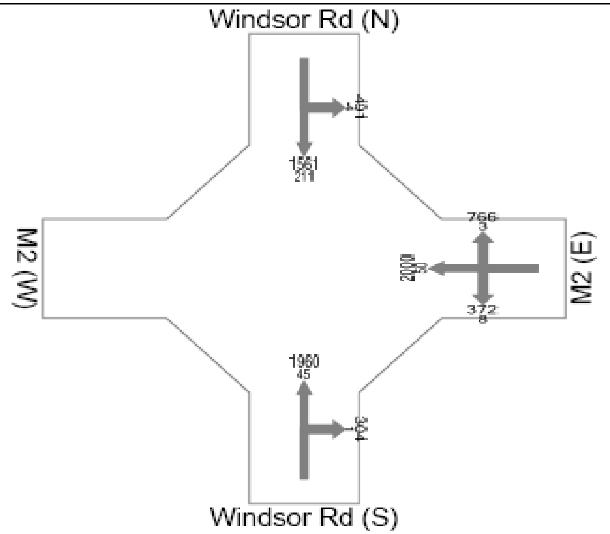
C = **140** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

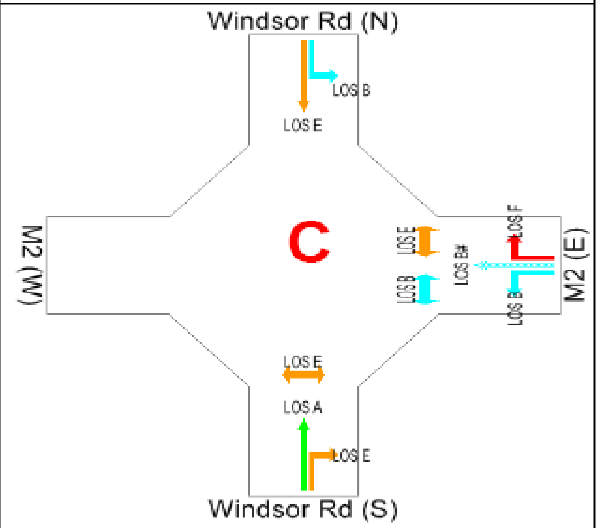
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2021 Status Quo PM

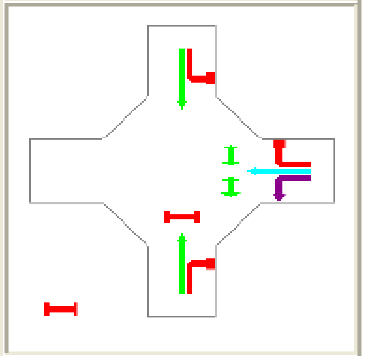
Layout	Volumes	Level of Service





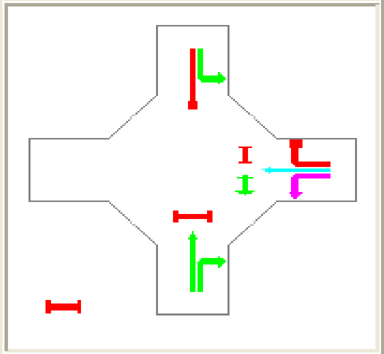


Phase A



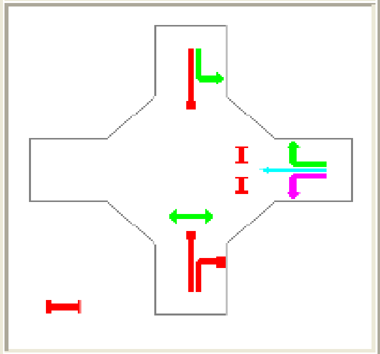
Green Time = **47** seconds
Phase Time = **54** seconds
Phase Split = **39** %

Phase B



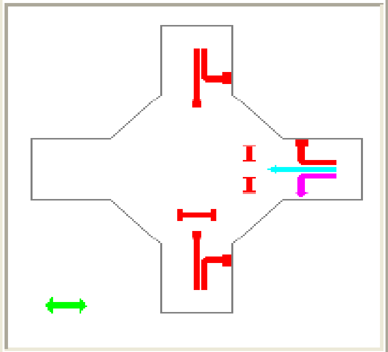
Green Time = **35** seconds
Phase Time = **42** seconds
Phase Split = **30** %

Phase C



Green Time = **30** seconds
Phase Time = **37** seconds
Phase Split = **26** %

Phase D (bus phase)



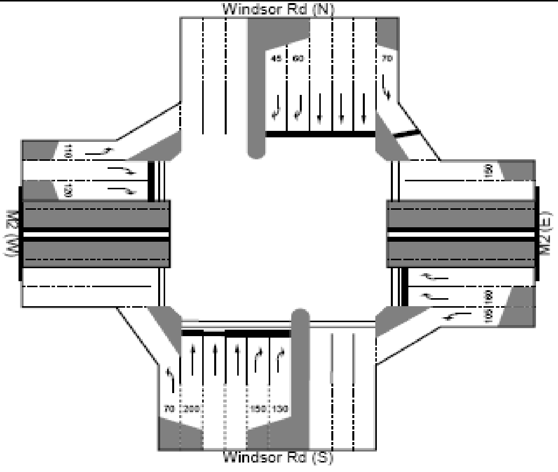
Green Time = **1** seconds
Phase Time = **7** seconds
Phase Split = **5** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

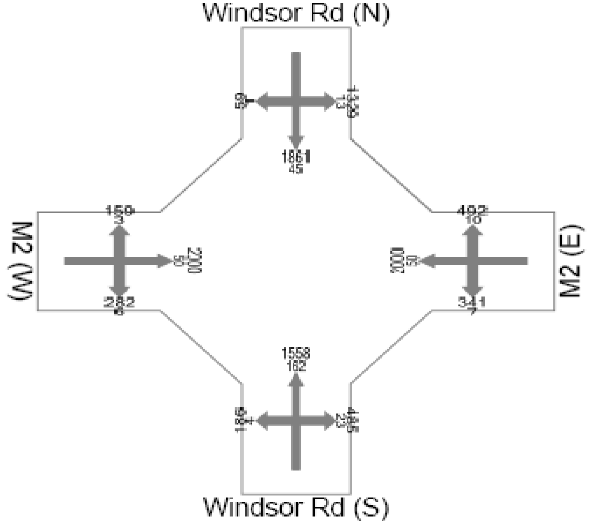
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2021 with Upgrade AM

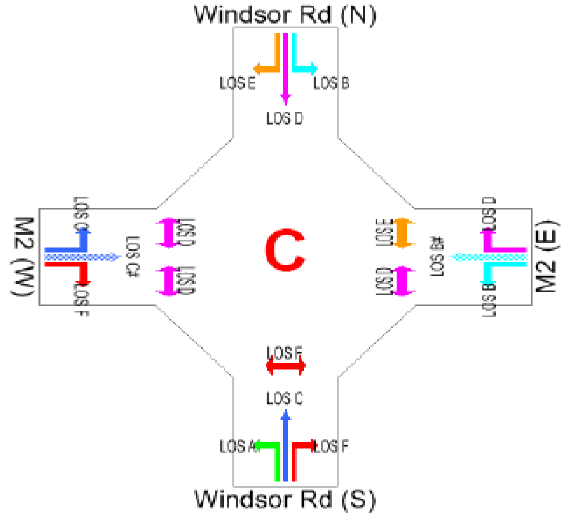
Layout



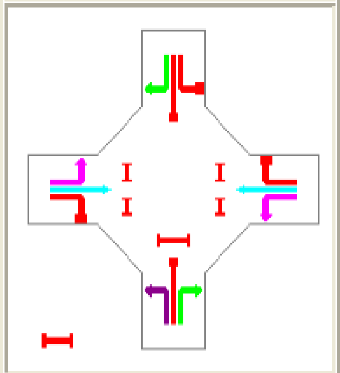
Volumes



Level of Service

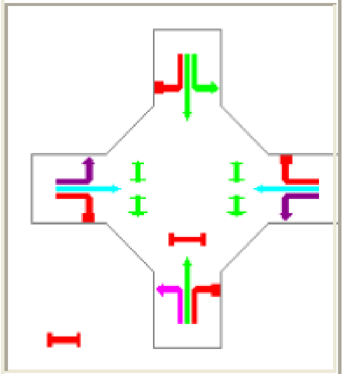


Phase G



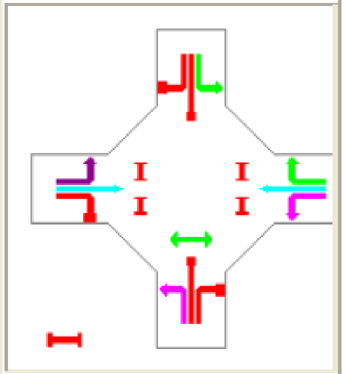
Green Time = **23** seconds
Phase Time = **29** seconds
Phase Split = **19** %

Phase A



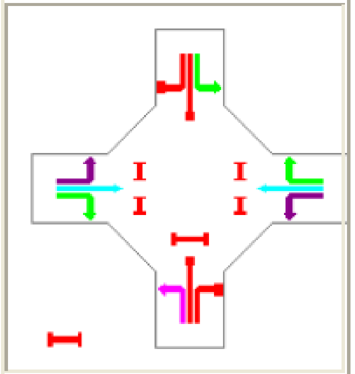
Green Time = **58** seconds
Phase Time = **65** seconds
Phase Split = **43** %

Phase C1



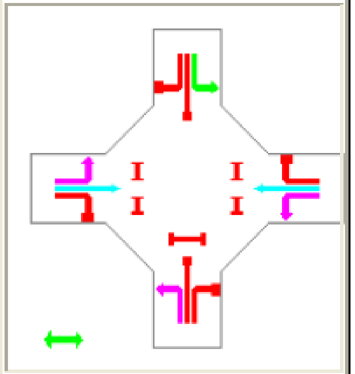
Green Time = **24** seconds
Phase Time = **31** seconds
Phase Split = **21** %

Phase C



Green Time = **13** seconds
Phase Time = **20** seconds
Phase Split = **13** %

Phase D (bus phase)



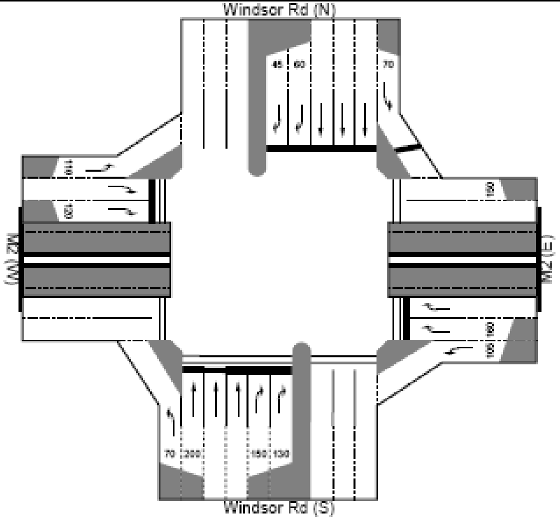
Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

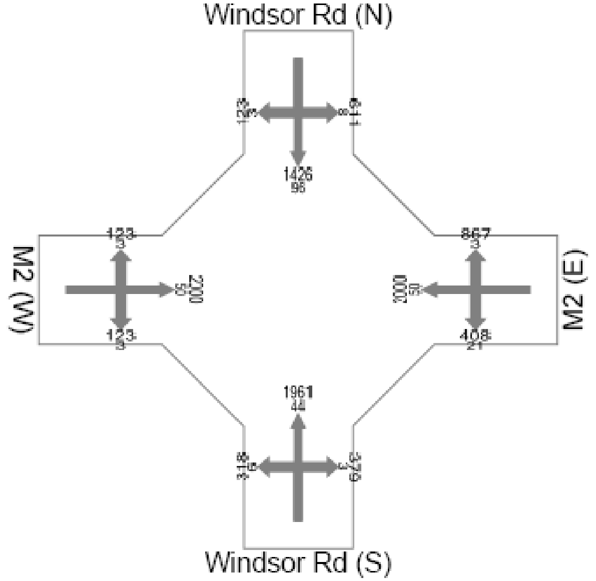
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Windsor Road / M2 Motorway 2021 with Upgrade PM

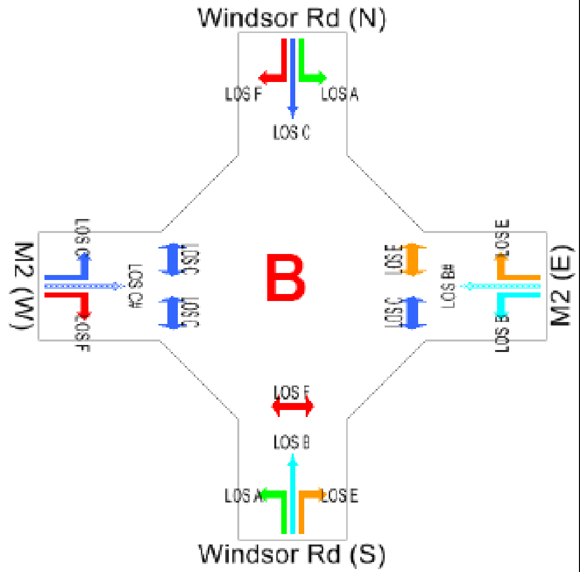
Layout



Volumes

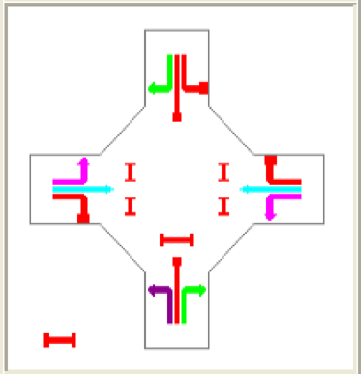


Level of Service



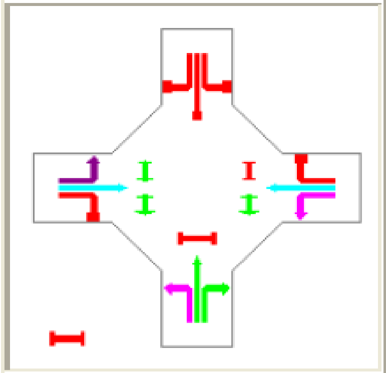
Windsor Road / M2 Motorway 2021 with Upgrade PM

Phase G



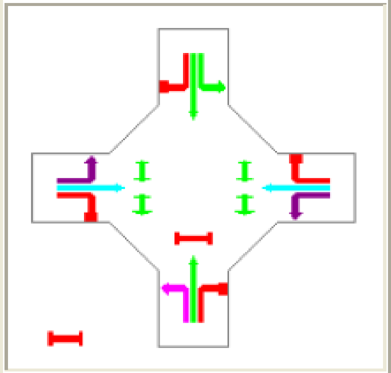
Green Time = **7** seconds
Phase Time = **13** seconds
Phase Split = **9** %

Phase A2



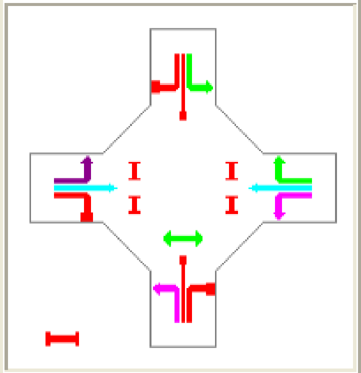
Green Time = **19** seconds
Phase Time = **26** seconds
Phase Split = **17** %

Phase A



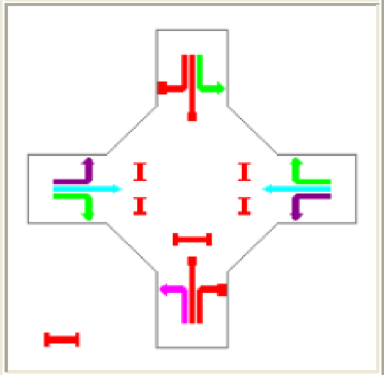
Green Time = **49** seconds
Phase Time = **56** seconds
Phase Split = **37** %

Phase C1



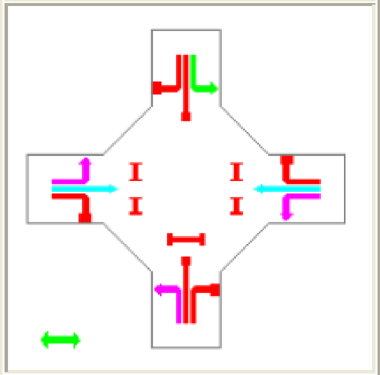
Green Time = **26** seconds
Phase Time = **33** seconds
Phase Split = **22** %

Phase C



Green Time = **10** seconds
Phase Time = **17** seconds
Phase Split = **11** %

Phase D (bus phase)



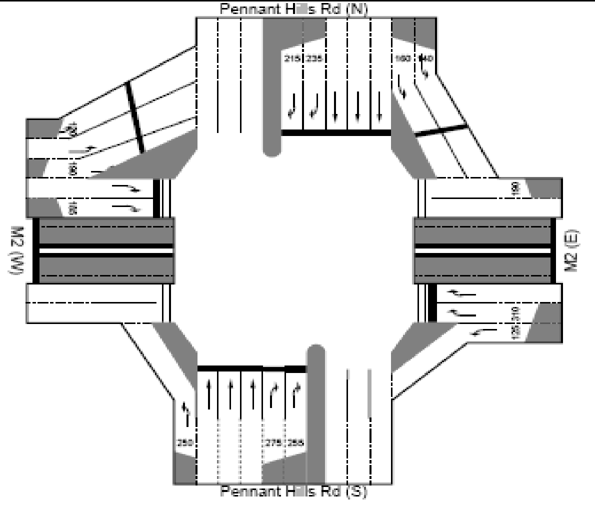
Green Time = **1** seconds
Phase Time = **5** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

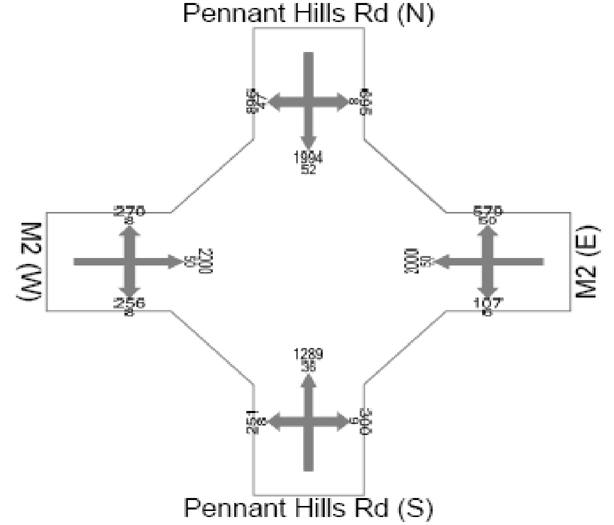
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2009 Base (Existing) AM

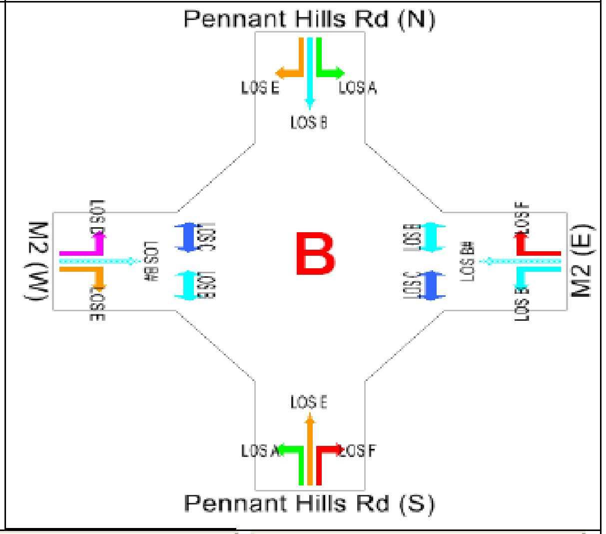
Layout



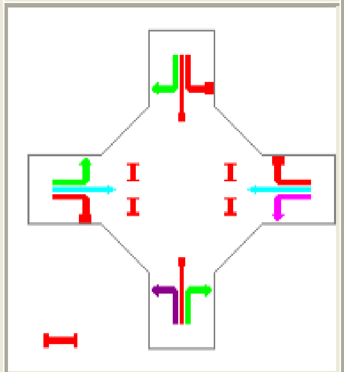
Volumes



Level of Service

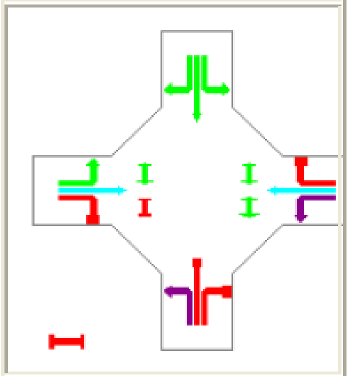


Phase G



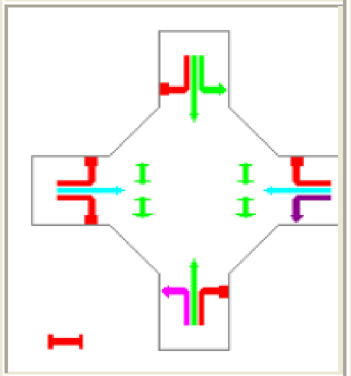
Green Time = **18** seconds
Phase Time = **25** seconds
Phase Split = **17** %

Phase C



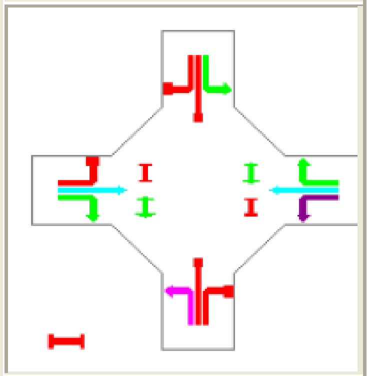
Green Time = **23** seconds
Phase Time = **30** seconds
Phase Split = **20** %

Phase A



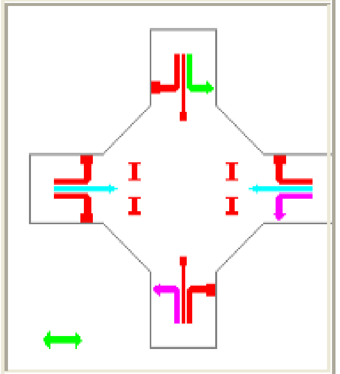
Green Time = **42** seconds
Phase Time = **49** seconds
Phase Split = **33** %

Phase E



Green Time = **33** seconds
Phase Time = **40** seconds
Phase Split = **27** %

Phase D (bus phase)

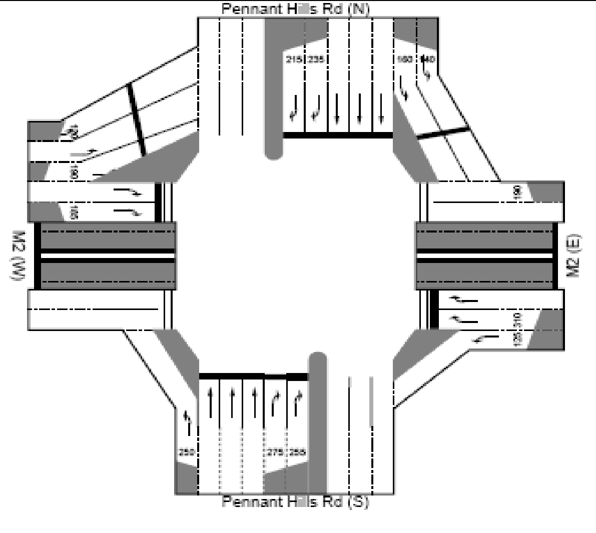
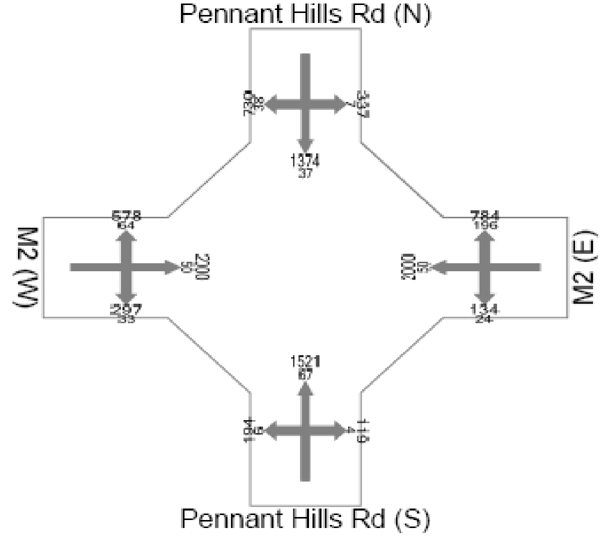
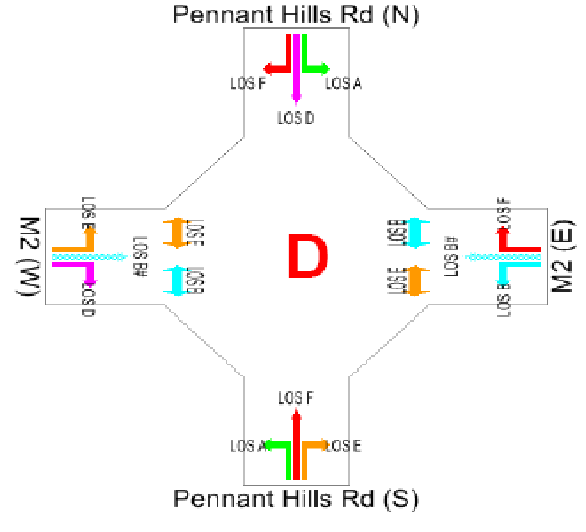


Green Time = **1** seconds
Phase Time = **6** seconds
Phase Split = **4** %

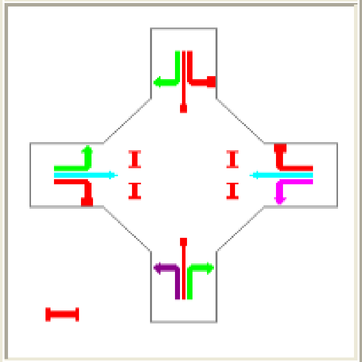
C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2009 Base (Existing) PM

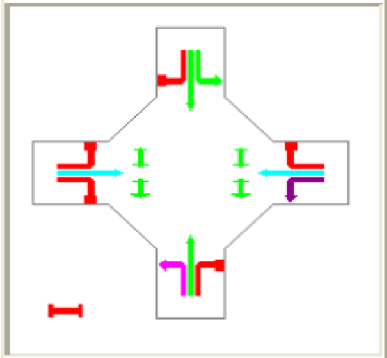
Layout	Volumes	Level of Service
		

Phase G



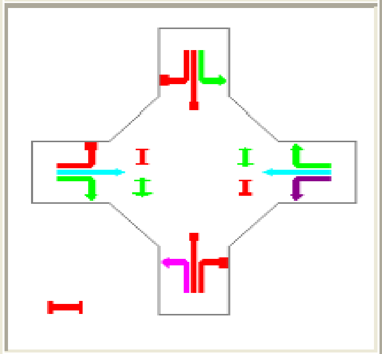
Green Time = **34** seconds
Phase Time = **41** seconds
Phase Split = **27** %

Phase A



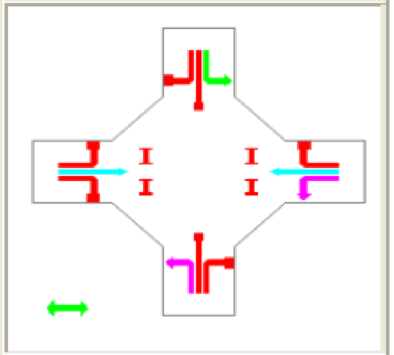
Green Time = **44** seconds
Phase Time = **51** seconds
Phase Split = **34** %

Phase E



Green Time = **47** seconds
Phase Time = **54** seconds
Phase Split = **36** %

Phase D (bus phase)



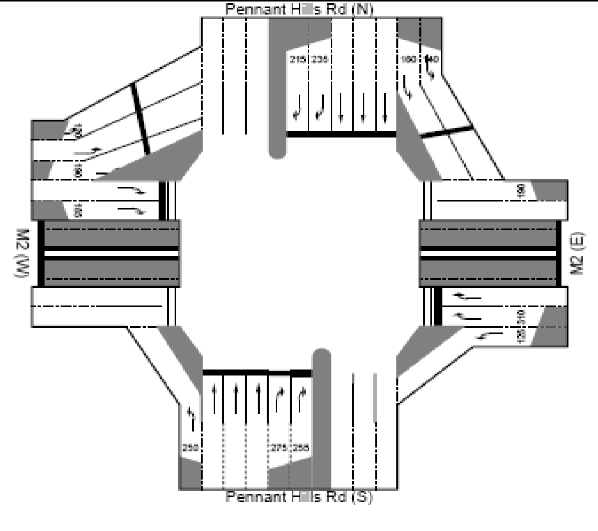
Green Time = **1** seconds
Phase Time = **4** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

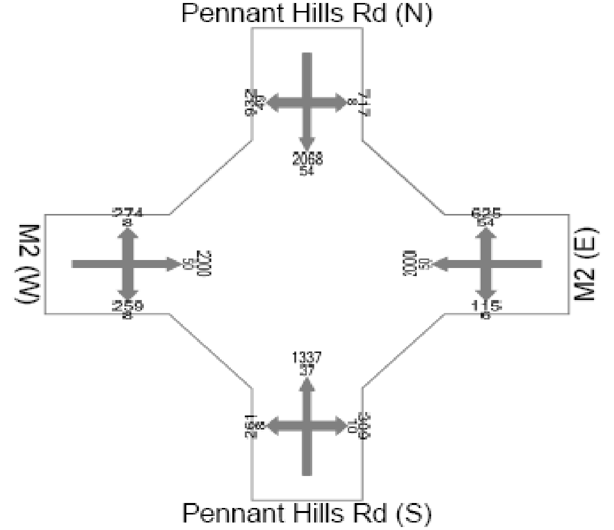
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2011 Status Quo AM

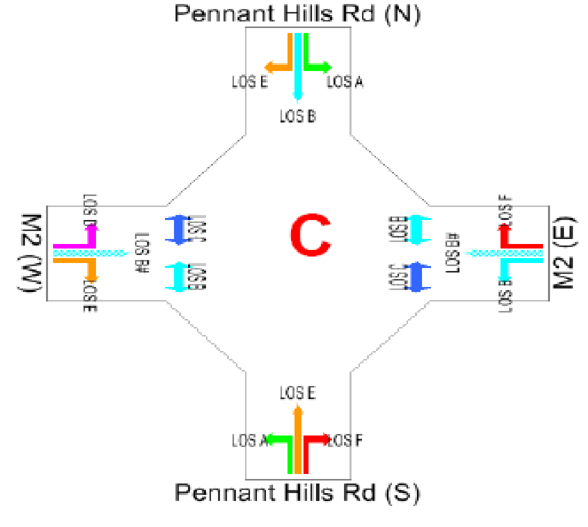
Layout



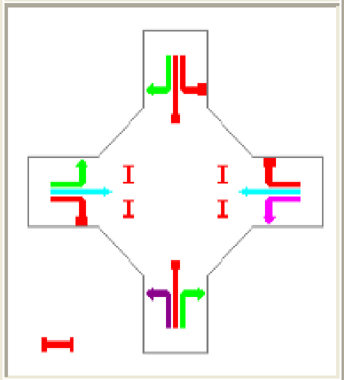
Volumes



Level of Service

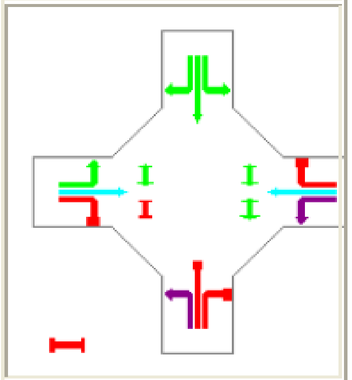


Phase G



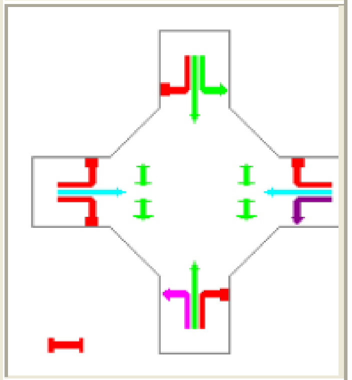
Green Time = **17** seconds
Phase Time = **24** seconds
Phase Split = **16** %

Phase C



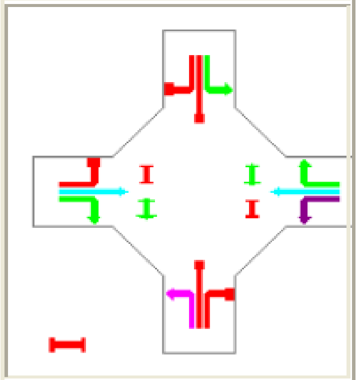
Green Time = **23** seconds
Phase Time = **30** seconds
Phase Split = **20** %

Phase A



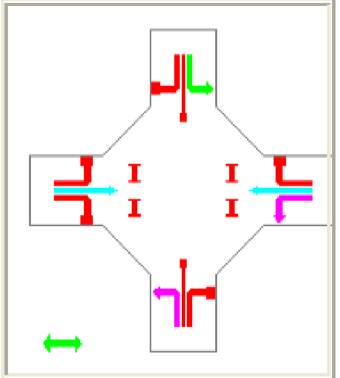
Green Time = **42** seconds
Phase Time = **49** seconds
Phase Split = **33** %

Phase E



Green Time = **34** seconds
Phase Time = **41** seconds
Phase Split = **27** %

Phase D (bus phase)



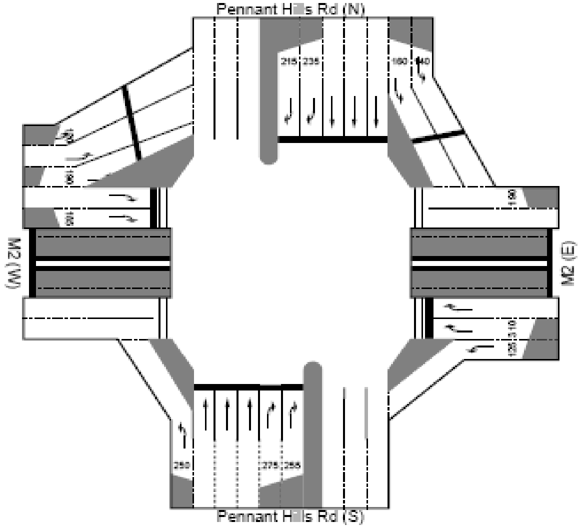
Green Time = **1** seconds
Phase Time = **6** seconds
Phase Split = **4** %

C = **150** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

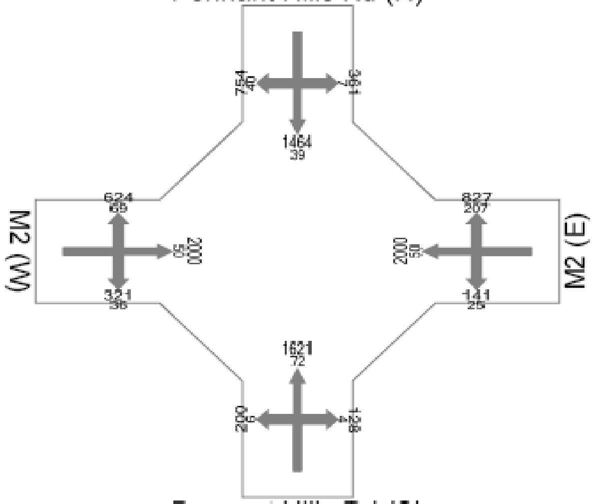
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2011 Status Quo PM

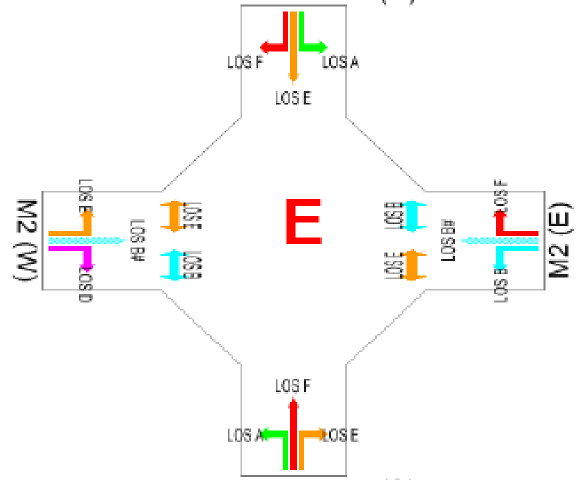
Layout



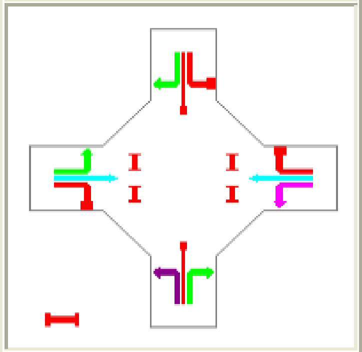
Volumes



Level of Service

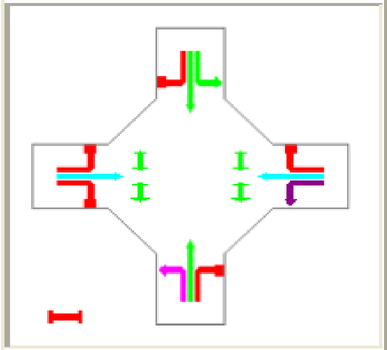


Phase G



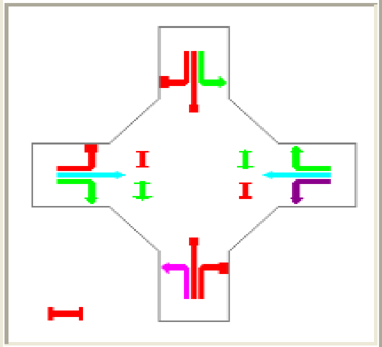
Green Time = **33** seconds
Phase Time = **40** seconds
Phase Split = **27** %

Phase A



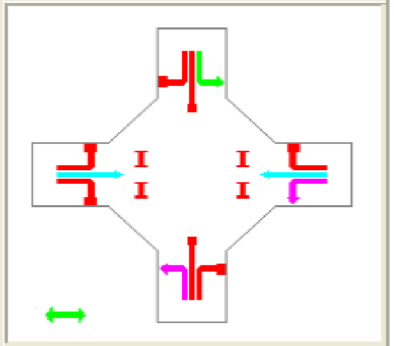
Green Time = **44** seconds
Phase Time = **51** seconds
Phase Split = **34** %

Phase E



Green Time = **48** seconds
Phase Time = **55** seconds
Phase Split = **37** %

Phase D (bus phase)

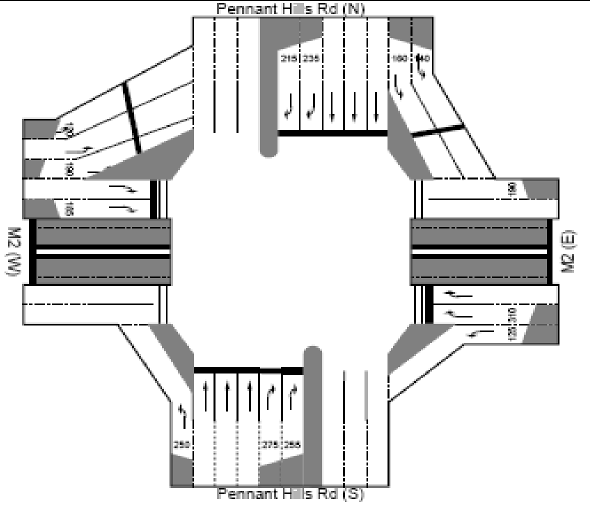
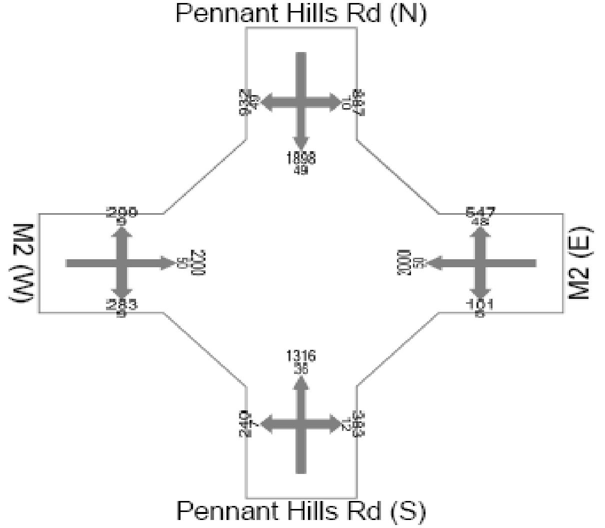
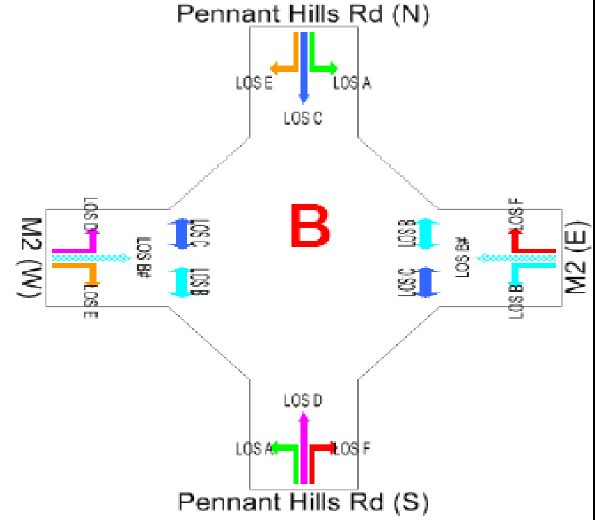


Green Time = **1** seconds
Phase Time = **4** seconds
Phase Split = **3** %

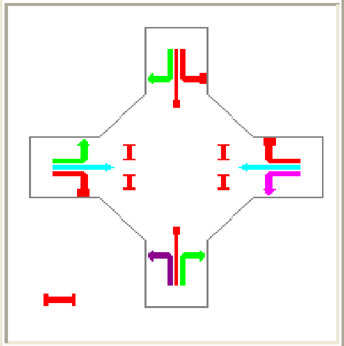
C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2011 with Upgrade AM

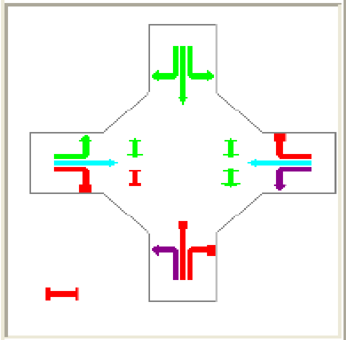
Layout	Volumes	Level of Service
		

Phase G



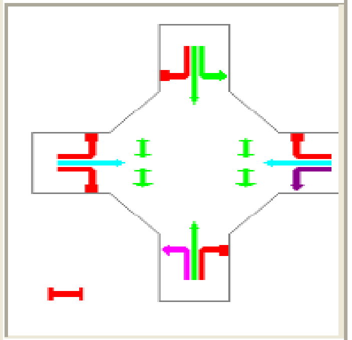
Green Time = **23** seconds
Phase Time = **30** seconds
Phase Split = **20** %

Phase C



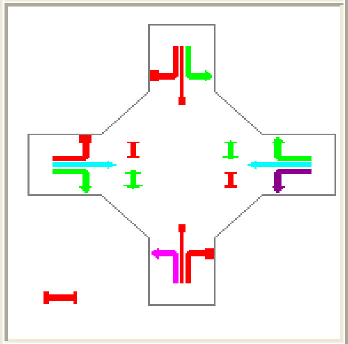
Green Time = **19** seconds
Phase Time = **26** seconds
Phase Split = **17** %

Phase A



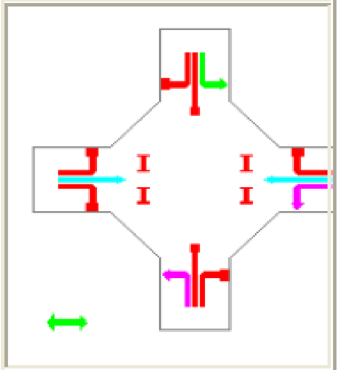
Green Time = **43** seconds
Phase Time = **50** seconds
Phase Split = **33** %

Phase E



Green Time = **31** seconds
Phase Time = **38** seconds
Phase Split = **25** %

Phase D (bus phase)



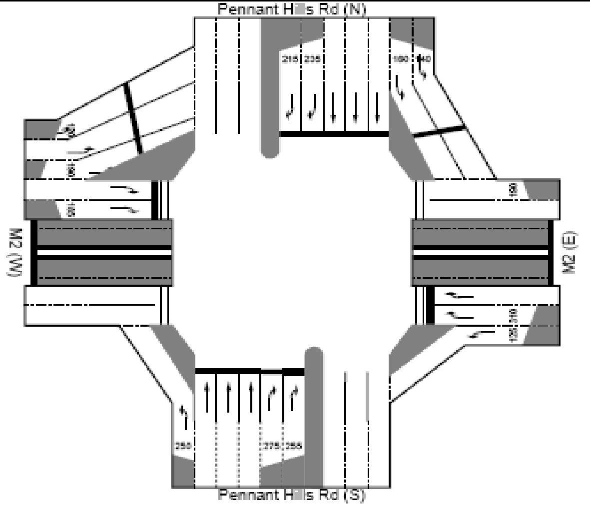
Green Time = **1** seconds
Phase Time = **6** seconds
Phase Split = **4** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

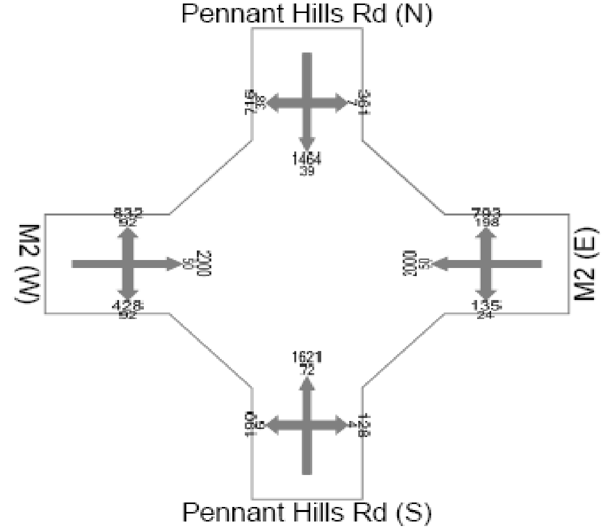
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2011 with Upgrade PM

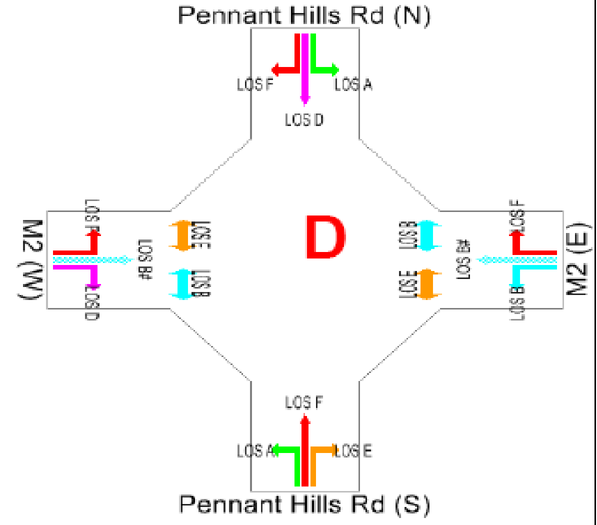
Layout



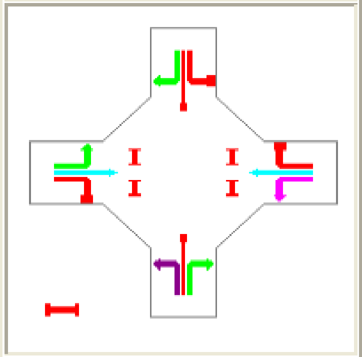
Volumes



Level of Service

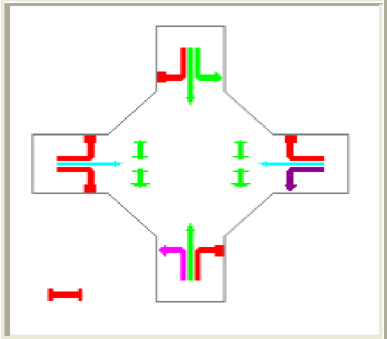


Phase G



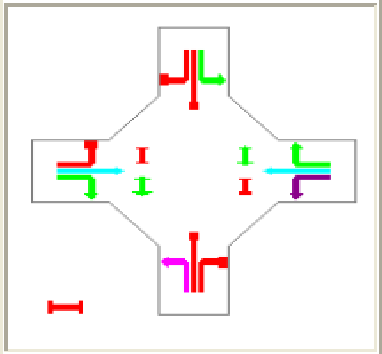
Green Time = **32** seconds
Phase Time = **39** seconds
Phase Split = **26** %

Phase A



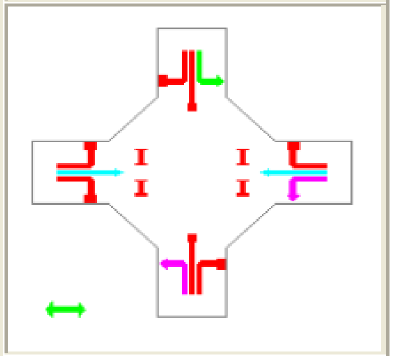
Green Time = **46** seconds
Phase Time = **53** seconds
Phase Split = **35** %

Phase E



Green Time = **47** seconds
Phase Time = **54** seconds
Phase Split = **36** %

Phase D (bus phase)



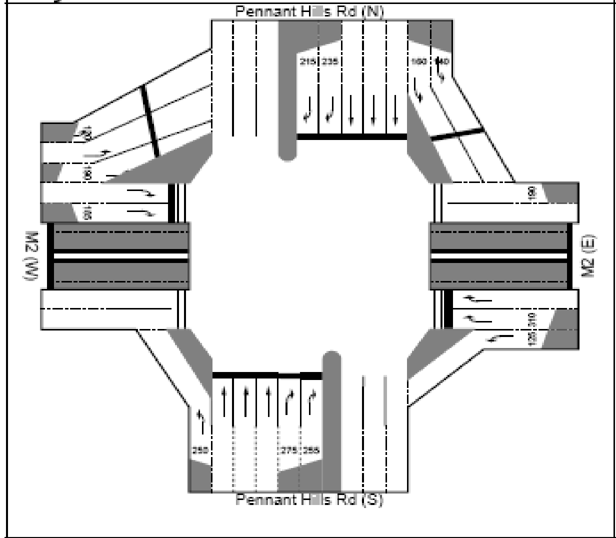
Green Time = **1** seconds
Phase Time = **4** seconds
Phase Split = **3** %

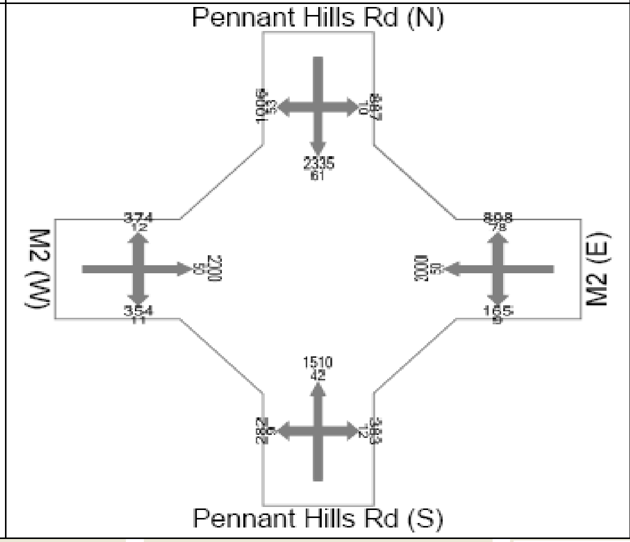
C = **150** sec | Cycle Time Option: **User-specified cycle time** | **Phase times determined by the program.**

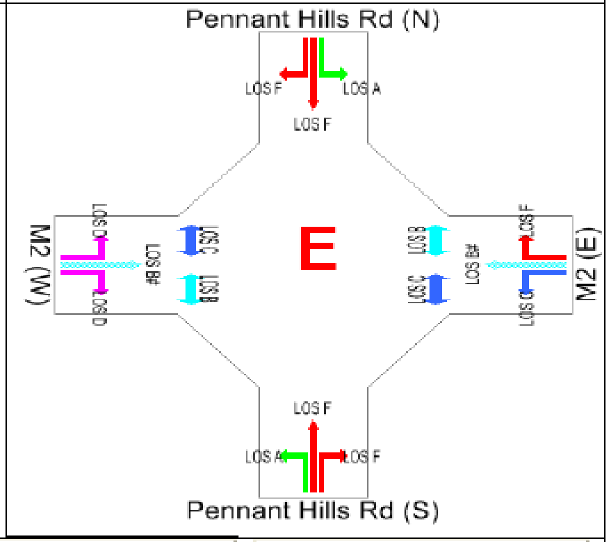
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2021 Status Quo AM

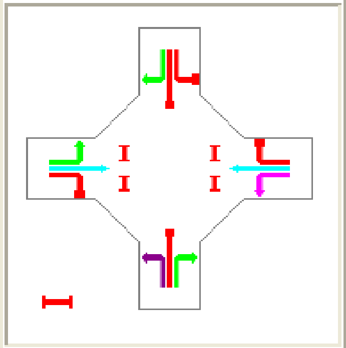
Layout	Volumes	Level of Service





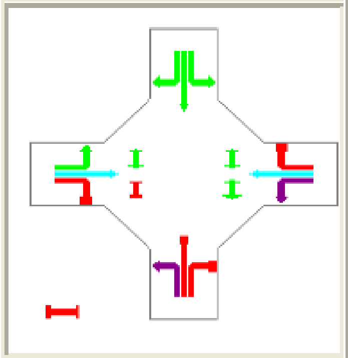


Phase G



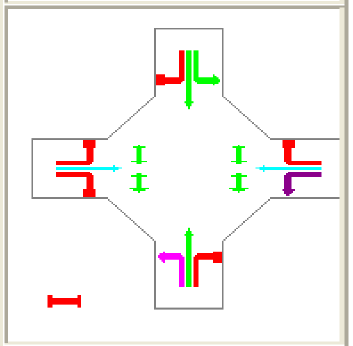
Green Time = **18** seconds
Phase Time = **25** seconds
Phase Split = **17** %

Phase C



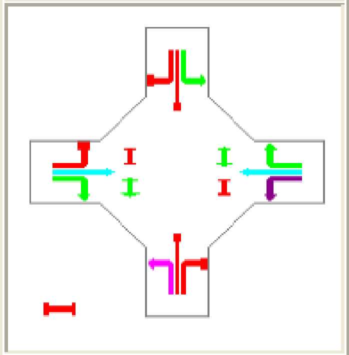
Green Time = **17** seconds
Phase Time = **24** seconds
Phase Split = **16** %

Phase A



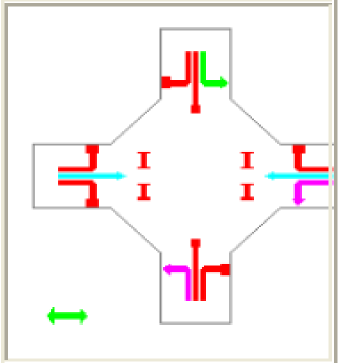
Green Time = **40** seconds
Phase Time = **47** seconds
Phase Split = **31** %

Phase E



Green Time = **41** seconds
Phase Time = **48** seconds
Phase Split = **32** %

Phase D (bus phase)

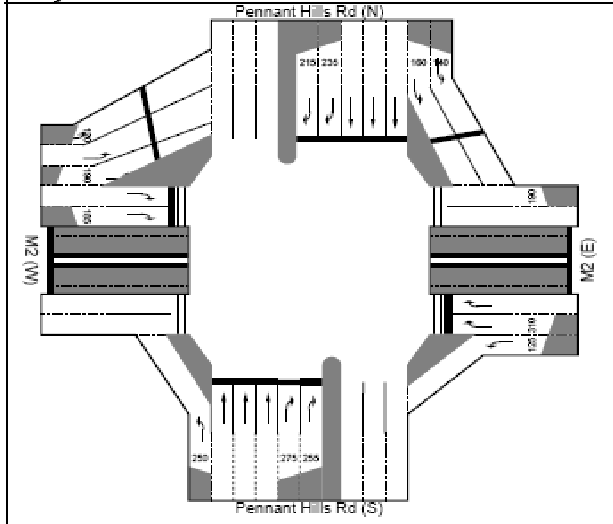
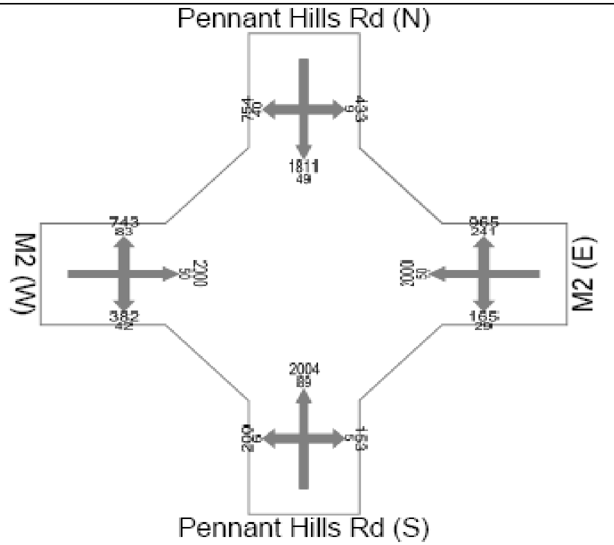
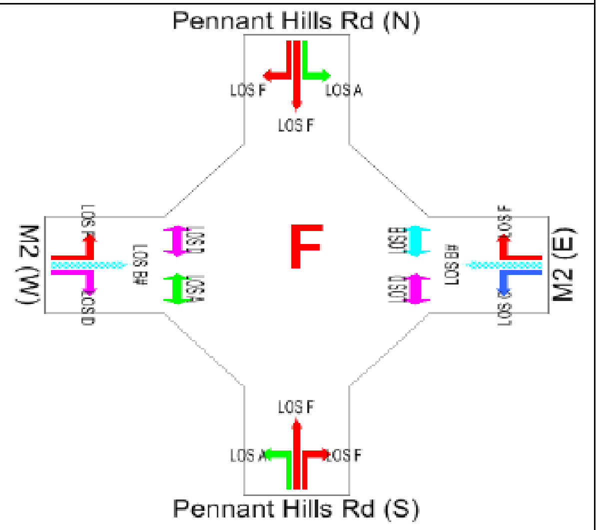


Green Time = **1** seconds
Phase Time = **6** seconds
Phase Split = **4** %

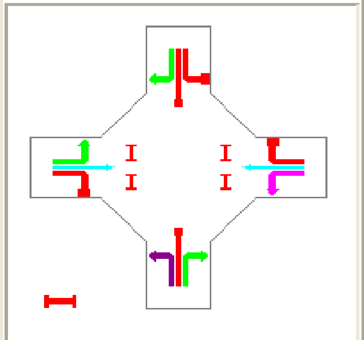
C = **150** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2021 Status Quo PM

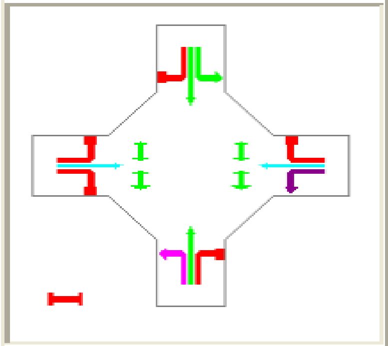
Layout	Volumes	Level of Service
		

Phase G



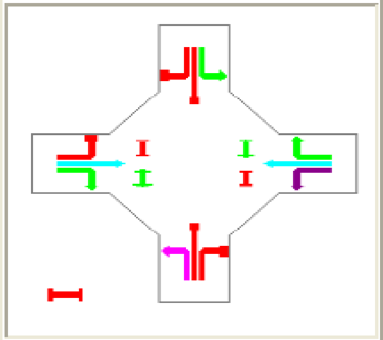
Green Time = **24** seconds
Phase Time = **31** seconds
Phase Split = **21** %

Phase A



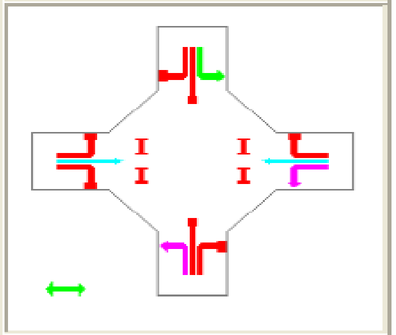
Green Time = **49** seconds
Phase Time = **56** seconds
Phase Split = **37** %

Phase E



Green Time = **52** seconds
Phase Time = **59** seconds
Phase Split = **39** %

Phase D (bus phase)



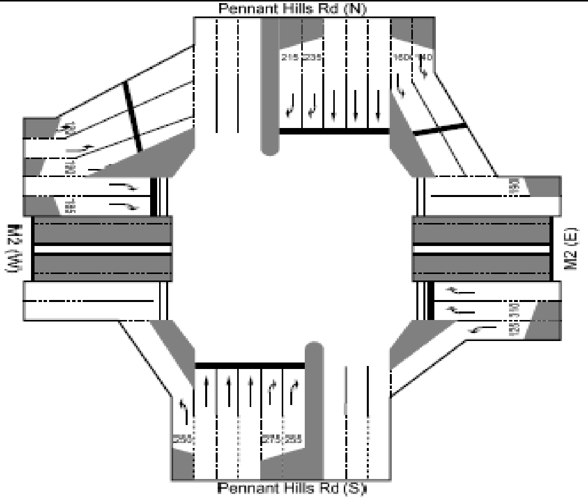
Green Time = **1** seconds
Phase Time = **4** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

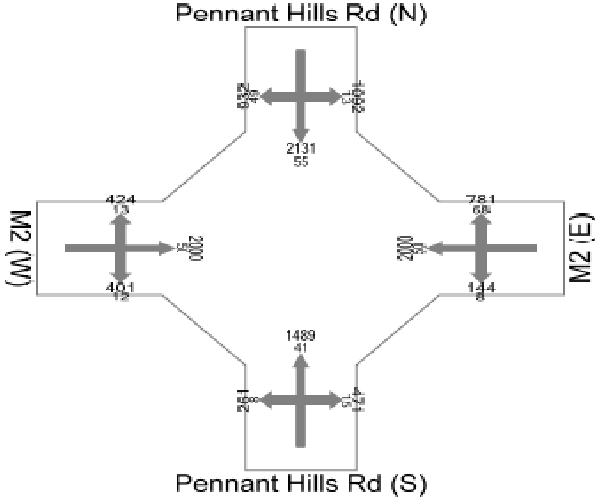
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2021 with Upgrade AM

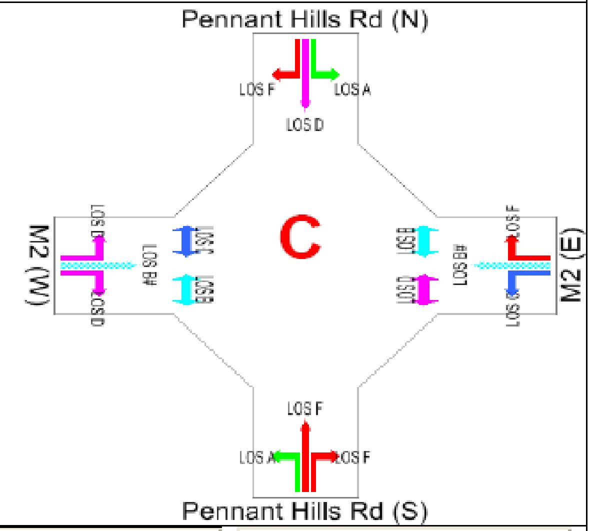
Layout



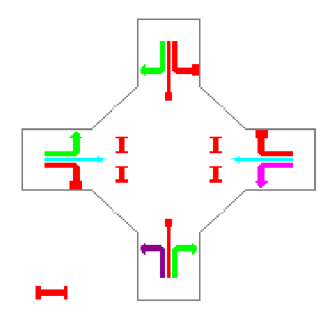
Volumes



Level of Service

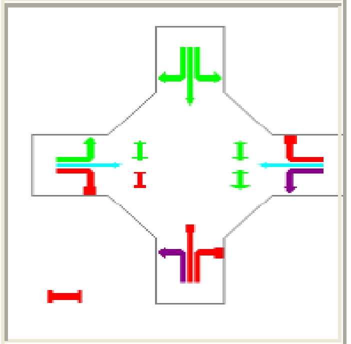


Phase G



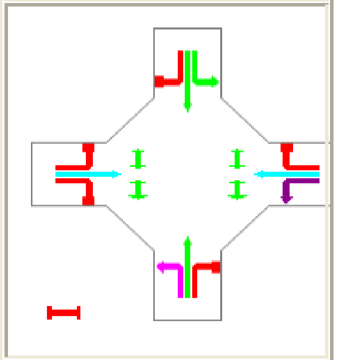
Green Time = **22** seconds
Phase Time = **29** seconds
Phase Split = **19** %

Phase C



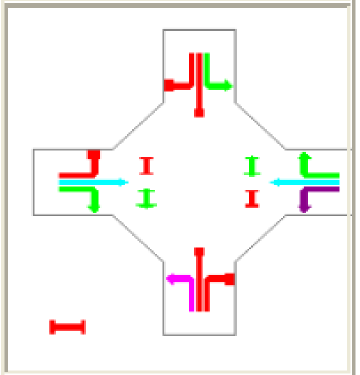
Green Time = **14** seconds
Phase Time = **21** seconds
Phase Split = **14** %

Phase A



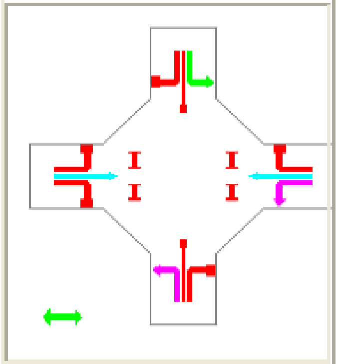
Green Time = **42** seconds
Phase Time = **49** seconds
Phase Split = **33** %

Phase E



Green Time = **38** seconds
Phase Time = **45** seconds
Phase Split = **30** %

Phase D (bus phase)



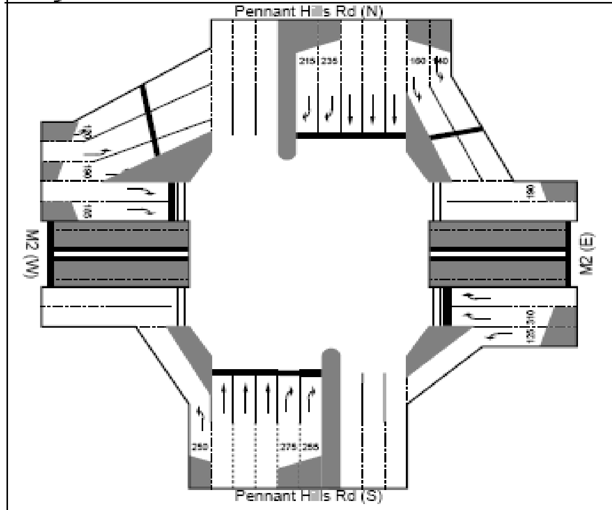
Green Time = **1** seconds
Phase Time = **6** seconds
Phase Split = **4** %

C = **150** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

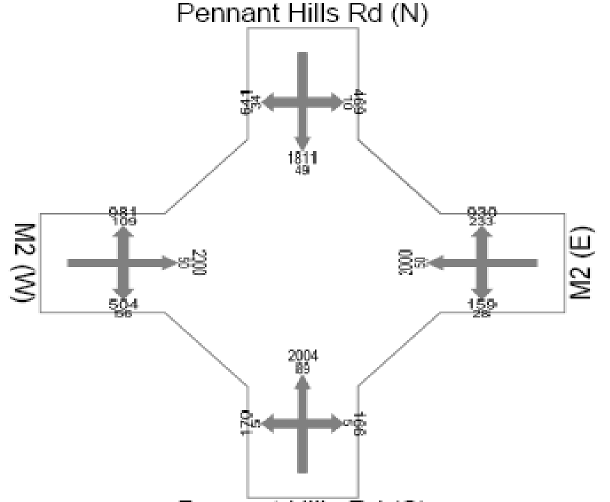
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Pennant Hills Road / M2 Motorway 2021 with Upgrade PM

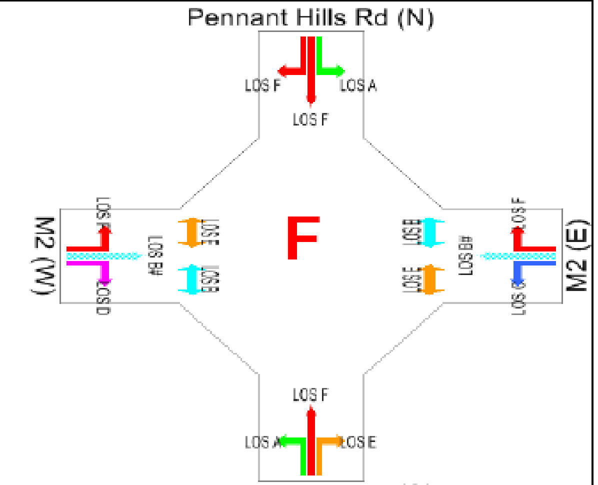
Layout



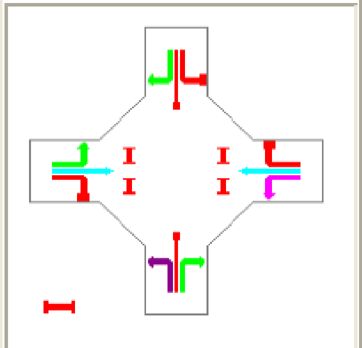
Volumes



Level of Service

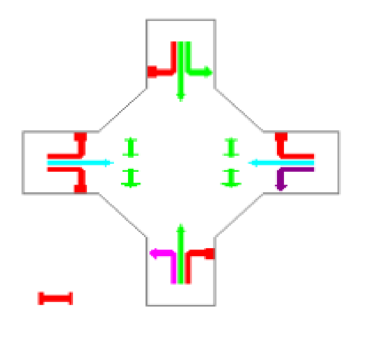


Phase G



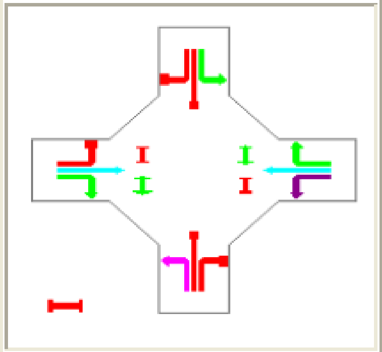
Green Time = **31** seconds
Phase Time = **38** seconds
Phase Split = **25** %

Phase A



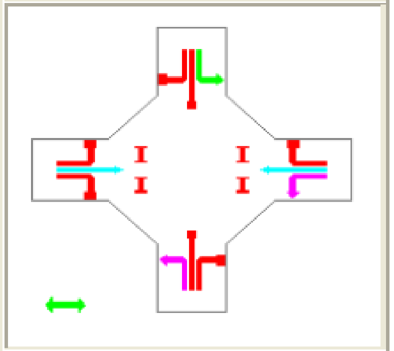
Green Time = **46** seconds
Phase Time = **53** seconds
Phase Split = **35** %

Phase E



Green Time = **48** seconds
Phase Time = **55** seconds
Phase Split = **37** %

Phase D (bus phase)



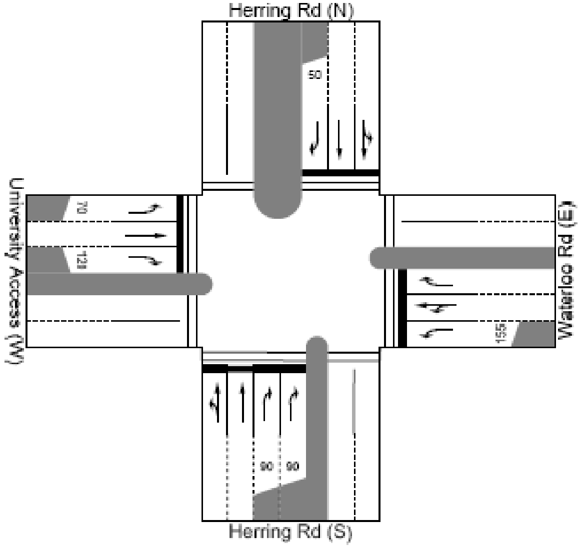
Green Time = **1** seconds
Phase Time = **4** seconds
Phase Split = **3** %

C = **150** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

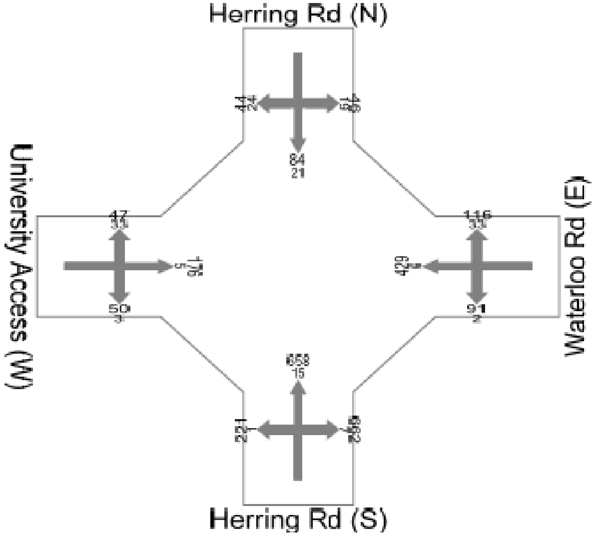
NOTE: modelled as an interchange rather than a normal signalised intersection; bus ramp approach could not be modelled as part of the interchange however, the percentage of bus phase have been taken into account

Herring Road / Waterloo Road 2009 Base (Existing) AM

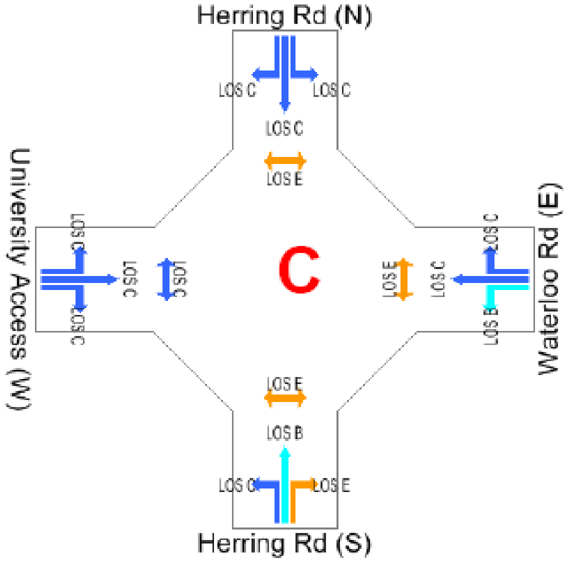
Layout



Volumes

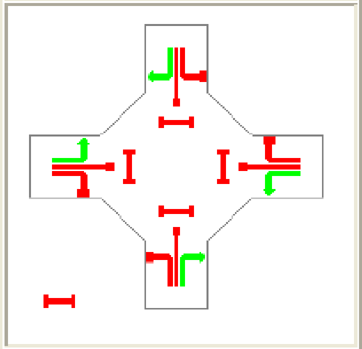


Level of Service



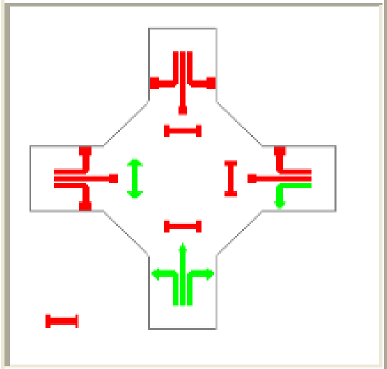
Herring Road / Waterloo Road 2009 Base (Existing) AM

Phase G



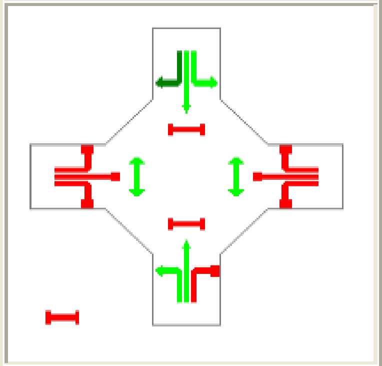
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **12** %

Phase G2



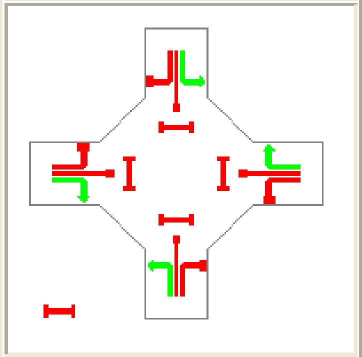
Green Time = **9** seconds
Phase Time = **15** seconds
Phase Split = **15** %

Phase A



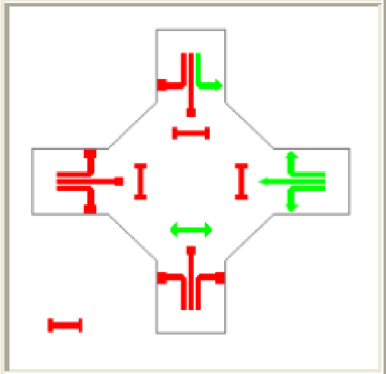
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **28** %

Phase D



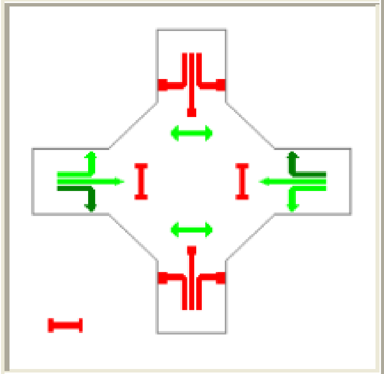
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **12** %

Phase D1



Green Time = **0** seconds
Phase Time = **2** seconds
Phase Split = **2** %

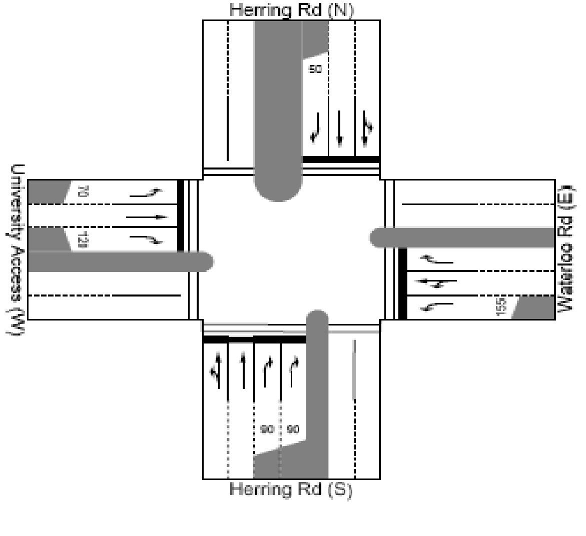
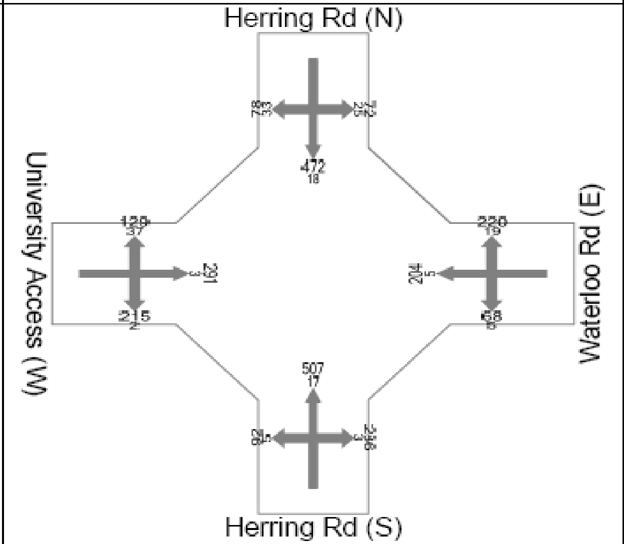
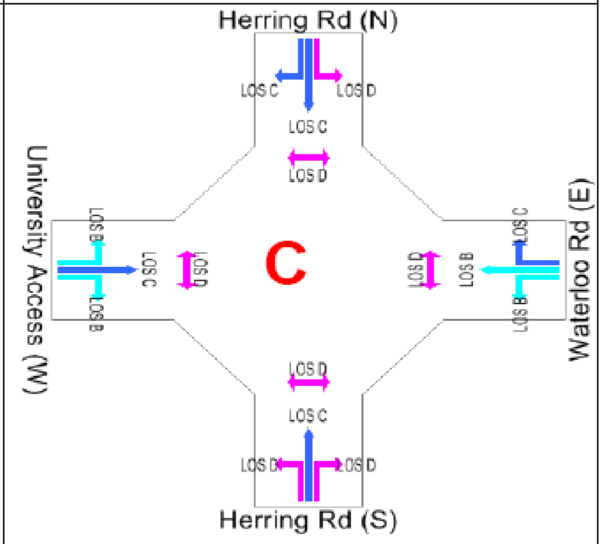
Phase E



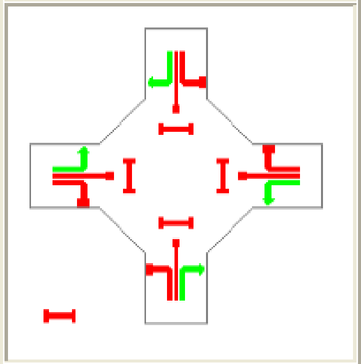
Green Time = **25** seconds
Phase Time = **31** seconds
Phase Split = **31** %

C = **100** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Herring Road / Waterloo Road 2009 Base (Existing) PM

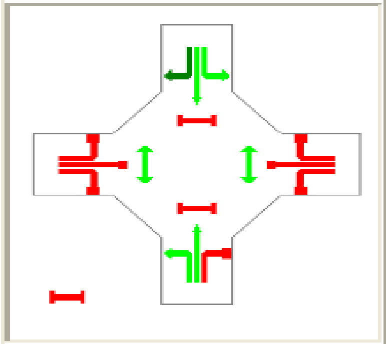
Layout	Volumes	Level of Service
		

Phase G



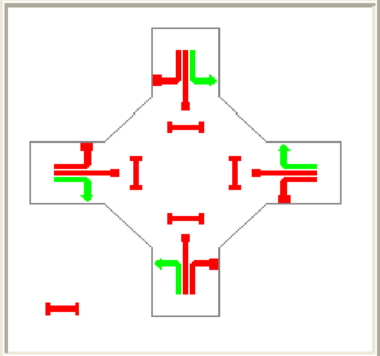
Green Time = **10** seconds
Phase Time = **16** seconds
Phase Split = **18** %

Phase A



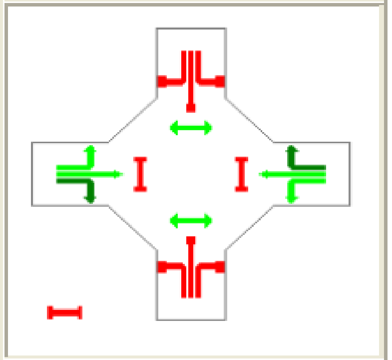
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **31** %

Phase D



Green Time = **8** seconds
Phase Time = **14** seconds
Phase Split = **16** %

Phase E



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **36** %

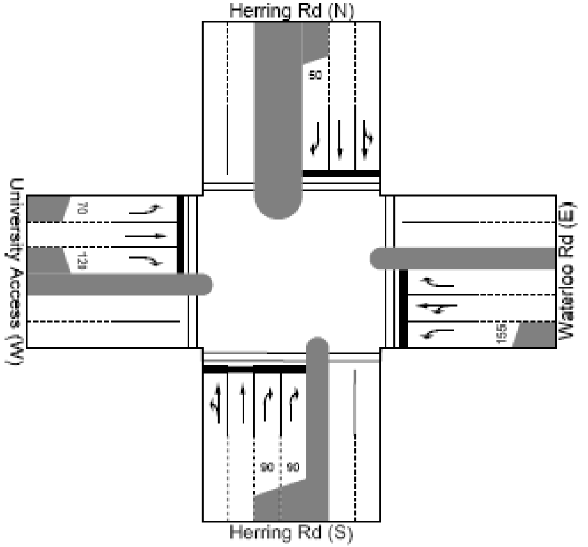
C = **90** sec

Cycle Time Option: **Optimum cycle time**

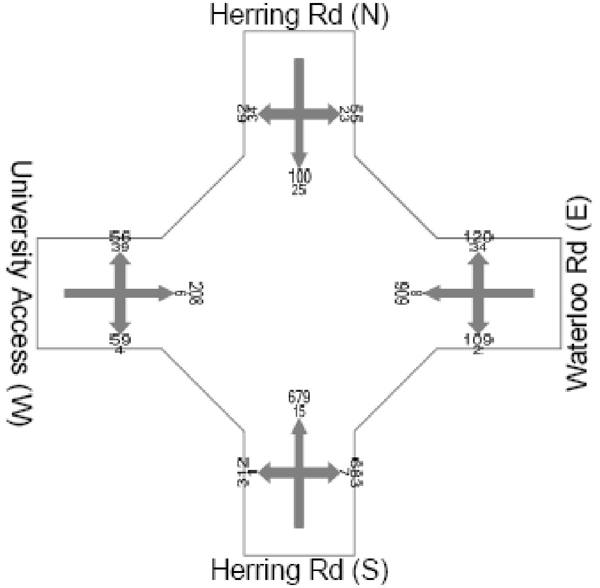
Phase times determined by the program.

Herring Road / Waterloo Road 2011 Status Quo AM

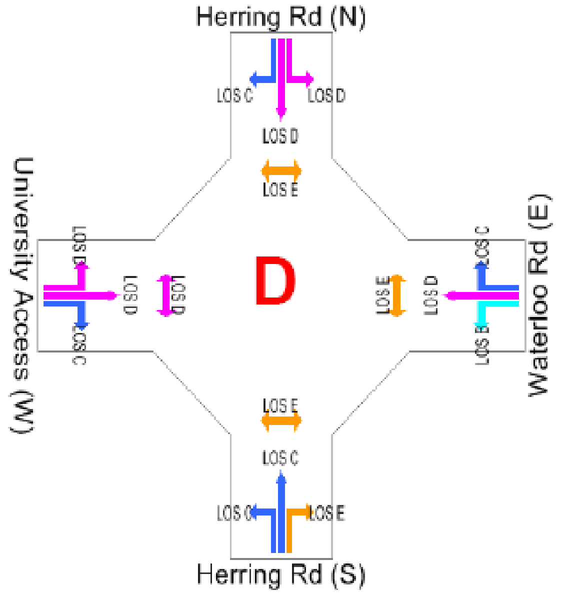
Layout



Volumes

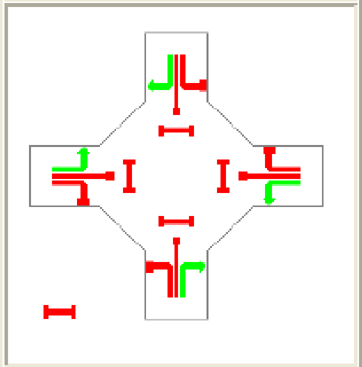


Level of Service



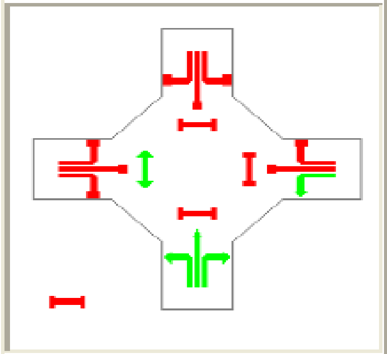
Herring Road / Waterloo Road 2011 Status Quo AM

Phase G



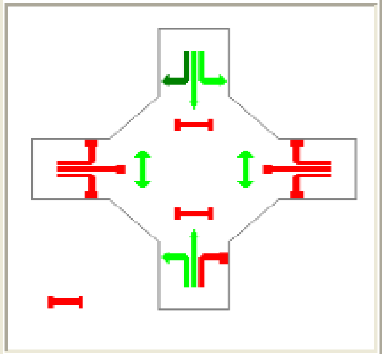
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **10** %

Phase G2



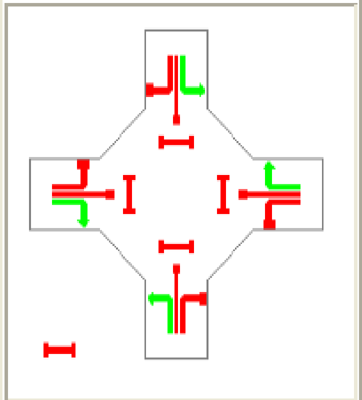
Green Time = **15** seconds
Phase Time = **21** seconds
Phase Split = **18** %

Phase A



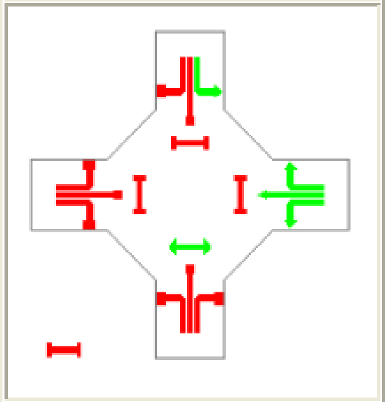
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **23** %

Phase D



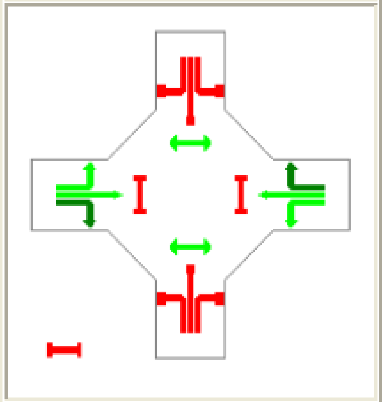
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **10** %

Phase D1



Green Time = **10** seconds
Phase Time = **16** seconds
Phase Split = **13** %

Phase E

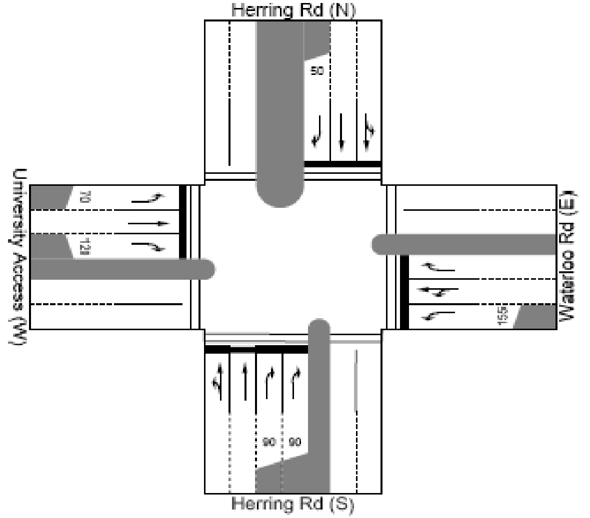


Green Time = **25** seconds
Phase Time = **31** seconds
Phase Split = **26** %

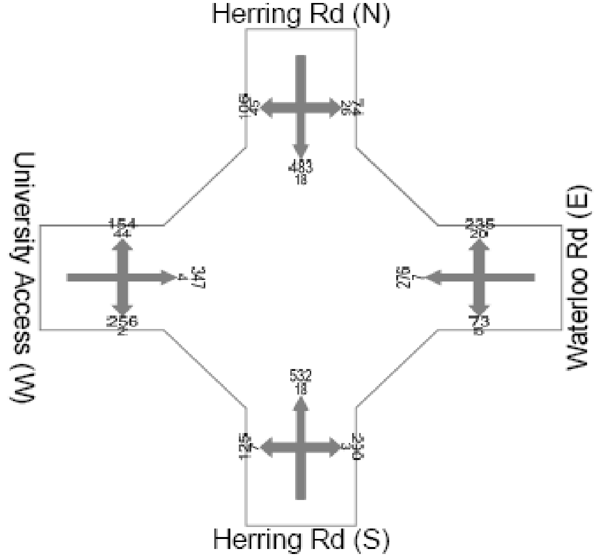
C = **120** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Herring Road / Waterloo Road 2011 Status Quo PM

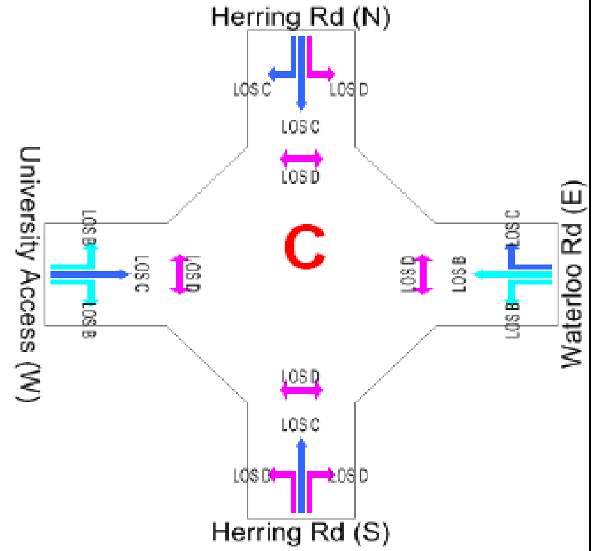
Layout



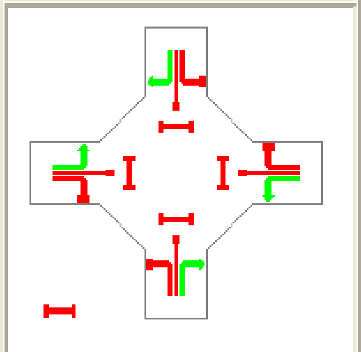
Volumes



Level of Service

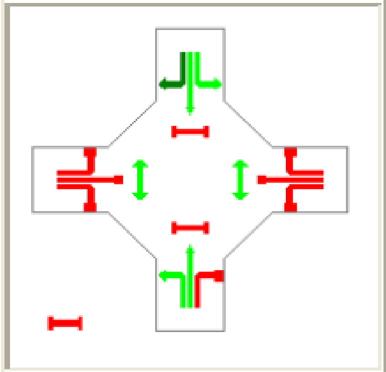


Phase G



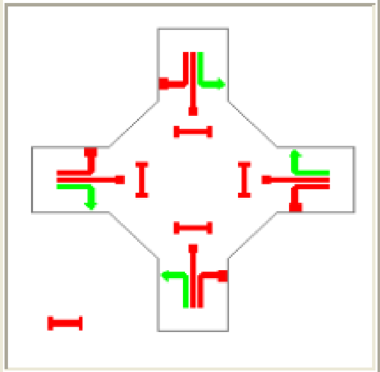
Green Time = **9** seconds
Phase Time = **15** seconds
Phase Split = **17** %

Phase A



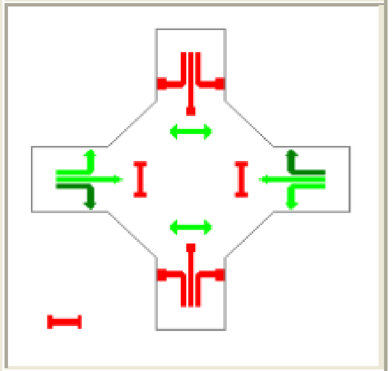
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **31** %

Phase D



Green Time = **8** seconds
Phase Time = **14** seconds
Phase Split = **16** %

Phase E

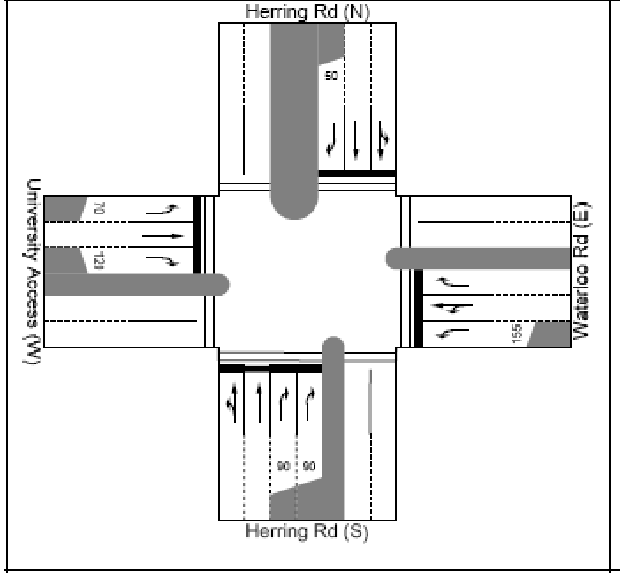


Green Time = **27** seconds
Phase Time = **33** seconds
Phase Split = **37** %

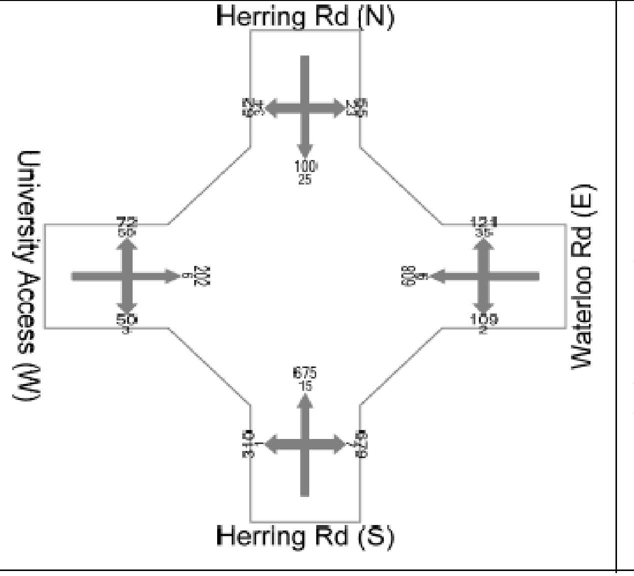
C = **90** sec Cycle Time Option: **Optimum cycle time** **Phase times determined by the program.**

Herring Road / Waterloo Road 2011 with Upgrade AM

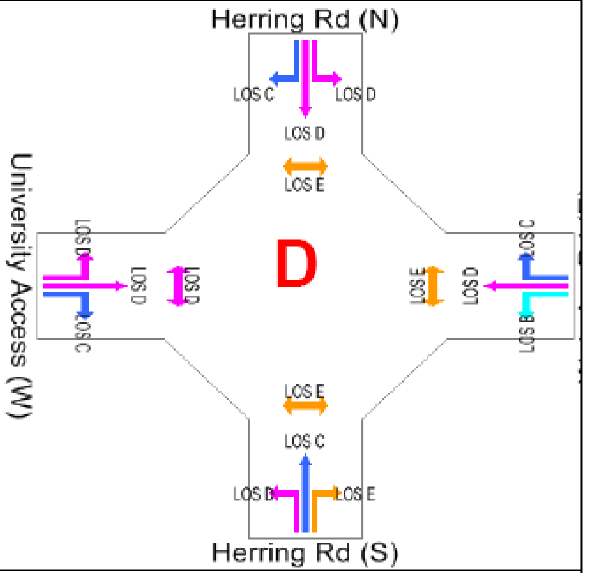
Layout



Volumes

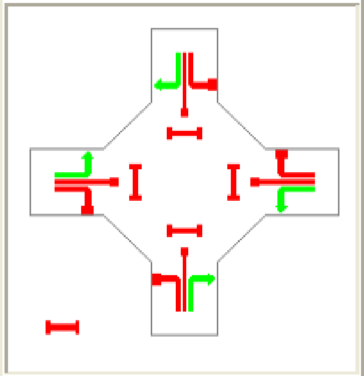


Level of Service



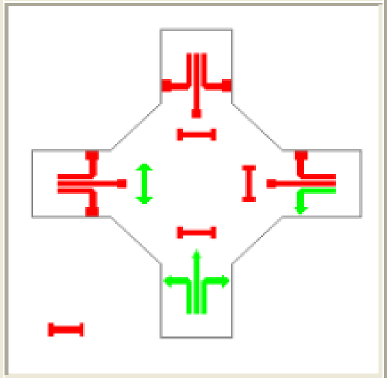
Herring Road / Waterloo Road 2011 with Upgrade AM

Phase G



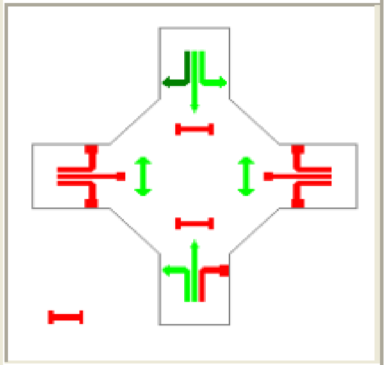
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **10** %

Phase G2



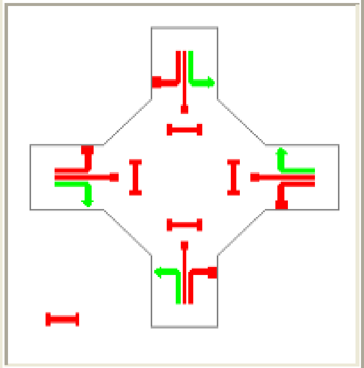
Green Time = **14** seconds
Phase Time = **20** seconds
Phase Split = **17** %

Phase A



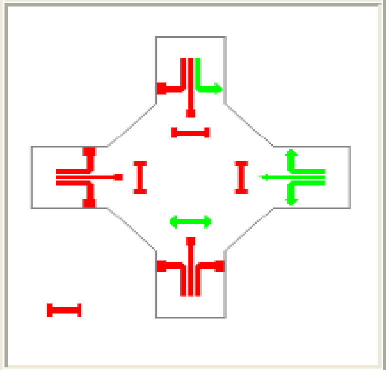
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **23** %

Phase D



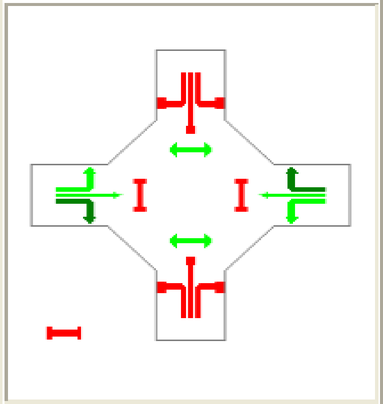
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **10** %

Phase D1



Green Time = **11** seconds
Phase Time = **17** seconds
Phase Split = **14** %

Phase E

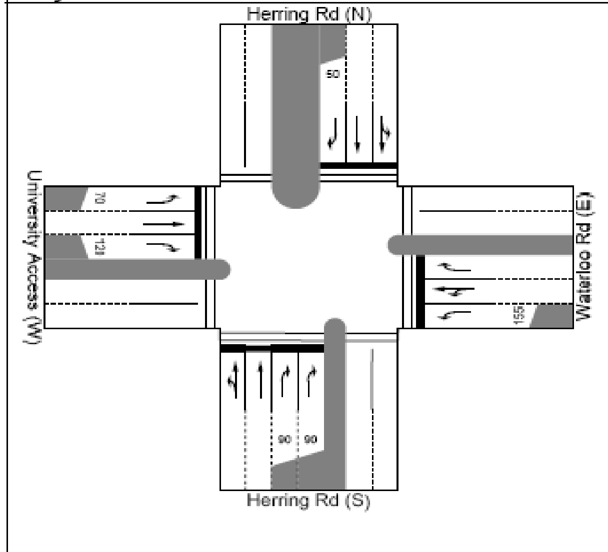


Green Time = **25** seconds
Phase Time = **31** seconds
Phase Split = **26** %

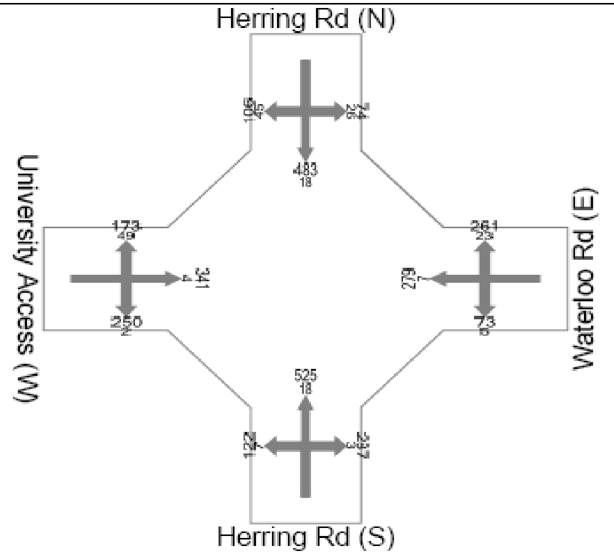
C = **120** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Herring Road / Waterloo Road 2011 with Upgrade PM

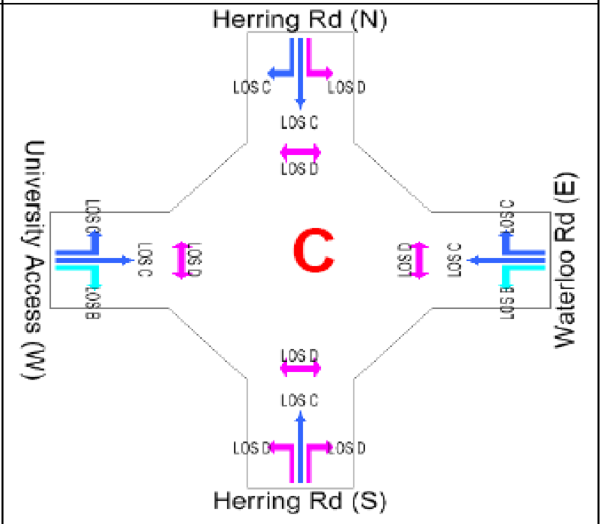
Layout



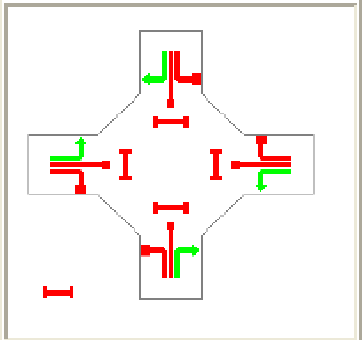
Volumes



Level of Service

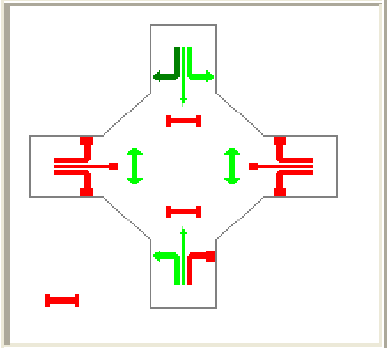


Phase G



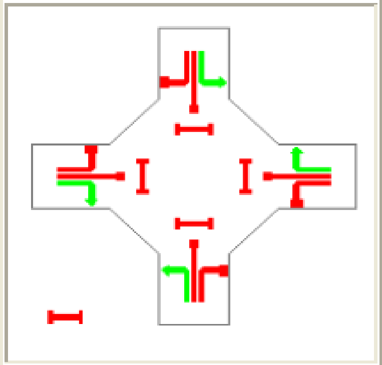
Green Time = **9** seconds
Phase Time = **15** seconds
Phase Split = **17** %

Phase A



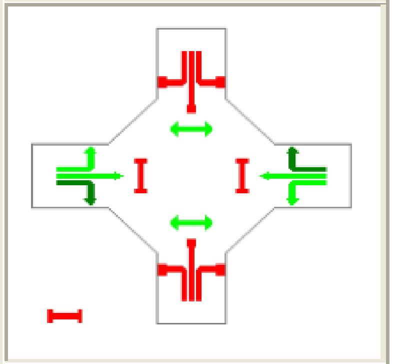
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **31** %

Phase D



Green Time = **9** seconds
Phase Time = **15** seconds
Phase Split = **17** %

Phase E



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **36** %

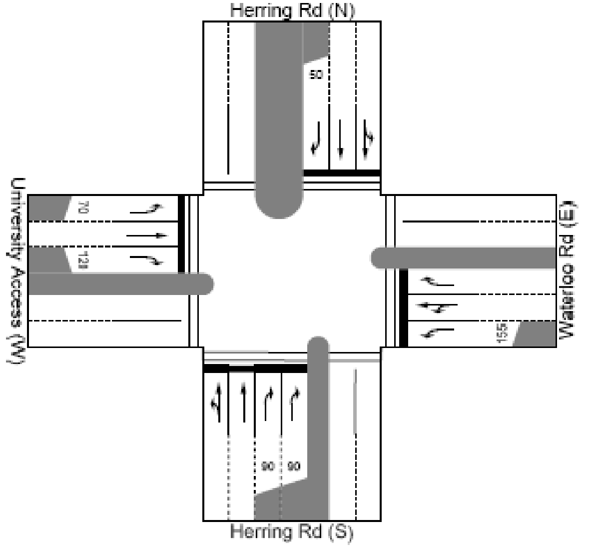
C = **90** sec

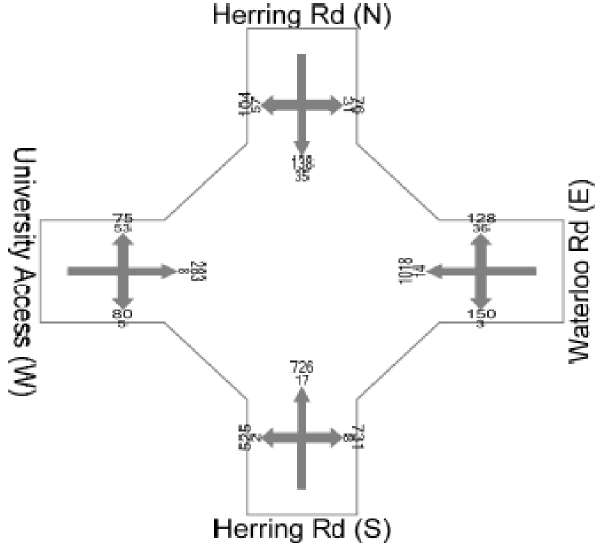
Cycle Time Option: **Optimum cycle time**

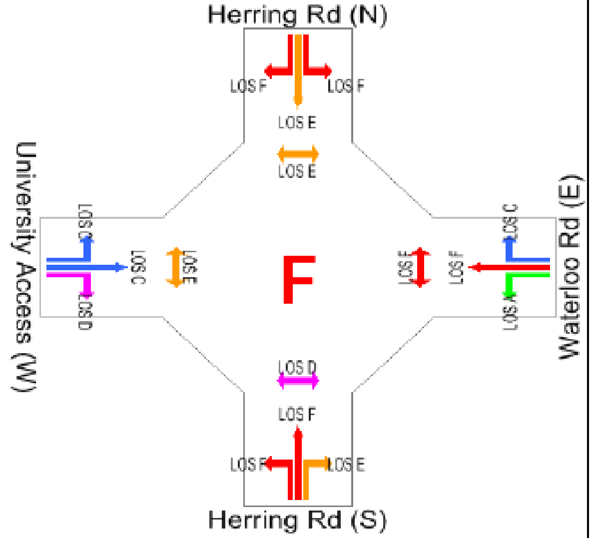
Phase times determined by the program.

Herring Road / Waterloo Road 2021 Status Quo AM

Layout	Volumes	Level of Service

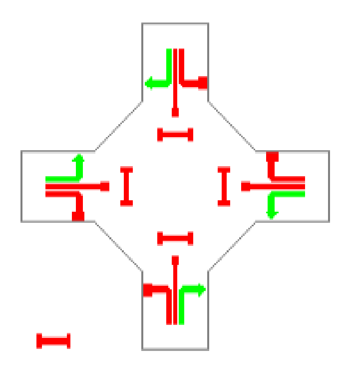






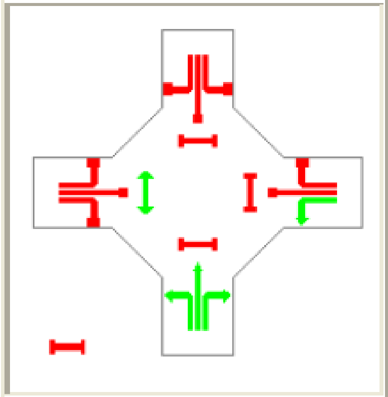
Herring Road / Waterloo Road 2021 Status Quo AM

Phase G



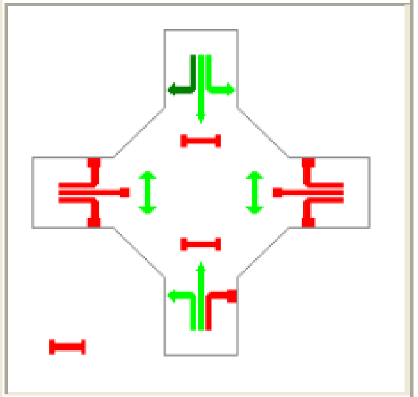
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **8** %

Phase G2



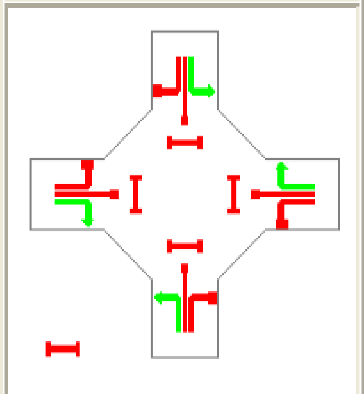
Green Time = **19** seconds
Phase Time = **25** seconds
Phase Split = **17** %

Phase A



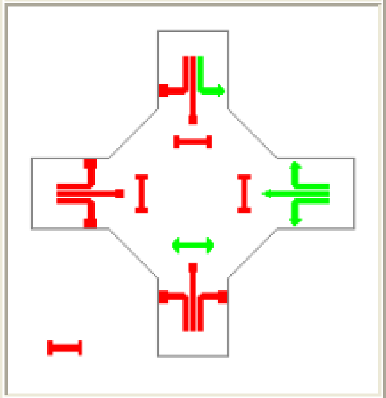
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **19** %

Phase D



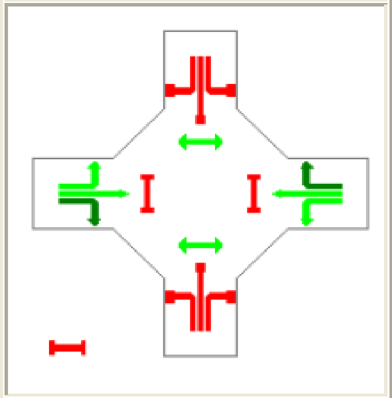
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **8** %

Phase D1



Green Time = **2** seconds
Phase Time = **8** seconds
Phase Split = **5** %

Phase E

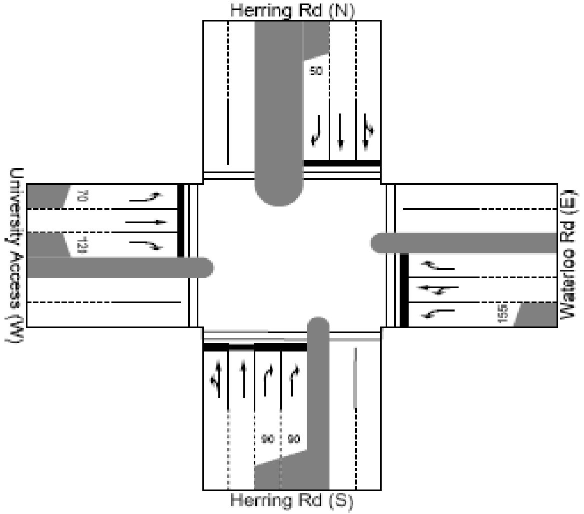


Green Time = **59** seconds
Phase Time = **65** seconds
Phase Split = **43** %

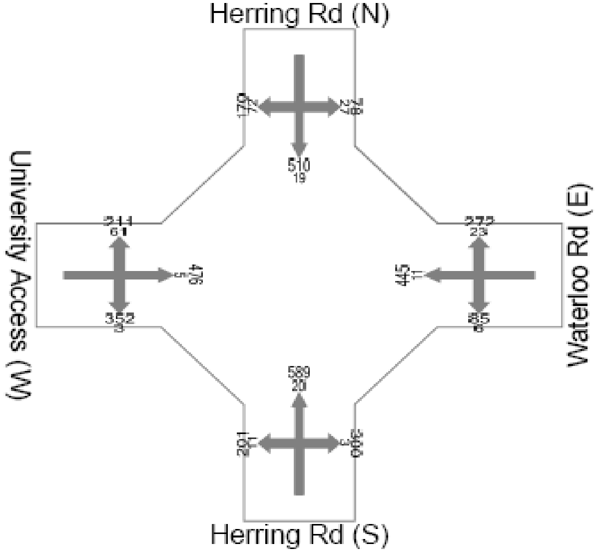
C = **150** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Herring Road / Waterloo Road 2021 Status Quo PM

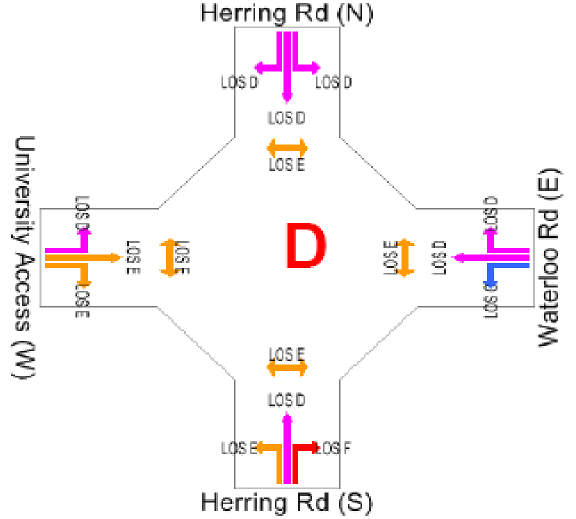
Layout



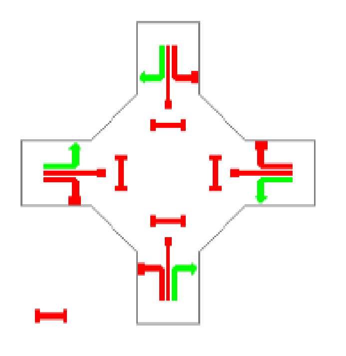
Volumes



Level of Service

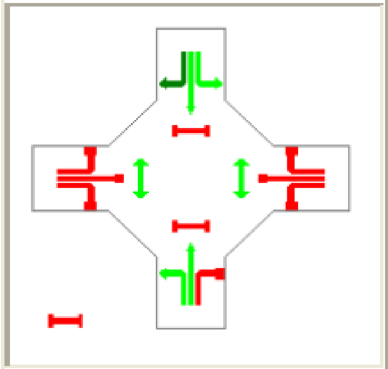


Phase G



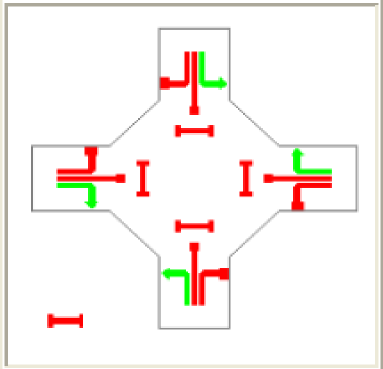
Green Time = **10** seconds
Phase Time = **16** seconds
Phase Split = **15** %

Phase A



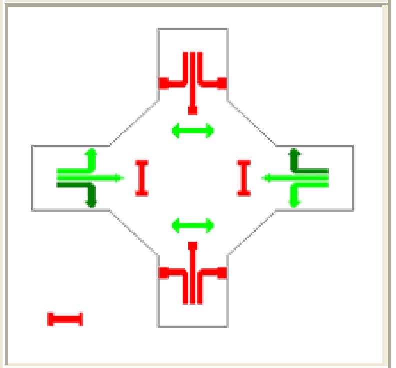
Green Time = **28** seconds
Phase Time = **34** seconds
Phase Split = **31** %

Phase D



Green Time = **18** seconds
Phase Time = **24** seconds
Phase Split = **22** %

Phase E



Green Time = **30** seconds
Phase Time = **36** seconds
Phase Split = **33** %

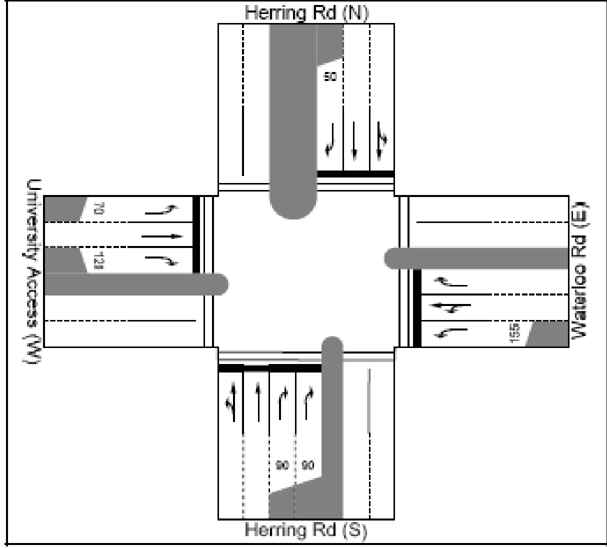
C = **110** sec

Cycle Time Option: **Optimum cycle time**

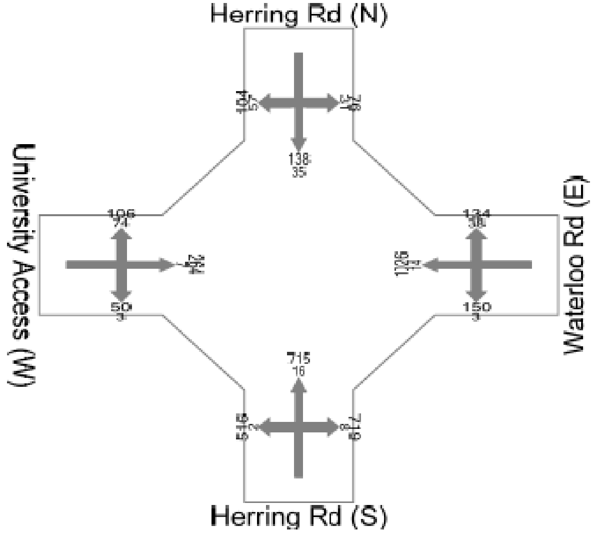
Phase times determined by the program.

Herring Road / Waterloo Road 2021 with Upgrade AM

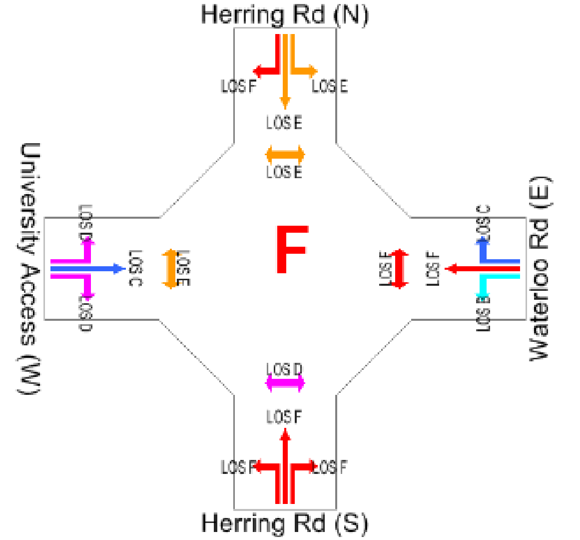
Layout



Volumes

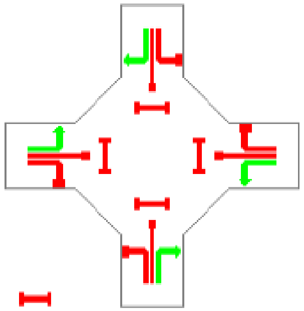


Level of Service



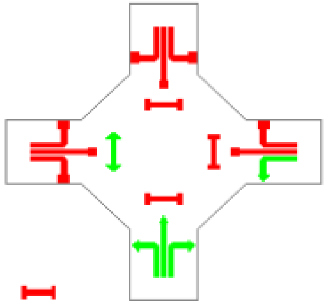
Herring Road / Waterloo Road 2021 with Upgrade AM

Phase G



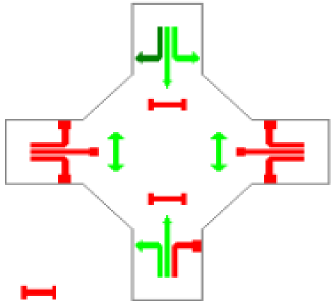
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **8** %

Phase G2



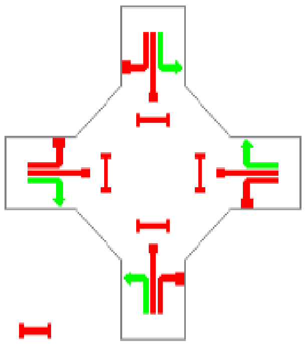
Green Time = **11** seconds
Phase Time = **17** seconds
Phase Split = **11** %

Phase A



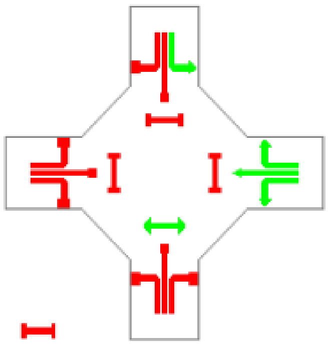
Green Time = **30** seconds
Phase Time = **36** seconds
Phase Split = **24** %

Phase D



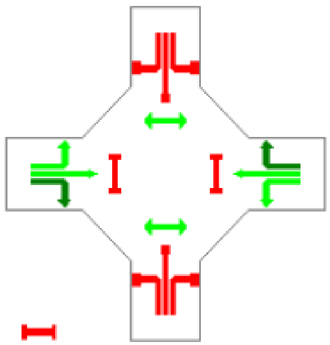
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **8** %

Phase D1



Green Time = **9** seconds
Phase Time = **15** seconds
Phase Split = **10** %

Phase E



Green Time = **52** seconds
Phase Time = **58** seconds
Phase Split = **39** %

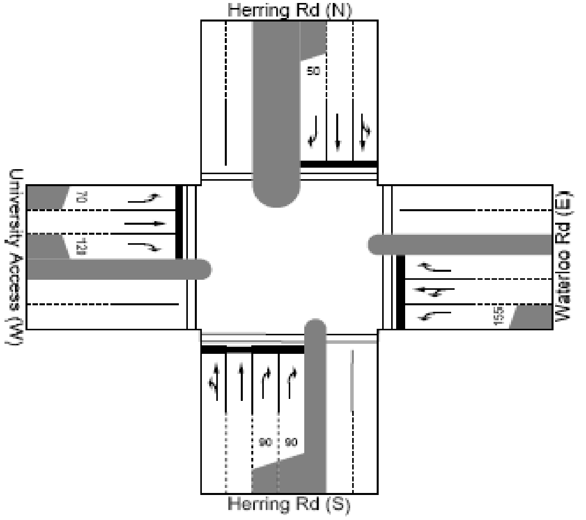
C = **150** sec

Cycle Time Option: **Optimum cycle time**

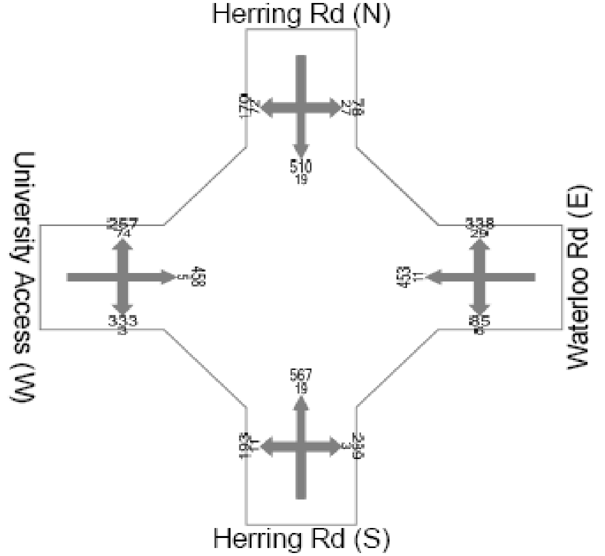
Phase times determined by the program.

Herring Road / Waterloo Road 2021 with Upgrade PM

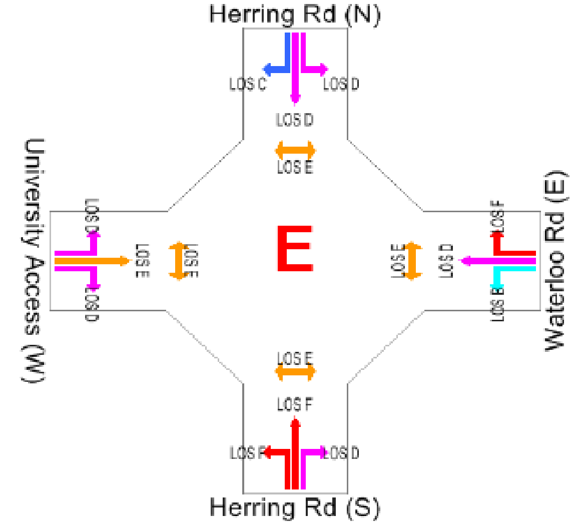
Layout



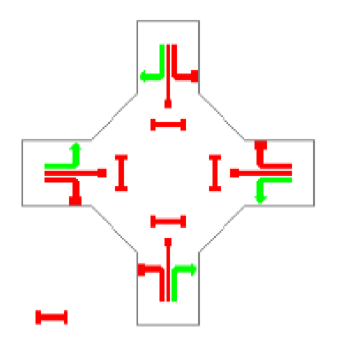
Volumes



Level of Service

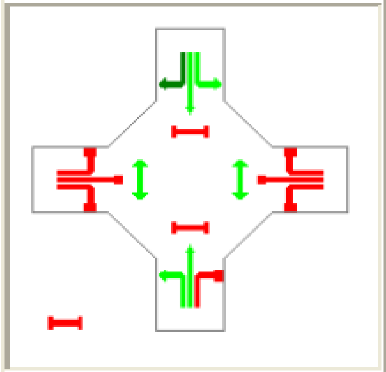


Phase G



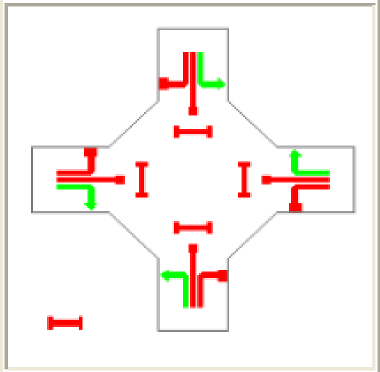
Green Time = **12** seconds
Phase Time = **18** seconds
Phase Split = **18** %

Phase A



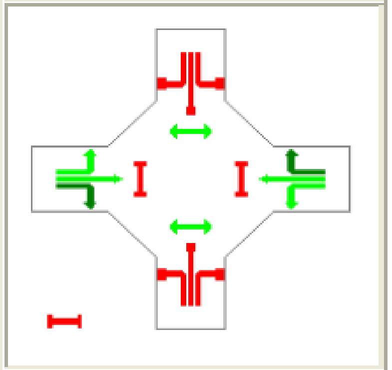
Green Time = **22** seconds
Phase Time = **28** seconds
Phase Split = **28** %

Phase D



Green Time = **16** seconds
Phase Time = **22** seconds
Phase Split = **22** %

Phase E



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **32** %

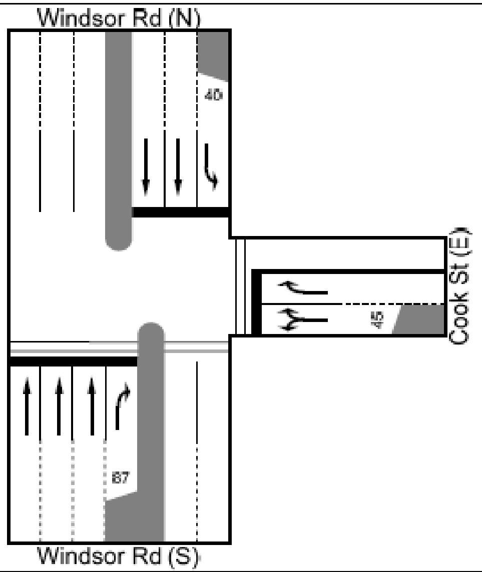
C = **100** sec

Cycle Time Option: **Optimum cycle time**

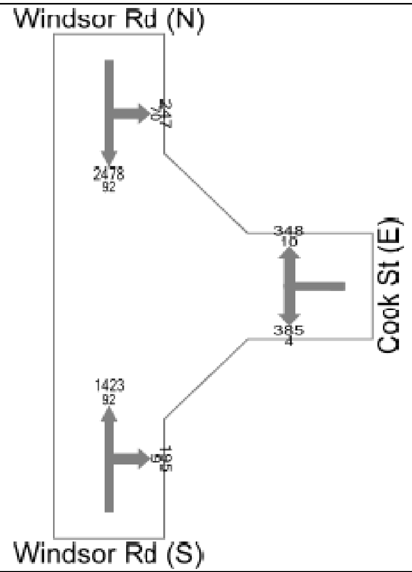
Phase times determined by the program.

Windsor Rd / M2 Motorway 2009 Base (Existing) AM

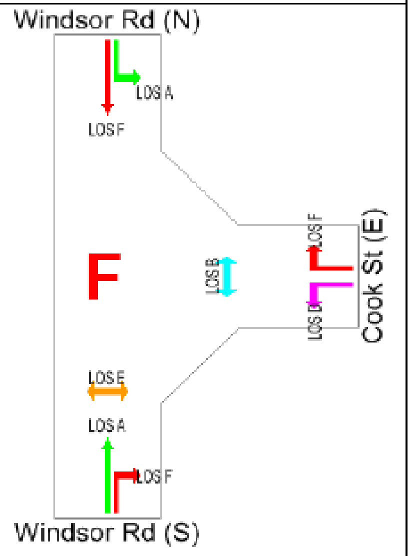
Layout



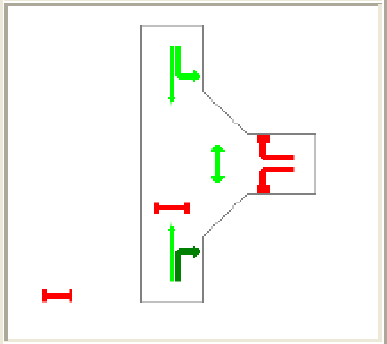
Volumes



Level of Service

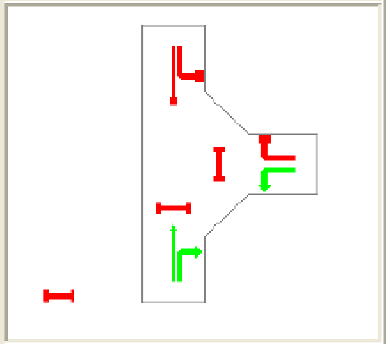


Phase A



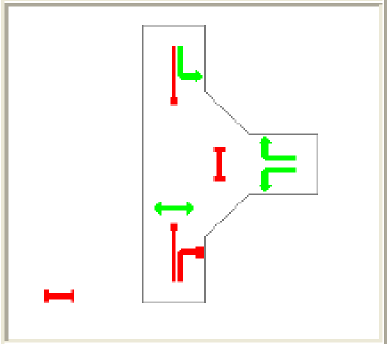
Green Time = **80** seconds
Phase Time = **86** seconds
Phase Split = **61** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

Phase C

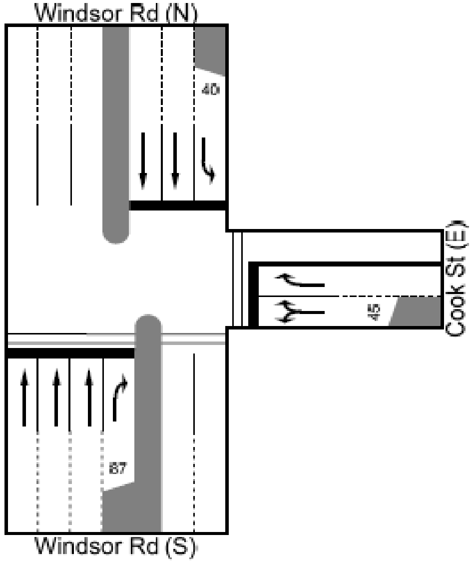


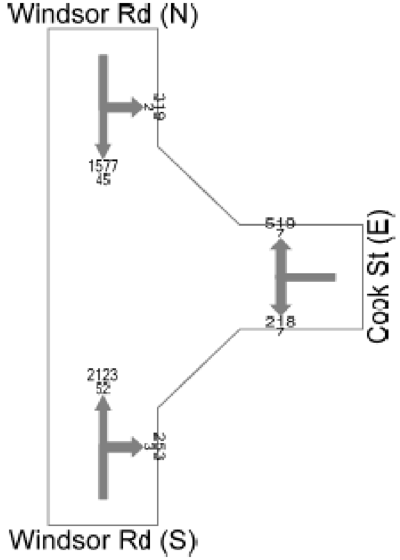
Green Time = **36** seconds
Phase Time = **42** seconds
Phase Split = **30** %

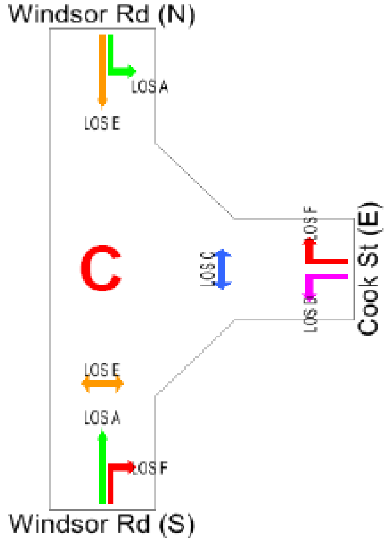
C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2009 Base (Existing) PM

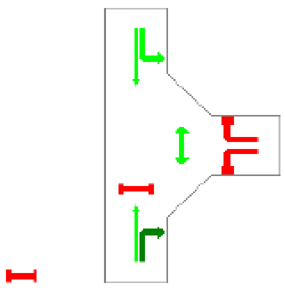
Layout	Volumes	Level of Service





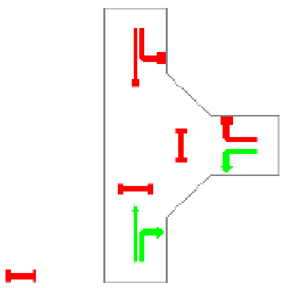


Phase A



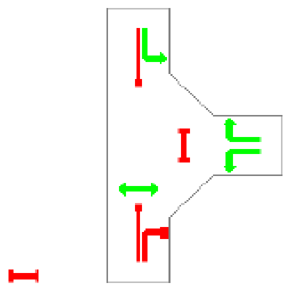
Green Time = **63** seconds
Phase Time = **69** seconds
Phase Split = **49** %

Phase B



Green Time = **16** seconds
Phase Time = **22** seconds
Phase Split = **16** %

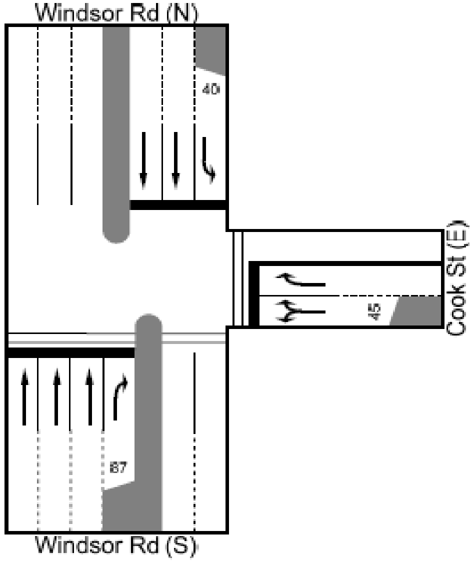
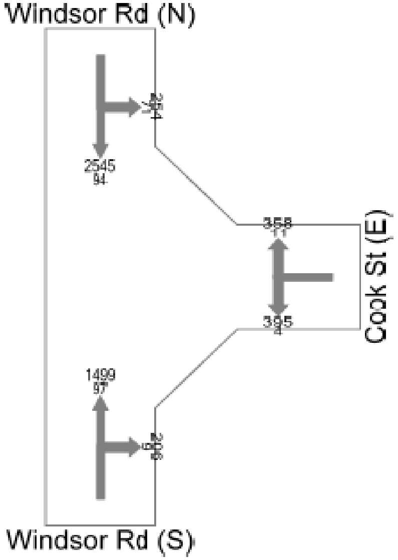
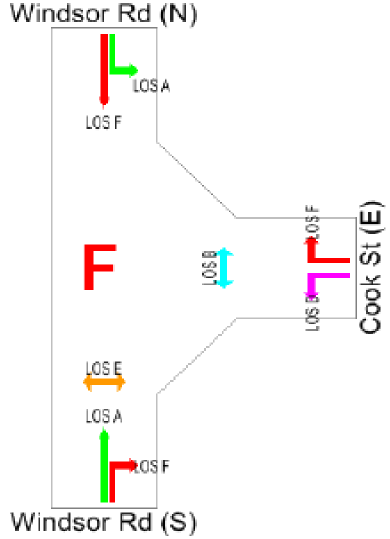
Phase C



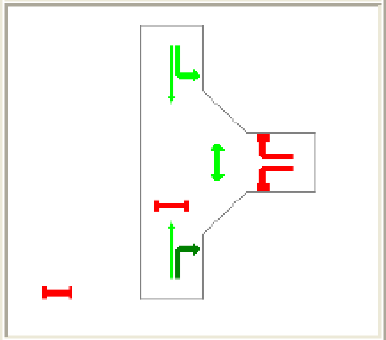
Green Time = **43** seconds
Phase Time = **49** seconds
Phase Split = **35** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2011 Status Quo AM

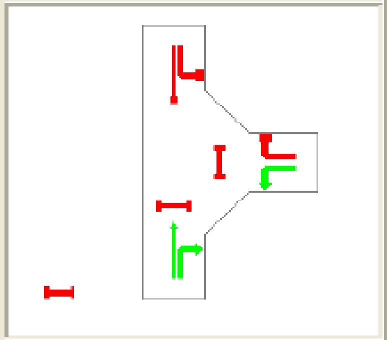
Layout	Volumes	Level of Service
		

Phase A



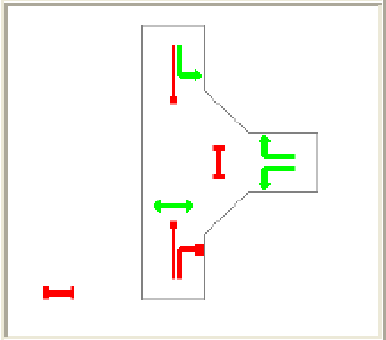
Green Time = **80** seconds
Phase Time = **86** seconds
Phase Split = **61** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

Phase C

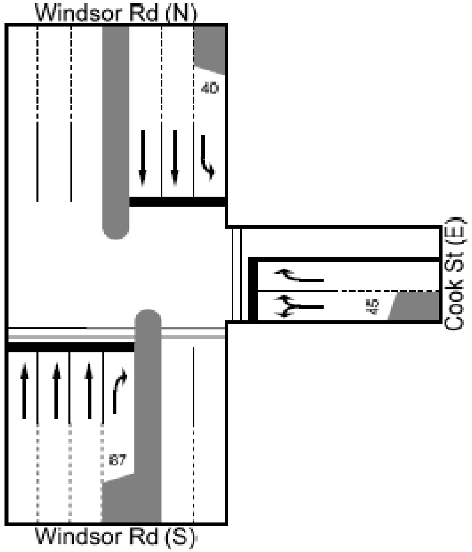


Green Time = **36** seconds
Phase Time = **42** seconds
Phase Split = **30** %

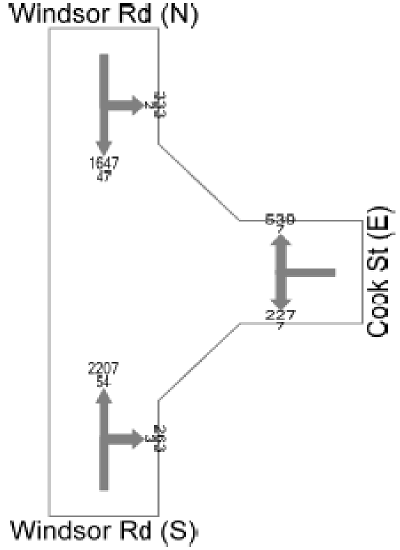
C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2011 Status Quo PM

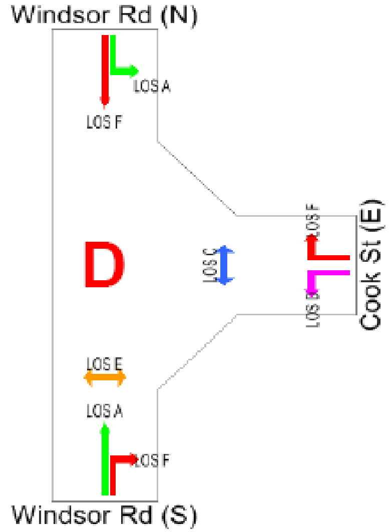
Layout



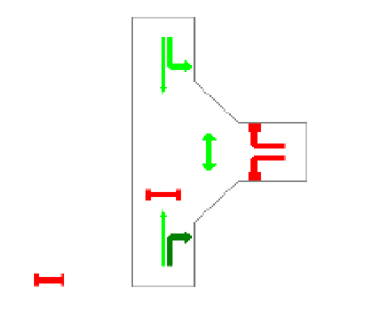
Volumes



Level of Service

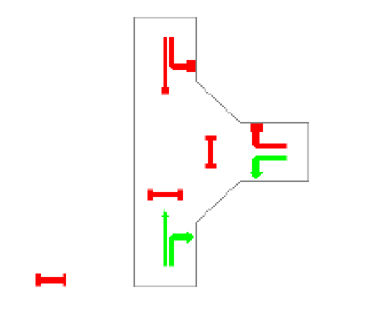


Phase A



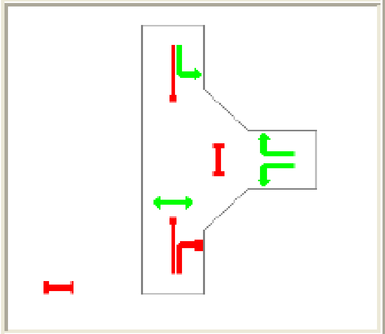
Green Time = **64** seconds
Phase Time = **70** seconds
Phase Split = **50** %

Phase B



Green Time = **15** seconds
Phase Time = **21** seconds
Phase Split = **15** %

Phase C

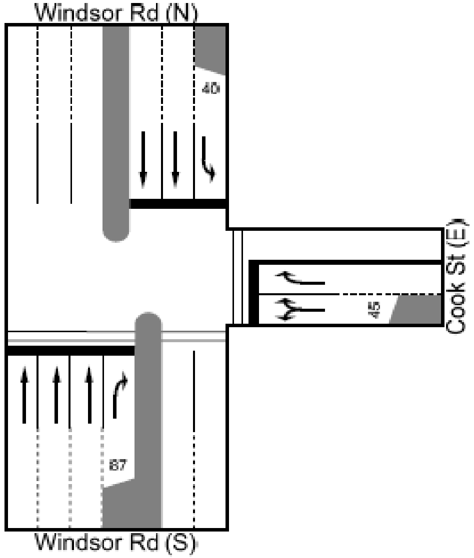


Green Time = **43** seconds
Phase Time = **49** seconds
Phase Split = **35** %

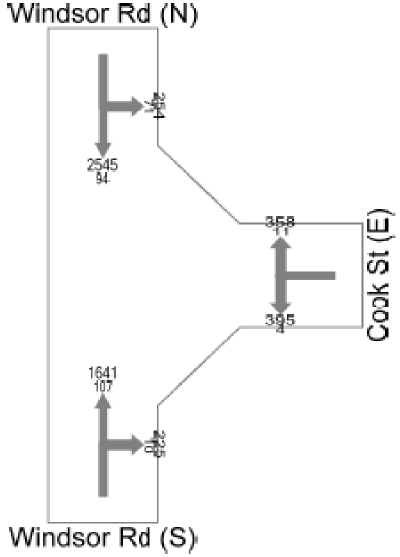
C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2011 with Upgrade AM

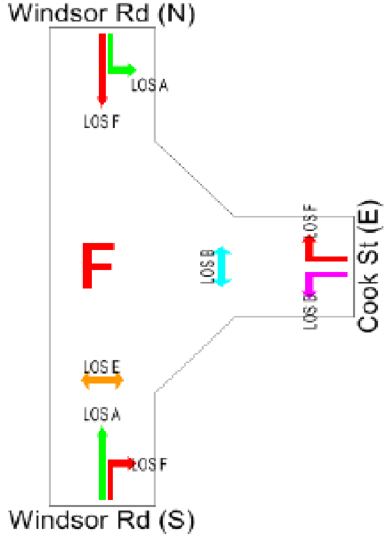
Layout



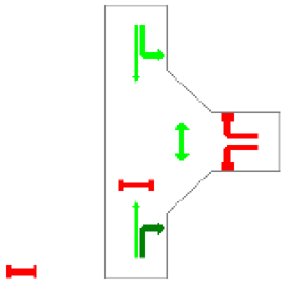
Volumes



Level of Service

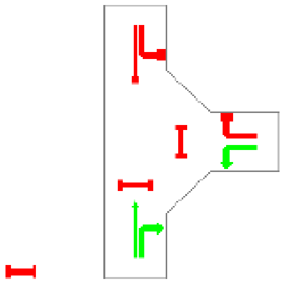


Phase A



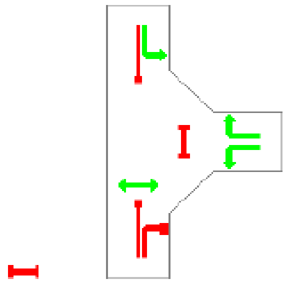
Green Time = **80** seconds
Phase Time = **86** seconds
Phase Split = **61** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

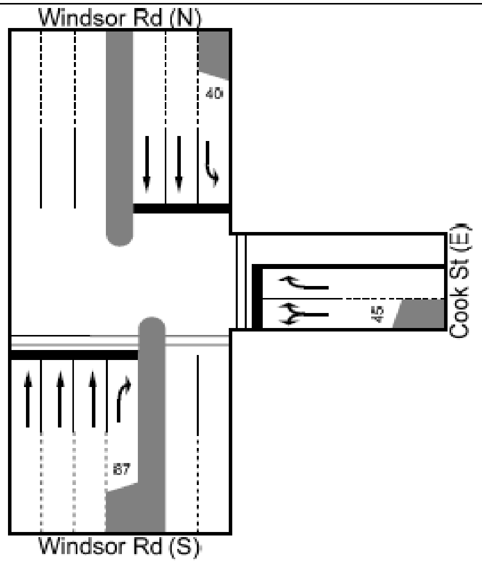
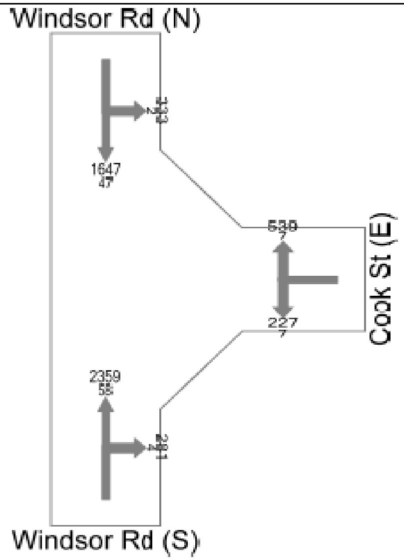
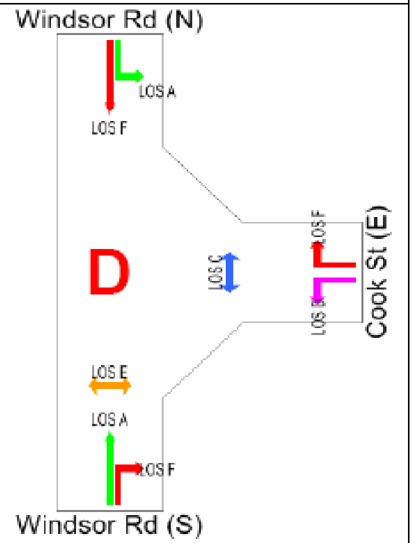
Phase C



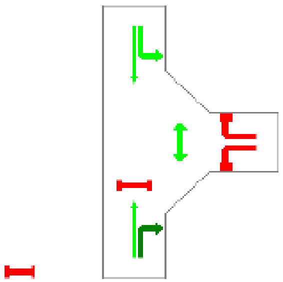
Green Time = **36** seconds
Phase Time = **42** seconds
Phase Split = **30** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2011 with Upgrade PM

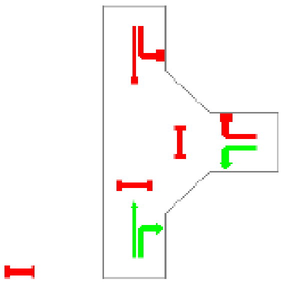
Layout	Volumes	Level of Service
		

Phase A



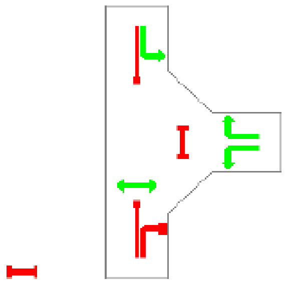
Green Time = **64** seconds
Phase Time = **70** seconds
Phase Split = **50** %

Phase B



Green Time = **15** seconds
Phase Time = **21** seconds
Phase Split = **15** %

Phase C

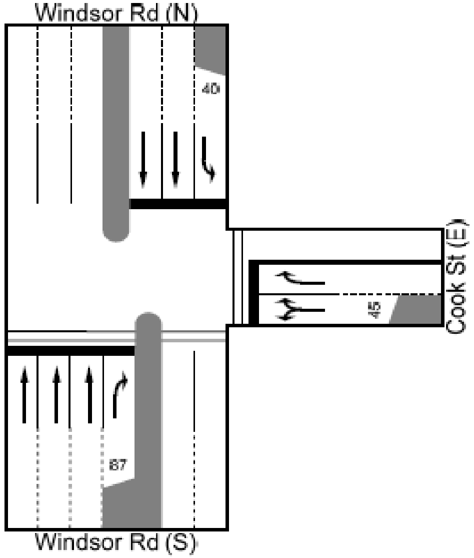


Green Time = **43** seconds
Phase Time = **49** seconds
Phase Split = **35** %

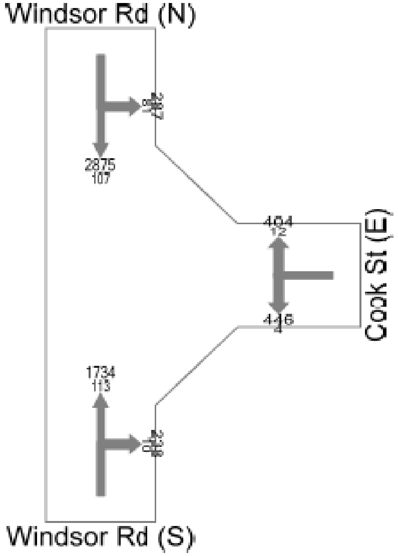
C = **140** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2021 Status Quo AM

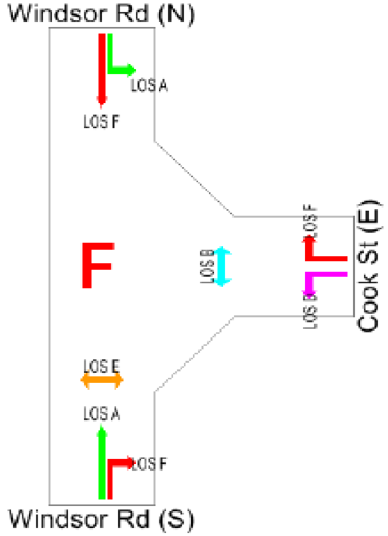
Layout



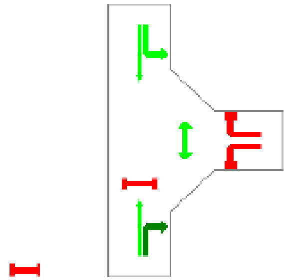
Volumes



Level of Service

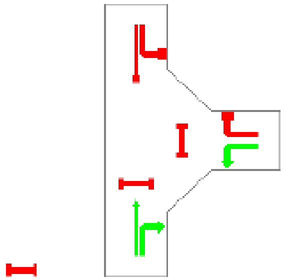


Phase A



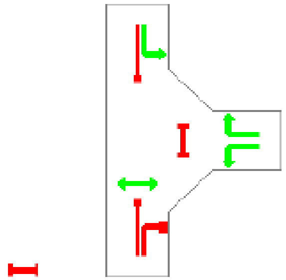
Green Time = **79** seconds
Phase Time = **85** seconds
Phase Split = **61** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

Phase C

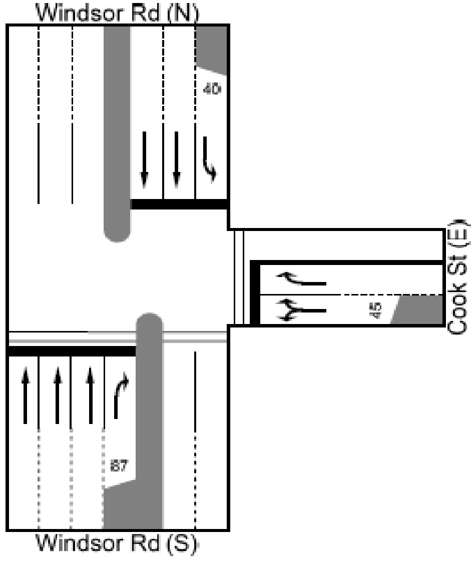


Green Time = **37** seconds
Phase Time = **43** seconds
Phase Split = **31** %

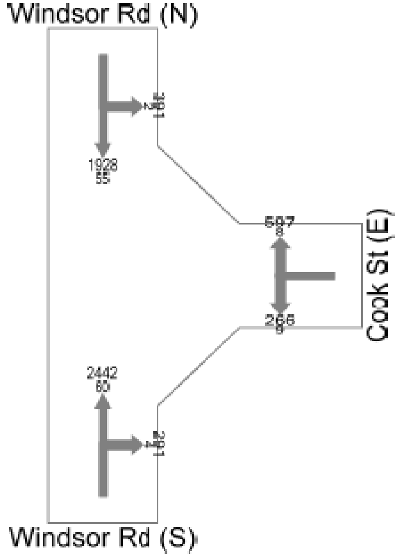
C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2021 Status Quo PM

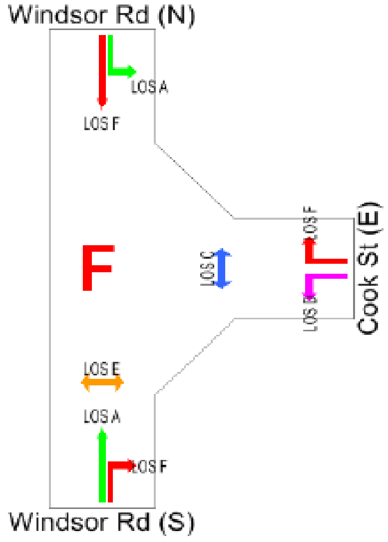
Layout



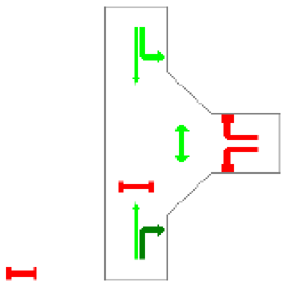
Volumes



Level of Service

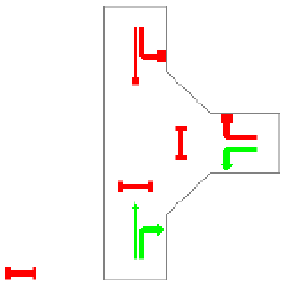


Phase A



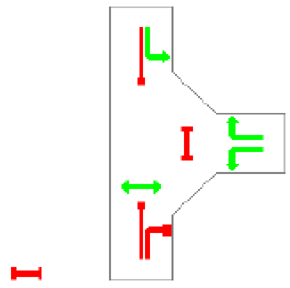
Green Time = **69** seconds
Phase Time = **75** seconds
Phase Split = **54** %

Phase B



Green Time = **16** seconds
Phase Time = **22** seconds
Phase Split = **16** %

Phase C

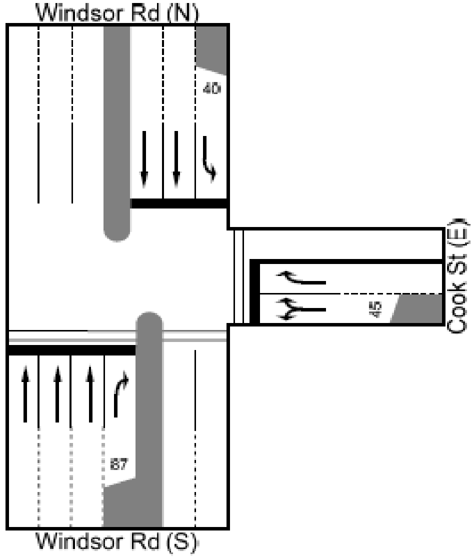


Green Time = **47** seconds
Phase Time = **53** seconds
Phase Split = **38** %

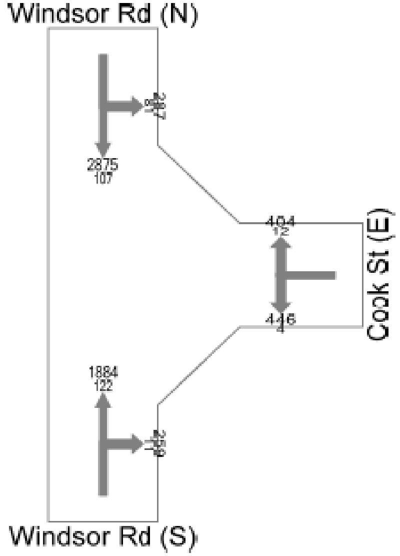
C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2021 with Upgrade AM

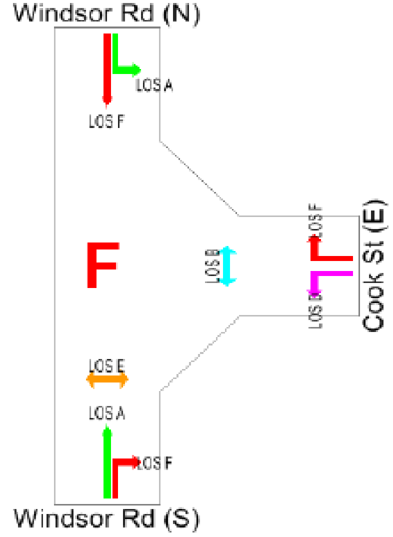
Layout



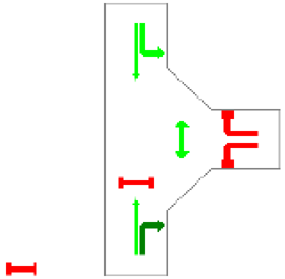
Volumes



Level of Service

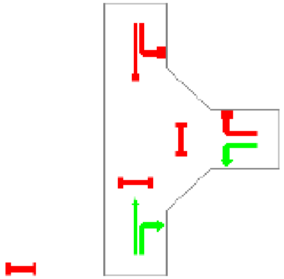


Phase A



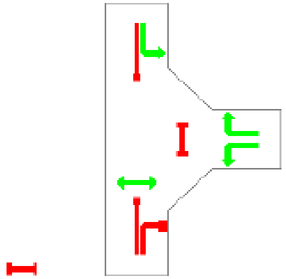
Green Time = **79** seconds
Phase Time = **85** seconds
Phase Split = **61** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

Phase C



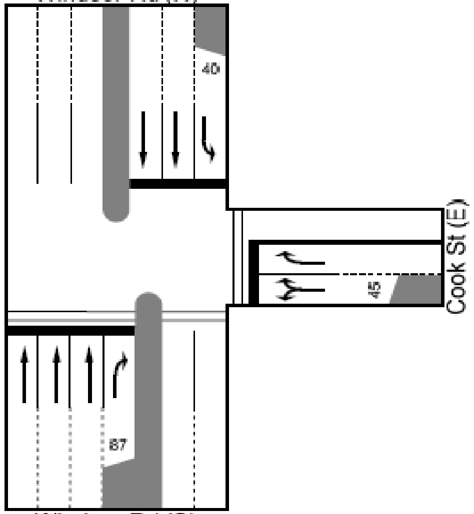
Green Time = **37** seconds
Phase Time = **43** seconds
Phase Split = **31** %

C = **140** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Windsor Rd / M2 Motorway 2021 with Upgrade PM

Layout

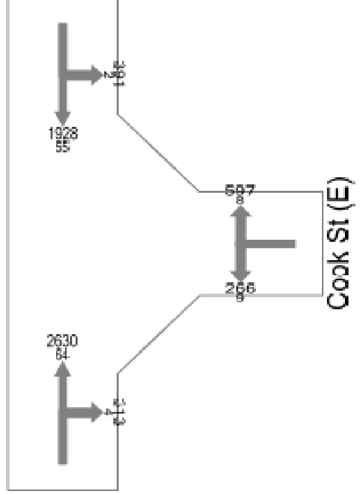
Windsor Rd (N)



Windsor Rd (S)

Volumes

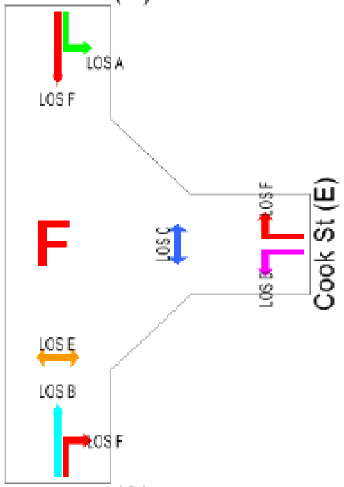
Windsor Rd (N)



Windsor Rd (S)

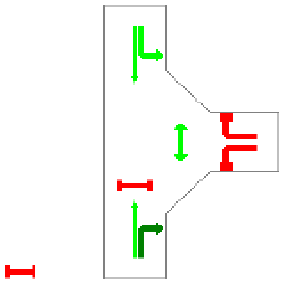
Level of Service

Windsor Rd (N)



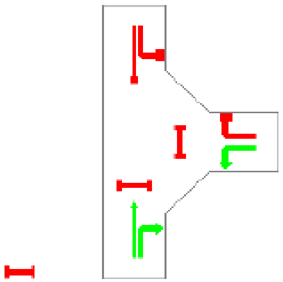
Windsor Rd (S)

Phase A



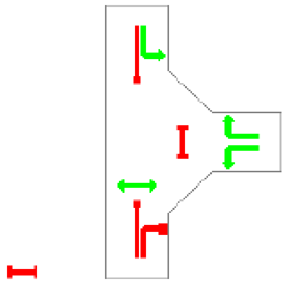
Green Time = **69** seconds
Phase Time = **75** seconds
Phase Split = **54** %

Phase B



Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **9** %

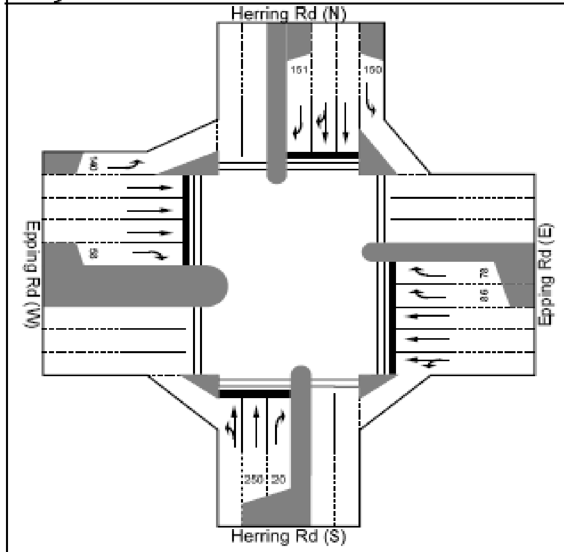
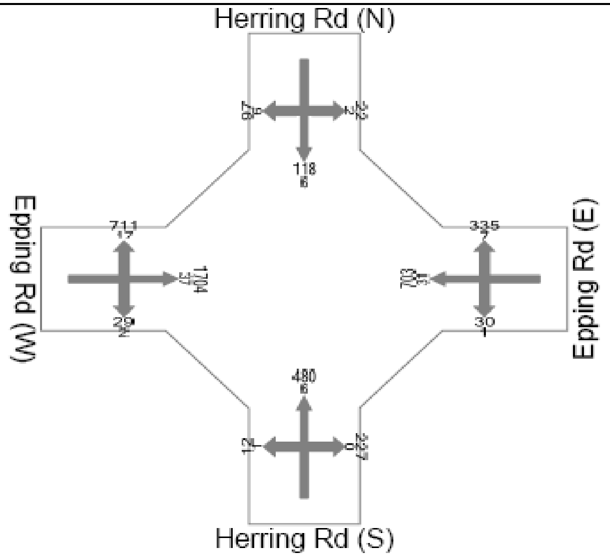
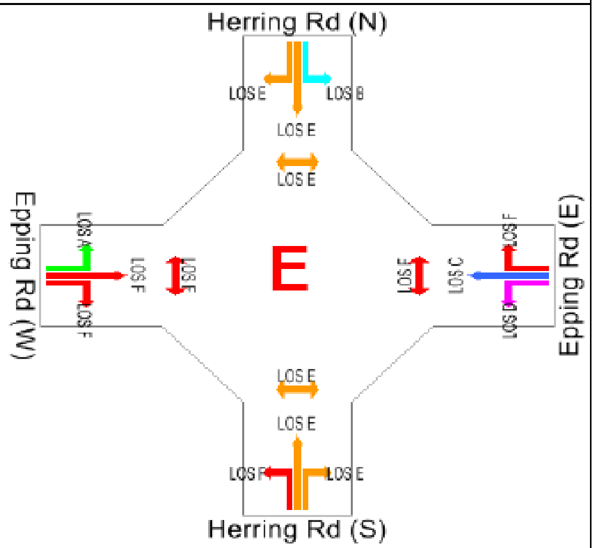
Phase C



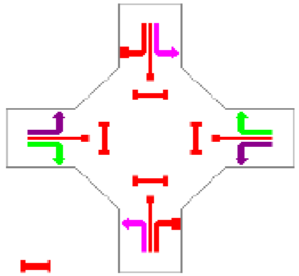
Green Time = **47** seconds
Phase Time = **53** seconds
Phase Split = **38** %

C = **140** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2009 Base (Existing) AM

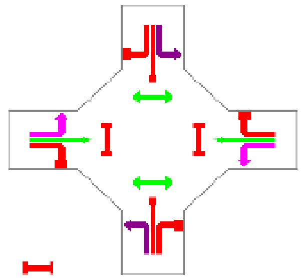
Layout	Volumes	Level of Service
		

Phase F



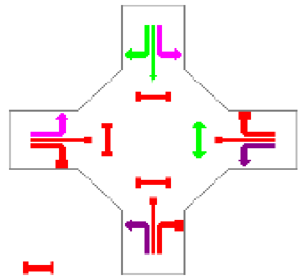
Green Time = **15** seconds
Phase Time = **21** seconds
Phase Split = **14** %

Phase A



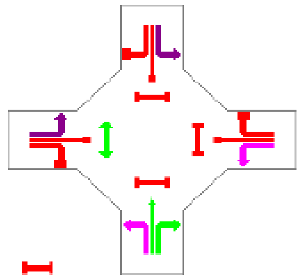
Green Time = **52** seconds
Phase Time = **58** seconds
Phase Split = **39** %

Phase D



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **21** %

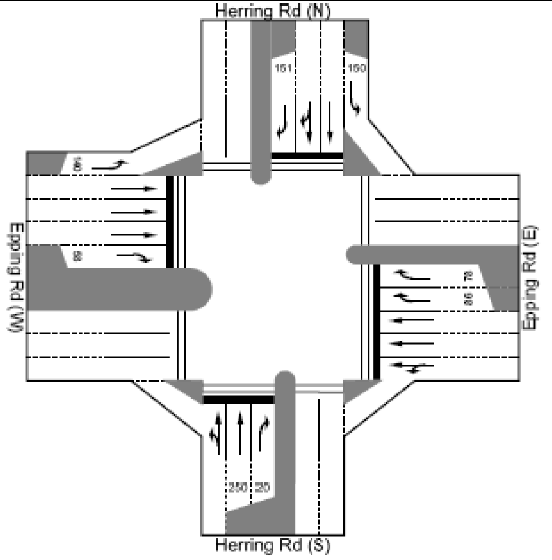
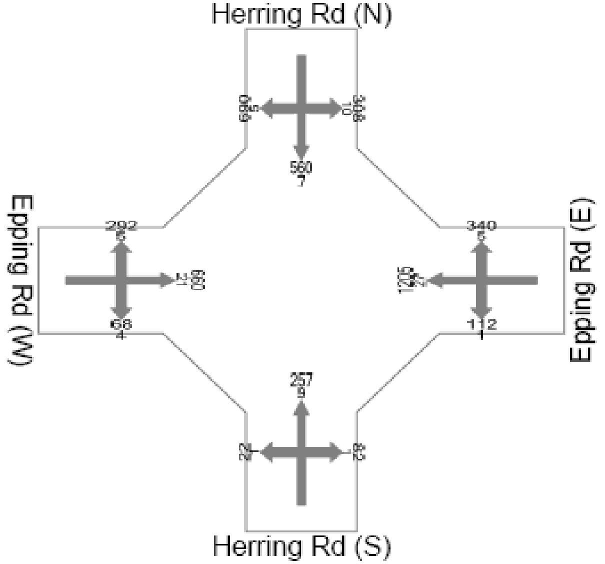
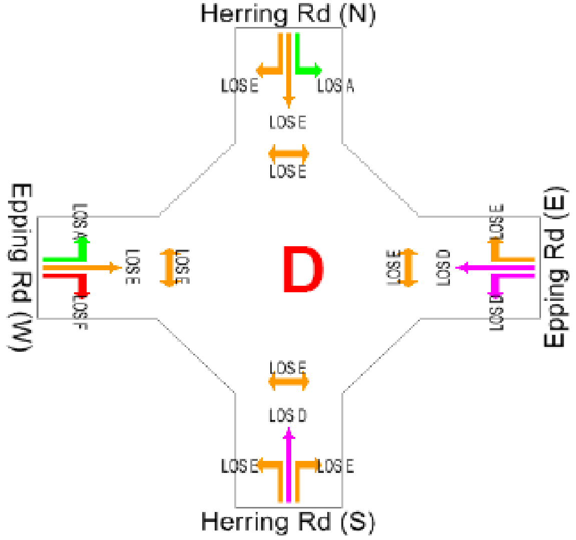
Phase E

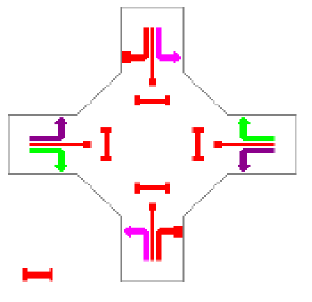
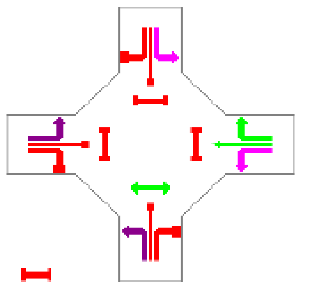
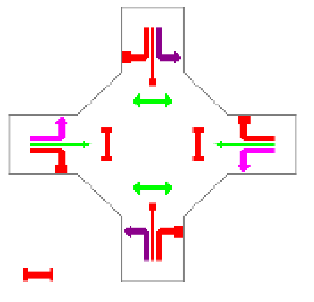
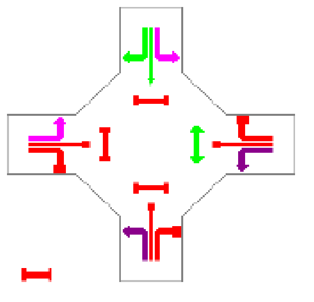
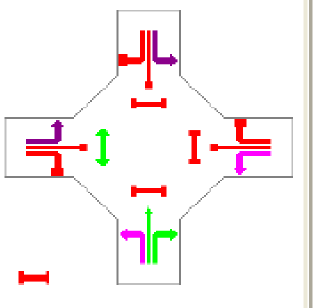


Green Time = **33** seconds
Phase Time = **39** seconds
Phase Split = **26** %

C = **150** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2009 Base (Existing) PM

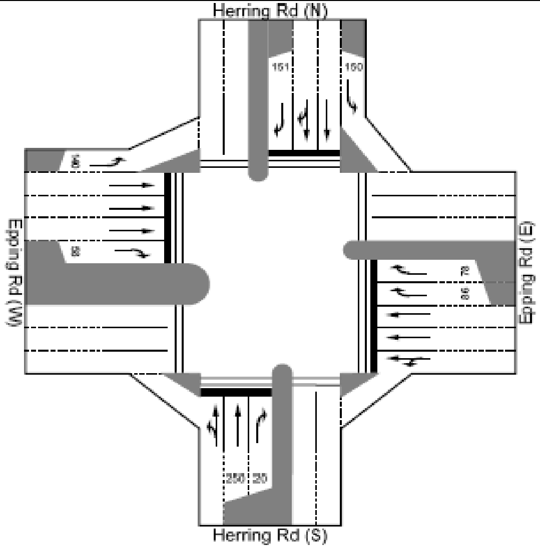
Layout	Volumes	Level of Service
		

Phase F	Phase C	Phase A	Phase D	Phase E
				
Green Time = **6** seconds Phase Time = **12** seconds Phase Split = **10** %	Green Time = **12** seconds Phase Time = **18** seconds Phase Split = **14** %	Green Time = **18** seconds Phase Time = **24** seconds Phase Split = **19** %	Green Time = **31** seconds Phase Time = **37** seconds Phase Split = **30** %	Green Time = **28** seconds Phase Time = **34** seconds Phase Split = **27** %

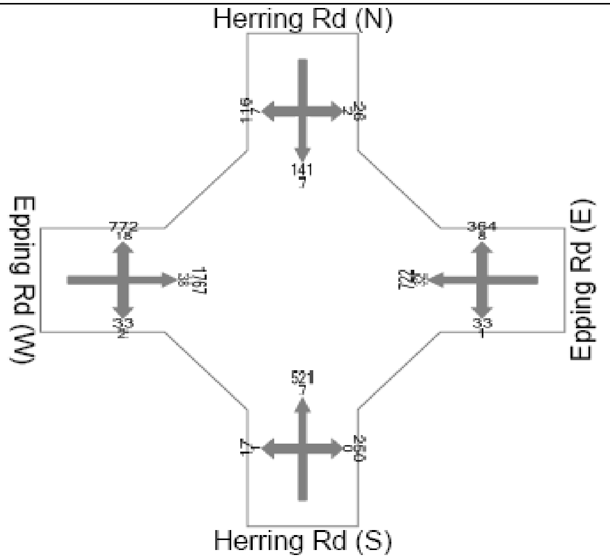
C = **125** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Epping Road / Herring Road 2011 Status Quo AM

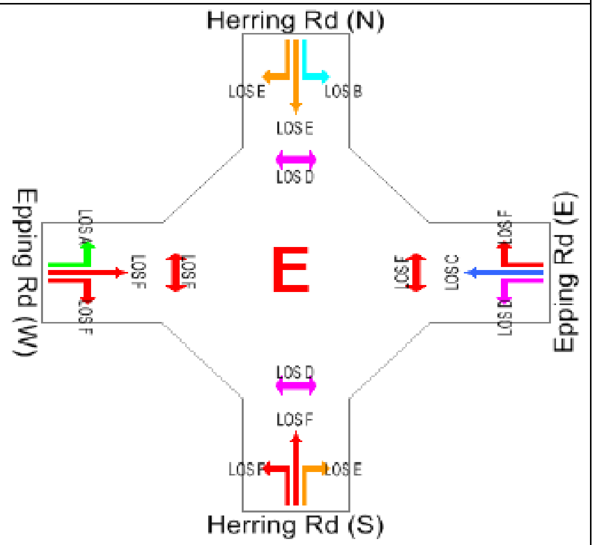
Layout



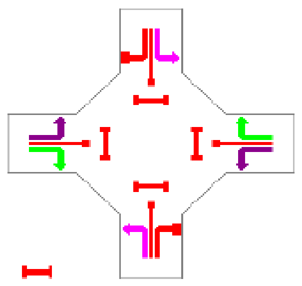
Volumes



Level of Service

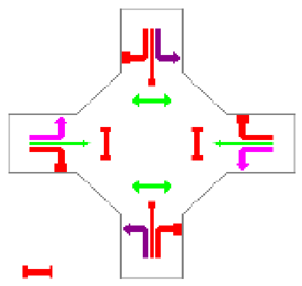


Phase F



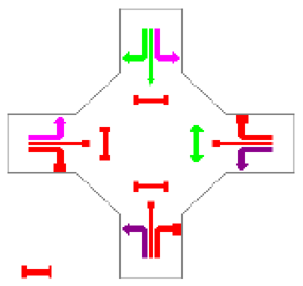
Green Time = **16** seconds
Phase Time = **22** seconds
Phase Split = **15** %

Phase A



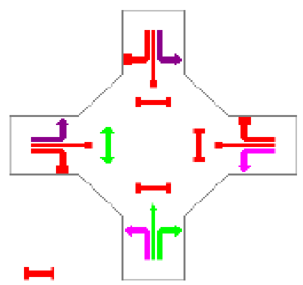
Green Time = **53** seconds
Phase Time = **59** seconds
Phase Split = **39** %

Phase D



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **21** %

Phase E



Green Time = **31** seconds
Phase Time = **37** seconds
Phase Split = **25** %

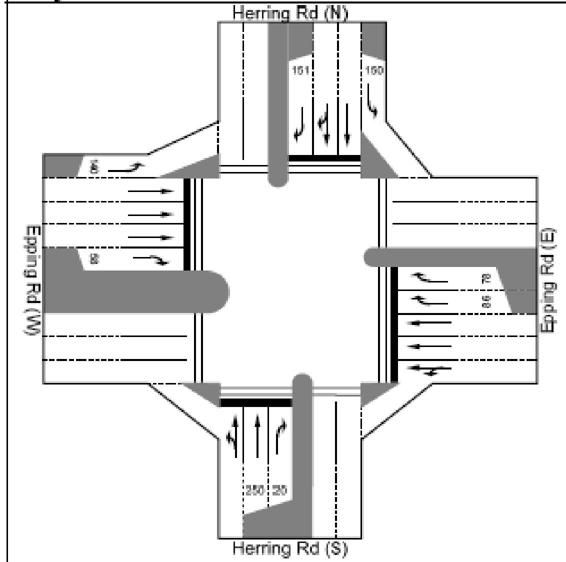
C = **150** sec

Cycle Time Option: **Optimum cycle time**

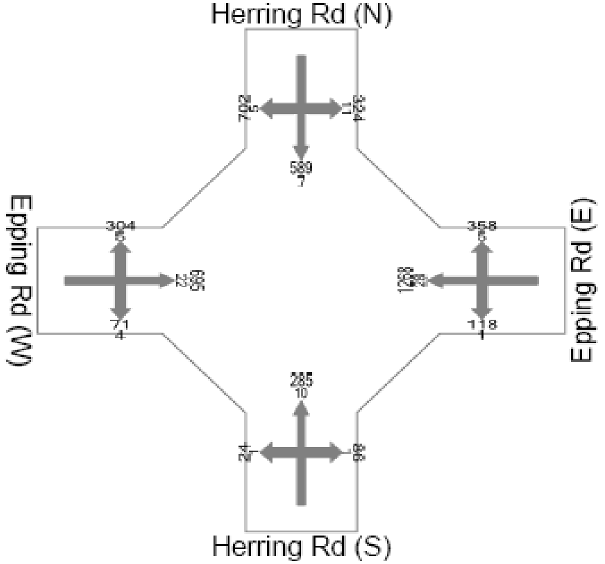
Phase times determined by the program.

Epping Road / Herring Road 2011 Status Quo PM

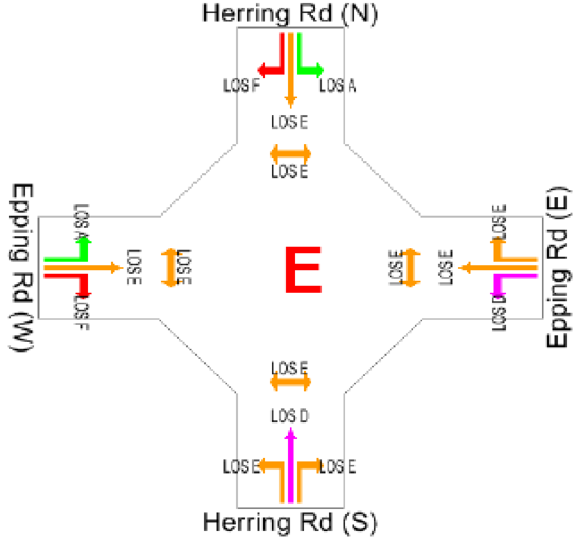
Layout



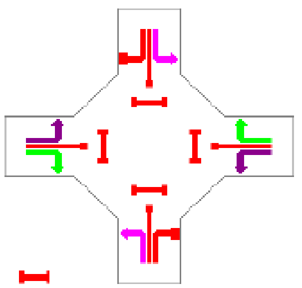
Volumes



Level of Service

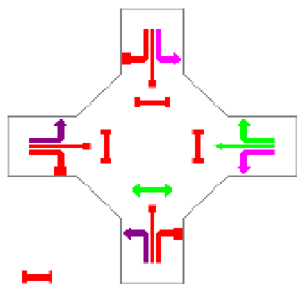


Phase F



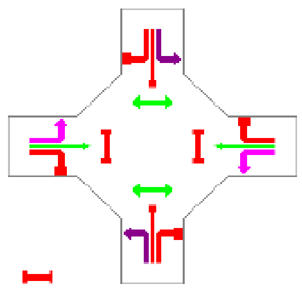
Green Time = **6** seconds
Phase Time = **12** seconds
Phase Split = **10** %

Phase C



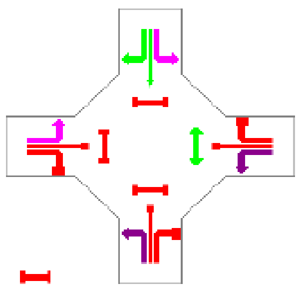
Green Time = **12** seconds
Phase Time = **18** seconds
Phase Split = **14** %

Phase A



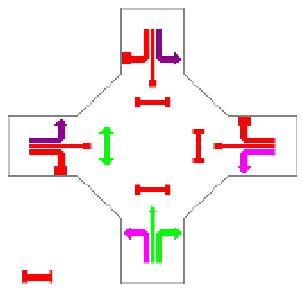
Green Time = **18** seconds
Phase Time = **24** seconds
Phase Split = **19** %

Phase D



Green Time = **31** seconds
Phase Time = **37** seconds
Phase Split = **30** %

Phase E

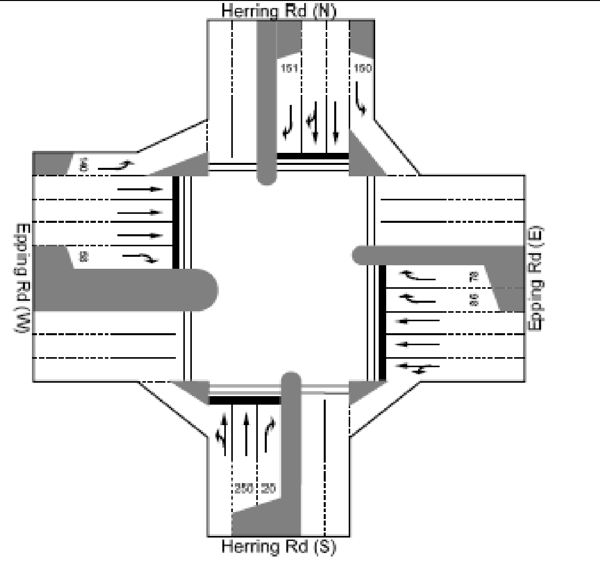


Green Time = **28** seconds
Phase Time = **34** seconds
Phase Split = **27** %

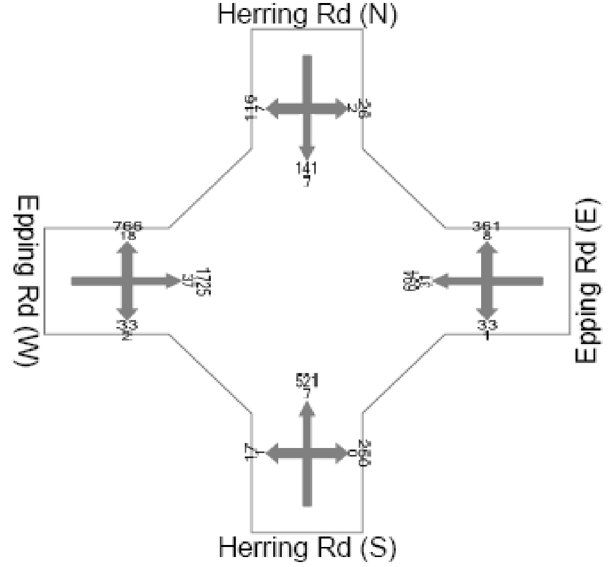
C = **125** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2011 with Upgrade AM

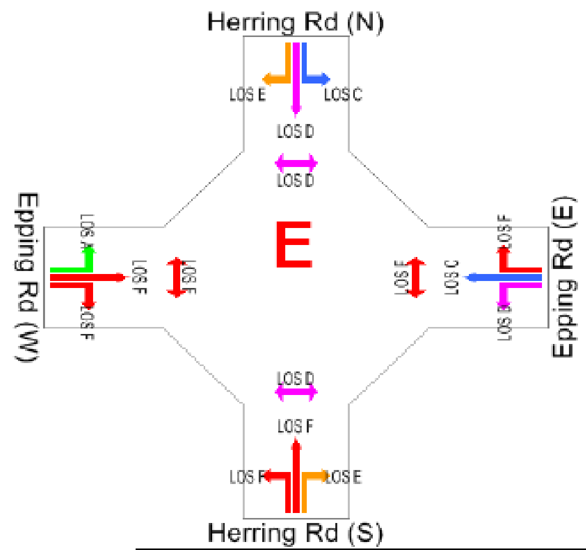
Layout



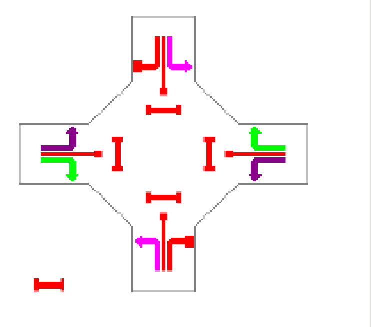
Volumes



Level of Service

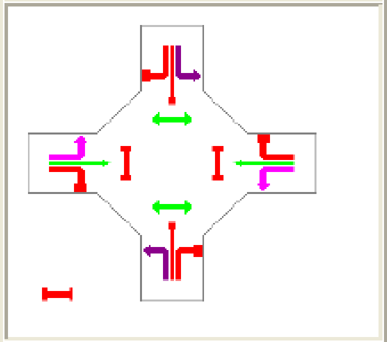


Phase F



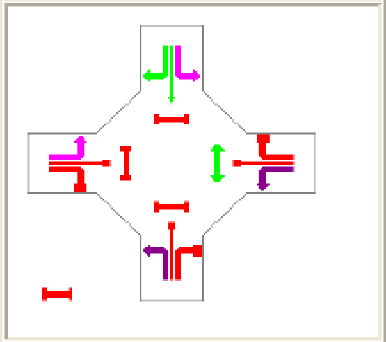
Green Time = **15** seconds
Phase Time = **21** seconds
Phase Split = **14** %

Phase A



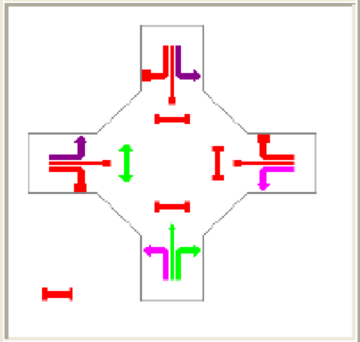
Green Time = **50** seconds
Phase Time = **56** seconds
Phase Split = **39** %

Phase D



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **22** %

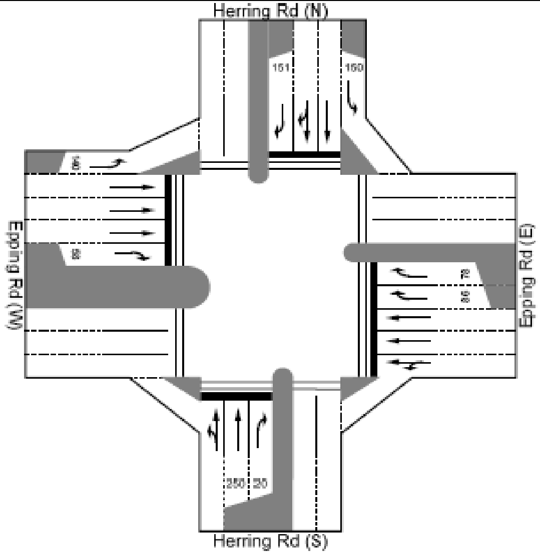
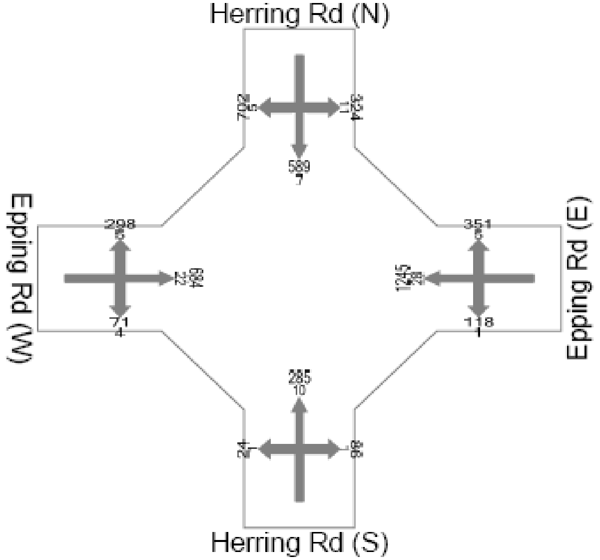
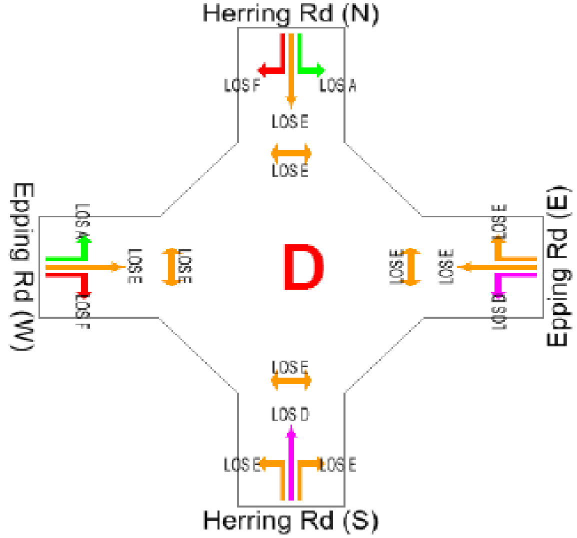
Phase E

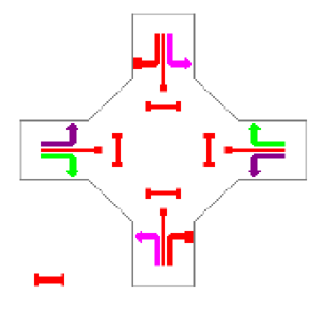
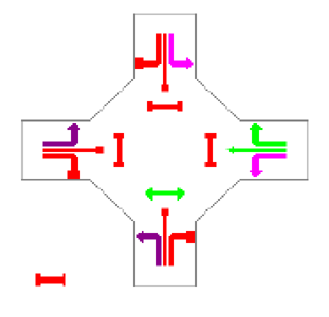
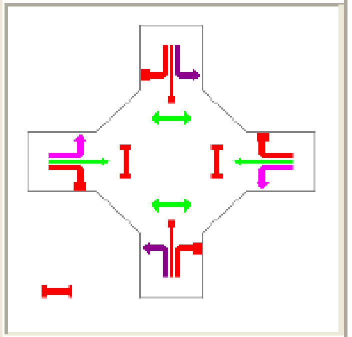
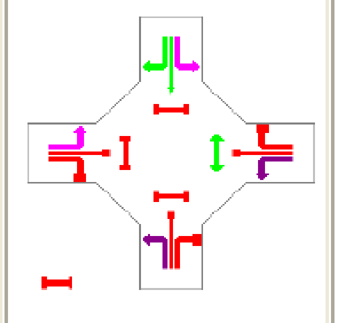
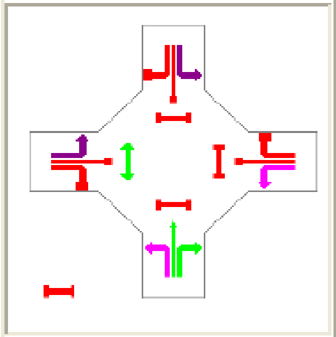


Green Time = **30** seconds
Phase Time = **36** seconds
Phase Split = **25** %

C = **145** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2011 with Upgrade PM

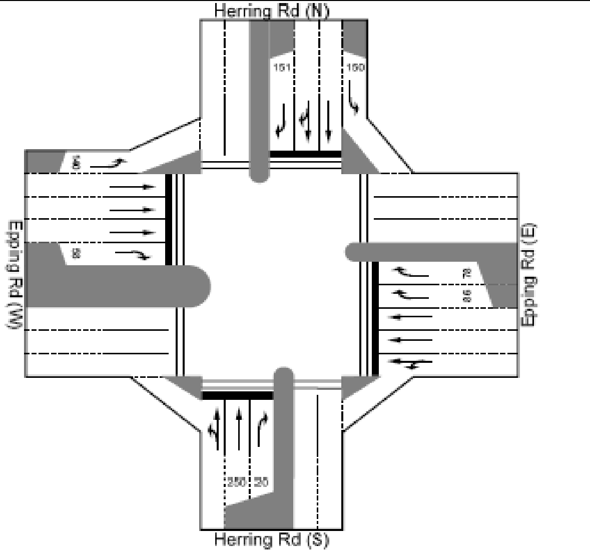
Layout	Volumes	Level of Service
		

Phase F	Phase C	Phase A	Phase D	Phase E
				
Green Time = **6** seconds	Green Time = **12** seconds	Green Time = **18** seconds	Green Time = **31** seconds	Green Time = **28** seconds
Phase Time = **12** seconds	Phase Time = **18** seconds	Phase Time = **24** seconds	Phase Time = **37** seconds	Phase Time = **34** seconds
Phase Split = **10** %	Phase Split = **14** %	Phase Split = **19** %	Phase Split = **30** %	Phase Split = **27** %

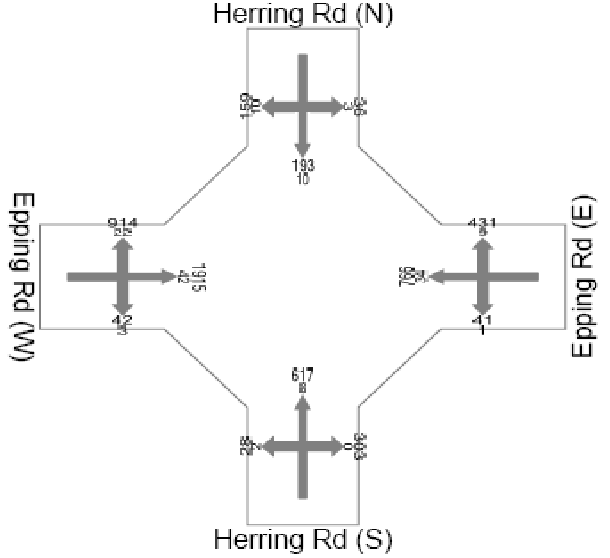
C = **125** sec   Cycle Time Option: **User-specified cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2021 Status Quo AM

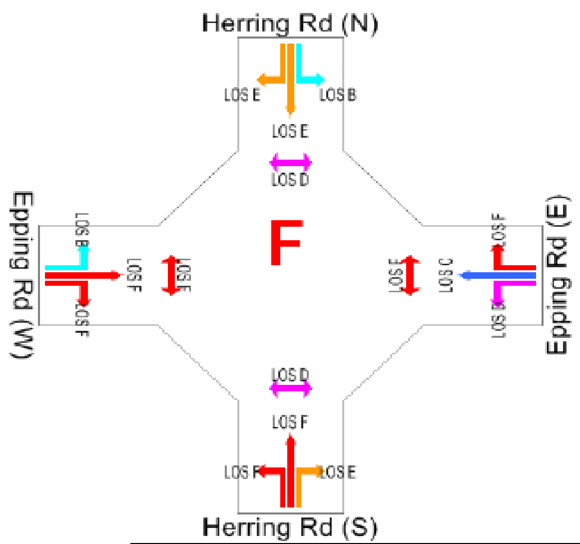
Layout



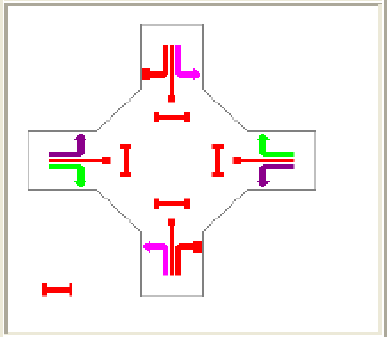
Volumes



Level of Service

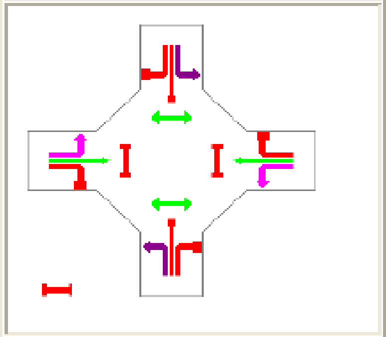


Phase F



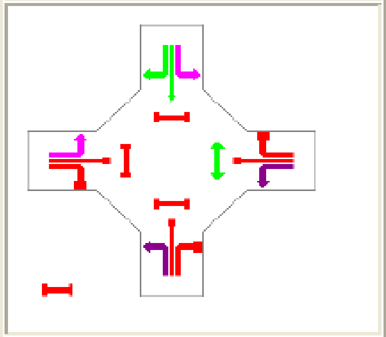
Green Time = **14** seconds
Phase Time = **20** seconds
Phase Split = **13** %

Phase A



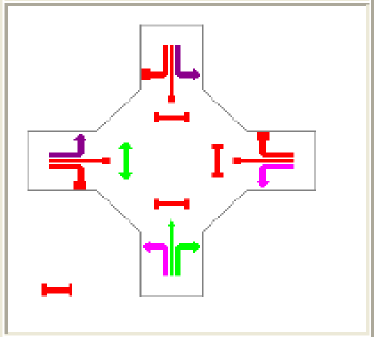
Green Time = **53** seconds
Phase Time = **59** seconds
Phase Split = **39** %

Phase D



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **21** %

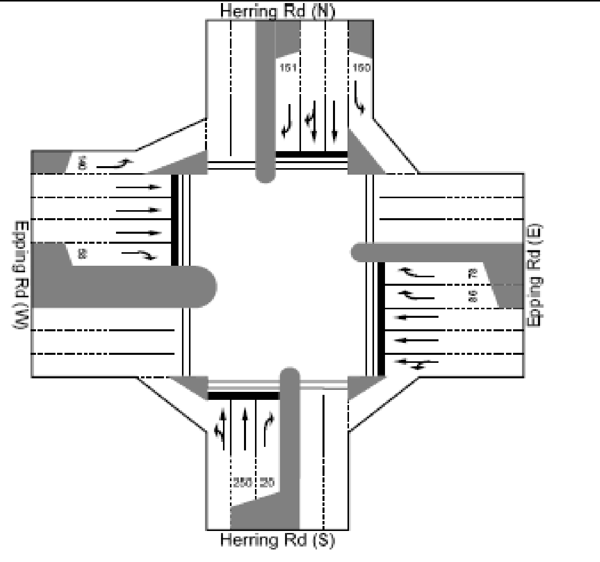
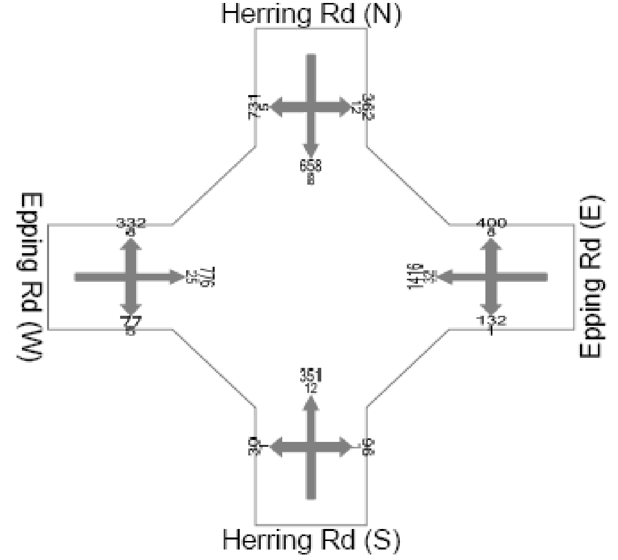
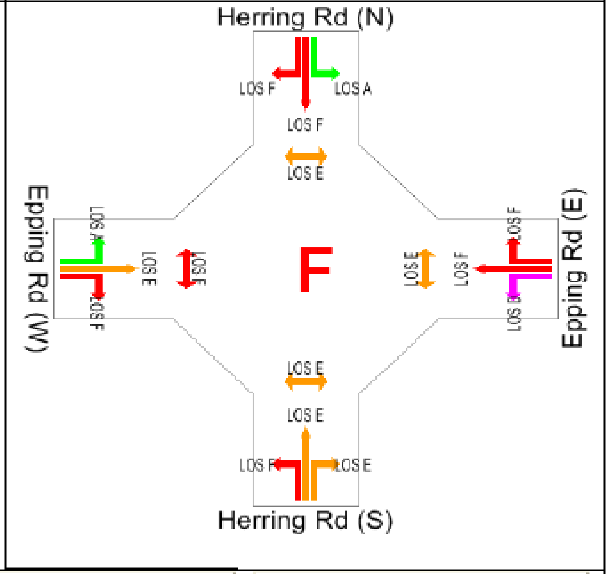
Phase E

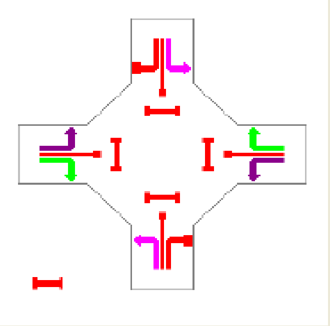
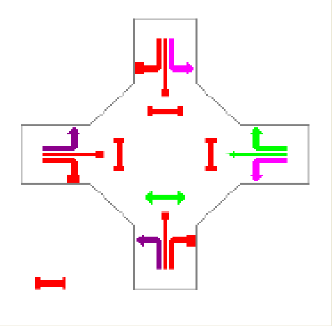
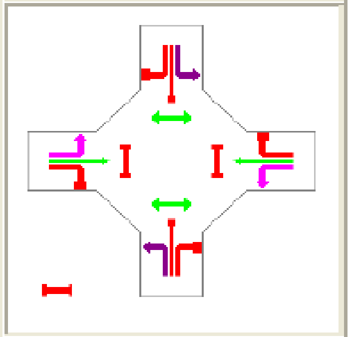
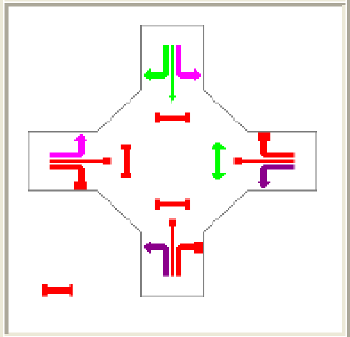
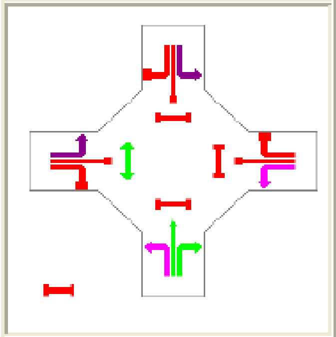


Green Time = **33** seconds
Phase Time = **39** seconds
Phase Split = **26** %

C = **150** sec Cycle Time Option: **Optimum cycle time** **Phase times determined by the program.**

Epping Road / Herring Road 2021 Status Quo PM

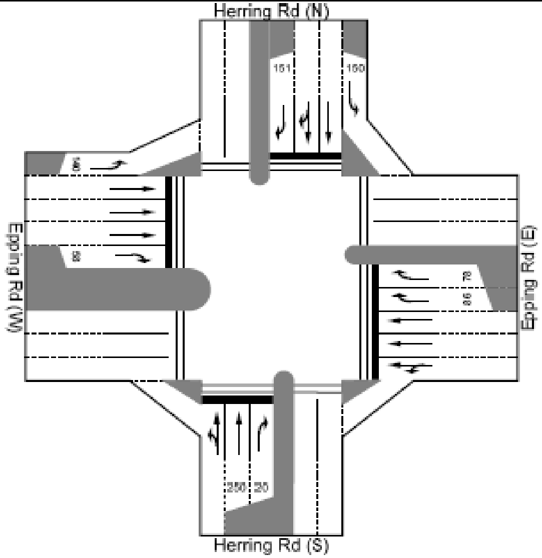
Layout	Volumes	Level of Service
		

Phase F	Phase C	Phase A	Phase D	Phase E
				
Green Time = **8** seconds Phase Time = **14** seconds Phase Split = **9** %	Green Time = **13** seconds Phase Time = **19** seconds Phase Split = **13** %	Green Time = **28** seconds Phase Time = **34** seconds Phase Split = **23** %	Green Time = **39** seconds Phase Time = **45** seconds Phase Split = **30** %	Green Time = **32** seconds Phase Time = **38** seconds Phase Split = **25** %

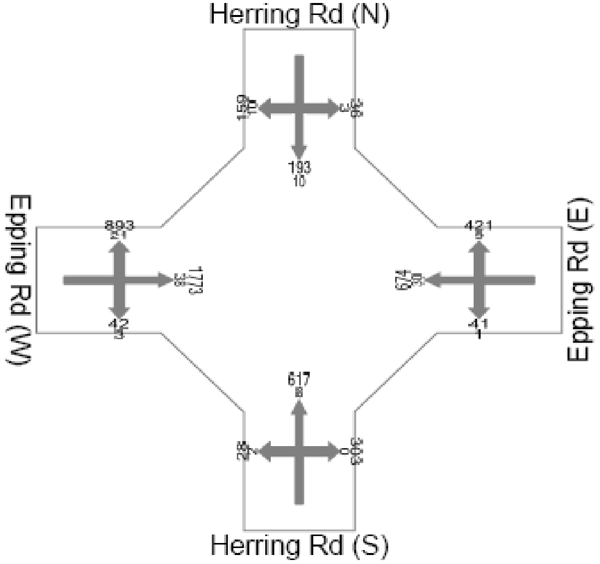
C = **150** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

Epping Road / Herring Road 2021 with Upgrade AM

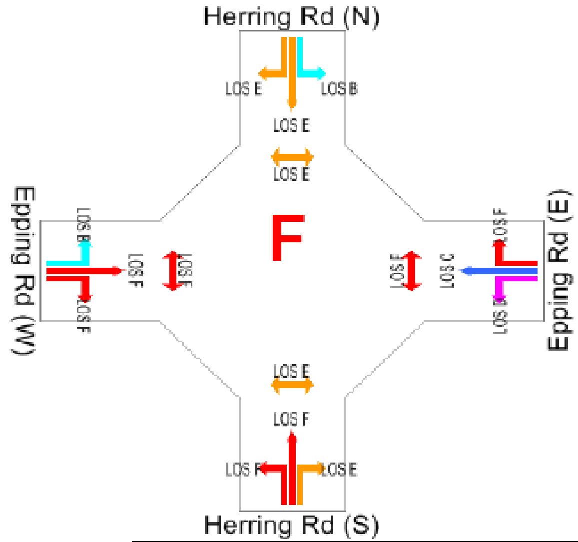
Layout



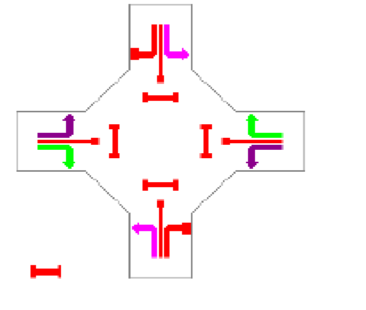
Volumes



Level of Service

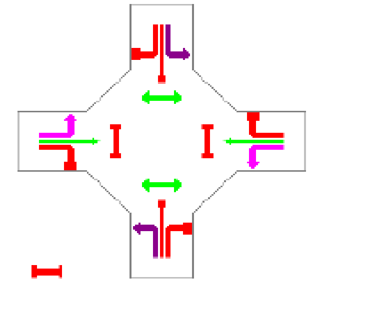


Phase F



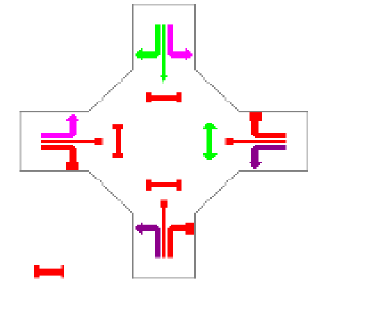
Green Time = **14** seconds
Phase Time = **20** seconds
Phase Split = **13** %

Phase A



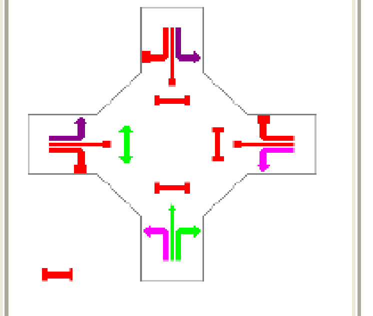
Green Time = **50** seconds
Phase Time = **56** seconds
Phase Split = **37** %

Phase D



Green Time = **26** seconds
Phase Time = **32** seconds
Phase Split = **21** %

Phase E

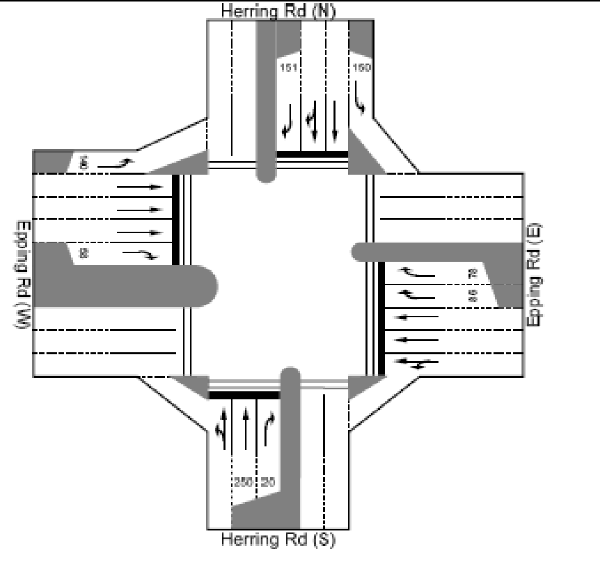


Green Time = **36** seconds
Phase Time = **42** seconds
Phase Split = **28** %

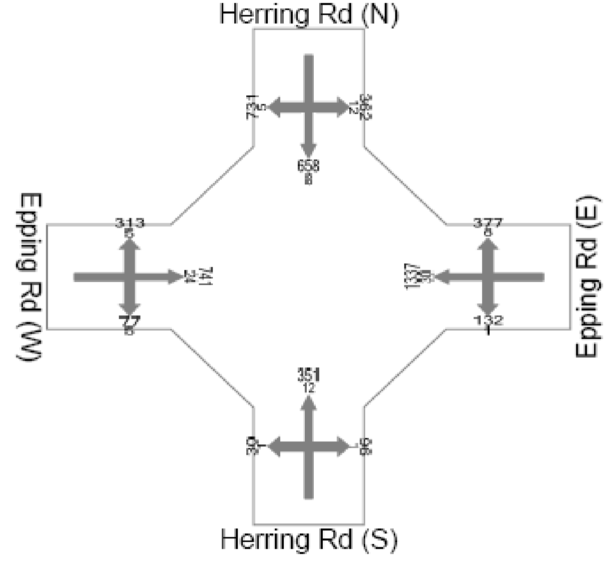
C = **150** sec   Cycle Time Option: **Optimum cycle time**   **Phase times determined by the program.**

Epping Road / Herring Road 2021 with Upgrade PM

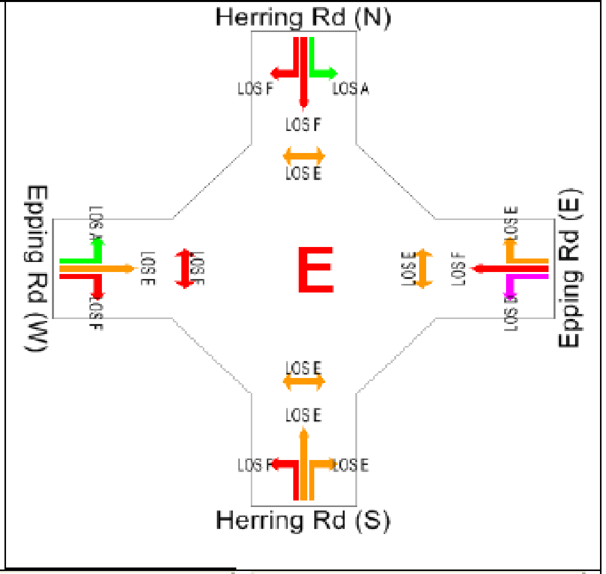
Layout



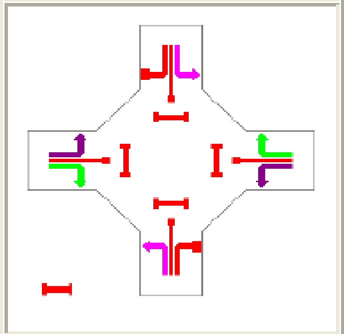
Volumes



Level of Service

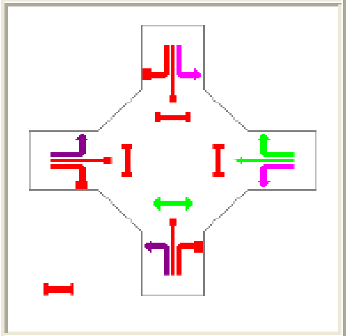


Phase F



Green Time = **7** seconds
Phase Time = **13** seconds
Phase Split = **9** %

Phase C



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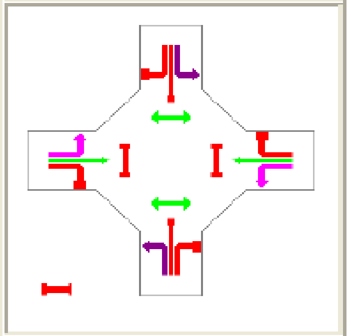

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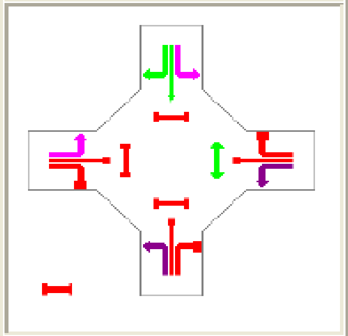

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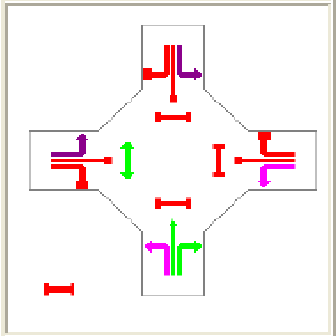
Phase E



Green Time = **33** seconds
Phase Time = **39** seconds
Phase Split = **27** %

C = **145** sec Cycle Time Option: **User-specified cycle time** **Phase times determined by the program.**

REPORT 10-7434-R1

Revision 3

M2 Motorway Upgrade Project
Environmental Assessment
Noise and Vibration
(M2U-REP-30-00-EN003A-01)

PREPARED FOR

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28 APRIL 2010

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M2 Motorway Upgrade Project
Environmental Assessment
Noise and Vibration
(M2U-REP-30-00-EN003A-01)

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EXECUTIVE SUMMARY

INTRODUCTION

The M2 Motorway spans approximately 21 km from Baulkham Hills to North Ryde and is, in several sections, in close proximity to a number of densely populated residential areas.

The current demands on the M2 Motorway are well known, with the motorway being seen to be at capacity during busy periods of the day. It is therefore proposed to widen the motorway in various sections along its length to help reduce the strain on the motorway. Associated upgrades to some of the interchanges along the route are also planned.

The purpose of this document is to provide a detailed assessment of the noise and vibration impacts associated with the construction and operation of the upgrade project.

The potential noise and vibration impacts of the M2 Upgrade Project can be broken down as follows:

- Impact on surrounding areas during the construction phase of the project due to the widening of the motorway and interchange upgrade works, including:
  - Construction noise
  - Construction vibration
  - Construction ground-borne noise from widening of the Norfolk Tunnel
- Operational impacts after project commissioning, consisting primarily of:
  - Noise emissions due to changed road traffic conditions
  - Mechanical noise emissions from the Norfolk Tunnel ventilation fan system

AMBIENT NOISE MONITORING

In order to characterise the existing noise environment adjacent to the project area and to establish the noise levels upon which to base the noise emission objectives, environmental noise monitoring was performed at a number of representative locations along the length of M2 Upgrade Project corridor.

The monitoring was completed over two separate surveys. The first of these surveys was carried out in March and April 2008 at 24 receptor locations along the motorway route; the second survey was performed in December 2008 at a further 13 locations.

CONSTRUCTION NOISE

Construction Noise Criteria

Heggies has conducted a review of guidelines and current practices for the assessment and subsequent mitigation of construction noise, and has adopted the quantitative assessment approach embodied within the Department of Environment, Climate Change and Water (DECCW) Interim Construction Noise Guideline (ICNG).

The ICNG requires the determination of *Noise Management Levels* (NMLs) for noise affected receivers consistent with current practices to deal with construction noise in a transparent and consistent way.

In line with this approach, the following $L_{Aeq(15minute)}$ NMLs have been adopted for sensitive receivers:

- Daytime (7.00 am to 6.00 pm) RBL or L_{A90} Background + 10 dBA
- Evening (6.00 pm to 10.00 pm) RBL or L_{A90} Background + 5 dBA
- Night-time (10.00 pm to 7.00 am) RBL or L_{A90} Background + 5 dBA

Daytime Construction Works

Construction noise during the daytime period is generally predicted to be in line with the Noise Management Levels at most of the assessment locations. This results mainly from the relatively high daytime background noise levels which are apparent from existing traffic movements on the M2 Motorway. A number of small exceedances are predicted for the construction scenarios associated with Road Widening and Bridgeworks.

Out of Hours Works

During the evening period, exceedances of the project Noise Management Levels are apparent for most of the construction scenarios assessed. These exceedances range from minor (ie just above compliance levels) to around 15 dBA.

For the night-time period there are significant exceedances for most activities as a result of the more stringent NMLs which apply to this period.

Prior to undertaking significant "out of hours" works, justification for undertaking such works would be established, noise mitigation and management measures would be implemented (where required) to minimise the potential impacts at nearby sensitive receivers combined with extensive consultation with affected communities.

Discussion Regarding Construction Noise Exceedances

Although the assessment predicts significant exceedances at times, it is noted that the sensitive receiver noise levels predictions arise out of simulated *"worst-case"* scenarios whereby all the equipment within a particular scenario is operating concurrently, for the full 15-minute assessment period, in a location immediately adjacent to the residences of interest.

This situation, and any resulting Noise Management Level exceedances, may therefore only be apparent at a particular receiver of interest for a relatively short period of time. When all of the equipment assumed to comprise a particular construction scenario is not operating simultaneously (which will often be the case) and as plant and equipment moves along the road section of interest, the noise levels would be expected to reduce accordingly.

Notwithstanding the above, the following approach will be undertaken, in accordance with the ICNG:

- All reasonable and feasible work practices need to be applied to meet the noise goals.
- Where Noise Management Levels are likely to be exceeded (especially during the more sensitive evening and night-time periods), community liaison must be undertaken and negotiation take place to arrive at the final mitigation strategy.

The assessment indicates that in the daytime, evening and night-time periods, the higher exceedances are generally related to the use of the following items of plant:

- Concrete saws (and reinforcement cutting)
- Rockbreakers
- Jackhammers

These noise intensive activities may therefore need to be restricted where possible to daytime and evening periods.

Construction Site Compounds

The M2 Upgrade Project would require several temporary Site Compounds to be constructed along the length of the route. These compounds would be used for a variety of purposes including laydown areas, stockpiling, stores, team offices, car parking, etc.

The proposed locations of the Site Compounds are all immediately adjacent to the M2 Motorway, and as such, are already subject to reasonably high levels of ambient (road traffic) noise.

It is noted that the majority of the smaller Site Compounds are intended to be used during the daytime periods, with only the Major Compounds being used 24 hours a day.

Exceedances of Noise Management Levels are predicted where sensitive receivers are situated in proximity to Site Compounds. As such, it will be necessary to provide varying degrees of noise mitigation to minimise the impact of noise generated by the compounds.

As there are negligible existing barriers between the Site Compounds and the sensitive receivers, it is likely that some form of noise barrier would be required to be erected through dedicated and/or temporary noise walls, temporary hoardings, site sheds, etc, in locations where sensitive receivers are situated in close proximity to the proposed construction compounds. Correctly designed and constructed barriers (of solid construction using appropriate materials) would be expected to result in the following reductions in noise levels:

- Minor Barriers (hoarding of indicative height of 3 m - 4 m): 5 dBA to 10 dBA reduction
- Major Barriers (hoarding of indicative height of 6 m - 8 m): 10 dBA to 15 dBA reduction

Close liaison with the local community and a proactive information protocol (ie information on the duration and likely intensity of upcoming works) would play an important part of the management of noise emissions at these locations.

CONSTRUCTION VIBRATION

The major potential sources of construction vibration related to the M2 Upgrade Project include the use of excavators, rockbreakers and vibratory rollers.

In general, vibration produced by earthworks and road forming operations is expected to lie below structural damage criteria at the nearest sensitive receptors. Where vibration-intensive operations are being conducted in close proximity to buildings nearest to the roadworks (eg construction of the Windsor Road Ramps), judicious selection of plant and equipment will be necessary. Vibration may be perceptible for relatively short periods of time when construction activities are immediately adjacent to specific dwellings.

Finally, given the distances of the nearest residences to the proposed construction works, a review of the construction plan would be required to confirm the extent of pre-construction building condition surveys.

CONSTRUCTION IMPACTS OF WIDENING THE NORFOLK TUNNEL

During the widening of the Norfolk Tunnel both airborne and ground-borne noise will have the potential to exceed the relevant criteria at times. The potential noise impacts from the widening works which will be performed entirely within the tunnel will be mitigated with the use of acoustic sheds during the widening of the tunnel, together with an acoustic curtain at either end of tunnel at other times. The acoustic shed will only be in place for the excavation phase of the widening. All other noise generating night-time works within the tunnels will have a noise curtain in place at the portal entrances.

For the early widening works (ie adjustment to the portal transition areas and breaking out of existing concrete barriers) there would be limited mitigation measures, as the options for physical noise attenuation devices and procedural management measures (such as scheduling of activities) would be neither effective nor feasible.

It is recommended that where exceedances are indicated, suitable consultation with the affected land owners should take place to determine the appropriate feasible and reasonable management strategies, together with monitoring to confirm the predicted levels.

CONSTRUCTION NOISE AND VIBRATION MITIGATION STRATEGIES

Certain “baseline” mitigation strategies should be adopted along the route at any section where the noise goals are exceeded. The construction contractor will, where reasonable and feasible, apply best practice noise mitigation measures including:

- Erecting temporary noise walls around Site Compounds which are in proximity to residential receivers.
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers whenever possible.
- Where possible, equipment with directional noise emissions should be orientated away from sensitive receivers.
- Where practical, the layout of plant and equipment at any site compounds should be developed so as to minimise noise exposure.
- Loading and unloading should be carried out away from sensitive receivers.
- The selection of site access points should take into account the proximity of noise sensitive receivers.
- Maintenance work on all construction plant should be carried out away from noise sensitive receivers and confined to standard daytime construction hours, where possible.
- Minimising consecutive works in the same locality.
- Relocate any vibration generating plant and equipment away from noise sensitive receivers in order to lower any potential vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of excavation plant and equipment eg smaller capacity rockbreaker hammers, wherever possible.

- Schedule a minimum respite period of at least 0.5 hour before activities commence which are to be undertaken for a continuous 4 hour period.
- Use only dampened rockbreakers and/or “city” rockbreakers to minimise the impacts associated with rockbreaking works.

The mitigation of noise impacts can often involve noise management as distinct from noise control (interpreted as simply meaning noise minimisation). For example, the scheduling of noise-intensive activities could be an effective noise management strategy in the present instance.

Specifically, time restrictions should be placed on the most noise-intensive activities, especially concrete sawing, rockbreaking and the use of jackhammers. Where there is a definite requirement for such activities to be completed out of the normal construction hours, they could be restricted to 9:00 pm to 11:00 pm for example.

A primary aim of the project should be to ensure that the local community is kept informed of the progress of the construction work in a proactive and progressive manner. This could be enabled by a combination of internet-based information, community meetings, local newsletters, leaflets, newspaper advertisements and community notice boards.

As part of the Community Liaison process a contact person would be nominated within the Construction Noise and Vibration Management Plan to directly address any noise and/or vibration complaints that the community may have during the construction phase of the project.

Noise monitoring would be carried out for assessment against the adopted construction noise goals where, subsequent to project approval, detailed construction noise impact assessments indicate significant potential exceedance at the nearest impacted noise sensitive receivers.

It is also recommended that vibration monitoring be carried out for assessment against the transient vibration guidelines (BS 7385 and DIN 4150) as a result of potential impacts on structures when working within the safe working distances for cosmetic damage as a result of vibration intensive construction activities, and where the vibration levels are greater than the maximum recommended values.

OPERATIONAL NOISE

Operational Noise Criteria

The assessment of operational noise has been performed in line with the requirements of the Environmental Criteria for Road Traffic Noise (ECRTN) and Environmental Noise Management Manual (ENMM). This document provides guidance for assessing traffic noise impacts through setting design objectives for a range of development types and provides procedures for determining noise mitigation in situations where the exceedances of the objectives occur.

The proposed M2 Upgrade Project is classified as a “Redevelopment of an Existing Freeway/Arterial Road”.

The existing noise walls do not extend over the complete length of the M2 Motorway. It is noted that the opening of the M7 increased traffic volumes, particularly heavy vehicles, in the section of road between the M7 and Pennant Hills Road. An assessment of all sensitive receivers adjacent to the M2, both in sections with existing noise walls and in those sections currently without, has been undertaken with regard to the operational noise criteria for the project.

EXECUTIVE SUMMARY

Operational Noise Assessment

Noise emissions from the M2 Motorway are currently mitigated through noise walls of various heights along almost the entire length of the motorway. These range from approximately 1.8 m up to around 7.0 m in height.

The widening upgrade process of the M2 will require alterations to the existing alignment of the road corridor in many areas along the length of the motorway. These alterations include the modification of various existing cuttings, embankments and batter slopes in areas where widening works are proposed.

The widening process will therefore affect a significant number of the existing noise walls along the route of the motorway. Some of the affected noise walls are situated adjacent to the road carriageway and others are on top of embankments. All such affected noise walls will be required to taken down and re-instated as part of the project.

In all sensitive receiver locations where future exceedances of the operational noise criteria have been predicted, new or increased height noise walls have been considered where three or more exceeding properties are situated within a catchment area. As part of the design of the M2 Upgrade Project, there is also the requirement for a small number of new walls to be included in the design of the proposed widening scheme.

At some locations where the noise criteria are exceeded as a result of the project, feasibility and reasonableness considerations have concluded that the construction, or modification, of noise barriers is not feasible, reasonable or cost effective. At such locations, where residual impacts remain after all feasible and reasonable approaches have been exhausted, noise mitigation in the form of acoustic treatment for existing individual dwellings would be required.

The assessment of sensitive land use areas showed that as no exceedances of the appropriate criteria were apparent, there is no requirement to investigate additional mitigation measures at these locations.

An optimisation process (including a cost-benefit analysis) has been undertaken when designing the noise walls using the approach outlined in the RTA's ENMM. All of the noise wall designs presented within this Report therefore reflect these RTA procedures. The need for architectural treatment to address residual exceedances of the adopted noise objectives has been considered as part of the optimisation process. A total of 91 properties have been identified as requiring consideration for architectural treatment. Architectural treatment would however be subject to feedback from the community consultation process which would be performed as part of the detailed design phase of the project.

Furthermore, the final mix of the selected noise mitigation strategies will be determined after the opinions of the local affected community have been consulted. The local affected community might prefer (on aesthetic grounds) a different option mix of noise barriers and property treatment than has been proposed in this assessment. The benefits of community preferred options would then need to be considered in light of additional factors such as future noise levels in the affected area and changes in land use in the local area.

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1 INTRODUCTION

In conjunction with the NSW Roads and Traffic Authority (RTA), Hills M2 and Leighton Contractors Pty Ltd, AECOM Pty Ltd and a team of specialist sub-consultants are preparing an Environmental Assessment (EA) for the proposed upgrade of the M2 Motorway.

The current demands on the M2 Motorway are well known, with the motorway being seen to be at capacity during busy periods of the day. It is therefore proposed to widen the motorway in various sections along its length to help reduce the strain on the motorway. Associated upgrades to some of the interchanges along the route are also planned.

Heggies Pty Ltd (Heggies) have been commissioned to provide a detailed assessment of the noise and vibration impacts associated with the construction and operation of the upgrade project.

1.1 Overview of the Present Study

The potential noise and vibration impacts of the M2 Upgrade Project can be broken down as follows:

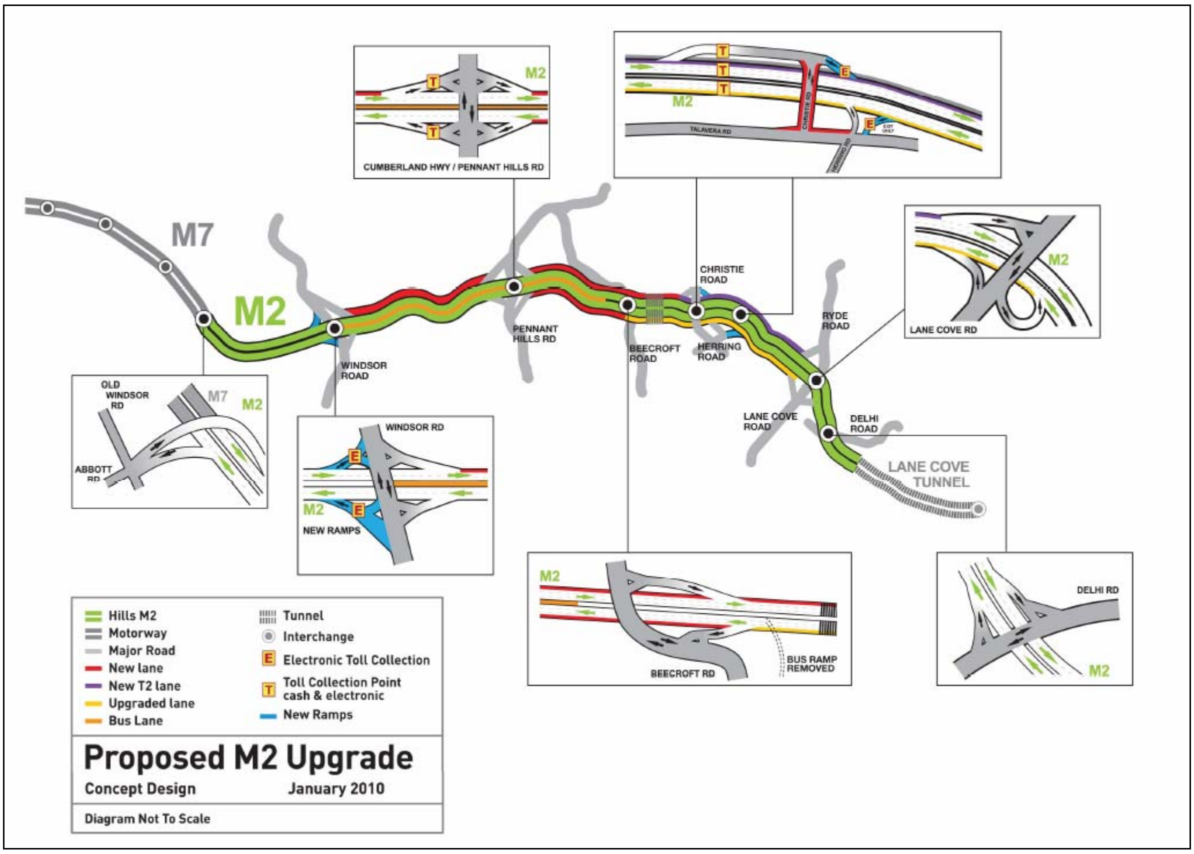
- Impact on surrounding areas during the construction phase of the project due to the widening of the motorway and interchange upgrade works, including:
  - Construction noise
  - Construction vibration
  - Construction ground-borne noise from widening of the Norfolk Tunnel
- Operational impacts after project commissioning, consisting primarily of:
  - Noise emissions due to changed road traffic conditions
  - Mechanical noise emissions from the Norfolk Tunnel ventilation fan system

2 PROJECT DESCRIPTION

2.1 General

The M2 Motorway spans approximately 21 km from Baulkham Hills to North Ryde and is, in several sections, in close proximity to a number of densely populated residential areas. The M2 Motorway Upgrade Project Area is illustrated in **Figure 1**, together with the schematic descriptions of the proposed upgrades along the route of the motorway.

Figure 1 M2 Upgrade Project Area



The proposed alterations to M2 Motorway are summarised below:

- Additional eastbound lane from Windsor Road to Pennant Hills Road
- Additional eastbound lane from Pennant Hills Road through the Norfolk Tunnel to Lane Cove Road
- Widening the westbound carriageway to provide wider lanes from Lane Cove Road to Beecroft Road
- Additional westbound lane from Beecroft Road to Pennant Hills Road
- New west-facing Windsor Road on and off-access ramps
- New Christie Road eastbound on-access ramp
- New Herring Road westbound off-access ramp

A comprehensive description of the M2 Upgrade Project is contained within **Part C – The Proposal** of the main Environmental Assessment report.

2.2 Terminology

2.2.1 Road Chainage

Consistent with the terminology adopted for other components of the Environmental Assessment of the project, road chainages for the M2 alignment are referenced to 0 km at the start of the M2 in the vicinity of Old Windsor Road at Baulkham Hills (at the junction with the M7).

2.2.2 Noise and Vibration Terminology

A detailed description of the acoustic terminology used within this report is presented within **Appendix A**.

2.2.3 Operational Assessment Years

Throughout the Operational Assessment of this document (contained in **Section 9**), reference is made to two assessment scenarios: the Future *Existing* and the Future *Design* scenarios. These are used to assess the noise impact of new and upgraded roads projects.

- The Future *Existing* scenario represents the "baseline" scenario and is used to determine the more-or-less current level of road noise, in the absence of the M2 Upgrade Project, predicted at the year of opening of the proposed project. This scenario makes use of the M2 alignment in its existing geometry, with traffic volumes extrapolated to the project opening year by applying an incremental factor to measured existing flows.
- The Future *Design* scenario represents the "assessment" scenario for the M2 Upgrade Project and uses the proposed new alignment for the project, together with future traffic volumes predicted to 10 years after the scheduled project opening year.

2.2.4 Study Area Description

The extent of works covered in this assessment starts at the western end of the M2 Motorway at the junction with the M7 Motorway (at chainage 0000), and ends to the east of the intersection of the M2 Motorway with Lane Cove Road (at chainage 18000).

It is noted that the actual widening works associated with the M2 Upgrade Project start at around chainage 3500, just west of the Windsor Road interchange, and finish at chainage 17800, just east of Lane Cove Road.

The project study area also extends out from the M2 carriageway to a distance which equates to 5 dBA below the operational noise goals for the M2 Upgrade Project, detailed in **Section 5**. Areas outside of this region have not been considered in this assessment.

3 DIRECTOR GENERAL'S REQUIREMENTS

Following receipt of the Project Application for the M2 Motorway Upgrade, Director-General's Requirements (DGRs) were issued for the Environmental Assessment on 6 April 2009.

This report has been prepared to address the DGRs that relate to potential noise and vibration impacts. The specific requirements that relate to the M2 Motorway Upgrade Project are provided below:

> ***"Operational Noise Impacts*** *– the Environmental Assessment must include an assessment of the noise impacts of the project during operation, consistent with the Environmental Criteria for Road Traffic Noise (EPA, 1999). The assessment must include specific consideration of impacts to sensitive receivers (schools, hospitals, aged care facilities), as relevant.*
>
> ***General Construction Impacts*** *– the Environmental Assessment must consider the potential impacts associated with the construction of the project, and present a management framework for construction works to ensure that impacts are mitigated, monitored and managed. The Environmental Assessment must include consideration of, and a management framework for:*
>
> - *construction noise and vibration, including a considered approach to scheduling construction works having regard to the nature of construction activities (including transport, blasting and tonal or impulsive noise-generating works, as relevant), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially-affected human receivers and structures, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management). The Environmental Assessment must also present a strategy for monitoring and mitigating construction noise and vibration, with a particular focus placed on those activities identified as having the greatest potential for adverse noise or vibration impacts, and a broader, more generic approach developed for lower-risk activities;"*

The Operational Assessment of the M2 Upgrade Project is contained within **Section 9** of this report and the Construction Assessment is within **Section 7**.

4 CONSTRUCTION ASSESSMENT CRITERIA

4.1 Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions:

$L_{A1(1minute)}$ the "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level

$L_{Aeq(15minute)}$ the "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.

L_{A90} the "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction Noise Management Levels are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

4.2 NSW Interim Construction Noise Guideline

Heggies has conducted a review of guidelines and current practices for the assessment and subsequent mitigation of construction noise, and, for the M2 Upgrade Project, has adopted the approach laid down in the NSW Department of Environmental, Climate Change and Water (DECCW) *"Interim Construction Noise Guideline"* (ICNG), issued in July 2009.

The ICNG was developed with an emphasis on minimising construction noise impacts by implementing various work practices rather than focussing only on achieving numerical noise levels. A recurring feature of the guideline is the use of the term "feasible and reasonable" in relation to the control of construction noise impacts. The guideline recognises that construction activities are often inherently noisy but are generally of a temporary nature.

On the basis of the guideline, Heggies has adopted the following approach for the M2 Upgrade Project:

- Determine project specific **Noise Management Levels** (NMLs) for noise affected receivers consistent with current practices to deal with construction noise in a transparent and consistent way.
- Where the construction noise levels are predicted to exceed the NMLs, all **feasible** and **reasonable** work practices will be investigated to minimise noise emissions.

Consistent with this approach, the following $L_{Aeq(15minute)}$ NMLs have been adopted for sensitive receivers:

- Daytime (7.00 am to 6.00 pm) RBL or L_{A90} Background +10 dBA
- Evening (6.00 pm to 10.00 pm) RBL or L_{A90} Background +5 dBA
- Night-time (10.00 pm to 7.00 am) RBL or L_{A90} Background +5 dBA

The DECCW's Guideline also presents Noise Management Levels for areas of other sensitive land uses. These are detailed in **Table 1** below.

Table 1 Interim Construction Noise Guideline – Other Sensitive Land Uses

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (applies when properties are being used)
Classrooms at schools and other educational facilities	45 dBA (internal)
Hospital wards and operating theatres	45 dBA (internal)
Places of worship	45 dBA (internal)
Active recreation areas[1]	65 dBA (external)

Note 1: Characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.

Where internal Noise Management Levels are presented in the table above, the corresponding external noise level (which the assessments are based upon) has been determined on the assumption that a 10 dBA reduction from outside to inside noise is applicable for an openable window, with a 20 dBA reduction where mechanical ventilation has been provided.

Sleep Disturbance

The most recent guidance in relation to sleep disturbance is contained in the DECCW's *"Application Notes - NSW Industrial Noise Policy"*. The pertinent section of the DECCW's Application Notes states the following:

> *"DECC*[W] *reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, DECC*[W] *recognised that current sleep disturbance criterion of an L_{A1}, (1 minute) not exceeding the L_{A90}, (15 minute) by more than 15 dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DECC*[W] *will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or L_{A1}, (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *How often high noise events will occur.*
> - *Time of day (normally between 10pm and 7am).*
> - *Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*
> - *The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under "fast" time response. DECC*[W] *will accept analysis based on either LA1, (1 minute) or LAmax"*

Scope for Exceedances

Where predicted or measured levels exceed the Noise Management Levels the ICNG recommends that the proponent apply all "feasible and reasonable" work practices in order to minimise noise.

Where $L_{Aeq(15minute)}$ construction noise levels are predicted to be “highly noise affected” (ie above 75 dBA) the relevant authority (consent, determining or regulatory) may require respite periods to be observed. This may include restricting the hours that the very noisy activities can occur, taking into account:

1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences).
2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

The implementation of an effective community consultation and liaison programme is emphasised as being a critical tool in successfully handling adverse noise impacts from construction works.

The ICNG provides comprehensive guidance for work practices which aim to achieve *“desired environmental outcomes - there are no prescribed noise controls for construction works.”*

4.2.1 Ground-borne Noise

Ground-borne construction noise is usually present on tunnelling projects when vibration from activities such as rock breaking, road heading, rotary cutting, tunnel boring and rock drilling/sawing can be transmitted through the ground and into the habitable areas of nearby buildings. Ground-borne (or regenerated) noise occurs when this vibration in the ground and/or building elements is regenerated as audible noise within areas of occupancy inside the building.

Sometimes the vibration generated by the above activities may be perceptible in nearby buildings. In such cases, the human comfort vibration goals discussed in **Section 4.3** are applicable.

As the M2 Upgrade Project includes the widening of the Norfolk Tunnel, which would be completed using roadheaders and drill rigs, there is potential for ground-borne noise impacts at the sensitive receivers situated above the tunnel.

Internal ground-borne noise goals of $L_{Aeq(15minute)}$ 40 dBA (evening) and $L_{Aeq(15minute)}$ 35 dBA (night-time) are specified within the DECCW’s ICNG. These goals are only applicable when the ground-borne noise levels are higher than the airborne noise levels inside residential dwellings. During daytime periods, only the human comfort vibration goals are applicable.

4.3 Construction Vibration Assessment Criteria

Vibration targets vary primarily according to whether the particular activities of interest are continuous in nature or intermittent and whether they occur during the day or night-time. The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed, ie human disturbance;
- Those in which the integrity of the building or the structure itself may be prejudiced; and
- Those where the building contents may be affected.

Criteria which are relevant to the response of building occupants to vibration are more stringent than those relevant to building damage. This is because people are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building.

This ability of people to sense vibration at relatively low magnitudes has created a widespread and strong public misconception which can cause considerable overestimation of the risk of damage associated with vibration in buildings. This is particularly the case when the source of that vibration is outside the building, visible and audible, but generally not within the occupant's control.

Many people, for example, believe that even barely perceptible levels of building vibration from say, traffic, excavation or construction works, can damage dwellings, or may affect delicate objects or other items of personal value within their homes. This largely subjective response is particularly the case when these low levels of vibration are accompanied by high noise levels, or if there are other adverse connotations or effects associated with the source of the vibration. These might include startlement, loss of privacy or perceived loss of property value, fear, inconvenience, odour, etc.

On the other hand, sources of much higher levels of vibration (eg domestic appliances, people walking on floors, slamming of doors, etc) are readily accepted due to their day-to-day familiarity or because they are "within the control" of the occupant.

It is primarily these day-to-day effects which cause the gradual, long-term fatigue-induced deterioration of most structures - considered to be normal ageing. Provided that the levels of vibration-induced structural stress from an additional source are well below those of these "normal" stress-inducing events, then the additional source of vibration is unlikely to accelerate the normal ageing process.

4.3.1 General

Humans are far more sensitive to vibration than is commonly realised. They can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 2**.

Table 2 Peak Vibration Levels and Human Perception of Motion

Approximate Vibration Level		Degree of Perception
Peak Vibration Level	**RMS Vibration Level**	
0.10 mm/s	0.07 mm/s	Not felt
0.15 mm/s	0.1 mm/s	Threshold of perception
0.35 mm/s	0.25 mm/s	Barely noticeable
1 mm/s	0.7 mm/s	Noticeable
2 mm/s	1.4 mm/s	Easily noticeable
6 mm/s	4.2 mm/s	Strongly noticeable
14 mm/s	10 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz. The RMS vibration levels assume a crest factor of 1.4 for sinusoidal vibration.

Table 2 suggests that people will just be able to feel floor vibration at levels of about 0.1 mm/s (RMS) and that the motion becomes "noticeable" at a level of approximately 0.7 mm/s (RMS).

The DECCW's "*Assessing Vibration: a technical guideline*" notes that *"vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time)."*

Construction activities typically generate building vibrations that are intermittent or impulsive in nature, however vibration levels may sometimes be constant from sources such as generators or ventilation fans.

Examples of intermittent vibration events include the vibration generated by rockbreakers, vibratory rollers, drilling/piling and excavators. Examples of impulsive vibration events include the vibration generated by demolition activities, blasting or the dropping of heavy equipment.

Where vibration is intermittent or impulsive in character, the DECCW vibration guideline (and other similar guidelines) recognise that higher vibration levels are tolerable to building occupants than for continuous vibration. As such, higher vibration goals are usually applicable for short term, intermittent and impulsive vibration activities than for continuous vibration sources.

The following sections describe the applicable continuous and intermittent vibration goals for the M2 Upgrade Project construction activities.

4.3.2 Human Comfort Goals for Continuous and Impulsive Vibration

The DECCW's "*Assessing Vibration: a technical guideline*" is applicable for the M2 Upgrade Project and is based on the guidelines contained in British Standard BS 6472-1992 "*Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*". The DECCW guideline refers only to human comfort considerations and nominates preferred and maximum vibration goals for critical areas, residences and other sensitive receivers.

The criteria in the DECCW guideline are non-mandatory, "*they are goals that should be sought to be achieved through the application of all feasible and reasonable mitigation measures. Where all feasible and reasonable measures have been applied and vibration values are still beyond the maximum value, the operator would need to negotiate directly with the affected community*".

Construction vibration can be continuous, intermittent or impulsive and the DECCW's vibration guideline provides different goals for each category. The continuous vibration goals are most stringent and higher vibration levels are acceptable for intermittent and impulsive vibration on the basis of the shorter exposure times. Examples of typical vibration sources are provided in **Figure 2**.

Figure 2 Examples of Vibration (DECCW Vibration Guideline)

Examples of types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

The applicable human comfort vibration goals for continuous, intermittent and impulsive vibration sources are provided in **Table 3**, **Table 4** and **Table 5** respectively. In all cases, the vibration goals are expressed in terms of the RMS vibration velocity level in mm/s, measured in the most sensitive direction (z-axis).

The DECCW vibration guideline notes the following in relation to the preferred and maximum vibration levels:

> *"There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Activities should be designed to meet the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum value may be used if they can be justified. For values beyond the maximum value, the operator should negotiate directly with the affected community. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short term duration. An example is a construction or excavation project.*
>
> *In circumstances where work is short term, feasible and reasonable mitigation measures have been applied, and the project has a demonstrated high level of social worth and broad community benefits, then higher vibration values (above the maximum) may apply. In such cases, best management practices should be used to reduce values as far as practicable, and a comprehensive community consultation programme should be instituted."*

Table 3 Preferred and Maximum Vibration Levels for Continuous Vibration

Building Type	Preferred Vibration Level RMS Velocity (mm/s)	Maximum Vibration Level RMS Velocity (mm/s)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.10	0.20
Residential Daytime	0.20	0.40
Residential Night-time	0.14	0.28
Offices, schools, educational institutions and places of worship	0.40	0.80
Workshops	0.80	1.60

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Table 4 Preferred and Maximum Vibration Levels for Intermittent Vibration (Vibration Dose Values)

Building Type	Preferred Vibration Dose Value ($m/s^{1.75}$)	Maximum Vibration Dose Value ($m/s^{1.75}$)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.10	0.20
Residential Daytime	0.20	0.40
Residential Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80
Workshops	0.80	1.60

Note: For the definition of the Vibration Dose Value refer to the discussion in the following section. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Table 5 Preferred and Maximum Vibration Levels for Impulsive Vibration

Building Type	Preferred Vibration Level RMS Velocity (mm/s)	Maximum Vibration Level RMS Velocity (mm/s)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.1	0.2
Residential Daytime	6.0	12.0
Residential Night-time	2.0	4.0
Offices, schools, educational institutions and places of worship	13.0	26.0
Workshops	13.0	26.0

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

4.3.3 Intermittent Vibration (Vibration Dose Values)

For most construction activities that generate perceptible vibration in nearby buildings, the character of the vibration emissions is intermittent. This includes equipment such as rockbreakers, excavators, piling rigs, rock drills, vibratory rollers and heavy vehicle movements.

Intermittent vibration is defined in the DECCW vibration guideline as follows:

> *"**Intermittent vibration** can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values".*

Where vibration comprises a number of events, a Vibration Dose (Dv) may be estimated for each event by the following formula using vibration measured in velocity:

$$Dv = 0.07\ V\ (rms) \times t^{0.25}\ \ m/s^{1.75}$$

Where, V (rms) = rms particle velocity (mm/s)

t = Total cumulative time (seconds) of the vibration event or period of vibration

The total vibration dose is then calculated using the following formula:

$$Dv = \left(\sum_{n=1}^{n=N} Dv_n^4 \right)^{0.25}$$

Where, Dv = Total vibration dose value for the day or night

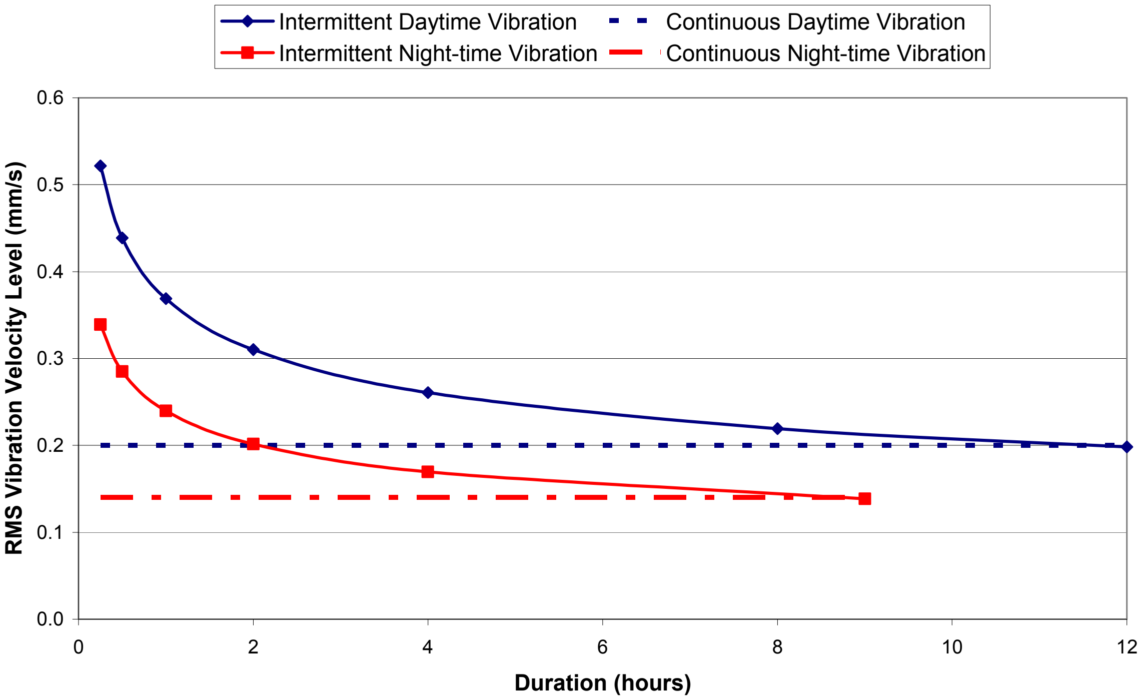
Dvn = Vibration dose value for each vibration dose event

N = Total number of vibration dose events

The permissible vibration level corresponding to the vibration dose value varies according to the duration of exposure. For example, higher vibration levels are permitted if the total duration of the vibration event(s) is small and lower vibration levels are permitted with if the total duration of the vibration event(s) is large.

This concept is illustrated graphically in **Figure 3** where the intermittent vibration curves for the daytime and night-time periods correspond to the preferred Vibration Dose Values in **Table 4**. As the total duration of the intermittent vibration sources during the daytime and night-time periods get larger, the intermittent vibration goals approach the preferred continuous vibration goals in **Table 3**.

Figure 3 Vibration Levels Corresponding to "Low Probability of Adverse Comment" for Residential Receivers - Continuous and Intermittent Vibration



4.3.4 Vibration Criteria - Surface Structures

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

British Standard 7385: Part 2 - 1993 Guidelines

In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 *"Explosives - Storage and Use - Part 2: Use of Explosives"* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2"* as they "are applicable to Australian conditions".

The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 6** and graphically in **Figure 4**.

Table 6 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

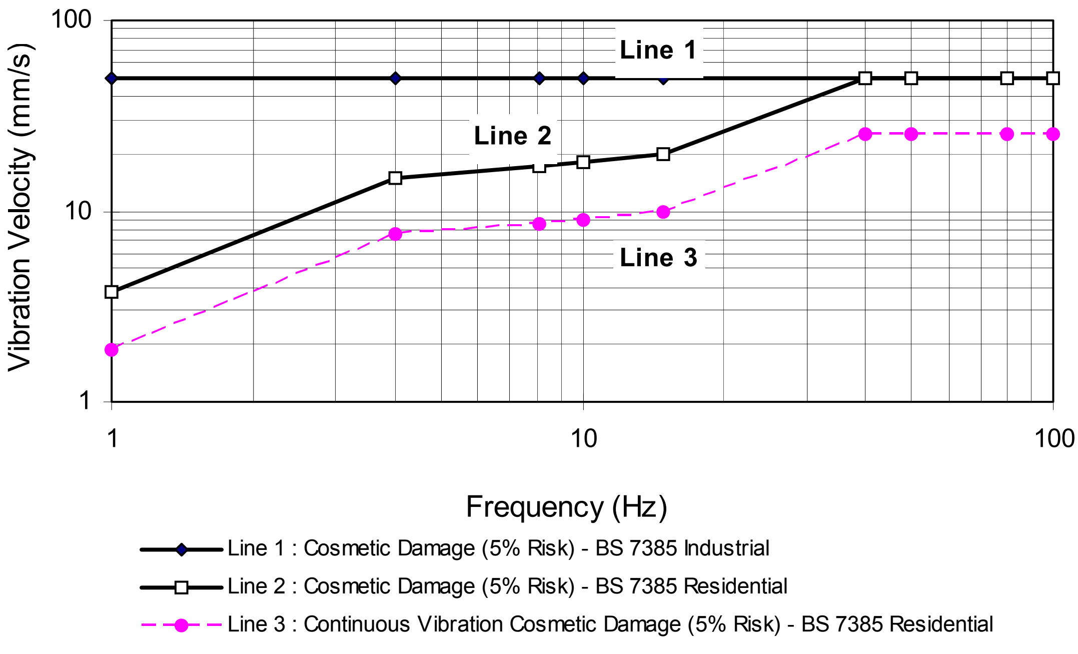
Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	**15 Hz and Above**
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The Standard states that the guide values in **Table 6** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 6** may need to be reduced by up to 50%.

Note: rockbreaking/hammering activities are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

Figure 4 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to "Line 2" are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The Standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 6**, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 6** should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the guidance curves presented in **Figure 4**.

It is noteworthy that extra to the guide values nominated in **Table 6**, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

5 OPERATIONAL NOISE ASSESSMENT CRITERIA

5.1 Operational Noise Criteria

The roadway corridor for the M2 Motorway Upgrade Project runs through several areas of urban residential development. As a result the acoustical design of the project - as well as the design and management of potential residual noise impacts at dwellings in the vicinity of the motorway - introduces significant challenges with respect to achieving timely, efficient, balanced, equitable, reasonable and cost-effective outcomes for the project and the community.

Achieving a balanced acoustical design, especially in terms of feasibility and reasonableness, is guided primarily by the following two references:

- DECCW (formerly EPA), *"Environmental Criteria for Road Traffic Noise"* (ECRTN), May 1999
- RTA, *"Environmental Noise Management Manual"* (ENMM), December 2001

The original noise mitigation for the M2 Motorway was developed with reference to the Interim Noise Policy (ITNP). It is noted that the ECRTN base criteria are more stringent than those specified within the ITNP.

5.2 Environmental Criteria for Road Traffic Noise (ECRTN)

In May 1999, the NSW Environment Protection Authority (now the DECCW) issued the *"Environmental Criteria for Road Traffic Noise"* (ECRTN). This document provides guidance for assessing traffic noise impacts through setting design objectives for a range of development types and provides procedures for determining noise mitigation in situations where the exceedances of the objectives occur.

In addition to road design and development controls, the document nominates a number of other strategies which may be used to reduce the impact of traffic noise. These include:

- Governing maximum noise levels from individual vehicles
- Developing programmes to monitor and control noisy vehicles on the road system
- Controlling noise from heavy vehicle exhaust and engine brakes
- Implementing traffic management policy at local and regional levels
- Continuing encouragement of the community to use public transport and to increase the number of passengers travelling in private vehicles

The ECRTN embodies a non-mandatory performance-based approach. The proposed criteria (or objectives) are to be applied as targets, applicable to the future volumes of traffic projected to 10 years' time, however it is recognised that situations will exist where planning strategies are not feasible.

Solutions that can be reasonably applied in the short-term may not always achieve the targets. In such cases, a longer-term perspective may need to be taken to institute ongoing strategies that will minimise traffic noise impacts over time.

The ECTRN notes that there are generally limited resources to provide noise control on existing roads to meet the target criteria and that the noise minimisation strategies adopted must take into account what is reasonable and feasible. The ECTRN goes on to note that in the urban context, background noise levels are elevated and generally increase incrementally over long periods of time. This affects the level of noise mitigation that is practicably achievable.

It is recommended that the criteria in the ECRTN be referred to in the early stages of planning for new roads or modifications to existing roads. The effects of road traffic noise can then be assessed and controlled throughout the planning process. Where feasible, a new or existing road should be aligned and designed and constructed to meet the criteria. However, if this is not practicable, other initiatives such as the control of road use behaviour (including speed control), managing the use of exhaust brakes, land use planning and building design would need to be instituted to assist in minimising the impacts.

5.2.1 ECRTN Classification of the M2 Upgrade Project

The proposed M2 Upgrade Project is classified as a “Redevelopment of an Existing Freeway/Arterial Road”. Based on this definition the appropriate criteria are presented in **Table 7** (refer first row of table).

The M2 Upgrade Project would also have a potential impact on a number of sensitive land usage areas. These include Model Farms High School, Winston Hills Public School, Muirfield High School, Our Lady of Lourdes Primary School and Church, the Royal Institute for Deaf and Blind Children School, Epping Heights Public School and the Macquarie University Campus. Muirfield Golf Course and Pennant Hills Golf Course are also situated in close proximity to the M2 Motorway.

The relevant ECRTN criteria for these land uses have also been included in **Table 7**.

Table 7 Operational Traffic Noise Criteria

<table>
<tr><th>Road Type</th><th>Daytime Criteria
(7 am to 10 pm)</th><th>Night-time Criteria
(10 pm to 7 am)</th><th>Guidance when the Existing Ambient Noise Already Exceeds the Base Criteria</th></tr>
<tr><td>Redevelopment of existing freeway/arterial road</td><td rowspan="2">LAeq(15 hr)
60 dBA</td><td rowspan="2">LAeq(9 hr)
55 dBA</td><td rowspan="2">In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dB.
Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In many instances this may be achievable only through long-term strategies, such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage</td></tr>
<tr><td>Redevelopment of existing collector roads</td></tr>
<tr><td>Places of Worship</td><td>LAeq(1 hr)
40 dBA
(internal)</td><td>LAeq(1 hr)
40 dBA
(internal)</td><td rowspan="4">The most practicable mitigation measures to achieve internal noise goals often involve building (facade) treatments. Other mitigation options include regulation of vehicle exhaust noise, limiting access of heavy vehicles during sensitive times, limitations on exhaust brake use, etc.
When such treatments are not able to achieve the nominated target internal noise levels, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dB</td></tr>
<tr><td>Hospital Wards</td><td>LAeq(1 hr)
35 dBA
(internal)</td><td>LAeq(1 hr)
35 dBA
(internal)</td></tr>
<tr><td>Existing School Classrooms</td><td>LAeq(1 hr)
45 dBA
(internal)</td><td>-</td></tr>
<tr><td>Active Recreation (eg Golf Courses)</td><td>Freeways and Arterial Roads:
LAeq(15 hr)
60 dBA</td><td>-</td></tr>
</table>

It is noted that in situations where the existing ambient noise level already exceeds the above criteria, and where all reasonable and feasible noise mitigation measures have been considered and implemented, an "allowance" criterion is applicable. For a redeveloped road this allowance criterion limits the noise increase from the project under consideration to no more than 2 dBA.

5.3 Environmental Noise Management Manual (ENMM)

The RTA's *"Environmental Noise Management Manual"* (ENMM) was issued in December 2001 and provides guidance in managing and controlling noise (and vibration) from all aspects of road traffic generated noise.

Within the ENMM, properties which are subject to noise levels exceeding 60 dBA $L_{Aeq(15hour)}$ or 55 dBA $L_{Aeq(9hour)}$ are identified as being "noise affected". These levels correspond to the ECRTN criteria detailed in **Table 7** as applying to the redevelopment of the motorway.

The ENMM recognises that the base criteria recommended by the ECTRN are not always practicable, and that it is not always feasible or reasonable to expect that they should be achieved. This is particularly relevant to existing roads in urban environments. Guidance is provided when this situation is apparent.

The ENMM also uses the term "acute". This refers to properties which are exposed to adverse levels of road traffic generated noise (ie at least 65 dBA $L_{Aeq(15hour)}$ or 60 dBA $L_{Aeq(9hour)}$). In operational road traffic noise assessments, consideration for noise mitigation treatment is given to properties that experience acute levels of noise at the project design year even when there is no change in noise level due to the project.

The ENMM notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Examples of such measures could include:

- Reducing traffic volumes by promotion of public transport
- Implementation of more stringent noise standards for new vehicles
- The progressive replacement of older, noisier vehicles
- Measures to ensure noise-control equipment on heavy vehicles and older cars is properly maintained
- The selection and design of road routes and alignments so as to reduce gradients and achieve smooth traffic flows
- The use of "low noise" pavements
- Restricted access to noisy vehicles
- Traffic management measures to achieve smooth traffic flows

Where the above source measures are not practical, or do not provide sufficient noise reduction, additional methods would be required to reduce levels to within acceptable margins. Such methods may include the use of noise walls or architectural treatment of properties.

Generally speaking, and for the M2 Upgrade Project, preference is given to the use of noise walls to mitigate noise levels. This is because all sensitive receivers behind a particular noise wall benefit from the resulting reduction in noise.

Architectural property treatments are utilised to mitigate adverse noise only after all of the other mitigation options noted above have been considered.

5.4 Road Traffic Noise Criteria – General Discussion

Achieving a balanced acoustical design, especially in terms of feasibility and reasonableness, is guided by the DECCW's ECRTN and the RTA's ENMM.

These documents provide guidance for optimising the at-roadway noise mitigation measures in terms of noise reduction, cost-effectiveness, urban landscape design requirements and community preferences. It is noted that where road noise affected multi-storey buildings are apparent, the use of road side noise walls to mitigate upper storeys is usually not practicable.

Guidance is also provided for determining the reasonableness of additional architectural treatments at individual dwellings where residual noise impacts may potentially remain after the optimisation process.

In addition to the tests of reasonableness for individual dwellings or specific localities, the ECRTN (and the ENMM) however recognises the need to address any unique project-wide demands and outcomes of a major project.

The ECRTN presents the NSW Government's guidelines for road traffic noise assessment. The policy document provides road traffic noise criteria for proposed road or residential developments as well as criteria for other sensitive land uses.

The noise level objectives and the processes for optimising noise mitigation for roadway projects in the ENMM are consistent with those embodied in the ECRTN.

Both the ECRTN and ENMM acknowledge that achieving the base objectives for existing roads in urban environments is sometimes not realistic. This is especially apparent in situations where the existing levels of background noise are already high and exceed the objectives.

Retrofitting of engineering-type noise controls to existing roads is also noted as having limited effectiveness. For example, increasing the height of already high noise walls provides diminishing additional noise benefit whilst the associated visual impacts, shadowing, constructability and costs can become prohibitive. These factors must be taken into account when determining appropriate and realistic noise objectives for any proposal.

5.5 M2 Upgrade Project Road Traffic Noise Objectives

The following summarises the noise objectives which have been adopted for the M2 Upgrade Project with consideration of the ECRTN and ENMM. As such, additional noise mitigation is therefore to be considered where either:

Scenario 1

- The predicted 2021 Future *Design* noise level exceeds the ECRTN base criteria for redeveloped roads *and* the noise level increase due to the project is greater than 2 dBA.

or

Scenario 2

- The predicted 2021 Future *Design* noise levels are acute (≥65 dBA $L_{Aeq(15hour)}$ or ≥60 dBA $L_{Aeq(9hour)}$) regardless of the incremental impact of the project.

5.5.1 New Windsor Road On/Off Ramps – ECRTN Noise Goals

Incorporated within the design for the proposed upgrade of the M2 Motorway is the construction of two new west-facing access ramps at the intersection of the M2 with Windsor Road. It is noted that the ECRTN criteria which is applicable to the rest of the M2 Project Area, as previously detailed in **Table 7**, is the "Redevelopment of Existing Freeway/Arterial Road" category.

To determine the appropriate criteria with which to assess the proposed Windsor Road access ramps, the following definitions have been taken from the ENMM.

Figure 5 ENMM Extract Regarding Category Definitions

'Existing road traffic noise exposure'

A site is defined as having an "existing road traffic noise exposure" if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) $L_{eq(15hr)}$ (day) or 50 dB(A) $L_{eq\ (9hr)}$ (night).

The noise level contours corresponding to these day and night noise levels define the "noise catchment" for an existing road. In areas outside these contours, road traffic is unlikely to be a significant noise source.

'Significant contribution to road traffic noise exposure'

A "significant contribution to road traffic noise exposure" from a road development or upgrading proposal is defined as an increase in road traffic noise at any exposed façade of more than 2 dB(A) compared to the road traffic noise level from the existing road.

'New source of road traffic noise'

A "new road traffic noise source" can be either:

- A new road where a road of the same category (i.e. arterial, collector or local road) did not previously exist
- A new road within an existing but previously undeveloped road corridor, *or*
- An alignment or realignment producing noise at a receptor *from a different direction* which makes a "significant contribution to noise exposure", as defined above, on top of any increase in traffic noise from the same direction as at present.

It is apparent, following the background noise monitoring carried out for the project as well as preliminary noise modelling, that the residential receivers in the vicinity of the proposed access ramps have an "existing road traffic noise exposure" as these areas are currently exposed to noise levels which are greater than 55 dBA $L_{Aeq(15hour)}$ or 50 dBA $L_{Aeq(9hour)}$.

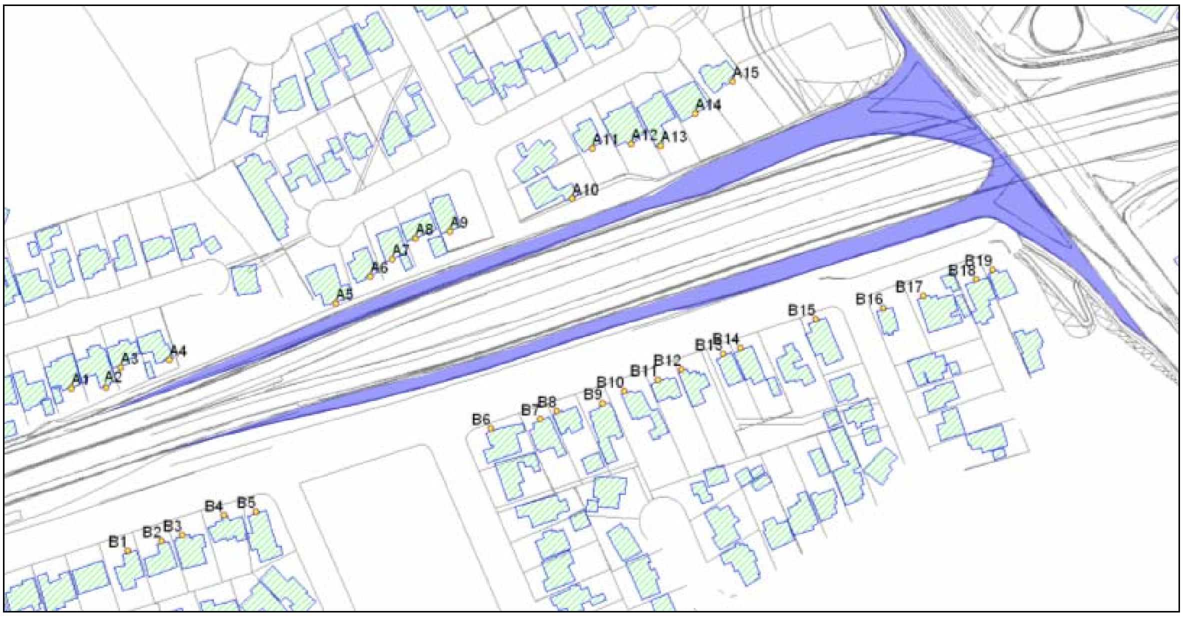
Although the proposed Windsor Road access ramps will introduce a potential "new" source of noise to the locality, in addition to the existing carriageway, the ENMM states that they would only be required to be assessed as a "New Source of Road Traffic Noise" if they provide a "significant contribution to the road traffic noise exposure" of the area. This contribution is defined as being significant if the increase in road traffic noise due to the development (ie the proposed access ramps), at any facade of any affected receiver, is found to be increased by more than 2 dBA over the existing road traffic noise.

To assess whether the contribution of noise from the proposed new on/off access ramps is "significant" at the receivers in the vicinity of Windsor Road, a noise modelling exercise was performed. The model set-up procedure and model calibration for this exercise is described in subsequent sections of this assessment.

The calibrated noise model allows the Future *Existing* and Future *Design* noise levels at all residential receivers in the vicinity of the new access ramps to be predicted, along with the stand-alone contribution of the proposed access ramps to the noise levels to be determined.

The properties at which noise levels have been calculated are illustrated in **Figure 6**, together with the location of the proposed access ramp in blue.

Figure 6 Potentially Affected Properties at the Newly Proposed Windsor Road Access Ramps



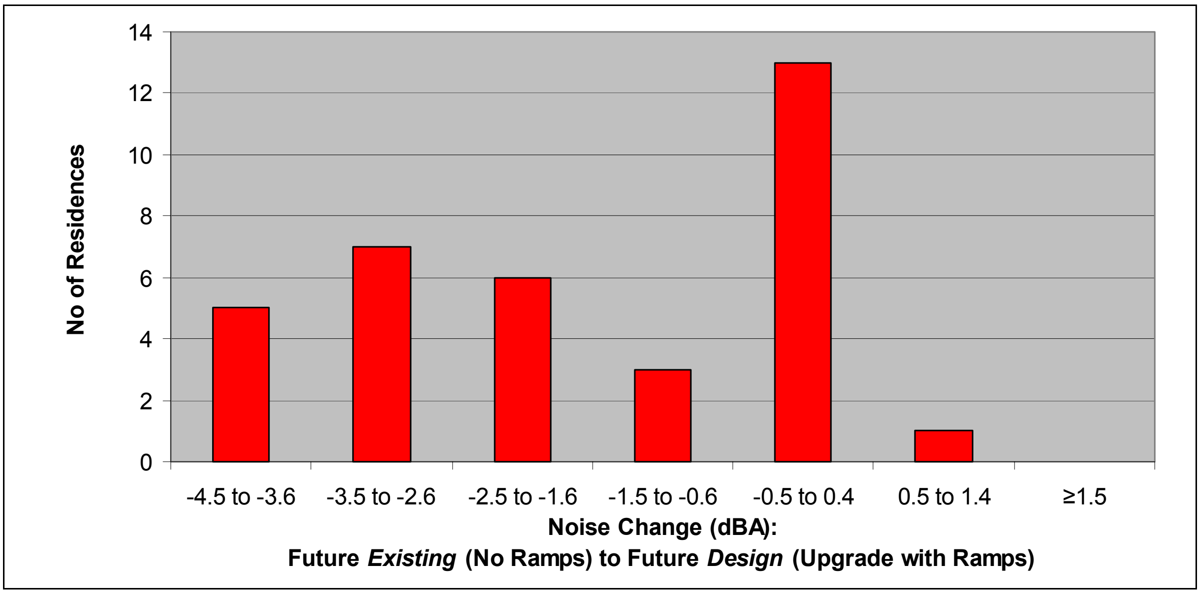
The results of the modelling exercise were found to show that, upon completion of the upgrade, the contribution of the new on/off access ramps alone were predicted to be well below the combined noise levels of both the main M2 carriageway and the proposed access ramps (around 10 dBA below, which adds 0 dBA to the total noise level).

As such, the contribution of the proposed on/off access ramps to the total noise can therefore be taken as not being significant. Accordingly, it is concluded that they do not constitute a “new” source of road traffic noise and that the ECRTN’s “Redeveloped” road noise objectives apply.

In absolute terms, the Future *Design* noise levels at almost all properties in the precinct actually reduce when compared to Future *Existing* noise levels, as is shown in **Figure 7**.

This reduction occurs as a result of the new access ramps having to rise in height to meet with Windsor Road. The access ramps therefore effectively act as noise barriers to the road traffic on the main M2 carriageway (which is the dominant source of noise) thereby resulting in less overall noise exposure for the properties situated adjacent. The small number of overall noise level increases occurs at the western end of the new ramps precinct where they merge with the main carriageway.

Figure 7 Noise Change Adjacent to New Windsor Road On/Off Ramps



5.5.2 Traffic Noise Objectives Outside of the M2 Project Area

The ECRTN and ENMM criteria which are relevant to the M2 Upgrade Project are to be applied at all locations where physical widening of M2 Motorway is occurring. The adopted criteria for the project have been previously detailed in **Section 5.5** of this report.

The widening works associated with the M2 Upgrade Project are noted as starting at chainage 3500 (which is just west of the proposed new Windsor Road access ramps) and finishing at chainage 17800 (which is just east of the Lane Cove Road Intersection).

As such, there are two sections of the M2 Motorway where no works associated with the M2 Upgrade Project are occurring. These locations are:

- From the junction of the M7 with the M2 to just west of Windsor Road (chainage 0 – 3500)
- From east of Lane Cove Road to the Lane Cove Tunnel entrance (chainage 17800 – 20200)

In these locations, where no works associated with the M2 Upgrade Project are occurring, only the incremental criterion, which limits the noise level increase as a result of the additional traffic flow from the project to 2 dBA (ie 2021 Future *Design* minus 2011 Future *Existing*), is applicable.

Properties which are outside of the extent of the upgrade works and which currently experience acute noise levels would be subject to the original conditions of approval for construction of the M2 Motorway and will be considered accordingly. This process would be performed separately to the proposed M2 Upgrade Project.

5.5.3 Sleep Disturbance and Maximum Noise Level Events

The DECCW's ECRTN and the RTA's ENMM provide guidance as to the likelihood of sleep disturbance resulting from road traffic related maximum noise level events (mainly associated with heavy vehicle movements).

The ECRTN document does not set explicit criteria for road traffic noise as no definitive quantitative correlation has been yet established between heavy vehicles noise levels and sleep disturbance. The ECRTN does however point out the following:

> *"There are no universally accepted criteria governing the likelihood of sleep disturbance. In other words, at the current level of understanding, it is not possible to establish absolute noise levels that correlate to levels of sleep disturbance (for all or even a majority of people)."*

Notwithstanding the above, the ECRTN/ENMM suggests that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions.
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

A maximum noise event can be defined as any passby for which the difference in the L_{Amax} and $L_{Aeq(1hour)}$ noise levels is greater than 15 dBA. Furthermore, the ECRTN recommends that the assessment of sleep disturbance should include a consideration of the maximum noise level exceedances occurring during the night-time period and the emergence of these exceedances above the ambient noise level.

5.6 Noise Criteria – Operational Phase: Mechanical Services

Operational noise from mechanical services plant is assessed against different criteria to those applying to operational noise from road traffic. For the M2 Upgrade Project, items of mechanical plant are situated in the Norfolk Tunnel in the form of ventilation fans. The criteria used are taken from:

- DECCW (formerly EPA), *"Industrial Noise Policy"* (INP), January 2000

The procedures contained in the DECCW's *"NSW Industrial Noise Policy"* require a determination of the Rating Background Level (RBL) and ambient L_{Aeq} noise levels during daytime, evening and night-time periods.

The RBL is the background noise level used for assessment purposes and represents the median of the daily background noise levels during each assessment period. The L_{Aeq} noise level represents the energy-averaged noise level during each assessment period.

The assessment procedure for industrial (eg mechanical) noise sources has two components:

- Controlling the intrusive noise impacts in the short-term for residents, and
- Maintaining noise level amenity for residences and other land uses.

Intrusive Criterion

The intrusive criterion for stationary noise sources limits $L_{Aeq,15minute}$ noise emissions levels to the RBL plus 5 dBA.

Amenity Criterion

The amenity noise goal depends upon the level of ambient "industrial" L_{Aeq} noise already existing within an area and how this level compares to the acceptable noise levels specified in **Table 8**.

For example, where existing industrial L_{Aeq} noise levels already *exceed* the acceptable noise levels given in **Table 8** by 2 dBA or more, the L_{Aeq} amenity noise criterion would be set at 10 dBA *below* the existing L_{Aeq} levels in order to limit any further increase in ambient industrial noise levels. The amenity noise goal also depends upon the acoustical environment of the receivers, which in the case of the M2 Upgrade Project is "suburban" (as opposed to "rural" or "urban").

The final $L_{Aeq(15minute)}$ design noise goal applicable to stationary noise sources is then chosen as the *lower* of the intrusive and amenity goals.

Table 8 NSW Industrial Noise Policy Amenity Criteria Relevant to M2 Upgrade Project

Type of Receiver	Indicative Noise Amenity Area	Time of Day[1]	Recommended L_{Aeq} Noise Level	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55 dBA	60 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA
Active Recreation Area	All	When in Use	55 dBA	60 dBA
Commercial Premises	All	When in Use	65 dBA	70 dBA

Note 1: DECCW Governing Periods: Day: 7.00 am to 6.00 pm, Evening: 6.00 pm to 10.00 pm, Night: 10.00 pm to 7.00 am.

6 AMBIENT NOISE ENVIRONMENT

6.1 Noise Monitoring Locations

In order to characterise the existing noise environment adjacent to the Project Area (in relation to both the construction and operational noise assessments) and to establish the noise levels upon which to base the noise emission objectives, environmental noise monitoring was performed at a number of representative locations along the length of M2 Upgrade Project corridor.

These locations were selected based on previous monitoring surveys carried out for the motorway as well as a detailed inspection of potentially affected areas, giving consideration to other noise sources which may adversely influence the measurements, security issues for the noise monitoring devices and gaining permission for access from the resident or landowner.

The monitoring was completed over two separate surveys. The first of these surveys was completed in March and April 2008 at 24 receptor locations along the motorway route and the second survey was performed during December 2008 at a further 13 locations.

A list of the various monitoring locations, split over the two surveys, is provided in **Table 9**, whilst **Appendix B** shows their locations on the M2 Site Plan.

Unattended noise loggers were deployed adjacent to residential dwellings in order to measure the prevailing levels of road traffic noise over a minimum period of one week. The measurements were conducted at a height of 1.5 m above ground and generally at a distance of 1 m from the facade of the subject building, in accordance with the ECRTN.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of AS 1259.2-1990 *"Acoustics - Sound Level Meters. Part 2: Integrating - Averaging"* and carried appropriate and current NATA calibration certificates.

The equipment utilised for the continuous unattended noise surveys comprised of Acoustic Research Laboratories Type EL215 and Type EL316 Environmental Noise Loggers, fitted at all times with microphone wind shields.

The calibration of the loggers was checked prior to, and following, each measurement survey and the variation in calibration at any location was found to not exceed 0.5 dBA at all times.

All noise loggers were set to record statistical noise descriptors in continuous 15-minute sampling periods for the duration of their deployment.

Weather data recorded during the noise monitoring survey periods by the Sydney Bureau of Meteorology was used to assist in identifying potentially adverse weather conditions that could have a detrimental impact on the measured noise levels such as rainy periods, etc.

Table 9 Unattended Noise Logging Locations (March-April 2008 and December 2008 Surveys)

M2 Section	Survey	ID	Address	
Section 1: (Abbot Road to Windsor Road Access Ramps)	1	S1-1	13 Sierra Place	Baulkham Hills
		S1-2	89 Baulkham Hills Road	Baulkham Hills
		S1-3	24 Lambert Crescent	Baulkham Hills
		S1-4	15 Leatherwood Court	Baulkham Hills
		S1-5	108 Junction Road	Baulkham Hills
		S1-6	17 Livingston Avenue	Baulkham Hills
		S1-7	10 Murrills Crescent	Baulkham Hills
	2	S1-8	13 Leatherwood Court	Baulkham Hills
		S1-9	4 Craig Avenue	Baulkham Hills
		S1-10	10 Petrina Close	Baulkham Hills
Section 2: (Windsor Road Access Ramps to Beecroft Road)	1	S2-1	12 Mill Drive	North Rocks
		S2-2	10 Virginia Place	West Pennant Hills
		S2-3	11 Wilshire Avenue	Carlingford
		S2-4	70 Westmore Drive	West Pennant Hills
		S2-5	3 Mundon Place	West Pennant Hills
		S2-6	25 Coral Tree Drive	Carlingford
		S2-7	5 Orchard Road	Beecroft
		S2-8	24A Castle Howard Road	Cheltenham
	2	S2-9	13 Williams Road	North Rocks
		S2-10	8 Rajola Place	North Rocks
		S2-11	33 Carmen Avenue	Carlingford
		S2-12	30 Austral Avenue	Beecroft
Section 3: (Beecroft Road to Delhi Road)	1	S3-1	30 Dunmore Road	Epping
		S3-2	4 Somerset Street	Epping
		S3-3	56 Somerset Street	Epping
		S3-4	19 Woodvale Avenue	North Epping
		S3-5	6/8 Nile Close	Marsfield
		S3-6	40 Ashburton Avenue	South Turramurra
		S3-7	45/147 Talavera Road	Marsfield
		S3-8	3/3 Tasman Place	North Ryde
		S3-9	21 Epping Road	North Ryde
	2	S3-10	13 Stewart Close	Cheltenham
		S3-11	140 Crimea Road	Marsfield
		S3-12	150 Crimea Road	Marsfield
		S3-13	2/4 Nile Close	Marsfield
		S3-14	1A Busaco Road	Marsfield
		S3-15	1 Fontenoy Road	Macquarie Park

6.2 Ambient Noise Monitoring Results

The results of the ambient noise surveys are presented in tabular form in **Table 10** and **Table 11**, and are also illustrated graphically in **Appendix C** (in the form of plots which show the average 24 hour noise levels at each monitoring location for the duration each logging period).

Representative Rating Background Levels (RBL) during the DECCW's standard daytime construction hours (7.00am to 6.00pm), the evening period (6.00pm to 10.00pm) and the night-time period (10.00pm to 7.00am), as required by the NSW "*Industrial Noise Policy*" (INP), are provided in **Table 10**. These noise levels are used to set noise objectives in relation to the construction phase of the project.

To represent overall day to day variations in road traffic noise emissions for freeways, use is made of the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise indices. These indices represent the energy-averaged noise level that prevails during the daytime (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods. These indices, which are used for the operational assessment, are provided in **Table 11**.

Observations of the acoustical environment at the noise monitoring locations indicate that, during some periods, the noise environment would be influenced by short-term high noise level events such as sirens, street conversations, horns, etc, as well as the prevailing road traffic. As these former noise sources are relatively short-term in nature, they would have the effect of increasing the higher order L_{Amax} and L_{Aeq} indices rather than the L_{A10} and L_{A90} levels.

The ECRTN requires that, when conducting ambient noise surveys, it is only the noise level contributions from road traffic noise that are relevant, therefore in order for the measured data to reflect the prevailing levels of road traffic noise, the data was processed taking into account the following:

- Prevailing weather conditions.
- Uncharacteristic changes in the noise indices.
- Uncharacteristic variations of the L_{Aeq} compared to the L_{A10} index.

The unattended noise logging results measured in the vicinity of the tunnel portals have been utilised to determine the existing L_{A90} background and ambient L_{Aeq} noise levels during the daytime, evening and night-time periods applicable to operational stationary noise sources.

Table 10 Summary of Unattended Noise Logging – Construction Noise Indices

Receiver ID	Address		Construction Noise Indices (RBL) (dBA)		
			Daytime Period [1]	Evening Period [2]	Night-time Period [3]
S1-1	13 Sierra Place	Baulkham Hills	44	45	38.5
S1-2	89 Baulkham Hills Road	Baulkham Hills	50	47	38
S1-3	24 Lambert Crescent	Baulkham Hills	52	47	39.5
S1-4	15 Leatherwood Court	Baulkham Hills	48.5	49	47
S1-5	108 Junction Road	Baulkham Hills	51.5	47.5	37.5
S1-6	17 Livingstone Avenue	Baulkham Hills	47.5	44	36.5
S1-7	10 Murrills Crescent	Baulkham Hills	46	43.5	38.5
S1-8	13 Leatherwood Court	Baulkham Hills	51	48	36
S1-9	4 Craig Avenue	Baulkham Hills	57.5	54	38
S1-10	10 Petrina Close	Baulkham Hills	59.5	56.5	41.5
S2-1	12 Mill Drive	North Rocks	37	38	34
S2-2	10 Virginia Place	West Pennant Hills	52	48	39.5
S2-3	11 Wilshire Avenue	Carlingford	56.5	52.5	42
S2-4	70 Westmore Drive	West Pennant Hills	53.5	50	38
S2-5	3 Mundon Place	West Pennant Hills	47	46	35.5
S2-6	25 Coral Tree Drive	Carlingford	46	49	41.5
S2-7	5 Orchard Road	Beecroft	51.5	47	36
S2-8	24A Castle Howard Road	Cheltenham	53.5	48.5	33
S2-9	13 Williams Road	North Rocks	57.5	53	38.5
S2-10	8 Rajola Place	North Rocks	58	52.5	41.5
S2-11	33 Carmen Avenue	Carlingford	57.5	54.5	37.5
S2-12	30 Austral Avenue	Beecroft	57	52.5	39
S3-1	30 Dunmore Road	Epping	58	52	46
S3-2	4 Somerset Street	Epping	52	48	35
S3-3	56 Somerset Street	Epping	49	44.5	32.5
S3-4	19 Woodvale Avenue	North Epping	54.5	50	33
S3-5	6/8 Nile Close	Marsfield	44.5	42	36.5
S3-6	40 Ashburton Avenue	South Turramurra	45.5	47	38.5
S3-7	45/147 Talavera Road	Marsfield	50	46	35
S3-8	3/3 Tasman Place	North Ryde	51	48.5	41.5
S3-9	21 Epping Road	North Ryde	53.5	51.5	41
S3-10	13 Stewart Close	Cheltenham	54	50.5	33.5
S3-11	140 Crimea Road	Marsfield	53	49	36.5
S3-12	150 Crimea Road	Marsfield	49	45	31
S3-13	2/4 Nile Close	Marsfield	47	44.5	31.5
S3-14	1A Busaco Road	Marsfield	48.5	47.5	37
S3-15	1 Fontenoy Road	Macquarie Park	54	51.5	42

Note 1: DECCW's standard construction hours: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Note 2: Evening hours: 6.00 pm to 10.00 pm.

Note 3: Night-time hours: 10.00 pm to 7.00 am Sunday to Friday, 10.00 pm Saturday to 8.00 am Sunday.

Table 11 Summary of Unattended Noise Logging – Road Traffic Noise Indices

Receiver ID	Address		Road Traffic Noise Indices (dBA)		
			$L_{A10(18hour)}$	$L_{Aeq(15hour)}$	$L_{Aeq(9hour)}$
S1-1	13 Sierra Place	Baulkham Hills	52.5	51.5	47
S1-2	89 Baulkham Hills Road	Baulkham Hills	58.5	56.5	52.5
S1-3	24 Lambert Crescent	Baulkham Hills	60.5	59	55
S1-4	15 Leatherwood Court	Baulkham Hills	57	55.5	55.5
S1-5	108 Junction Road	Baulkham Hills	62	59	53.5
S1-6	17 Livingston Avenue	Baulkham Hills	58	56	52
S1-7	10 Murrills Crescent	Baulkham Hills	55.5	54	50
S1-8	13 Leatherwood Court	Baulkham Hills	59.5	57.5	53.5
S1-9	4 Craig Avenue	Baulkham Hills	68	65.5	61
S1-10	10 Petrina Close	Baulkham Hills	66.5	65.5	60
S2-1	12 Mill Drive	North Rocks	48.5	51	45
S2-2	10 Virginia Place	West Pennant Hills	58	56	54
S2-3	11 Wilshire Avenue	Carlingford	61.5	59.5	56
S2-4	70 Westmore Drive	West Pennant Hills	60	58	54
S2-5	3 Mundon Place	West Pennant Hills	54	53	48
S2-6	25 Coral Tree Drive	Carlingford	55.5	53	50.5
S2-7	5 Orchard Road	Beecroft	58.5	56.5	50.5
S2-8	24A Castle Howard Road	Cheltenham	59.5	57.5	52.5
S2-9	13 Williams Road	North Rocks	63.5	61.5	58
S2-10	8 Rajola Place	North Rocks	63.5	61.5	58
S2-11	33 Carmen Avenue	Carlingford	65	63.5	59
S2-12	30 Austral Avenue	Beecroft	64	62	57
S3-1	30 Dunmore Road	Epping	64	61.5	57.5
S3-2	4 Somerset Street	Epping	59.5	57.5	52.5
S3-3	56 Somerset Street	Epping	56	53.5	48
S3-4	19 Woodvale Avenue	North Epping	61	59	54
S3-5	6/8 Nile Close	Marsfield	53	51.5	46.5
S3-6	40 Ashburton Avenue	South Turramurra	56.5	55	50
S3-7	45/147 Talavera Road	Marsfield	61.5	60	52.5
S3-8	3/3 Tasman Place	North Ryde	57	56	50.5
S3-9	21 Epping Road	North Ryde	60	58.5	53
S3-10	13 Stewart Close	Cheltenham	60	58	53.5
S3-11	140 Crimea Road	Marsfield	59	58	52.5
S3-12	150 Crimea Road	Marsfield	54.5	53.5	48
S3-13	2/4 Nile Close	Marsfield	55.5	55	48.5
S3-14	1A Busaco Road	Marsfield	56	54.5	49.5
S3-15	1 Fontenoy Road	Macquarie Park	61.5	60	55

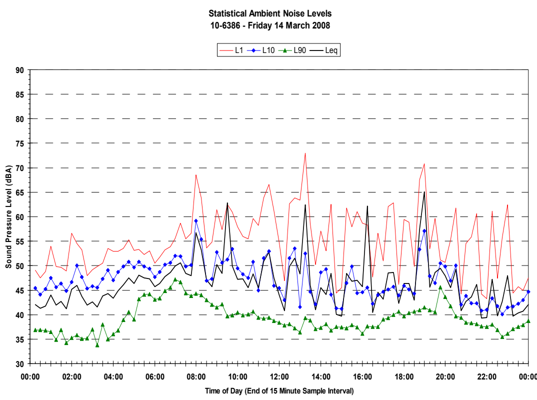
Reference to the background noise logging data contained in **Table 11** shows that where receivers are situated adjacent to the M2 Motorway and are not screened from view of the motorway by other houses, the existing levels of road traffic noise are, in the majority of cases, already above the ECRTN base criteria of 60 dBA $L_{Aeq(15hour)}$ and 55 dBA $L_{Aeq(9hour)}$.

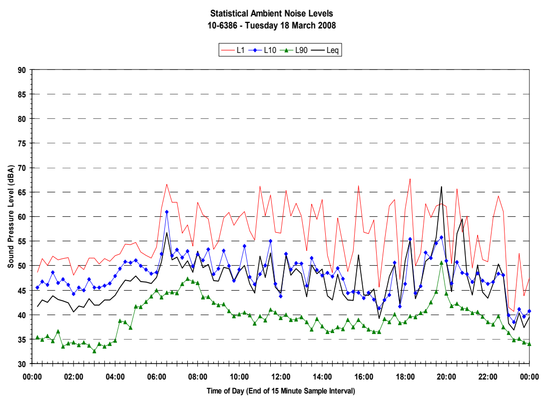
6.2.1 Discussion

Four of the above monitoring locations (15 Leatherwood Court, 12 Mill Drive, 3 Mundon Place and 40 Ashburton Avenue) were excluded from some of the subsequent analysis for the following reasons:

- The noise level data amassed at both 12 Mill Drive and 40 Ashburton Avenue was found to have been significantly influenced by extraneous sources present in the vicinity of the measurement locations, in both cases unrelated to road traffic noise. For example, **Figure 8** shows the location map for 12 Mill Drive (North Rocks) and two typical daily noise plots. The residence is some distance from the motorway and experiences highly variable noise levels throughout the day and night that is not related to "steady" road traffic noise.
- The L_{Aeq} noise data for 15 Leatherwood Court was found to have very little variance throughout the period of the day, with practically no difference between the daytime and night time noise levels, as can be seen in **Table 11**. As a result of this the logging at this location was deemed to be erroneous and was discounted.
- 30 Mundon Place was monitored separately to the March to April monitoring exercise and was subsequently found also to be not representative (in terms of dominant noise levels) of typical motorway operation.

Figure 8 Aerial Location Map for 12 Mill Drive, North Rocks





7 ASSESSMENT OF CONSTRUCTION PHASE

The M2 Upgrade Project represents a major infrastructure development project, constructed over two years, and as such there would be periods when impacts on the surrounding areas are expected.

As it will be necessary for the motorway to, at least partly, remain open during the daytime, works would often be required to be conducted during the less busy night-time period.

7.1 Construction Noise Modelling Procedure

The general methodology adopted for the prediction of construction noise impacts is as follows:

- A review of the construction works is undertaken to identify the various main stages of the construction process, the equipment involved and the scheduling of these activities. This leads to the distillation of the construction programme into a series of distinct construction scenarios which are fully representative of the range of activities and planned scheduling of the project – refer to **Section 7.1.2**.
- The start point for the calculations is to assign representative sound power levels to all the equipment involved in the above construction scenarios.
- To enable comparison of equipment noise emissions to the project construction noise goals, it is necessary to convert the above sound power levels to equivalent L_{Aeq} noise emissions.
- Finally, the simulated construction scenarios are "placed" in realistic configurations at representative Noise Catchment Areas along the project route to determine the impact at nearest sensitive receivers.

7.1.1 Construction Noise Modelling – SoundPLAN

In order to quantify noise emissions from the proposed construction works, noise calculations have been undertaken to predict the $L_{Aeq(15minute)}$ noise levels at the nearest sensitive receivers using the CONCAWE industrial noise algorithm within the SoundPLAN noise modelling software.

The calculations take into account the source noise levels of the anticipated equipment, the location of the nearest residential receivers, the number of items of equipment likely to be operating at any given time and the distance and topography (including existing noise barriers) between the equipment and the nearest receivers.

The upgrade works are essentially repeated along the length of the M2 Motorway, and as such, the impact of the proposed works has been assessed by examining representative receivers along the length of the Motorway in selected noise catchment areas. A map illustrating each of the construction noise catchment areas is provided within **Appendix B**.

7.1.2 Construction Scenarios, Equipment and Sound Power Levels

For the M2 Upgrade Project, a series of construction scenarios has been developed which represent the various construction phases of the upgrade process.

Table 12 details each of the critical work elements of relevance to construction impacts, together with the equipment required during each scenario and the corresponding sound power levels for each item of plant.

The expected location and duration of each of the key construction scenarios is indicated in **Table 13** together with the period of the day in which the activity will be undertaken. It is noted that not all scenarios are required at all locations along the motorway.

Table 12 Construction Scenarios and Typical Equipment Involved

Scenario	Activity	Equipment Used	Sound Power Level (dBA)	
			L_{Aeq}	L_{Amax}
1a + 1b	Road Widening	Excavator 30t	109	115
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Mobile Crane	105	113
		Vibratory Roller	106	114
		(PLUS at selected locations – Scenario 1b)		
	(Scenario 1b includes the additional equipment associated with Rocksawing/breaking)	Rocksaw	114	118
		Rockbreaker	117	124
		Compressor	106	107
		Generator	100	103
2	Cross-Stitching & Temporary Median Works	Excavator 30t with Hammer	109	115
		Jack Hammer	115	117
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Mobile Crane	105	113
		Vibratory Roller	106	114
3	Intelligent Transport System (ITS) Works	Excavator 30t	109	115
		Truck (delivery / removal)	93	97
		Concrete Truck	109	113
		Concrete Saw	114	118
		Reinforcement Cutting	109	118
		Mobile Crane	105	113
		Generator	100	103
		Lighting Tower	87	88
4	Re-Surfacing Asphalt Works	Asphalt Paver	104	112
		Vibratory Roller	109	114
		Tip Trucks	93	97
5	Traffic Management, Set-Up and Line Marking	Truck (delivery / removal)	93	97
		Generator	100	103
		Lighting Tower	87	88
6	Hydroblasting	Drilling Rig	104	104
		Truck (delivery / removal)	93	97
		Compressor	106	107
		Generator	100	103
		Jackhammer	115	117
		Mobile Crane	105	113
		Lighting Tower	87	88
7a	Bridgeworks (Daytime - Bored Piling, Abutments and Piers, Deck and Finishing)	Piling Rig (bored)	107	110
		Rockbreaker	117	124
		Excavator 30t	109	115
		Backhoe	106	111
		Truck (delivery / removal)	93	97
		Generator	100	103
		Compressor	106	107
		Jackhammer	115	117
		Crane (up to 70t)	109	113
		Concrete Pump	108	112
		Vibratory Roller	106	114
7b	Bridgeworks (Evening and Night-time works)	Generator	100	103
		Compressor	106	107
		Concrete Truck	109	113
		Concrete Pump	108	112
		Concrete Vibrator	105	112
		Truck (delivery / removal)	93	97
		Mobile Crane	105	113
		Boom Lift	102	108

Table 13 Key Construction Activities, Likely Duration and Scheduling Times

Chainage/Location	Duration	Period	Activity
0 – 4000 West of Windsor Road	4 months	Day	ITS Works (eg signage)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			Traffic Management Set-Up and Line Marking
			Re-Surfacing Asphalt Works
Windsor Road Ramps	15 months	Day	Widening & Ramp Construction
			Bridgeworks
			Re-Surfacing Asphalt Works
		Night	Hydroblasting
			Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
4000 – 6000 Windsor Road to Barclay Road	12 months	Day	Widening Works (including rockhammering)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
6000 – 7900 Barclay Road to Carmen Drive	14 months	Day	Widening Works (including rockhammering)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
7900 – 9400 Carmen Drive to Pennant Hills Road	6 months	Day	ITS Works (eg signage)
			Cabling and Trenching Works
9400 – 12000 Pennant Hills Road to Beecroft Road	10 months	Day	Widening Works (including rockhammering)
			Bridgeworks
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
12000 – 12400 Beecroft Road to West Tunnel Portal	5 months	Day	Widening Works (including rockhammering)
			ITS Works (eg signage)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			Traffic Management Set-Up and Line Marking
			Re-Surfacing Asphalt Works
12400 – 13550 Portal & Tunnel Works1	18 months	Day	Tunnel Drilling
			Widening Works (including rockhammering)
			ITS Works (eg signage)
			Re-Surfacing Asphalt Works
		Night	Tunnel Drilling
			Widening Works (including rockhammering)
			Cross-Stitching & Temporary Median Works
			Traffic Management Set-Up and Line Marking
			Re-Surfacing Asphalt Works
13550 – 15000 East Tunnel Portal to Busaco Road	16 months	Day	Widening Works (including rockhammering)
			Bridgeworks (Terry's Creek, Busaco Road)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
15000 – 15400 Busaco Road to Toll Plaza	12 months	Day	Widening Works (including rockhammering)
			Re-Surfacing Asphalt Works
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
15400 – 15700 Toll Plaza Works	15 months	Day	Widening Works
			ITS Works (eg signage)

Chainage/Location	Duration	Period	Activity
		Night	Cross-Stitching & Temporary Median Works
			ITS Works (eg signage)
			Traffic Management Set-Up and Line Marking
15700 – 16000 Toll Plaza to Christie Road	12 months	Day	Widening Works (including rockhammering)
			Re-Surfacing Asphalt Works
			ITS Works (eg signage)
		Night	Cross-Stitching & Temporary Median Works
			Re-Surfacing Asphalt Works
			Traffic Management Set-Up and Line Marking
16200 – 17650 Christie Road to Lane Cove Road	23 months	Day	Widening Works (including rockhammering)
			Herring Road Bridgeworks/Ramps
			Re-Surfacing Asphalt Works
			ITS Works (eg signage)
		Night	Cross-Stitching & Temporary Median Works
			Re-Surfacing Asphalt Works
			Traffic Management Set-Up and Line Marking

Note 1: The impacts from the construction works associated with the widening of the Norfolk Tunnel are discussed in detail in **Section 7.7**.

It is noted that the majority of the proposed construction works associated with the M2 Upgrade Project would be undertaken during the standard daytime construction hours. Night-time works would be completed on an as-needed basis.

Furthermore, where evening and night-time works are required, it is noteworthy that they would not be continuous at any one location for the full duration of the works within that section.

7.2 Construction Noise Predictions

Using the sound power levels in **Table 12**, construction noise levels have been predicted at the nearest receiver locations to the various Noise Catchment Areas for each of the construction scenarios detailed in **Table 13** (noting that not every scenario is apparent of each assessment location).

The resultant daytime, evening and night-time $L_{Aeq(15minute)}$ noise levels are presented in **Table 14**, **Table 15** and, **Table 16** respectively (where appropriate) and compared with the relevant Noise Management Levels.

The predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. A receiver will therefore experience a range of values, representing the variation in construction noise depending upon the location of the particular construction activity and the likelihood of the equipment of interest operating simultaneously.

Where a range of values are apparent, the values presented in the assessment tables represent the predicted noise levels at several receivers within that Noise Catchment Area at various offset distances from the construction works.

It is noted that the following predictions are representative of typical construction works situated on the carriageway of M2 in the vicinity of each of the assessment locations, and that for extended periods of time, noise levels would potentially be lower than the calculated levels as predicted for the construction scenarios evaluated.

In each construction scenario, all of the equipment belonging to a particular activity is assumed to be operating concurrently for the full 15 minute period.

It is noted that the following predictions relate to when the particular plant is approximately adjacent to the residences of interest and that as plant and equipment moves along the road of concern, noise levels will reduce.

7.2.1 Daytime Construction Noise

The assessment of the impacts of construction noise during the daytime period, for each of the construction scenarios, is provided in **Table 14**.

Table 14 Construction Noise Predictions – Daytime

Noise Catchment Area (Refer to Appendix B)	Side of Motorway	Daytime NML (dBA) (RBL +10 dBA)	Predicted LAeq(15minute) Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
1	North	62	-	-	-	57- 63	49- 52	-	-	-
	South	62	-	-	-	54	45	-	-	-
2	North	62	-	-	-	59	52- 54	-	-	-
3	North	61	-	-	-	51- 54	44- 48	-	-	-
	South	61	-	-	-	56	49	-	-	-
4	North	61.5	-	-	-	57	53	-	-	-
	South	61.5	-	-	-	55	49	-	-	-
5[1]	North	57.5	51- 67	53- 68	-	-	44- 54	-	-	49- 63
	South	56	54- 66	52- 67	-	-	49- 53	-	-	50- 63
6	South	69.5	54	56- 60	-	-	46- 48	-	-	-
7	North	67.5	52- 54	57- 59	-	-	48	-	-	-
	South	67.5	56	59- 60	-	-	49	-	-	-
8	North	68	50	55	-	-	45	-	-	-
	South	68	51	53	-	-	42	-	-	-
9	South	68	53	57	-	-	47	-	-	-
10	North	62	51	55	-	-	44	-	-	-
	South	66.5	43	48	-	-	38	-	-	-
11	North	63.5	47	51	-	-	42	-	-	-
	South	67.5	58- 62	67	-	-	56	-	-	-
12	South	61.5	-	-	-	61	-	-	-	-
13	North	67	59- 61	61- 64	-	-	50- 53	-	-	-
	South	61.5	52	59	-	-	49	-	-	-
14	South	61.5	48- 54	53- 57	-	-	43- 47	-	-	-
15	North	63.5	55- 60	60- 63	-	-	49- 52	-	-	59
	South	68	49- 53	54- 59	-	-	44- 47	-	-	54- 59
16	North	63.5	53- 55	59	-	-	47	-	-	-
	South	68	56- 60	60- 61	-	-	49- 51	-	-	-
17	North	62	57- 62	61- 64	-	57- 59	52	-	-	-
	South	62	57	59	-	55	48	-	-	-
	Tunnel	66	54	59	-	56	49	-	-	-
18	North	59	50- 54	57	-	51- 54	44- 47	-	-	54- 60
	South	59	52- 55	54- 58	-	51- 55	44- 49	-	-	48- 55
19	North	55.5	47	51	-	-	41	-	-	-
	South	57	57	60	-	-	51	-	-	-
20	North	58.5	46- 51	52- 55	-	-	39- 45	-	-	50- 63
	South	60	42- 51	53- 55	-	-	37- 45	-	-	56- 61
21	North	64	49- 53	63	-	59	52	-	-	-

Note 1: Location 5 presents the worst-case noise levels apparent when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Construction noise during the daytime period is generally predicted to be in line with the Noise Management Levels at most of the assessment locations detailed in **Table 14**. This results from the high background noise levels which are apparent from existing traffic movements on the M2 Motorway.

A number of small exceedances (less than 5 dBA) of the Noise Management Levels are predicted for the scenarios associated with Road Widening and Bridgeworks. The largest exceedance is predicted at Noise Catchment Area 5 in the vicinity of the proposed new Windsor Road access ramps. This exceedance, however, represents the worst-case noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

7.2.2 Evening Construction Noise

The assessment of the impacts of construction noise during the evening period, for each of the construction scenarios, is provided in **Table 15**.

Table 15 Construction Noise Predictions – Evening

Noise Catchment Area (Refer to Appendix B)	Side of Motorway	Evening NML (dBA) (RBL +5 dBA)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7b Bridge-works
1	North	52	-	-	59- 65	-	49- 52	50- 55	-	-
	South	52	-	-	54	-	45	45	-	-
2	North	52	-	-	62	-	52- 54	49- 51	-	-
3	North	53	-	-	56	-	44- 48	43- 46	-	-
	South	53	-	-	59	-	49	48	-	-
4	North	52.5	-	-	61	-	53	50- 52	-	-
	South	52.5	-	-	59	-	49	46- 48	-	-
5[1]	North	49	-	-	53- 67	49- 68	-	44- 53	50- 63	38-56
	South	48.5	-	-	52- 67	49- 67	-	46- 54	51- 63	57-66
6	South	61.5	-	-	55- 57	51- 57	-	46	-	44-63
7	North	58	-	-	55- 57	52- 54	-	45- 47	-	44-69
	South	58	-	-	58	55	-	47	-	45-51
8	North	57.5	-	-	52	49- 51	-	43	-	-
	South	57.5	-	-	56	48	-	42	-	-
9	South	57.5	-	-	55	54	-	43- 45	-	44-51
10	North	53	-	-	53	51	-	42	-	-
	South	57.5	-	-	46	43	-	36	-	-
11	North	55	-	-	49	47	-	39	-	-
	South	59.5	-	-	62- 64	59- 63	-	50- 52	-	-
12	South	52	-	-	-	-	-	-	-	-
13	North	57.5	-	-	60- 62	59- 61	-	49- 51	-	52-58
	South	52	-	-	58	53	-	47	-	40-41
14	South	52	-	-	52- 56	49- 54	-	39- 44	-	60-69
15	North	53.5	-	-	58- 61	56- 59	-	47- 50	-	-
	South	57	-	-	52- 56	49- 54	-	42- 44	-	-
16	North	53.5	-	-	56	55	-	45	-	46-50
	South	57	-	-	58- 60	56	-	47- 50	-	51-57
17	North	53	57- 62	61- 64	59- 63	-	52	50	-	-
	South	53	57	59	57	-	48	45	-	-
	Tunnel	57	54	59	58	-	49	47	-	-
18	North	49.5	50- 54	57	53- 56	-	44- 47	43- 46	-	40-45
	South	49.5	52- 55	54- 58	53- 57	-	44- 49	43- 47	-	39-53
19	North	52	-	-	50	47	-	40	-	-
	South	49.5	-	-	60	57	-	49	-	-
20	North	52.5	-	-	50- 54	45- 50	-	40- 44	-	-
	South	51	-	-	50- 53	50	-	35- 44	-	-
21	North	56.5	-	-	61	-	52	50	-	41-48

Note 1: Location 5 presents the worst-case noise levels when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

During the evening period exceedances are apparent for most of the construction scenarios assessed. Exceedance of the project Noise Management Levels in these scenarios typically range from zero (ie compliance) to around 15 dBA.

The largest exceedance (of about 20 dBA) is predicted at Noise Catchment Area 5 in the vicinity of the proposed new Windsor Road access ramps. This exceedance represents the worst-case noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

It is noted that evening construction works would not be expected to be continuous at any one location for the full duration of the works within that section.

7.2.3 Night-time Construction Noise

The assessment of the impacts of construction noise during the night-time period, for each of the construction scenarios, is provided in **Table 16**.

Table 16 Construction Noise Predictions – Night-time

Noise Catchment Area (Refer to Appendix B)	Side of Motorway	Night NML (dBA) (RBL +5 dBA)	Predicted LAeq(15minute) Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7b Bridge-works
1	North	44.5	-	-	59- 65	-	49- 52	50- 55	-	-
	South	44.5	-	-	54	-	45	45	-	-
2	North	44.5	-	-	62	-	52- 54	49- 51	-	-
3	North	41	-	-	56	-	44- 48	43- 46	-	-
	South	41	-	-	59	-	49	48	-	-
4	North	42.5	-	-	61	-	53	50- 52	-	-
	South	42.5	-	-	59	-	49	46- 48	-	-
5[1]	North	41.5	-	-	53- 67	49- 68	-	44- 53	50- 63	38-56
	South	43.5	-	-	52- 67	49- 67	-	46- 54	51- 63	57-66
6	South	46.5	-	-	55- 57	51- 57	-	46	-	44-63
7	North	43.5	-	-	55- 57	52- 54	-	45- 47	-	44-69
	South	43.5	-	-	58	55	-	47	-	45-51
8	North	46.5	-	-	52	49- 51	-	43	-	-
	South	46.5	-	-	56	48	-	42	-	-
9	South	46.5	-	-	55	54	-	43- 45	-	44-51
10	North	44.5	-	-	53	51	-	42	-	-
	South	47	-	-	46	43	-	36	-	-
11	North	43	-	-	49	47	-	39	-	-
	South	42.5	-	-	62- 64	59- 63	-	50- 52	-	-
12	South	41	-	-	-	-	-	-	-	-
13	North	44	-	-	60- 62	59- 61	-	49- 51	-	52-58
	South	41	-	-	58	53	-	47	-	40-41
14	South	41	-	-	52- 56	49- 54	-	39- 44	-	60-69
15	North	38	-	-	58- 61	56- 59	-	47- 50	-	-
	South	51	-	-	52- 56	49- 54	-	42- 44	-	-
16	North	38	-	-	56	55	-	45	-	46-50
	South	51	-	-	58- 60	56	-	47- 50	-	51-57
17	North	40	57- 62	61- 64	59- 63	-	52	50	-	-
	South	40	57	59	57	-	48	45	-	-
	Tunnel	44	54	59	58	-	49	47	-	-
18	North	37.5	50- 54	57	53- 56	-	44- 47	43- 46	-	40-45
	South	37.5	52- 55	54- 58	53- 57	-	44- 49	43- 47	-	39-53
19	North	43.5	-	-	50	47	-	40	-	-
	South	36.5	-	-	60	57	-	49	-	-
20	North	42	-	-	50- 54	45- 50	-	40- 44	-	-
	South	40	-	-	50- 53	50	-	35- 44	-	-
21	North	47	-	-	61	-	52	50	-	41-48

Note 1: Location 5 presents the worst-case noise levels when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

For the night-time period there are significant exceedances for many activities as a direct result of the more stringent NMLs.

It is noted that night-time construction works would not be expected to be continuous at any one location for the full duration of the works within that section.

7.2.4 Discussion on Exceedances

Although the above assessment predicts the potential for significant exceedances, at times, it is again noted that the sensitive receiver noise levels presented above are all predicted during a worst-case scenario when all of the equipment within a particular scenario is operating concurrently, for the full 15 minute assessment period, in a location immediately adjacent to the residences of interest.

This situation, and the associated higher Noise Management Level exceedances, may therefore only be apparent at a particular receiver of interest for a relatively short period of time. As the plant and equipment moves along the road of concern, the noise levels would be expected to reduce accordingly.

Certain proposed night-time works have the potential to result in noise levels well above background noise levels. As such they have the potential to impact upon adjacent sensitive receivers causing possible disturbance and nuisance.

However, evening and night-time works are only proposed for specific works on the motorway or on the major roads that intersect with the motorway. Undertaking these works during the daytime would have the potential to cause significant traffic disruption both directly at the works location and also extending out widely into the surrounding road networks. Due to the large number of people potentially affected by such works, it is therefore considered that night-time works are appropriate in these instances.

Working on busy roads can pose safety risks to both construction personnel and the users of the roads if appropriate measures are not put in place. Construction works associated with roads often require temporary modification to existing lane alignments and other traffic control measures which are different to the usual conditions experienced by road users at these locations. This increases the potential for traffic incidents that could affect the safety of construction personnel and other the road users. As such, certain activities are proposed at night-time to address these safety concerns. Some of these works involve short-term activities such as making appropriate changes to the lane alignment and other intersection features to create safer daytime working environments for both construction personnel and road users.

In summary, whilst the noise associated with the proposed night-time work activities may have the potential to impact upon the amenity of adjacent sensitive receivers, their justification is based on significant safety considerations and the potential for widespread traffic disruption.

On the basis of the above, the following approach would be undertaken, in accordance with DECCW's Interim Construction Noise Guideline:

- All reasonable and feasible work practices need to be applied to meet the noise goals.
- Where Noise Management Levels are likely to be exceeded (especially during the more sensitive evening and night-time periods), community liaison must be undertaken and negotiation take place to arrive at the final mitigation strategy.

Suitable methods for mitigating the impact of construction noise (and vibration) are discussed in more detail in **Section 8**.

It is noteworthy that in the above assessment of the daytime, evening and night-time periods, the higher exceedances are generally related to the use of the following items of plant:

- Concrete saws (and reinforcement cutting)
- Rockbreakers
- Jackhammers

7.2.5 Sleep Disturbance

The assessment of the predicted sensitive receiver LAmax noise levels during the night-time period is presented in **Table 17**. The corresponding Sleep Disturbance Screening Criterion (RBL +15 dBA) for each assessment location is also presented.

Table 17 Construction Noise Predictions – Sleep Disturbance

Location (Refer to Appendix B)	Side of Motorway	Sleep Disturbance Screening Criterion (dBA) (RBL +15 dBA)	Predicted LAmax Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
			1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7b Bridge-works
1	North	54.5	-	-	60- 65	-	54- 57	54- 62	-	-
	South	54.5	-	-	57	-	51	50	-	-
2	North	54.5	-	-	64	-	56- 59	56- 58	-	-
3	North	51	-	-	56- 58	-	50- 52	48- 51	-	-
	South	51	-	-	61	-	55	53	-	-
4	North	52.5	-	-	63- 66	-	58	58	-	-
	South	52.5	-	-	61	-	55	52- 54	-	-
5[1]	North	51.5	-	-	57- 68	56- 71	-	50- 62	52- 59	45-61
	South	53.5	-	-	63- 72	63- 75	-	58- 61	55- 67	64-71
6	South	56.5	-	-	58- 61	58- 62	-	50- 52	-	50-67
7	North	53.5	-	-	58- 60	58- 60	-	53	-	51-73
	South	53.5	-	-	60	61	-	52	-	52-57
8	North	56.5	-	-	57	57	-	48	-	-
	South	56.5	-	-	56	58	-	49	-	-
9	South	56.5	-	-	56- 59	59	-	47- 50	-	50-55
10	North	54.5	-	-	57	57	-	48	-	-
	South	57	-	-	49	50	-	43	-	-
11	North	53	-	-	53	53	-	44	-	-
	South	52.5	-	-	63- 67	69	-	57- 59	-	-
12	South	51	-	-	66	-	-	-	-	-
13	North	54	-	-	60- 63	68	-	52- 55	-	58-63
	South	51	-	-	59- 61	65- 67	-	55	-	45-47
14	South	51	-	-	52- 57	58- 60	-	45- 49	-	65-72
15	North	48	-	-	62	54- 58	-	52- 54	-	-
	South	61	-	-	56- 61	62- 65	-	48- 50	-	-
16	North	48	-	-	58	56- 61	-	49	-	50-54
	South	61	-	-	61- 64	59	-	53- 55	-	55-61
17	North	50	64- 68	69	64- 67	-	57	55- 58	-	-
	South	50	63	65	63	-	54	52- 54	-	-
	Tunnel	54	60	65	60	-	54	52	-	-
18	North	47.5	57- 60	63	57- 59	-	49- 52	51	-	47-50
	South	47.5	58- 61	60- 64	56- 61	-	49- 54	49- 52	-	45-57
19	North	53.5	-	-	52	54	-	46- 49	-	-
	South	46.5	-	-	61- 63	64	-	54	-	-
20	North	52	-	-	54- 57	52- 58	-	48- 50	-	-
	South	50	-	-	55- 57	52- 56	-	48	-	-
21	North	57	-	-	64	-		55	-	48-52

Note 1: Location 5 presents the worst-case noise levels when the existing noise walls are temporarily removed to construct the new Windsor Road access ramps.

Exceedance of the project Sleep Disturbance Screening Criteria ranges from zero (ie compliance) to around 20 dBA.

The largest exceedance is predicted at Assessment Location 5 which is in the vicinity of the proposed new Windsor Road access ramps. This exceedance represents the noise levels subject to the nearby properties when the existing noise barrier is removed to allow construction of the new ramps.

Again, the higher exceedances of the Sleep Disturbance Screening Criteria are generally related to the use of the following items of plant:

- Concrete saws (and reinforcement cutting)
- Rockbreakers
- Jackhammers

7.3 Construction Noise - Sensitive Land Uses

The assessment of the impact of construction noise on other sensitive land used is provided in **Table 18** and **Table 19.**

Table 18 Assessment of Existing Educational Facilities

Location	NML (dBA)	Predicted $L_{Aeq(15minute)}$ Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
		1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
Model Farms High School	55 (external)[1]	-	-	-	40	33	-	-	-
Winston Hills Public School		-	-	-	51	45	-	-	-
Our Lady of Lourdes Primary School		47	55	-	-	40	-	-	39
Murfield High School		42	46	-	-	35	-	-	-
Royal Institute for Deaf and Blind Children School		43	48	-	-	37	-	-	-
Epping Heights Public School		55- 63	56- 64	-	-	47- 51	-	-	50- 57
Macquarie University		46	52	-	-	42	-	-	44

Note 1: Based on an internal NML of 45 dBA and a 10 dBA reduction from external to internal noise levels for openable windows.

The above assessment concludes that at the existing educational facilities, the majority of the predicted construction noise levels are below the Noise Management Levels. The only exception is at Epping Heights Public School, where exceedances of around 9 dBA are predicted for a number of the scenarios.

It is however noted that the ambient noise monitoring results, as presented in **Table 10**, show existing daytime background (L_{A90}) noise levels measured in the vicinity of Epping Heights Public School of 58 dBA (measured on Dunmore Road).

Table 19 Assessment of Places of Worship

Location	NML (dBA)	Predicted L_{Amax} Noise Level for each Scenario (dBA) (Refer to Table 12 for descriptions)							
		1a Road Widening	1b Road Widening	2 Cross Stitching	3 ITS Works	4 Re-Surfacing	5 Traffic Manage	6 Hydro-blasting	7a Bridge-works
Our Lady of Lourdes Church	55 (external) [1]	52	60	44	40	42	45	49	48

Note 1: Based on an internal NML of 45 dBA and a 10 dBA reduction from external to internal noise levels for openable windows.

Exceedances of the Noise Management Level at Our Lady of Lourdes Church are predicted when the Road Widening works are in proximity to the church.

7.4 Construction Site Compounds

The M2 Upgrade Project would require several temporary Site Compounds to be constructed along the length of the route. These compounds, which are located within the existing RTA Lease Boundary, would be used for a variety of purposes including laydown areas, stockpiling, stores, team offices, car parking, etc.

The location of each the Site Compounds is illustrated on aerial photographs in **Part C – The Proposal, Section 7 - Project Description** of the main EA. A discussion of the main Site Compound activities which are considered to be potentially noise generating is provided below.

Stockpiling, Stores, Laydown areas, etc

The majority of the Site Compounds would be used for the stockpiling and storing of materials and equipment. Noise from these activities would be expected to be generated by the movement of materials and equipment around the site.

Equipment Mobilisation

Most of the Site Compounds would also be used at times to store and mobilise items of construction plant prior to moving out onto the M2 carriageway.

Bridge Construction Compounds

A number of the Site Compounds are situated in close proximity to bridges which are required to be modified as part of the M2 Upgrade Project. In these compounds, equipment and plant related to the construction of the bridgeworks would be stored and mobilised, and concrete trucks, concrete pumps, cranes, and piling rigs would be made use of, as necessary.

The assessment of construction works associated with bridgeworks has previously been performed within **Section 7.2** of this report.

Major Compounds (TIDC Compound)

The TIDC Compound, which is likely to be used as the Main Site Compound, is located within a commercial area. Residential receivers are however situated to the south of the site, across Epping Road, at a distance of around 170 m. It is noted that the TIDC Compound has previously been used as one of the main site compounds during the construction of the Epping to Chatswood Rail Line.

The location of the various compounds, together with their size, intended use and points of access, are presented in **Table 20**.

It is noted that the majority of the smaller Site Compounds are intended to be made use of during the daytime periods, with the Major Compounds being used 24 hours a day. There may however be a requirement for some of the smaller Site Compounds to occasionally support some activities undertaken during the evening and night-time periods.

Table 20 Construction Site Compound Details

Compound	Location	Approx. Size (m^2)	Proposed Use	Proposed Access	Average Daily Traffic Movements[1]	
					Light	Heavy
Windsor Road (24 hour)	Windsor Road, North of M2	5,800	Bridge construction Team office Laydown Area	Torrs Street, onto Windsor Road	85	40
Darling Mills Creek	East of existing Windsor Road ramps	4,000	Bridge Construction Welfare Laydown Area	Windsor Road ramps	38	24
Barclay Road (Not in constant use)	Between Barclay Road, Perry Street & M2	6,600	Stockpile Rehandling Area Bridge Crew	Perry Street	26	24
Devlins Creek (Not in constant use)	Under bridge	16,000	Bridge Construction Welfare Laydown Area	Allerton Road (Bridge Construction Traffic Only)	36	24
Barombah Road	West of Beecroft Road	3,500	Stockpile Rehandling Area	Barombah Road	38	24
Beecroft Road (24 hour)	Old Bus Ramp, adjacent to Derby Street	1,460	Bridge Construction Welfare Laydown Area	Beecroft Road and W/B off ramp	38	24
Sutherland Road (Tunnelling – 24 hour)	North of M2, adjacent to Sutherland Road	3,800	Tunnel Construction Welfare Laydown Area	E/B, through existing Noise Wall and Sutherland Road	46	24
Somerset Road – Terrys Creek	Small strip at end of Somerset Street	2,850	Bridge Construction Welfare Laydown Area	Crimea Road	26	24
Terrys Creek	Long strip adjacent to W/B access at Crimea	20,500	Bridge Construction Welfare Laydown Area	Crimea Road (Bridge Construction Traffic Only)	36	24
Vimiera Road (Not in constant use)	South of M2, at end of Vimiera Road	8,200	Stockpile Rehandling Laydown Area	W/B, with suitable ramps (Light vehicle off Vimiera Road)	60	36
Busaco Road	Corner of Busaco/ Talavera Road	1,300	Bridge Works	Corner of Busaco and Talavera Road	38	24
Toll Plaza (24 Hour)	East of E/B Toll Plaza	2,200	Stockpile Rehandling Laydown Area	Toll Plaza Exit onto E/B	38	24
Christie Road (24 hour)	Western corner of Christie Road and Talavera Road	7,000	Bridgeworks	Talavera Road	46	24
Macquarie Park (24 hour)	North of M2	49,800	Stockpile Rehandling Laydown Area Subcontractor yards	E/B carriageway	124	64
TIDC Compound (24 hour)	South of M2, immediately off Delhi Road W/B On-ramp	35,000	Main Office, Welfare, Canteen, Laboratory, Traffic Management, Stores, Main Car Park	Delhi Road, W/B on-Ramp and Wicks Road feeding onto Epping Road	800	184
North Ryde Station	Behind North Ryde Station	11,500	Car Park	Delhi Road	580	52

Note 1: Average vehicle movements relate to round trips (ie one movement relates to a particular vehicle arriving at and departing from a particular Site Compound).

7.4.1 Construction Compounds - Noise Impact Assessment

The assessment of the potential noise impacts from the M2 Upgrade Project Site Compounds is presented below.

Smaller Site Compounds - Daytime

The proposed locations of the Site Compounds are all immediately adjacent to the M2 Motorway, and as such, are already subject to reasonably high levels of ambient (road traffic) noise.

Reference to the unattended noise logging data detailed in **Section 6.2** concludes that the following typical ambient RBL noise levels were measured during the daytime period at monitoring locations in close proximity to the M2 carriageway:

- Daytime Period (RBL): 50 dBA – 55 dBA

These RBL levels have been used to set the sensitive receiver Noise Management Levels for the daytime operations of the smaller Site Compounds.

The following table details the assessment of the potential noise impacts from the anticipated activities at the various smaller Site Compounds.

The predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at any one time within a particular compound and their precise location relative to the receiver of interest. A receiver will therefore experience a range of values, representing the variation in construction noise depending upon the location of the particular activity and the likelihood of the equipment of interest operating simultaneously.

It is noted that the following predictions are representative of typical Site Compound works, at a variety of offset distances, and that for extended periods of time, noise levels would potentially be lower than the calculated levels.

In each construction scenario, all of the equipment belonging to a particular activity is assumed to be operating concurrently for the full 15 minute period.

Table 21 Construction Compounds - Noise Impact Assessment (Daytime)

Site Compound Activity	Indicative Equipment	Daytime NML (dBA) (RBL +10 dBA)	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]		
			5 – 10 m	10 – 20 m	20 – 50 m
Stockpile, Laydown Area, Stores, etc	Pickup Truck Bobcat Hand Held Tool	60 – 65	83 - 77	77 - 71	71 - 63
Equipment Mobilisation	Front End Loader Crane Concrete Truck		91 - 85	85 - 79	79 - 71

Note 1: The range of noise levels represents items of plant working at different distances

Smaller Site Compounds – Night-time

A number of the smaller Site Compounds are proposed to be made use of on a 24 hour basis. These include the Windsor Road, Beecroft Road Old Bus Ramp, Beecroft Road, Christie Road and Macquarie Park compounds.

These compounds are required to be operational 24 hours per day as they would be used to support the previously outlined construction activities that need to occur outside of standard construction hours. This is to ensure the safety of road users and construction personnel, and to minimise any potential traffic implications.

Although these compounds are intended to be used during the more sensitive night-time periods, it is however noted that during these periods no major noise intensive activities would be likely to be carried out on a regular basis.

The night-time uses would typically be related to:

- Traffic management launch areas
- Storage and laydown areas
- Welfare and supervision area

Reference to the unattended noise logging data detailed in **Section 6.2** concludes that the following typical ambient RBL noise levels were measured during the night-time period at monitoring locations in close proximity to the M2 carriageway:

- Night-time Period (RBL): 39 dBA – 44 dBA

These RBL levels have been used to set the sensitive receiver Noise Management Levels for the night-time operations of the smaller Site Compounds.

The following table details the assessment of the potential noise impacts from the anticipated activities at the various smaller Site Compounds.

Table 22 Construction Compounds - Noise Impact Assessment (Night-time)

Site Compound Activity	Indicative Equipment	Night-time NML (dBA) (RBL +5 dBA)	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]		
			5 – 10 m	10 – 20 m	20 – 50 m
Stockpile, Laydown Area, Stores, etc	Pickup Truck Bobcat	44 – 49	83 - 77	77 - 71	71 - 63

Note 1: The range of noise levels represents items of plant working at different distances

The Macquarie Park and Christie Road compounds are noted as being situated at sufficiently large distances from any surrounding sensitive receivers so as to ensure that noise impacts at these locations are not likely.

TIDC Compound

The TIDC Compound is likely to be used as the Main Site Compound for the M2 Upgrade Project. As it would support all construction activities, including those that would need to be undertaken during evening and night-time periods due to safety risks and potential traffic implications, it is proposed to be used on a 24 hour basis. The following table presents the potential noise impacts at the nearest residential receivers.

It is noted that although all of the TIDC compound would be used by the M2 Upgrade Project, it is however proposed to only use the northern portion of the site for noise generating activities. This area is outlined in red in **Figure 9**.

Figure 9 Location of TIDC Compound

The majority of the sensitive receivers on Epping Road are shielded from the TIDC Site by large existing commercial buildings. A small number of receivers do however have a line of sight to the proposed TIDC Site. These receivers are situated to the south of the site, across Epping Road, at a distance of around 170 m.

The ambient noise data measured at 21 Epping Road, North Ryde, has been used to establish the various Noise Management Levels in **Table 23**.

Table 23 TIDC Construction Compound - Noise Impact Assessment

Site Compound Activity	Equipment	NML (dBA) (day/eve/night)	Predicted LAeq(15minute) Noise Level[1]
Stockpile, Laydown Area, Stores, etc	Pickup Truck Bobcat Hand Held Tool	64/57/46	52
Equipment Mobilisation	Front End Loader Crane Concrete Truck		60

Note 1: Noise levels are predicted at the nearest sensitive receivers situated at a distance of 170 m from the southern extent of the noise generating activities

Based on the above assessment of the TIDC Compound, it is recommended that all site sheds associated with this compound be located along the southern boundary site to provide additional noise attenuation to the receivers on Epping Road, and that all noise intensive activities be completed towards the northern end of the site.

Noise Mitigation

Exceedances of the Noise Management Levels are predicted where sensitive receivers are situated in proximity to the Site Compounds. As such, it will be necessary to provide some form of noise mitigation to minimise the impact of noise generated by the compounds.

As there are negligible existing barriers between the Site Compounds and the sensitive receivers, it is likely that some form of noise barrier would be required to be erected (through dedicated and/or temporary noise walls, temporary hoardings, etc) in locations where sensitive receivers are situated in close proximity to the proposed construction compounds.

Correctly designed and constructed barriers (of solid construction using appropriate materials) would be expected to result in the following reductions in noise levels:

- Minor Barriers (hoarding of indicative height of 3 m - 4 m): 5 dBA to 10 dBA reduction
- Major Barriers (hoarding of indicative height of 6 m – 8 m): 10 dBA to 15 dBA reduction

7.4.2 Construction Traffic Impacts

It is intended that the TIDC Compound will have a large staff/visitor car parking area, with another large Workforce Parking Area located in the North Ryde Station Compound.

The majority of the car parking facilities are provided at the Main Compound so as to minimise light vehicle parking in other compound areas along the Project Area. Light Vehicle Works buses (15 – 20 seaters) would then be used to ferry the workforce from the Main Compound areas to the various work sites.

The EPA (now part of DECCW) published the "*Environmental Criteria for Road Traffic Noise*" (ECRTN) which is appropriate for assessing road traffic noise. The criteria for arterial, collector and local roads are set out in **Table 24**.

Table 24 DECCW Road Traffic Noise Criteria

Development	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Land use development with potential to create additional traffic on existing freeways / arterials	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
Land use development with potential to create additional traffic on collector roads	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA
Land use development with potential to create additional traffic on local roads	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA

Where existing L_{Aeq} noise levels already exceed the above targets, the objective is then to limit any increase in noise level which may result from construction traffic movements. As changes in noise levels of around 2 dBA are not noticeable, mitigation measures are not required to be implemented where the increase in overall traffic noise is below this level.

However, when the contribution of construction traffic related noise increases the existing noise level by more than 2 dBA, feasible and reasonable noise mitigation measures are required to be applied to limit potential impacts to the general acoustic amenity of the area.

The majority of Site Compounds are proposed to be accessed from the M2 carriageway, and as such, the impact of light and heavy vehicle movements associated with these sites would be negligible over the existing ambient noise climate.

Where possible, construction traffic will utilise major roads, including the M2, Epping Road, Lane Cove Road, however to access some of the Site Compounds, it is likely that construction vehicles will, at times, need to travel short distances on local roads.

Local Roads - Light Vehicles

The potential noise impact of construction related light vehicle movements on local roads at the smaller Site Compound is considered to be negligible when considering the relatively small number of daily movements to these compounds. It is likely that the noise from these vehicles will be perceived as part of the general road traffic.

The Main Compound (TIDC Compound) which has large car parking facilities would be accessed from Lane Cove Road and Epping Road. As both of these road are major arterial routes, which are already subject to high daily volumes of traffic, the additional construction traffic that the M2 Upgrade Project would create is not expected to create any additional noise impacts.

Local Roads - Heavy Vehicles

Heavy vehicle movements on collector and arterial roads are likely to be perceived as part of the general road traffic, however once they move onto the local roads immediately adjacent to the Site Compounds, the community is likely to associate these heavy vehicle movements with the M2 Upgrade Project construction works.

The Site Compounds which require heavy vehicle access via local roads are detailed in **Table 25**, together with the expected number of hourly movements.

For the smaller Site Compounds it is anticipated that during the worst-case hour, four heavy vehicle movements would occur during the daytime in busy periods, with lower numbers during quieter periods. No night-time movements to these sites are expected along local roads.

For the TIDC Compound, the expected daytime and night-time worst-case hourly heavy vehicle movements are detailed in **Table 25**.

Table 25 Construction Traffic Impacts on Local Roads – Heavy Vehicles

Construction Compound	Accessed From	Expected Maximum Hourly Heavy Vehicle Movements	
		Daytime	Night-time
Windsor Road	Torrs Road, off Windsor Road	4	-
Devlins Creek	Allerton Road	4	-
Terrys Creek	Crimea Road	4	-
Culloden Road	Talavera Road/Culloden Road	4	-
TIDC	Wicks Road (onto Epping Road)	18	4

It is noted that the heavy vehicle movements associated with the TIDC Compound would be accessed from local roads with no residential receivers, and as such, there are anticipated to be no adverse impacts from heavy vehicles travelling to this Site Compound.

A summary of the predicted noise contribution of heavy vehicle movements to the Smaller Site Compounds, at various offset distances, is presented in **Table 26**. Only daytime values are presented in the table as night-time heavy vehicle movements are not anticipated at the Smaller Worksites.

Table 26 Predicted Off Site Heavy Vehicle Noise – Small Worksites

Distance	$L_{Aeq(1hour)}$ Sound Pressure Level (dBA)	
	Criteria (Daytime) [1]	Predicted (Daytime) [2]
10 m	55	55
20 m	55	53
30 m	55	51
40 m	55	49
50 m	55	48

Note 1 ECRTN local road criteria as shown in **Table 24**.

Note 2 Four trucks per hour are assumed for the daytime scenario, with no night-time movements anticipated.

The following mitigation measures are recommended in order to minimise the impact of exceedances of the criteria at residential receiver locations:

- All trucks to have mufflers and any other noise control equipment in good working order.
- Truck drivers are to avoid heavy acceleration and braking as far as is practicable.
- Truck drivers are to avoid compression braking as far as is practicable.
- Speed is to be minimised as far as is practicable.
- Truck movements are to be restricted to the daytime period to the furthest extent possible.

Noise from idling trucks near construction sites can also impact on amenity in some instances. For this reason, it is recommended that any queuing of trucks awaiting entry to the site outside normal construction hours should be restricted to locations away from residences and that if trucks are required to queue in such locations during construction hours, engines should be shut down.

The finalised construction traffic arrangements will be reviewed during the detailed design phase of the project.

7.4.3 Site Compounds - Noise Mitigation

The key control strategies involved for mitigating noise from the Site Compounds would include:

- Noise walls (enclosures) surrounding any continuously operating plant (ie generators)
- Truck management (eg limiting of "queuing" adjacent to residential areas)
- Temporary noise barriers (through temporary noise walls, hoardings, etc) wherever feasible to protect residents adjacent to the relevant sites, especially surrounding maintenance work areas.

Additional construction compound site hoardings and noise barriers (eg provided by site buildings) wherever feasible and practical could provide further shielding and reduce noise at the nearest relevant receivers.

Close liaison with the local community and a proactive information protocol (ie information on the duration and likely intensity of upcoming works) would play an important part of the management of noise emissions at these locations.

Assessment of the noise impacts from Site Compounds would be performed in more detail during the detailed design phase, when the specifics of each site would be known. Specific noise management strategies for each compound would also be developed at that time.

7.5 Construction Vibration

The major potential sources of construction vibration related to the M2 Upgrade Project include the use of excavators, rockbreakers and vibratory rollers.

Bulldozers/Excavators

Typical ground vibration levels from bulldozers range from 1 mm/s to 2 mm/s at a distance of approximately 5 m. At distances greater than 20 m, vibration levels are usually below 0.2 mm/s.

Hydraulic Rockbreakers

Table 27 sets out the typical ground vibration levels at various distances from a large rockbreaker operating in hard sandstone.

Table 27 Typical Rockbreaker Vibration Levels (mm/s) versus Distance

Operation	Vibration Level (mm/s) at Given Distance					
	5 m	10 m	20 m	30 m	40 m	50 m
Heavy Rockhammering	5	1.5	0.50	0.20	0.15	0.10

Use of light rock hammers is therefore recommended during construction near the closest buildings on the project, some of which may be in the order of 5 m from the works. At these residences, there may be occasions when vibration is perceptible during rock breaking immediately adjacent to the residences.

Vibratory Rollers

Levels of ground vibration caused by vibratory rollers can be up to 1.5 mm/s at 25 m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground structure.

Based on recommendations used by the NSW Roads and Traffic Authority, **Table 28** sets out safe working distances for the use of vibratory rollers adjacent to buildings.

Table 28 Safe Working Distances for Vibratory Rollers [1]

Roller Class	Weight Range	Centrifugal Force Range	Distance from Building	
			A	B
I - Very Light	Less than 1.25 tonnes	10 - 20 kN	3 m	No effect
II - Light	1 to 2 tonnes	20 - 50 kN	5 m	No effect
III - Medium	2 to 4 tonnes	50 - 100 kN	6 m	12 m
IV - Medium Heavy	4 to 6 tonnes	100 - 200 kN	12 m	24 m
V - Heavy	7 to 11 tonnes	200 - 300 kN	25 m	50 m
V- Very Heavy	12 tonnes and over	Over 300 kN	25 m	50 m

A Values suggested to prevent damage to buildings.
B Values suggested to minimise strongly adverse comment from residents.

Note: Source of data: ARRB Special Report No.11, *"Ground Vibrations: Damaging Effects to Buildings"*.

To minimise the vibration impact during use of the vibratory roller, **Table 28** recommends the use of a roller class “II Light” when operating as close as 5 m from the closest buildings on the project.

Expected Vibration Impacts

In general, vibration produced by earthworks and road forming operations is expected to lie below structural damage criteria. Where vibration-intensive operations are being conducted in close proximity to the buildings nearest to the roadworks (eg construction of the Windsor Road Ramps), judicious selection of plant and equipment will be necessary as outlined above.

Given the distances of the nearest residences to the proposed construction works, a review of the construction plan would be required to confirm whether pre-construction building condition surveys would be required.

Vibration may be perceptible for relatively short periods of time when construction activities are immediately adjacent to specific dwellings.

It is recommended that the construction methodology, plant and equipment, management of vibration impacts and community consultation protocol be reviewed prior to commencing construction. This should be addressed as part of the Construction Noise and Vibration Management Plan for the project.

7.6 Windsor Road Access Ramps and Intersection Re-Alignment

As has been previously detailed in **Section 7.2**, the potential impacts from the construction of the proposed Windsor Road Access Ramps are likely to be significant. This is especially apparent for the eastbound off-access ramp, where the existing properties are situated as close as approximately 5 m from the proposed construction works.

Similar impacts would also exist during the construction of the westbound on-access ramp, however the sensitive receivers on this side of the carriageway are noted as being situated further away from the construction works at a distance of around 15 m to 20 m away.

The potential impacts at both locations are likely to be most apparent when heavy plant, such as excavators and vibratory rollers, are situated in close proximity to the affected receivers. It is noted that there would also be the requirement to remove the existing noise walls (which are currently located at the edge of the outer carriageway) to allow the proposed ramps to be constructed.

It is however also noted that the proposed access ramps would be generally built up at this location and that widening of the road will typically not require cutting into virgin ground. As such, the use of rocksaws/rockbreakers at this location, which typically make a significant contribution to overall noise levels, will therefore be very minimal.

As part of the Windsor Road upgrade works, it is also proposed to widen the northbound side of Windsor Road from Woodlands Street up to the new on-access ramp to the M2. This will provide a more efficient flow of traffic at the intersection when the new access-ramps are built. The construction works associated with this phase of the project would be as close as approximately 5 m to 10 m from the nearest sensitive receivers on Windsor Road and as such, the impacts from the operation of heavy plant would be expected to potentially be significant at times.

Is it noteworthy that the majority of the noise intensive activities construction works associated with the upgrade of Windsor Road are proposed to be undertaken during the less sensitive daytime period, except for where a specific requirement for out of hours works exists.

7.7 Norfolk Tunnel Widening

As part of the M2 Upgrade Project three 3.5 m wide running lanes and a 2.5 m wide breakdown lane are proposed in each direction in the Norfolk Tunnel. This will require the removal of sandstone bedrock to widen the existing eastbound and westbound tunnel tubes together with modifications to the eastern and western tunnel portals. Other related works include the installation of rock bolts.

These works are expected to generate potentially significant noise and vibration which may affect nearby properties.

7.7.1 Sensitive Receivers

A number of residential properties are situated in close proximity to the Norfolk Tunnel. The location of the nearest receivers is illustrated in **Figure 10**.

Figure 10 Norfolk Tunnel

Image courtesy of Google Earth

It is noted that a number of newly built properties are now situated near the eastern portal of the tunnel, highlighted in red in **Figure 10**.

Reference to the above figure concludes that the properties which are in the vicinity of either tunnel portals are likely to be potentially affected by airborne noise from the construction works associated with the widening of the Norfolk Tunnel and tunnel portals.

Properties which are situated above the tunnel may also be potentially affected by ground-borne noise from the construction works.

The potentially affected properties are listed in **Table 29**.

Table 29 Properties Potentially Affected by Norfolk Tunnel Construction Works

Eastern End of Tunnel	Western End of Tunnel
2 Gillard Way, North Epping	59 Norfolk Road, North Epping
4 Gillard Way, North Epping	61 Norfolk Road, North Epping
6 Gillard Way, North Epping	27 Somerset Street, North Epping
8 Gillard Way, North Epping	29 Somerset Street, North Epping
10 Gillard Way, North Epping	31 Somerset Street, North Epping
12 Gillard Way, North Epping	1 Callistemon Close, North Epping
14 Gillard Way, North Epping	3 Callistemon Close, North Epping
16 Gillard Way, North Epping	3A Callistemon Close, North Epping
2 Sunden Way, North Epping	
3 Sunden Way, North Epping	
4 Sunden Way, North Epping	
5 Sunden Way, North Epping	
6 Sunden Way, North Epping	
7 Sunden Way, North Epping	
8 Sunden Way, North Epping	
9 Sunden Way, North Epping	
10 Sunden Way, North Epping	
11 Sunden Way, North Epping	
12 Sunden Way, North Epping	
13 Sunden Way, North Epping	

The effects of both airborne and ground-borne noise are discussed in more detail in the following sections.

7.7.2 Widening Methodology

The construction activities associated with the widening of the Norfolk Tunnel and supporting works, including haulage of spoil to disposal, are proposed to occur continuously (24 hours a day, six days a week) over certain periods.

Full possession of the tunnel tubes would be required to facilitate preliminary works associated with the tunnel widening. Services relocations, rock bolt installation to support the additional tunnel span and the construction of a proposed barrier to isolate the work areas from the trafficable portions of the M2 Motorway could not be completed with live traffic operating within the same tunnel tube without significant safety risks to road users and construction personnel.

Similarly, the contra-flow traffic arrangements required to maintain traffic flow in both directions along the motorway during a full tunnel tube possession could only occur safely during times of low traffic volumes. As such, full possession of a tunnel tube could only occur in the evening and night-time periods generally between 8.00 pm and 5.00 am when traffic volumes are low.

A key challenge associated with the proposed tunnel widening is maintaining the structural integrity of the tunnel. Excavation works within the Norfolk Tunnel are proposed on a 24 hours a day, six days a week basis for approximately four to six months in each tunnel tube.

For safety reasons during tunnelling operations it is necessary to stabilise the newly cut surface as soon as possible to maintain ground stability. Stabilisation is achieved through the installation of rock bolts, shotcrete and other devices.

A continuous tunnelling process (24 hours a day, six days a week) would reduce the duration between excavation and stabilisation and ensure tunnel integrity. This is required to enable the works within the tunnel to be completed within the proposed two year construction period and to minimise safety risks to motorists and the construction workforce.

The proposed methodology of the widening works is detailed in **Table 30**.

Table 30 Tunnel Widening Works

Stage	Works	Period	Duration	Proposed Mitigation
0 Early Works	Surveys, installation of Traffic Management, adjustment of portal transition areas (using excavator with hammer).	Night-time	4 Months	Limited potential for mitigation of works at portals.
1 Eastbound Tube	Service relocation, installation of new service trench and barrier (using excavator with hammer) within tunnel and at each portal. Installing rockbolts in tunnel.	Night-time	2.5 Months	Acoustic curtain at each end of tunnel, limited potential for mitigation of works at portals.
2 Eastbound Tube	Completion of service relocations and installation within tunnel and at each portal.	Night-time	1 Month	Acoustic curtain at each end of tunnel.
	Widening the existing rock batters at portals (using line drilling, excavators with hammers).	Daytime	1 Month	Limited potential for mitigation of works at portals.
3 Westbound Tube	Service relocation, installation of new service trench and barrier (using excavator with hammer) within tunnel and at each portal, installing rockbolts in tunnel.	Night-time	2.5 Months	Acoustic curtain at each end of tunnel, limited potential for mitigation of works at portals.
4 Westbound Tube	Completion of service relocations and installation within tunnel and at each portal, erection of separation barrier and Acoustic sheds in tunnel.	Night-time	1 Month	Acoustic curtain at each end of tunnel.
	Widening the existing rock batters at portals (using line drilling, excavators with hammers).	Daytime	1 Month	Limited potential for mitigation of works at portals.
5 Westbound Tube	Actual widening of the tunnel using S300 roadheader, rock drill and shotcrete rigs. Spoil removed by tipper truck.	24 hours, 6 days a week.	4.5 Months	Acoustic shed/curtain at each end of tunnel.
6 Westbound Tube	Removal of separation barrier and acoustic sheds. Installation of new drainage, barriers, wall lining, and profiling of new carriageway.	Night-time	1 Month	Acoustic curtain at each end of tunnel.
7 Eastbound Tube	Erection of separation barrier in tunnel and acoustic sheds at each portal.	Night-time	1 Month	Limited potential for mitigation of works at portals.
8 Eastbound and Westbound Tubes	Eastbound - Actual widening of the tunnel using S300 roadheader, rock drill and shotcrete rigs. Spoil removed by tipper truck.	24 hours, 6 days a week.	4.5 Months	Acoustic shed/curtain at each end of tunnel.
	Westbound - Completion of services and instrumentation and commissioning. Forming of new concrete portal.	Night-time		Limited potential for mitigation of works at portals.
9 Eastbound Tube	Removal of separation barrier and acoustic sheds. Installation of new drainage, barriers, wall lining, and profiling of new carriageway. Completion of services and instrumentation and commissioning. Forming of new concrete portal.	Night-time	2.5 Month	Acoustic curtain at each end of tunnel, limited potential for mitigation of works at portals.

7.7.3 Airborne Noise

Airborne noise will potentially affect receivers that are situated in proximity to the Norfolk Tunnel portals.

The potential noise impacts from the widening works which will be performed entirely within the tunnel will be mitigated with the use of acoustic sheds during the excavation of the tunnel, together with an acoustic curtain at either end of tunnel at other times.

The acoustic shed will only be in place for the excavation phase of the widening. All other night-time works within the tunnels will have a noise curtain in place at the portal entrances.

It is also noted that some works will be undertaken immediately outside of the portals at night-time (such as deluge diversion and cable pit works). Noise mitigation measures for these activities are limited.

For the early widening works (ie adjustment to the portal transition areas and breaking out of existing concrete barriers) there would also be limited mitigation measures, as the options for physical noise attenuation devices and procedural management measures (such as scheduling of activities) would either not be effective or are not feasible.

An assessment of the potential impacts from widening of the Norfolk Tunnel has been completed, and is detailed in **Table 31**. Noise levels have been predicted at the nearest affected sensitive receivers to both tunnel portals.

The Noise Management Levels are based on the unattended noise logging data measured at 56 Somerset Street, Epping. It is noted that the receivers which overlook the Norfolk Tunnel portals would be subject to higher ambient noise environment than was measured at this location, and would subsequently have higher Noise Management Levels. The assessment is therefore considered to represent a worst-case situation.

Noise levels have been predicted for the three scenarios, these being:

- Early widening construction works outside the portals – no mitigation
- Widening construction works at the tunnel portals – mitigation from acoustic shed only
- Widening construction works within the tunnels – mitigation from acoustic shed and curtain

Table 31 Norfolk Tunnel – Potential Noise impacts

Activity	Equipment	Proposed Mitigation	Predicted Noise Level $L_{Aeq(15min)}$ (dBA)[1]	Noise Goals (dBA)	
				Time Period Noise Management Level (Day/Eve/Night)	Sleep Disturbance $L_{A1(60sec)}$
A – Outside Portal Works	Excavator with hammer, rock drill	n/a	62	59/49.5/37.5	47.5
B – Widening Works at Tunnel Portal	Roadheader, rock drill, shotcrete rig	Acoustic Shed only	51		
C – Widening Works Entirely Within Tunnel	Roadheader, rock drill, shotcrete rig	Acoustic Shed and Acoustic Curtain	39		

Note 1: The predicted noise levels include a -5 dBA correction for the effect of the existing noise walls.

It is noted that the above noise levels have been predicted at the nearest potentially affected receivers to the construction works, and therefore represent the worst-case levels. Properties which are situated further away would be subject to lower levels of noise as a result of the increased separation distance.

The above assessment indicates that significant exceedances of the Evening and Night-time Noise Management Levels are predicted for the construction works which are required outside of the tunnel portals. It is not possible to apply any noise mitigation measures to these activities, although other impact minimisation strategies would be considered prior to commencement of these works.

Exceedances are also predicted when the widening works are at the tunnel portals, when the acoustic shed has been constructed but the acoustic curtain has not.

Grid Noise Map Predictions

As significant exceedances of the Noise Management Levels are likely to be apparent during some of the construction works associated with the Norfolk Tunnel, there is potential to restrict the activities to the following periods to ensure the impacts from the works are minimised:

- Activity A – Outside Portal Works: Daytime only
- Activity B – Widening Works at Tunnel Portal: Daytime and Evening only
- Activity C – Widening Works Entirely Within Tunnel: No restrictions.

To illustrate the potential exceedances with relation to the above activities, the following grid noise maps have been generated. All three maps, calculated at 1.5 m above the local ground level, indicate where potential exceedances of the appropriate Noise Management Levels (coloured in red) may occur for that phase of works.

Figure 11 Activity A – Outside Westbound Portal (Daytime 59 dBA NML) – No Mitigation

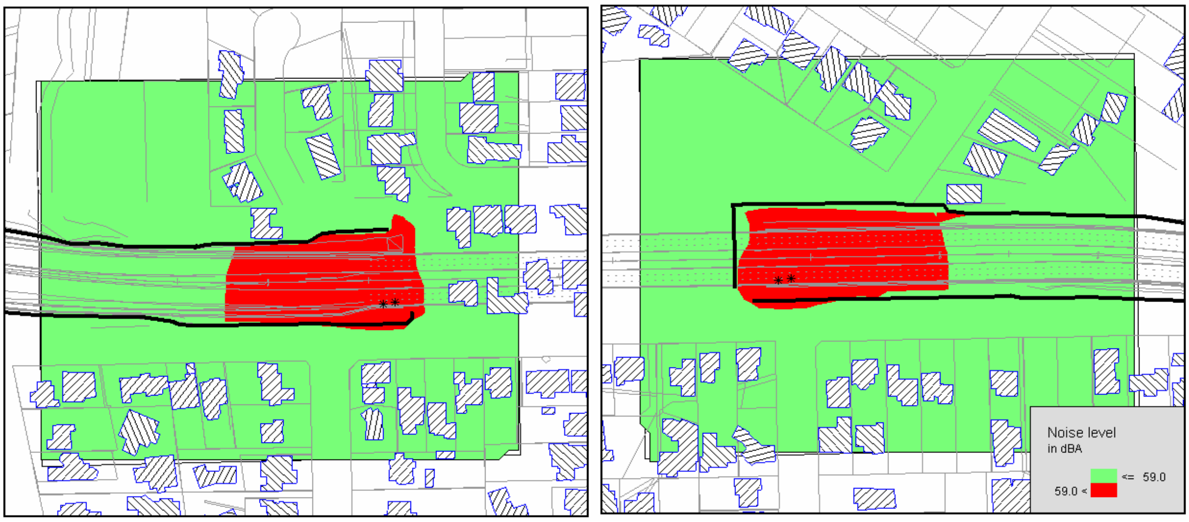


Figure 12 Activity B – Widening Westbound Portals – Shed Only (Evening 49.5 dBA NML)

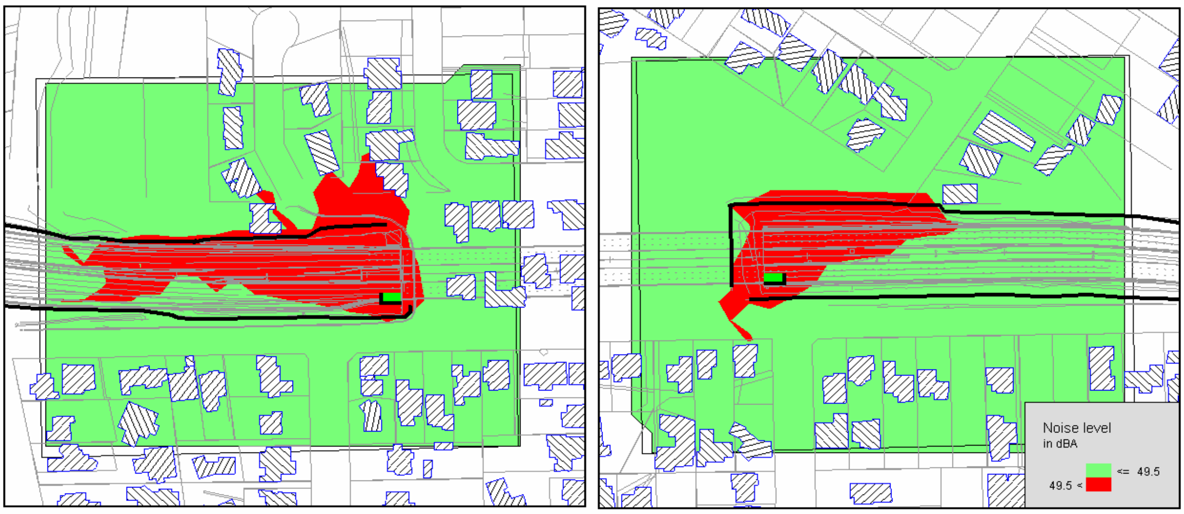
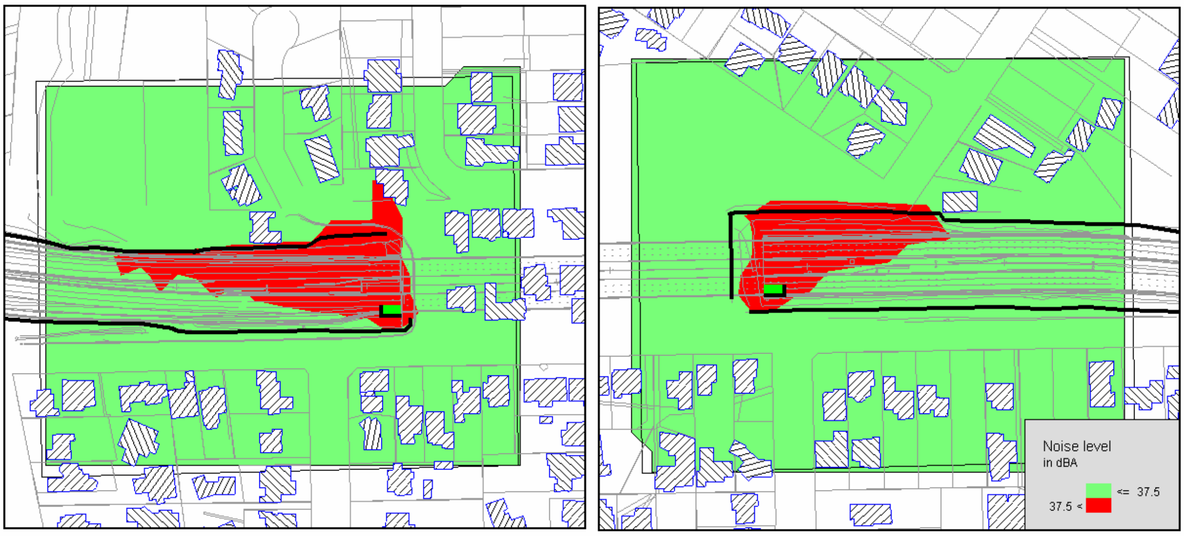


Figure 13 Activity C – Widening within Westbound Tunnel (Night-time 37.5 dBA NML) – Shed and Curtain in Place



Noise Mitigation

As discussed above, noise mitigation is proposed to be provided by the construction of a purpose built acoustic shed and an acoustic curtain at either end of the tunnel being widened. Both of these items are proposed to be constructed from 25 mm thick timber.

To ensure the noise attenuation of the acoustic shed and curtain is maximised it is vital that they are constructed and appropriately sealed, with air gaps being minimised. As doors would be required in both structures to allow access, it is also important that these form a good seal with the rest of the facade. Suitable operational procedures would also be required to be implemented to minimise the duration that the doors are required to be open, or manage the timing of when the doors are opened when tunnel excavation is in progress.

As a result of the potential exceedances it will also be vital that the local community is kept well informed of the constructions works. Where the higher exceedances are apparent, suitable consultations should take place with the affected land owners to determine the appropriate feasible and reasonable management strategies, together with monitoring to confirm the predicted levels.

7.7.4 Ground-borne Noise - Roadheaders

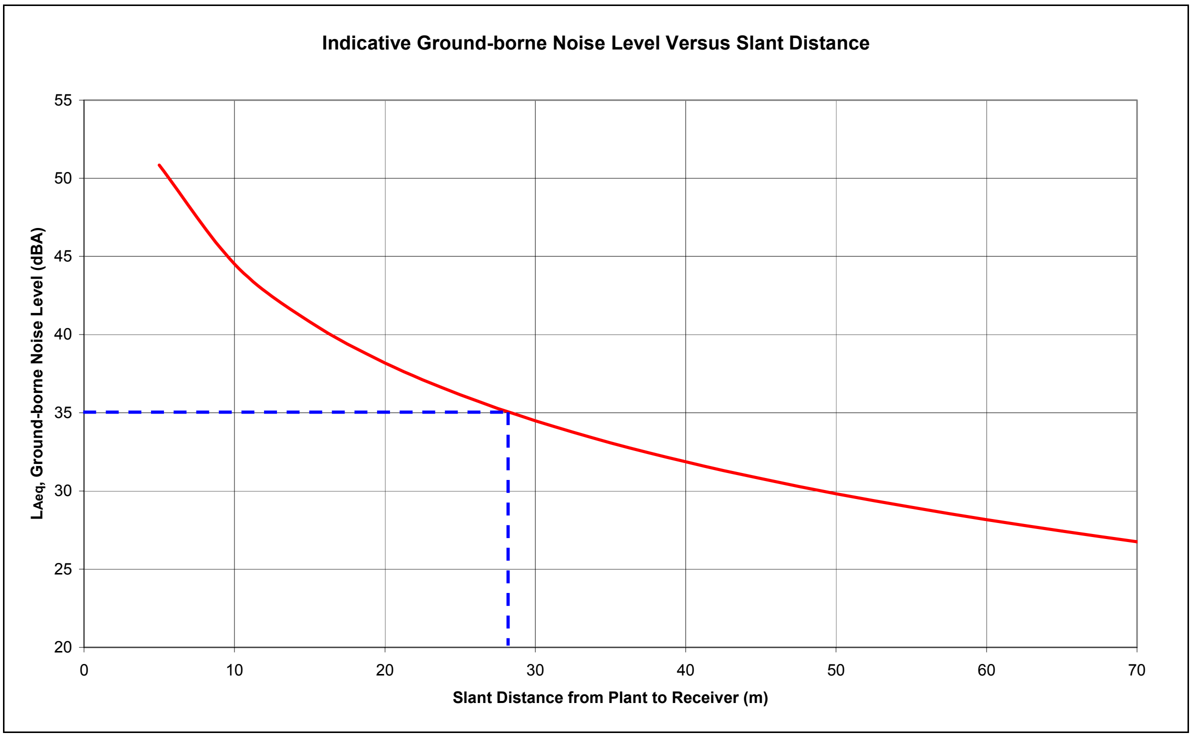
Ground-borne noise in buildings is caused by the transmission of ground-borne vibration rather than the direct transmission of noise through air. Vibration may be generated by construction equipment and can be transmitted through the ground into the adjacent building structures. After entering a building, this vibration may cause the walls and floors to faintly vibrate and hence to radiate noise. This type of ground-borne vibration and noise can occur due to the excavation of rock using roadheaders.

Attenuation with distance occurs due to the geometric spreading of the wave front and due to other losses within the ground material known as “damping”. In addition, losses occur with the transfer of vibration from floor-to-floor within buildings (typically 2 dBA per floor).

Reference to **Figure 10** shows that the impacts from ground-borne noise would be expected to be greatest when the roadheader is working at either end of the tunnel. The residential properties in these locations (ie directly above) would be situated approximately 15 m to 20 m above the works.

Figure 14 presents indicative ground-borne noise levels for roadheaders. As the figure demonstrates, ground-borne noise levels reduce as the distance between plant and the receivers increase.

Figure 14 Indicative Ground-borne Noise Levels from Roadheaders (Sydney Measured)



Reference: Tunnelling Noise and Vibration Management - Australian Acoustical Society, Technical Meeting, Dec 2003

The ground-borne noise impacts would be greatest when the roadheader is situated immediately below the property in question. As the roadheader moves along the tunnel, the impact from ground-borne noise would reduce. It is anticipated that the roadheader would be underneath a particular receiver location for around 10 to 12 days.

Reference to **Figure 14** concludes that at the nearest affected receivers, with a slant distance of around 15 m, the $L_{Aeq(15minute)}$ 35 dBA night-time noise goal would potentially be exceeded by around 5 dBA.

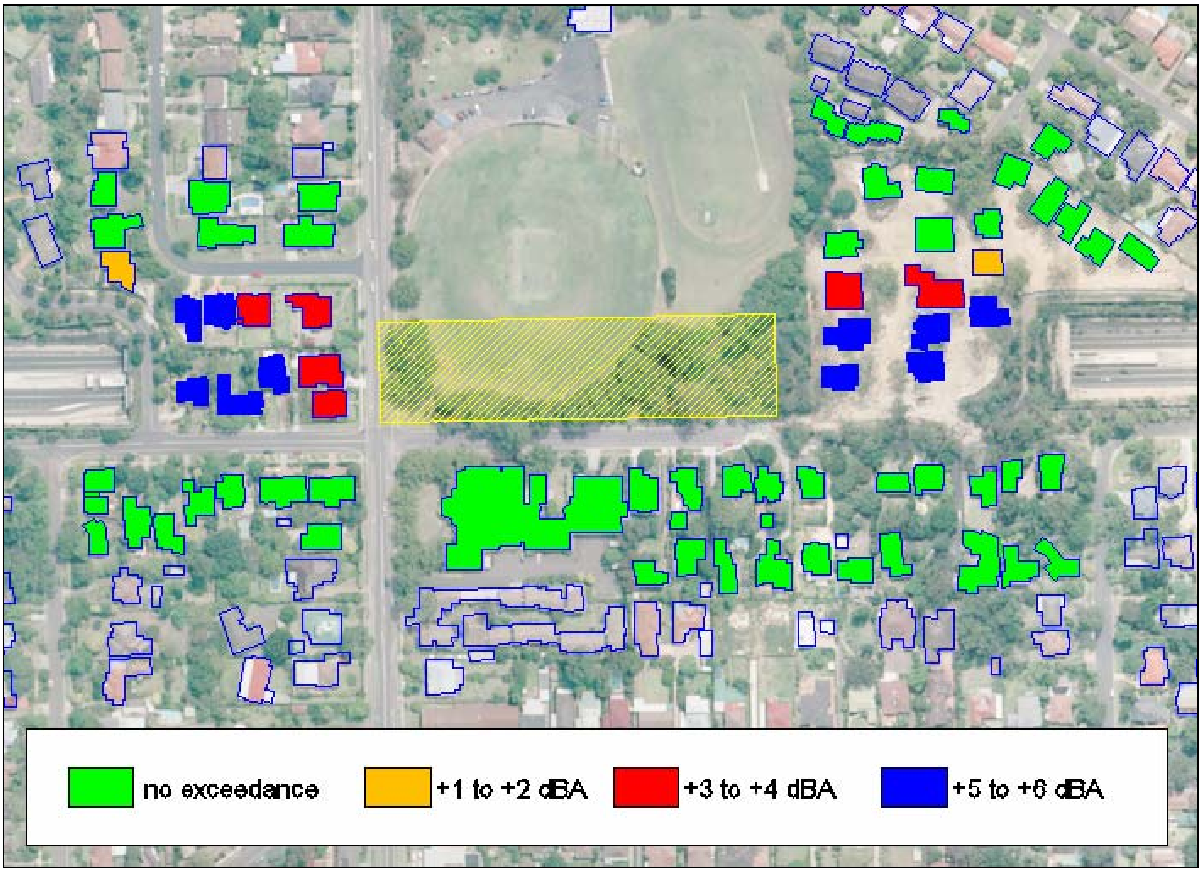
The graph also illustrates that properties which are less than 29 m away from the widening works would potentially experience night-time exceedances, up to a maximum of around 5 dBA, for a period of approximately two weeks (10-12 working nights).

It is however noted that the sensitive receiver ground-borne noise from the operation of the roadheader would be neither impulsive nor intermittent, and as such, the potential for sleep disturbance at sensitive receivers in these locations during the night-time period is considered to be low.

Notwithstanding the above, **Figure 15** presents the predicted extent of the exceedances of the $L_{Aeq(15minute)}$ 35 dBA night-time ground-borne noise goal for properties which are located above the tunnel widening works.

It should be noted that the figure illustrates the predicted worse-case ground-borne noise level when the roadheader is in the tunnel tube which is immediately below, or adjacent to, the residence in question. As the tunnel widening works proceed, or move to the other tunnel tube, the distance between the roadheader and the residence would increase and the ground-borne noise levels would noticeably reduce.

Figure 15 Potential Ground-borne Noise Impacts when Roadheader Immediately Below



Note 1: The yellow hatched area indicates where tunnel widening works could potentially occur with negligible exceedances of the night-time sensitive receiver ground-borne noise goal.

Although potential exceedances of the night-time goals are predicted, the vibration levels associated with the use of roadheaders at the Norfolk Tunnel would be expected to be below the levels required to cause structural damage to the properties situated above.

The options for mitigating ground-borne noise, such as noise resulting from the operation of a road header, are limited as physical attenuation devices are not available and procedural management measures are not feasible. Where exceedances are indicated, suitable consultation with the affected residents would be required regarding the nature of the works, the need for continuous (24 hour) tunnelling and the likely extent and duration of the predicted exceedances of NMLs.

Options such as the potential relocation of affected residents for the duration of the exceedance should also be considered.

8 CONSTRUCTION NOISE AND VIBRATION MITIGATION STRATEGIES

8.1 General Comments

The construction scenario predictions have been examined to evaluate (i) potential means for noise and/or vibration mitigation, and (ii) alternative methods to carry out specific construction activities.

In many instances the options available for reducing noise emissions are limited, given the limited range of plant and equipment able to carry out the tasks required. Furthermore, the mobility of much of the equipment limits the use of enclosures which are often very effective in reducing noise emissions from fixed noise sources.

8.2 Noise Control

Certain "baseline" mitigation strategies should be adopted along the route at any section where the noise goals are exceeded.

The construction contractor will, where reasonable and feasible, apply best practice noise mitigation measures including:

- Erecting temporary hoardings or other noise mitigation measures at Site Compounds which are in proximity to residential receivers, where practicable as determined by detailed assessment of each location.
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- The coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers should be avoided, where practicable.
- Where possible, equipment with directional noise emissions should be orientated away from sensitive receivers.
- Where practical, the layout of plant and equipment at any site compounds should be developed so as to minimise noise exposure.
- Loading and unloading should be carried out away from sensitive receivers, where practicable.
- The selection of site access points should take into account the proximity of noise sensitive receivers.
- Maintenance work on all construction plant with the potential to generate noise impacts should be carried out away from noise sensitive receivers and confined to standard daytime construction hours, where possible.
- Minimising consecutive works in the same locality, where practicable.

In order to minimise noise impacts during the works, the construction contractor will make use of reasonable and feasible measures to mitigate noise effects.

The contractor will also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

Operators of construction equipment should be made aware of potential noise issues and of techniques to minimise noise emission through a continuous process of operator education. For example:

- Large waste material should be *placed* into dump trucks as far as practical (rather than dropped in from a height).

- Where vehicle and equipment queuing is required close to sensitive receivers, engines should be shut down if queuing for extended periods, where practicable.
- Warming up of vehicles should be carried out as far away as possible from noise sensitive receivers.
- Reversing of equipment should be minimised so as to prevent nuisance caused by reversing alarms.
- Horn signals should be kept to as low a volume as possible, given appropriate OH&S considerations.

8.2.1 Discussion of Mitigation Strategies

Construction Noise and Vibration Management Plan and CNISs

To ensure the adequacy of the noise and vibration mitigation measures for the actual design and construction method, detailed Construction Noise and Vibration Impact Statements (CNISs) will be prepared for major noise-intensive construction activities, prior to and for inclusion into the Construction Noise and Vibration Management Plan (CNVMP) for that stage/activity. Both the CNVMP and individual supporting CNISs will be revised as required.

Source Noise Control Strategies

Engines and exhausts, which are often the dominant noise sources on mobile plant, should be fitted with residential class mufflers. Wherever feasible, silenced air compressors, fitted with noise labels indicating a maximum (L_{Amax}) sound pressure level of not more than 75 dBA at 7 m should be used on site.

Equipment Selection and Maintenance

The contractor carrying out the construction works should select equipment taking into account noise and vibration emissions, eg smaller equipment options or rubber-tracked equipment where equipment is fit-for-purpose and economically feasible, equipment to be provided with residential grade mufflers, etc.

All equipment should be maintained and operated in an efficient manner, as per manufacturer’s specifications, to reduce the potential for adverse noise impacts.

Concurrent Activities

There is some, albeit limited, scope for a proactive scheduling of equipment tasks to avoid “clustering” of equipment close to sensitive receivers. This applies to the equipment within the individual construction crews.

Reversing Alarms

The potential noise impact of reversing alarms should be recognised and addressed via a combination of proactive driver/operator training and operational procedures. The following mitigation strategies will be undertaken, taking into account that WorkCover OH&S requirements would need to be satisfied with respect to safety surrounding construction vehicles.

- The primary means for minimising reversing alarm noise should be through a dedicated effort on the part of all construction equipment drivers to minimise, wherever feasible, the amount of reversing of their vehicles.
- Wherever feasible, turning circles should be created at the end points of vehicle work legs, which would allow trucks, compactors, water carts, etc, to turn and avoid the need for reversing.

- Emphasis should be placed during driver training and site induction sessions on the potential adverse impact of reversing alarms and the need to minimise their use.

Noise Monitoring Plan during Critical Work Phases

A targeted noise (and vibration if necessary) monitoring plan at nearest residential and sensitive receivers based, at least initially, on the predictions provided in this report, will assist in ensuring that planned mitigation controls are being implemented during critical stages of work.

Equipment Noise Compliance Checks

Regular checks of equipment noise levels should be made to ensure that noise levels do not increase as a result of poor maintenance practice or say the replacement of individual items of equipment with alternatives which have higher noise emissions.

Noise (and Vibration) Monitoring

A well-planned, noise monitoring programme will assist in confirming and controlling the site-specific potential for disturbance at particularly sensitive localities as the works progress. Mitigation measures, including changes in work sequences or selection of smaller items of equipment, can then be put in place before significant disturbance occurs. The programme could include:

- Initial (ie pre-construction background) noise monitoring.
- Ongoing monitoring of emissions at residences and other sensitive receivers during critical phases of the work.
- Ongoing compliance checks of all critical plant and equipment.
- Investigation of complaints and follow-up monitoring to assess the effectiveness of adopted control strategies.

Temporary Construction Noise Walls

Wherever practicable, the proposed new noise walls will be constructed prior to the existing walls being taken down. However, in a number of areas the existing noise walls (or part of the existing wall) will have to be demolished before the new wall can be erected due to access restrictions and the limited availability of space required for the proposed work at that location.

In such situations a detailed assessment will be undertaken to determine the reasonable and feasible noise mitigation measures. Options such as the use of temporary noise walls would be considered and implemented where appropriate. Where required, temporary noise walls would be erected as soon as practicable after the existing walls are removed to ensure minimal impact on receivers in the area.

Moveable (Temporary) Noise Barriers

Many activities associated with the Project will involve large-sized plant moving along the Motorway, eg carrying out milling and asphalt laying. Temporary barriers for such activities are not generally practical.

The most noise-intensive activities associated with the project, namely concrete sawing, rockbreaking and the use of jackhammers, will be highly localised. Based on the outcomes of detailed assessments of each work location and scenario, the use of temporary and moveable noise barriers, eg loaded vinyl “curtains” around such sites, or at least between such sites and the nearest receivers, would be considered and made use of where reasonable and feasible. Such barriers could produce noticeable decreases in the associated noise emissions, even if these are restricted to limited hours (say 9:00 pm to 11:00 pm).

Limiting of Hours

The assessment of the potential impacts from construction noise for the M2 Upgrade Project found that the higher exceedances of the Noise Management Levels were generally associated with use of:

- Concrete Saws (and reinforcement cutting)
- Rockbreakers
- Jackhammers

There is therefore scope to reduce the potential noise impacts during the more sensitive periods by restricting such activities, where sensitive receivers are likely to be adversely affected, to daytime and evening periods, where feasible and reasonable.

Noise Management Versus Noise Control

The mitigation of noise impacts can often involve noise management as distinct from noise control. For example, the scheduling of noise-intensive activities could be an effective noise management strategy in the present instance.

Specifically, time restrictions should be placed on the most noise-intensive activities, especially concrete sawing, rockbreaking and the use of jackhammers in the vicinity of sensitive receivers, as discussed above. For example, where there is a definite requirement for such activities to be completed out of the normal construction hours, they could be restricted to 9:00 pm to 11:00 pm where reasonable and feasible.

Similarly, with respect to the activities located at any one section of the Motorway in the vicinity of sensitive receivers, advanced notice of high noise activities should be provided and respite periods employed, eg no two consecutive evenings in the same area where concrete saws are being used, where reasonably and feasibly practicable

An important component therefore of the noise management of the proposed works is comprehensive community consultation which should continue through all major stages of the construction programme.

The community would be kept informed as to the nature, timing and duration of impending works, the nearest sensitive receivers likely to be affected and the monitoring programme associated with the impending works.

Community Liaison

A primary aim of the project would be to ensure that the local community is kept informed of the progress of the construction work in a proactive and progressive manner. A combination of internet-based information, community meetings, local newsletters, leaflets, newspaper advertisements and community notice boards would be used as appropriate.

As part of the Community Liaison process a contact person would be nominated within the Construction Noise and Vibration Management Plan to directly address any noise and/or vibration complaints that the community may have during the construction phase of the project.

The community liaison process would be progressively “fine-tuned” to meet the specific requirements of the particular works under consideration. In this manner, equipment selections and work activities can be continuously coordinated and modified where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints and other issues of concern, should they arise.

8.3 Vibration Control

The following “baseline” vibration mitigation measures will be implemented by the construction contractor where reasonably and feasibly practicable:

- Relocate any vibration generating plant and equipment to areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of excavation plant and equipment eg smaller capacity rockbreaker hammers.
- Minimise consecutive works in the same locality (if applicable).
- Schedule a minimum respite period of at least 0.5 hour before activities commence which are to be undertaken for a continuous 4 hour period.
- Use only dampened rockbreakers and/or “city” rockbreakers to minimise the impacts associated with rockbreaking works.
- The use of a roller class “II Light” when operating as close as 5 m from the closest buildings.

8.4 Construction Monitoring Requirements

Noise monitoring would be undertaken as required for assessment against the adopted construction noise goals where, subsequent to project approval, detailed construction noise impact assessments indicate significant potential exceedance at the nearest impacted noise sensitive receivers.

It is also recommended that vibration monitoring be carried out for assessment against the transient vibration guidelines (BS 7385 and DIN 4150) as a result of potential impacts on structures when working within the safe working distances for cosmetic damage as a result of vibration intensive construction activities, and where the vibration levels are greater than the maximum recommended values.

9 OPERATIONAL NOISE ASSESSMENT OF THE M2 UPGRADE PROJECT

9.1 General Approaches to Controlling Road Traffic Noise

A range of noise mitigation options are available to reduce the effect of road traffic noise on the surrounding community. The general methods available are listed below.

Low Noise Road Surfaces: Such as Open Graded Asphaltic Concrete (OGAC) or Stone Mastic Asphalt (SMA). Such surfaces can produce noise level decreases of up to about 4 dBA when compared to standard road surface materials.

A full re-sheeting of the existing M2 road surface within the boundaries of the proposed Upgrade works will take place concurrently with the upgrade proposal.

Road Maintenance: Maintaining the running surface condition of a road can be important in lessening the incidence of sleep disturbance, eg where pot holes are allowed to remain for extended periods of time without repair.

Traffic Management: Such as limiting vehicle speed, speed humps, signage, etc. These methods can generate noise level improvements of up to 5 dBA, depending upon the carriageway of interest, however they are more suited to local roads than motorways. Compression brakes can be an important factor in the noise environment of roads used by heavy vehicles. While there are currently no statutory powers to limit the use of compression brakes, some success has been achieved on certain major arterial routes via the use of signage to promote awareness of their use in residential areas. In cases where inappropriate driving behaviour is identified as a significant source of annoyance (eg excessive use of compression brakes), vehicle driver education strategies should be considered.

Traffic Re-Routing: This option is particularly useful when applied to heavy vehicles using local and secondary roads in predominantly residential areas.

Noise Barriers: Noise walls gain their effectiveness by extending the path length of noise over and around the barrier between the source and the receiver. Barriers are usually most effective where both the source and receiver are at a similar elevation.

Increasing the height of already high noise walls provides diminishing additional attenuation. Noise walls are also ineffective when receivers are located at significantly elevated positions, as would be the case for upper levels of a residential apartment building overlooking a noise source.

The potential for using noise walls also depends upon other factors, including access to property, aesthetic impacts, daylight access, overshadowing, drainage, driver line-of-sight around sections of curved carriageway, maintenance access and safety (particularly for drivers and pedestrians).

Architectural Treatment of Buildings: This method involves the upgrading of property glazing for windows and sliding doors, and the upgrading of access doors if they are found to be weak points for noise access into a particular building. Double glazing, for example, can reduce internal noise levels by up to 10 dBA or more compared to a standard residential grade window. Property treatments may also include the provision of mechanical ventilation if the closure of windows and other facade openings is used as a means of managing internal noise levels in selected spaces.

9.2 Factors Affecting the Choice of M2 Upgrade Noise Mitigation Options

The specific measures adopted to seek to achieve the target noise goals would vary for a particular road in terms of the practicality and feasibility of their implementation and the sensitivity of the land use.

The noise strategies chosen would typically be found to involve a mix of the options cited in **Section 9.1**. Details of what noise mitigation measures would be feasible and reasonable to apply are typically only possible to identify at the detailed design stage of a road project. This is because site specific details are important in selecting the final mix of noise mitigation measures and the detailed design phase may require small changes to project specifics (such as the level of the road way). The process of obtaining feedback from the community may also identify a preference for a certain type of noise mitigation. During the design phase of the project the M2 Upgrade Project Team would be required to assess all available noise options.

It has already been noted that, in parallel with the M2 Upgrade Project, the motorway will be re-sheeted with low-noise Open Grade Asphalt Concrete. The primary noise mitigation options that are feasibly available for use (separate to the re-sheeting) are noise walls and/or architectural treatment of individual buildings.

The final mix of selected strategies will be based on a number of competing factors. For example, an analysis based on cost-effectiveness might yield a mix of a certain height noise wall combined with a certain degree of window upgrading of selected properties. However, the local affected community might prefer (on aesthetic grounds) a different option mix of noise barriers and property treatment. The benefits of community preferred options would then need to be considered in light of additional factors such as future noise levels in the affected area and changes in land use in the local area.

Shading and potential loss of direct solar access may be factors affecting the implementation of noise barriers located in close proximity to residential areas.

In general, noise walls and other noise source related treatments (eg quieter road pavements, traffic control, etc) are preferred to architectural treatments, where feasible and reasonable, as a result of both external and internal noise levels being reduced. However, in all instances, the opinions of the local affected community would be sought in determining the final mix of noise amelioration treatments.

Factors which impact on the potential for employing upgraded glazing include maintaining provision for natural ventilation when the glazing is closed and glazing disturbance for special buildings, eg heritage buildings. The performance of the remainder of the building envelope must also be investigated for its suitability to house upgraded glazing units.

Finally, it is noted that many sections of the M2 Motorway are protected by existing, and in some cases quite high, noise barriers. Where the proposed upgrade works will result in demolition of these existing barriers and construction of new barriers, the design of such barriers can proceed using the standard ENMM-based cost-effectiveness guidelines.

Where existing barriers are to remain, analysis of the possibility of extending their height to accommodate increased noise levels associated with the upgrade works would have additional feasibility and reasonableness considerations associated with refurbishment, foundation upgrading, etc.

9.3 Airborne Road Traffic Noise Assessment Methodology

Operational Road Traffic Scenarios

In **Section 5.2**, it was noted that the assessment of the impact of airborne noise during the Operational Phase of the M2 Upgrade Project is made using the guidance contained with the DECCW's ECRTN.

This document requires noise levels to be assessed based on traffic volumes which are projected to 10 years after the opening of the project. Accordingly, as the proposed project is scheduled to open in 2011, the future assessment year applicable to the project is taken to be 2021.

The impact assessment of the M2 Motorway Upgrade Project has therefore been performed by considering the following two assessment scenarios:

- Future *Existing* (2011) - ie the future road traffic noise that would have occurred at the proposed year of opening of the upgraded roadway assuming a "do-nothing" case.
- Future *Design* (2021) - which incorporates the alterations as a result of the proposed project and 10-year post-opening traffic levels.

A third "base" scenario (2008) has also been modelled to allow for validation of the noise model against the ambient noise surveys carried out in 2008.

Governing Criterion

The ECRTN stipulates 15-hour (daytime) and 9-hour (night-time) L_{Aeq} noise criteria of 60 dBA and 55 dBA respectively.

To determine the more stringent of the two criteria, a comparative exercise was performed using all baseline monitoring data to assess the difference between the daytime energy averaged noise level ($L_{Aeq,15hr}$) and the night-time energy averaged noise level ($L_{Aeq,9hr}$). This exercise showed that:

Average daytime $L_{Aeq(15hour)}$ noise level = Average night-time $L_{Aeq(9hour)}$ noise level + 4.8 dBA

The night-time criterion has therefore been taken as being the governing criterion as it set at 5 dBA less than the daytime criterion.

Changes in road traffic noise levels associated with the project have therefore been calculated by considering the traffic conditions for the following scenarios:

- 2011 Future *Existing* – Night-Time $L_{Aeq(9hour)}$ – refer results shown in **Appendix D**
- 2021 Future *Design* – Night-Time $L_{Aeq(9hour)}$ – refer results shown in **Appendix E**

In the above scenarios, all significant road traffic noise sources have been taken into account, ie M2 road traffic PLUS major arterial/secondary roads.

For each of the above scenarios the facade maps predict noise levels at every facade of each floor of all buildings along the length of the motorway.

All facade noise levels are evaluated at a distance of 1.0 m from the centre of the facade in question, at a height of 1.5 m for ground floor storeys and 4.3 m (1.5 m plus 2.8 m for a typical floor to floor height) for first floor storeys.

Noise levels have only been evaluated at ground and first floor storeys as is the general convention for assessments of the impacts from road traffic noise.

9.4 Calculation Procedure and Modelling Inputs

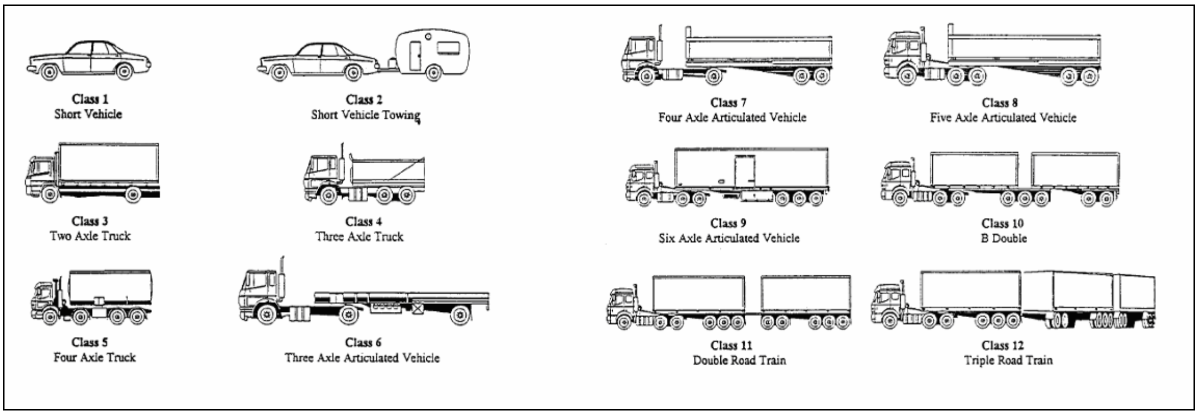
The noise modelling has been carried out using the SoundPLAN V6.5 suite of acoustics software using the Calculation of Road Traffic Noise (CORTN) prediction model for all calculations.

Road traffic noise levels were predicted using RTA and DECCW recommended procedures, as detailed in the CORTN methodology. The input data required for each section of road for these calculations includes the total traffic count, the percentage of heavy vehicles within total traffic flow and vehicle speed.

Vehicle Classification

Traffic has been split between cars and trucks based on Austroads vehicle classification system, as shown in **Figure 16**. For the purposes of the noise model, cars are considered Class 1 & 2 vehicles, and trucks are considered to be Class 3 and above.

Figure 16 Austroads Vehicle Classification System



2008 Base Year Traffic Figures

For the 2008 Base Year scenario, the traffic volumes and speeds along the various sections of the motorway were derived from traffic counts conducted in conjunction with the baseline ambient monitoring described in **Section 6**. These figures, along with representative vehicle speeds measured at the same time as the traffic counts, are presented in **Table 32**.

Table 32 2008 Base Traffic Volumes for M2 Motorway

Location	Direction	Speed (kph)	LA10(18hour) Traffic Volumes	
			Cars	Heavy Vehicles
M7 Carriageway West of M2	Eastbound	94	14597	2766
	Westbound	98	15327	3049
Old Windsor Road	Eastbound	76	7482	494
	Westbound	82	9655	712
Windsor Road Access Ramps	Eastbound	72	7279	319
	Westbound	83	7217	284
Carriageway East of Windsor Road	Eastbound	87	29227	3571
	Westbound	100	32262	4305
Pennant Hills Road On Ramps	Eastbound	79	7285	302
	Westbound	91	10640	2199
Pennant Hills Road Off Ramps	Eastbound	71	9919	2088
	Westbound	82	7350	444
Beecroft Road Access Ramps	Eastbound	76	3389	132
	Westbound	67	2420	113
Carriageway West of Toll Gates	Eastbound	84	28180	2026
	Westbound	80	31805	2971
Christie Road Access Ramps	Eastbound	63	2732	114
	Westbound	67	3078	189
Lane Cove Road Access Ramps	Eastbound	83	7101	766
	Westbound	76	1504	152
Lane Cove Loop Road	Westbound	58	5282	795
Delhi Road Access Ramps	Eastbound	84	6710	450
	Westbound	77	7607	642

Traffic volumes along the major intersections of the motorway are presented in **Table 33**. These have been sourced from the RTA's *Traffic Volume Data* from 1999 to 2007.

Table 33 RTA Traffic Volumes for Local Roads

Local Road	Intersection	LA10(18hour) Traffic Volumes	
		Cars	Heavy Vehicles
Lane Cove Road	Talavera Road	57344	6372
Beecroft Road	Copeland Road	32790	1726
Beecroft Road	Carlingford Road	45376	2388
Pennant Hills Road	Copeland Road	65519	11562
Pennant Hills Road	North Rocks Road	50980	8996
Windsor Road	Cook Street	54119	2848
Windsor Road	Churchill Drive	43150	2271

An assumed speed of 50 kph has been utilised for all surrounding local roads that are included in the noise model.

2011 and 2021 Future Traffic Figures

All traffic data, in 18 hour format, used within the modelling of the future years was supplied to Heggies by Hills M2 and is based on the traffic figures in the Transport and Traffic Impact Assessment undertaken as part of the M2 Upgrade Project Environmental Assessment. This included both M2 carriageway volumes along with data for the major surrounding arterial/secondary roads, and is presented in **Table 34**, **Table 35** and **Table 36**.

Table 34 Future Traffic Figures (M2 Carriageway)

Location	Direction	LA10(18hour) Traffic Volumes		
		2011 Future *Existing*	2021 Future *Design*	%HGV
Old Windsor - Windsor Road	Eastbound	29750	37480	17%
Windsor - Pennant Hills Road		38780	48360	14%
Pennant Hills - Beecroft Road		34140	44290	8%
Beecroft - Christie Road		38250	49190	8%
Christie - Lane Cove Road		34260	45300	8%
Lane Cove - Delhi Road		25250	35130	7%
Delhi - Lane Cove Road	Westbound	26550	34390	7%
Lane Cove - Herring Road		35360	46060	9%
Herring - Beecroft Road		39940	49840	9%
Beecroft - Pennant Hills Road		36940	46690	9%
Pennant Hills - Windsor Road		42390	50430	13%
Windsor - Old Windsor Road		32140	41170	16%

Table 35 Future Traffic Figures (M2 Access Ramps)

Location	Direction	LA10(18hour) Traffic Volumes		
		2011 Future *Existing*	2021 Future *Design*	%HGV
Western end of M2	Eastbound	19390	23220	21%
Western end of M2	Westbound	20700	23320	20%
M2 Abbott Road Exit and Entrance	Eastbound	10360	14260	8%
M2 Abbott Road Exit and Entrance	Westbound	12680	18070	8%
Windsor Road - Off-Ramp	Eastbound	n/a	3910	8%
Windsor Road - On-Ramp	Westbound	n/a	3910	8%
Windsor Road - On-Ramp	Eastbound	9030	14790	5%
Windsor Road - Off-Ramp	Westbound	10250	13170	4%
Pennant Hills Road - Off Ramp	Eastbound	13280	15590	23%
Pennant Hills Road - On Ramp	Westbound	14140	15040	22%
Pennant Hills Road - On Ramp	Eastbound	8640	11520	5%
Pennant Hills Road - Off Ramp	Westbound	8690	11300	6%
Beecroft Road - On Ramp	Eastbound	4110	4900	4%
Beecroft Road - Off Ramp	Westbound	3000	3150	5%
Christie Road Off Ramp	Eastbound	3990	6520	4%
Herring Road On Ramp	Westbound	4580	7390	6%
Herring Road On Ramp	Eastbound	n/a	2630	4%

Herring Road Off Ramp	Westbound	n/a	3610	3%
Lane Cove Road - Off Ramp	Eastbound	9010	10170	12%
Lane Cove Road - On Ramp	Westbound	1980	4250	10%
Lane Cove Road - Loop On Ramp	Westbound	6830	7420	15%

Table 36 Future Traffic Figures (Intersecting Roads)

Road	**LA10(18hour) Traffic Volumes**		
	2011 Future *Existing*	**2021** Future *Design*	**%HGV**
Windsor Road	52578	59793	5%
Pennant Hills Road	72433	73864	18%
Beecroft Road	50253	51524	5%
Herring Road	20739	29391	5%
Talavera Road (East of Herring Road)	12860	21902	5%
Talavera Road (West of Herring Road)	9936	15874	5%
Talavera Road (West of Christie Road)	7156	9598	5%
Lane Cove Road	85422	93534	11%

Multiple Height Source Methodology

All of the noise models used in the assessment of the M2 Motorway Upgrade Project make use of a Three Height Source noise modelling methodology. This method employs three separate noise sources, at varying heights above ground, to represent the main contributors of noise from vehicles.

The three sources and their associated heights are detailed in **Table 37**.

Table 37 Three Height Source CORTN Procedure

Source	Height Above Road Surface (m)
Heavy Vehicle/Car Tyre	0.0
Heavy Vehicle Engine	1.0
Heavy Vehicle Exhaust	3.0

Ground Topography

The topography of the area along the M2 Motorway was imported in 3-dimensional format into the noise model and was sourced as follows:

- Topography for the land surrounding the project area was provided by the project team, sourced from Sinclair Knight Merz Pty Ltd, in 2 m contour steps;
- Road design levels and road corridor data for the M2 Motorway was derived from surveyed data, where available.

Facade Reflection

A facade correction of +2.5 dBA has been incorporated into the predicted noise levels throughout this report, where appropriate, in accordance with DECCW/RTA procedures.

L_{A10} to L_{Aeq} Conversions

A conversion of -6.4 dBA has been used to convert the (CORTN) $L_{A10(18hour)}$ level to the $L_{Aeq(9hour)}$ governing night-time criterion required.

This figure was derived from the average difference (before rounding) between the L_{A10} and L_{Aeq} indices of measured noise data, as presented in **Section 6**.

Existing Noise Walls used in Model

The surveyed data described above contained top-of-noise-wall height information for the majority of the M2 Motorway. This data was extracted from the survey information and directly imported in to the noise model.

In areas where no survey data was available, aerial photography, supplemented with a walk-by visual site inspection, was used to determine the appropriateness of any barriers to be included in the model.

This data was also correlated against the as-built noise wall chainages and heights provided to Heggies by the M2 Motorway project team.

M2 Upgrade Proposed Design

All design information (altered road corridor, carriageway levels, new access ramps, etc) in areas where upgrade works are proposed was supplied to Heggies in 3 dimensional format by the M2 Motorway Project Team.

Road Way Surface

The baseline CORTN noise prediction model employed within SoundPLAN includes no correction factor for the road way surface.

M2 Road Surface Re-Sheeting

The proposed upgrade of the M2 Motorway will take place concurrently with a full re-sheeting of the existing road surface.

"Low noise" pavements are able to provide noise reductions of up to 4.5 dBA relative to the expected behaviour for dense graded asphalt (DGA). It is understood that the future road surface for the M2 will be open graded asphalt concrete (OGA).

Guidance as to the likely noise reduction that can be expected from the various surface types is provided in the ENMM. This is summarised in **Table 38**.

Table 38 ENMM Table 3.1 Surface Corrections Extract

Table 3.1

Road surface noise corrections, relative to dense graded asphaltic concrete

Surface type (regularly trafficked)	Noise level variation, dB(A)		
	Traffic noise	Individual vehicles pass-by noise	
		Cars	Trucks
14 mm chip seal	+ 4.0	+ 4.0	+ 4.0
Portland cement concrete: tyned and dragged	0 to + 3.0	+ 1.0 to + 3.5	– 1.0 to + 1.0
Cold overlay	+ 2.0	+ 2.0	+ 2.0
Portland cement concrete: exposed aggregate	– 0.5 to – 3.0	– 0.1	– 6.7
Stone mastic asphalt	– 2.0 to – 3.5	– 2.2	– 4.3
Open graded asphaltic concrete	0 to – 4.5	– 0.2 to – 4.2	– 4.9

The road surface correction applied depends on the road surface's porosity, macrotexture, depth and wavelength, the percentage of heavy vehicles and vehicle speeds.

Open graded asphalt concrete is noted as providing a correction of between 0 dBA and -4.5 dBA.

The re-sheeting of the M2 Motorway road surface with OGA is expected to provide a significant noise benefit over the existing cracked and substantially degraded surface.

Under normal circumstances (and consistent with the guidance provided in the ENMM) a correction factor of -2.5 dBA would typically be applied to OGA low-noise pavement types. However, as there is potential for degradation of the M2 Motorway road surface over time, and to ensure a conservative assessment is achieved, the standard -2.5 dBA OGA correction factor has been **entirely omitted** from all calculations.

This means that the noise benefit of the M2 re-sheeting currently being undertaken on the existing carriageways and on/off ramps, together with re-sheeting of the remaining section of the M2 Motorway which would form part of the proposed Upgrade works has **NOT** been taken into account in either the Future *Existing* 2011 or Future *Design* 2021 noise modelling scenarios.

9.5 Noise Modelling Validation

The validation of the noise model was performed by comparing the 2008 base $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise level predictions with the results from the ambient noise monitoring surveys presented in **Section 6**.

Small variations between measured and predicted values are to be expected within any noise model. This is due to the dependence of measured noise levels on road surface characteristics near the specific measurement sites, the incidence of vehicles changing gears near the site, the use of brakes in downhill sections, the bias in use of multiple lanes during different periods of the day, the effects of local screening (eg fences, sheds), etc.

Comparison of measured and predicted levels has been performed by undertaking single point receiver calculations at noise model locations coinciding with the ambient monitoring locations.

The CORTN algorithms are only valid for predicting noise levels up to a distance of 300 m. As a result of this, the monitoring location at 10 Virginia Place has been discounted from the validation process as it is situated at a distance of approximately 350 m from the M2 carriageway.

The comparison of the daytime noise levels is shown in **Table 39** and **Figure 17**. It is noted that monitoring locations S1-04, S2-01, S3-01, S3-06 and S3-07 have also been excluded from the validation process for the reasons discussed in **Section 6.2.1**.

Table 39 Comparison of Measured and Predicted Noise Data (Base 2008)

No.	Address	Measured		Predicted		Predicted MINUS Measured	
		LAeq(15hour)	LAeq(9hour)	LAeq(15hour)	LAeq(9hour)	LAeq(15hour)	LAeq(9hour)
S1-1	13 Sierra Place	51.7	47.1	53.4	48.6	1.7	1.5
S1-2	89 Baulkham Hills Road	56.7	52.7	55.7	50.9	-1.1	-1.8
S1-3	24 Lambert Crescent	59.0	55.1	59.9	55.1	0.9	0.0
S1-5	108 Junction Road	59.1	53.6	59.6	54.8	0.4	1.2
S1-6	17 Livingston Avenue	56.1	51.9	57.5	52.7	1.3	0.8
S1-7	10 Murrills Crescent	53.8	49.8	55.2	50.4	1.4	0.5
S1-8	13 Leatherwood Court	57.6	53.4	59.0	54.2	1.4	0.8
S1-9	4 Craig Avenue	65.5	61.0	67.2	62.4	1.7	1.4
S1-10	10 Petrina Close	65.5	59.9	64.9	60.1	-0.6	0.2
S2-3	11 Wilshire Avenue	59.7	55.8	60.1	55.3	0.4	-0.5
S2-4	70 Westmore Drive	58.2	53.9	60.4	55.6	2.1	1.7
S2-5	3 Mundon Place	53.1	48.1	52.8	48.0	-0.3	-0.1
S2-6	25 Coral Tree Drive	53.1	50.5	56.6	51.8	3.4	1.3
S2-7	5 Orchard Road	56.5	50.5	59.1	54.3	2.6	3.7
S2-8	24A Castle Howard Road	57.6	52.5	58.6	53.8	1.0	1.3
S2-9	13 Williams Road	61.4	57.8	61.1	56.3	-0.3	-1.5
S2-10	8 Rajola Place	61.6	57.9	61.8	57.0	0.2	-0.9
S2-11	33 Carmen Avenue	63.6	59.0	65.0	60.2	1.4	1.2
S2-12	30 Austral Avenue	61.8	56.8	64.7	59.9	2.9	3.1
S3-2	4 Somerset Street	57.5	52.3	56.3	51.5	-1.2	-0.9
S3-3	56 Somerset Street	53.7	48.2	55.5	50.7	1.7	2.5
S3-4	19 Woodvale Avenue	59.2	53.9	60.2	55.4	0.9	1.5
S3-5	6/8 Nile Close	51.5	46.5	53.7	48.9	2.2	2.4
S3-8	3/3 Tasman Place	55.9	50.4	56.1	51.3	0.2	0.8
S3-9	21 Epping Road	58.4	53.0	60.8	56.0	2.4	3.0
S3-10	13 Stewart Close (1st)	64.5	60.1	65.2	60.4	0.7	0.3
S3-11	140 Crimea Road	57.9	52.7	59.1	54.3	1.2	1.6
S3-12	150 Crimea Road	53.4	47.9	54.8	50.0	1.4	2.1
S3-13	2/4 Nile Close	55.0	48.3	54.1	49.3	-0.9	1.0
S3-14	1A Busaco Road	54.7	49.5	54.6	49.8	-0.1	0.3
S3-15	1 Fontenoy Road	60.2	55.0	62.3	57.5	2.1	2.5
Average { PREDICTED – MEASURED } Difference =						**+1.0 dBA**	**+1.0 dBA**

Figure 17 Validation Process – Predicted versus Measured Noise Levels - LAeq(15hr) and LAeq(9hr)

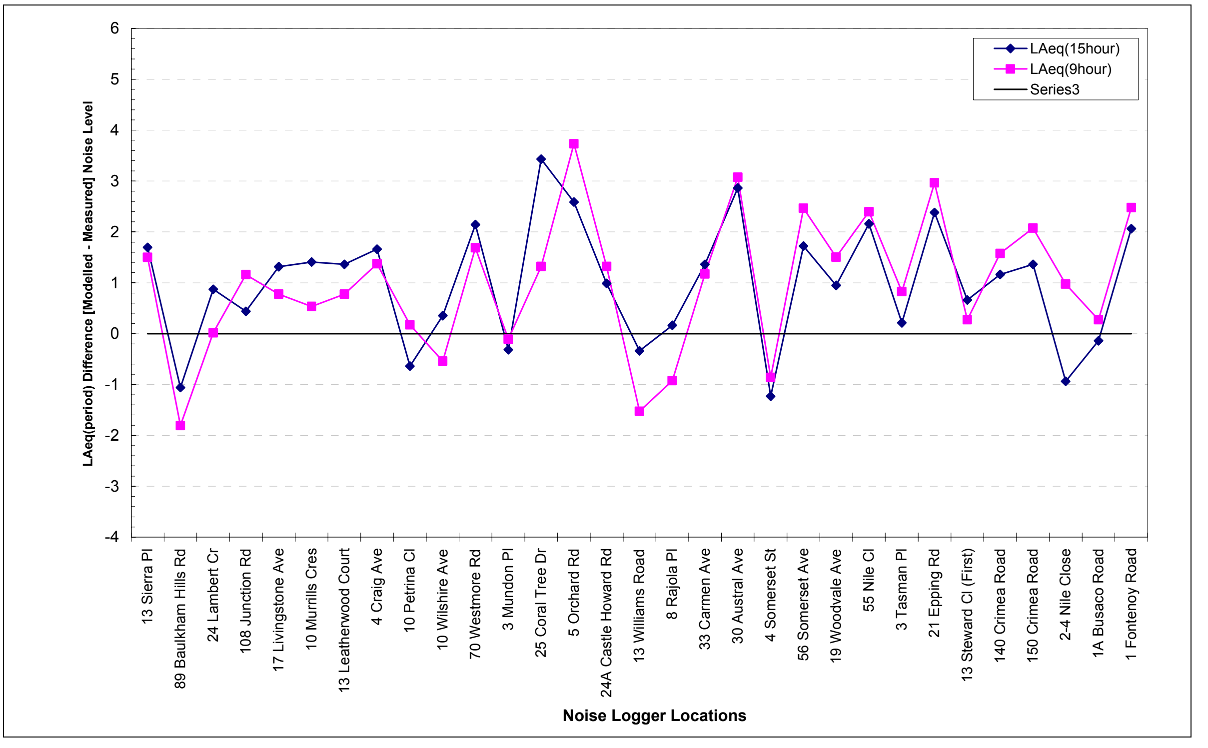


Figure 17 and **Table 39** show that the predicted noise levels provide a consistent, and slightly conservative, estimate of measured levels, with an average difference of +1.0 dBA for predicted versus measured levels.

It can also be seen that the predicted noise levels are within +3.4 dBA and -1.2 dBA of the measured noise levels for the LAeq(15hour) parameter, and +3.7 dBA and -1.8 dBA for the LAeq(9hour). These results are within acceptable tolerances for road traffic noise predictions.

Figure 18 shows the distribution of validation points in Predicted Noise Level minus Measured Noise Level bands for LAeq(15hour). It can be seen that an essentially normal distribution is apparent, with the majority of the results centred around the average of +1.0 dBA.

To assess the model performance as a function of the absolute magnitude of noise level, the same has been reproduced in **Figure 19**, showing the Measured Noise Level against the difference between the Predicted and Measured Noise Level at each of the validation points.

Figure 19 shows a relatively uniform and slightly conservative (more points above the “0” line than below) distribution of points. The trend line of the scatter results shows a modest downward tendency, implying that as the predicted noise level increases, the model becomes slightly more accurate. This is of interest given the relative significance normally applied to the provision of noise mitigation to “acute” noise-impacted properties.

Figure 18 Bar Chart Showing the Distribution of Validation Points - LAeq(15hour)

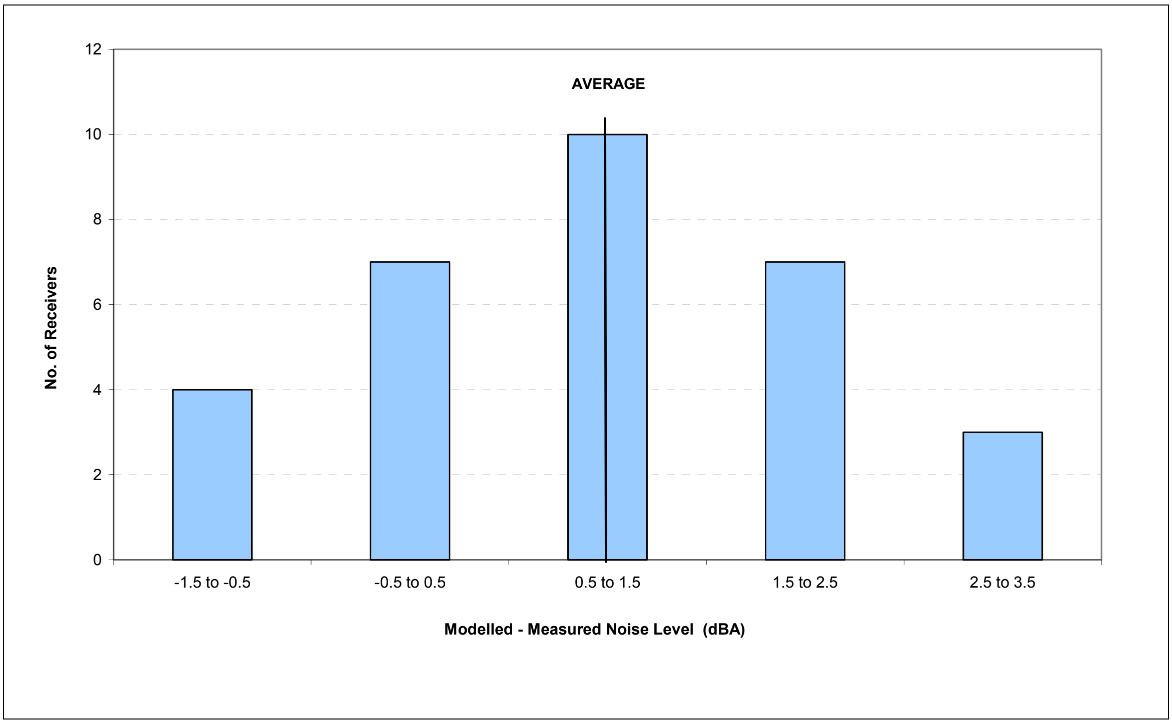
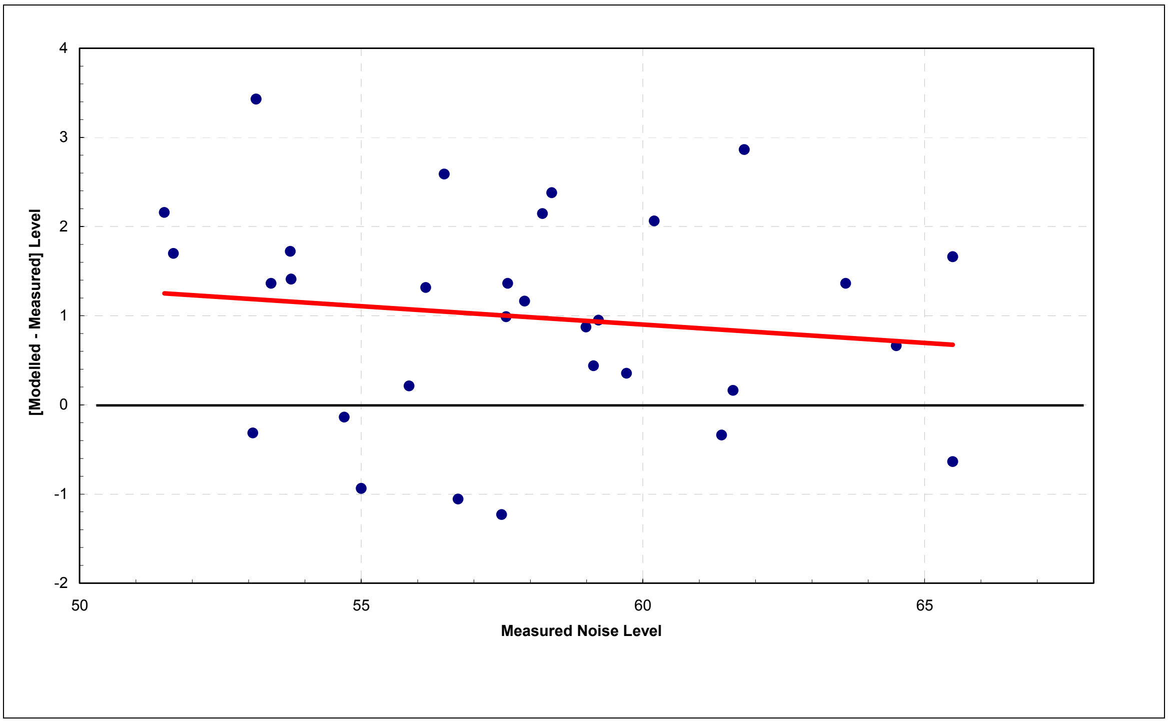


Figure 19 Scatter Graph of Predicted Minus Measured Noise Level Versus Measured Noise Level - LAeq(15hour)



On the basis of the comparison of M2 model predictions with baseline measurement results and the above discussion, it is concluded that the M2 noise model provides results which enable a reliable assessment of the proposed upgrade works and associated noise mitigation treatments.

9.6 Road Traffic Noise Associated with Intersecting Roads

The M2 Motorway is intersected at various points by a number of existing arterial/secondary roads. Residential receivers which are located close to these intersections are therefore exposed to road traffic noise from both the M2 and the roads in question. These include, Old Windsor Road, Windsor Road, Pennant Hills Road, Beecroft Road, Lane Cove Road and Delhi Road.

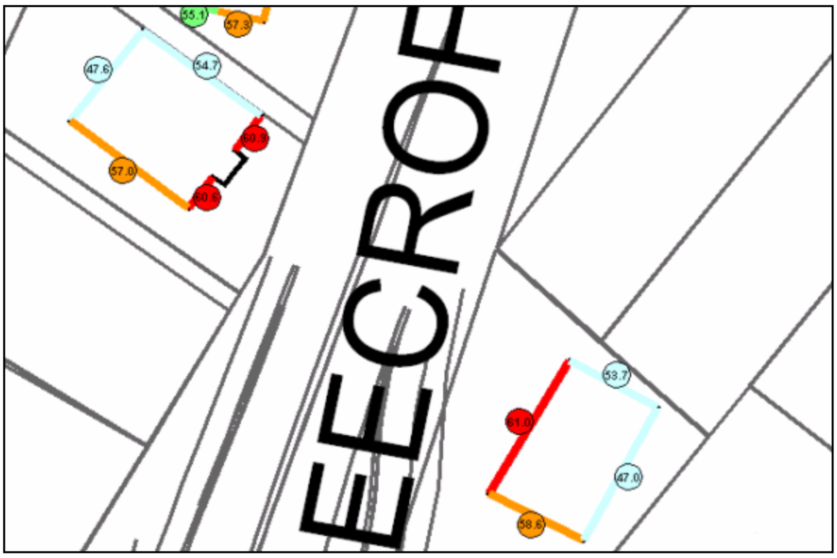
Where this situation is apparent, and an exceedance of the relevant criteria is predicted, a detailed inspection of the particular receiver in question has been performed to determine which facade(s) and hence which road source was the cause of the exceedance. An example of this is illustrated in **Figure 20**.

Furthermore, inherent within the noise model is the ability to determine the relative contributions to a particular noise level at a single facade from the various sources in the vicinity. Where an exceedance of the noise criteria is apparent near to multiple sources (ie at motorway junctions with secondary roads) this process is used to determine the dominant contribution to that particular noise level.

The facade maps in **Appendix D** and **Appendix E** represent the traffic noise levels from M2 operations combined with all major secondary roads within the M2 Project area. Residential and other sensitive receivers which are deemed to be exceeding the relevant operational criteria as a result of the noise generated by the secondary roads are highlighted on the facade maps in **Appendix E**.

Accordingly, only those residential receivers which exceed the nominated criteria as a direct result of noise generated by the M2 carriageway, M2 on/off access ramps and all associated upgrade works are included within the subsequent assessment of noise mitigation.

Figure 20 Sample Detailed Facade Noise Level Analysis (Indicative Only)



As part of the M2 Upgrade Project it is also proposed to widen a number of the roads which intersect or feed on to the M2. These include Windsor Road (north of Woodlands Street to the M2), Christie Road (M2 Exit ramp to Talavera Road) and Talavera Road (access to the School of Management to Alma Road). Of these, only Windsor Road has residential development fronting on to the road.

9.7 Noise Assessment and Mitigation

9.7.1 2011 Future Existing Scenario and Existing Noise Barriers

Noise emissions from the M2 Motorway are currently mitigated through noise walls along almost the entire length of the motorway of various heights. These range from approximately 1.8 m up to around 7.0 m in height. The noise walls are generally located either at the side of the carriageway or at the crest of cuttings, depending on which location provides the optimal noise benefit for the sensitive receivers situated behind.

The existing noise walls do not extend over the complete length of the M2 Motorway. The opening of the M7 increased traffic volumes, particularly heavy vehicles, in the section of road between the M7 and Pennant Hills Road. An assessment of all sensitive receivers adjacent to the M2, both in sections with existing noise walls and in those sections currently without, has been undertaken with regard to the operational noise criteria for the project.

The 2011 Future *Existing* facade plots in **Appendix D** show that several residential precincts along the route of the motorway are subject to noise levels exceeding ECRTN base criteria. This is confirmed by the unattended ambient noise survey detailed in **Table 11**.

9.7.2 2021 Future Design Scenario Assessment and Mitigation

Operational Noise Criteria Action Levels for Noise Treatment

The operational noise criteria for the M2 Upgrade Project have been previously defined in **Section 5.5** of this report. However, they are provided again below for reference.

Scenario 1

- The predicted 2021 Future *Design* noise level exceeds the ECRTN base criteria for redeveloped roads *and* the noise level increase due to the project is greater than 2 dBA.

or

Scenario 2

- The predicted 2021 Future *Design* noise levels are acute (≥65 dBA $L_{Aeq(15hour)}$ or ≥60 dBA $L_{Aeq(9hour)}$) regardless of the incremental impact of the project

Where exceedances of either of the above scenarios are apparent within the M2 Project Area, additional noise mitigation measures are required to be considered. Preference is to be first given to the use of noise walls as a mitigation measure as all sensitive receivers behind a particular noise wall benefit from the resulting reduction in noise.

After the design and optimisation process of any such noise walls is complete, architectural property treatment would then be utilised to mitigate <u>all</u> remaining properties in the M2 Project Area where residual exceedances of the above criteria are apparent.

The relevant sections of this report which relate to these processes are:

- **Noise Walls** affected by the project - **Section 9.7.3**
- **Architectural Treatment** of residual exceedances– **Section 9.7.7**

Evaluation of the incremental impact of the M2 Upgrade Project (2021 – 2011 difference plot are provided in **Appendix F**) concludes a 2 dBA increase in noise is not apparent in any location along the length of the Project Area (excluding two properties immediately adjacent to the realignment of Windsor Road), and as such, additional noise mitigation measures have only been considered where the predicted 2021 Future *Design* noise levels are found to be acute (ie Scenario 2).

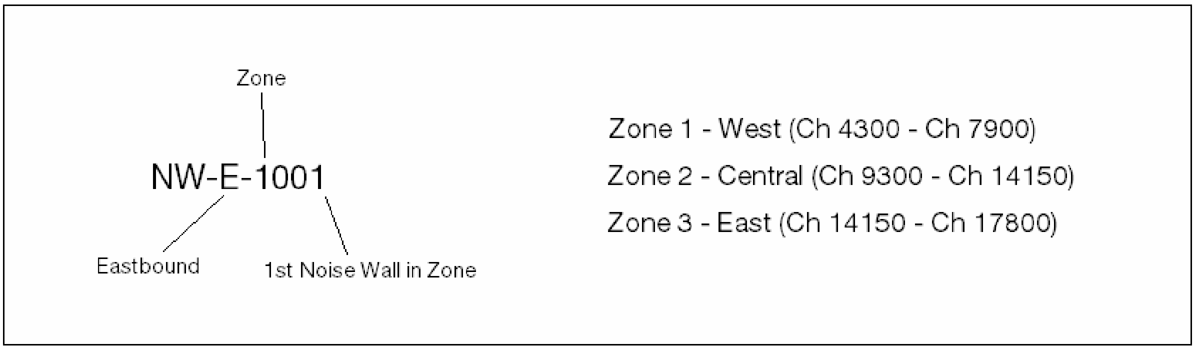
Properties which are outside of the areas directly affected by the upgrade works that currently experience acute noise levels (but are not predicted to experience a noise level increase of greater than 2 dBA due to the proposal) would be subject to the original conditions of approval for construction of the M2 Motorway and will be considered accordingly. This process would be performed separately to the proposed M2 Upgrade Project.

As preference is to be given to noise walls as the primary choice of noise mitigation, a discussion of how the noise walls were designed for the M2 Upgrade Project follows.

Noise Wall Reference Description

The various noise walls which are affected by the M2 Upgrade Project (ie existing noise walls which require horizontal displacement because of the widening works, noise walls which require an increase in height to provide additional mitigation, or entirely new noise walls) are referenced according to which side of the carriageway they are situated and by the zone in which they are located – ie NW-E-1001 is the first noise wall in Zone 1 on the eastbound side of the carriageway – refer to **Figure 21**.

Figure 21 Noise Wall Reference System for the M2 Upgrade



Alteration of Noise Walls

The widening upgrade process of the M2 will require alterations to the existing alignment of the road corridor in many areas along the length of the motorway. These alterations include the modification of various existing cuttings, embankments and batter slopes in areas where widening works are proposed.

The widening process will therefore affect a significant number of the existing noise walls along the route of the motorway. Some of the affected noise walls are situated adjacent to the road carriageway and others are on top of embankments. All such affected noise walls will be required to taken down and relocated as part of the project.

In certain areas, including some where residential receivers are in close proximity to the motorway, the proposed widening of the motorway will bring the new outer running lane (and hence the overall noise emission source) closer to affected receivers.

In all sensitive receiver locations where future exceedances of the operational noise criteria have been predicted, new or increased height noise walls have been considered where three or more exceeding properties are situated within a catchment area. Where the number of exceeding receivers is found to be less than three, the specification of noise walls is not considered to be a reasonable or cost-effective approach, and architectural treatment of these receivers would be considered.

Where noise walls are required to be relocated by the upgrade works, consideration has been given to increasing the existing height of such walls if exceedances of the operational noise criteria are apparent in the 2021 Future *Design* scenario. Where no exceedances of the criteria are apparent, the height of the relocated noise wall has been specified as being the same as the existing wall which it is replacing.

The relocation of noise walls is generally necessary to allow the widening process of the motorway to be completed. Where the horizontal alignment of the noise walls is required to be adjusted, an optimum location has been selected (taking constructability, maintenance, access, the extent of the site boundary and drainage issues into consideration) so as to ensure that the noise wall provides the maximum noise benefit possible to the areas situated behind.

To assist in maintaining the noise environment of affected areas during the construction phase of the project, it is planned that, in locations where noise walls are required to be relocated as part of the project, the new wall will be constructed <u>prior</u> to the existing one being demolished, subject to engineering and feasibility considerations. In areas where this is to happen, an offset distance of approximately 3.5 m will need to be maintained between the new noise wall and existing noise wall to allow for construction access behind the existing wall.

There is also the requirement for a small number of new walls to be included in the design of the proposed widening scheme.

Noise Wall Design and Optimisation

The RTA's ENMM provides guidance on how to optimise the design of noise walls in terms of engineering feasibility and safety. The design of noise walls for the M2 Upgrade Project addresses the following "<u>feasibility</u>" considerations:

- Safety and access requirements
- Structural feasibility and constructability
- Drainage and access requirements
- Accommodation of shared pathways

Consideration of the following "<u>reasonableness</u>" issues have also been addressed:

- Noise level reduction
- Visual impacts
- Overshadowing
- Compatibility with local ground and architectural features
- Cost-effectiveness

Guidelines for determining the cost-effectiveness in the design process of any noise wall are provided within Practice Note iv of the ENMM. The cost-effective height of a particular noise wall is determined by first predicting sensitive receiver noise levels (within a catchment area behind the particular noise wall) for a noise wall that increases in height incrementally from zero to about 8 m.

This data is then used determine the optimum height of a particular noise wall, taking into account the total noise reduction which the wall provides to the sensitive receivers behind the wall together with the cost of the wall.

The cost-effective analysis defined within the ENMM guidelines also states the following requirements:

- Noise walls which are less than 5 m in height should generally achieve a minimum of 5 dBA noise reduction at the ground floor level to be considered cost-effective.
- Noise walls which are 5 m and above should generally achieve a minimum of 10 dBA noise reduction at the ground floor level to be considered cost-effective.
- Noise walls more than 8 m high are generally considered visually unacceptable.

All of the noise wall designs presented within this Report reflect the RTA procedures as contained within the ENMM. Detailed calculation spreadsheets were developed to control this process and are summarised within **Appendix G**.

9.7.3 Noise Wall Affected by the M2 Upgrade Project

Table 40 details each of the affected noise walls which form part of the M2 Upgrade Project and their associated reason for requiring modification. The location of all affected noise walls is also illustrated in **Appendix H**.

Table 40 Noise Walls Affected by the M2 Upgrade Project

Noise Wall Ref.	Approximate Chainage	Location	Length (m)	Reason	Height of New Noise Wall[1]
Eastbound Carriageway					
NW-E-1001	3500 – 3900	New Windsor Road off-ramp	415	Re-located	Same as existing noise wall at western end, reduced in height from 3.0 m to 2.4 m at eastern end
NW-E-1002	5100 – 5950	Barclay Road	849	Re-located/ Heightened	Same as existing noise wall for majority of wall. Increased in height from 4.2 m to 4.8 m between chainage 5400 and 5500
NW-E-1003	7600 – 7700	Westmore Drive	132	Re-located	Same as existing noise wall
NW-E-2001	10700 – 10800	Murray Farm Road	92	Re-located	Same as existing noise wall
NW-E-2002	12350 – 12500	West Tunnel Portal	134	Re-located	Same as existing noise wall
NW-E-2003	13300 – 13900	East Tunnel Portal	606	Re-located	Same as existing noise wall
NW-E-3001	14850 – 15050	Busaco Road	208	Re-located	Same as existing noise wall
NW-E-3002	16700 – 17100	Khartoum Road	399	Re-located	Same as existing noise wall
NW-E-3003	17450 – 17600	Lane Cove off-ramp	170	New	2.4 m
Westbound Carriageway					
NW-W-1001	3500 – 4000	New Windsor Road on-ramp	491	Re-located	Same as existing noise wall at western end, reduced in height from 4.0 m to 2.4 m at eastern end
NW-W-1002	5900 – 6200	Hepburn Road	287	Re-located	Same as existing noise wall
NW-W-1003	6450 – 6700	Yale Close	264	Re-located	Same as existing noise wall
NW-W-1004	6750 – 6950	RIDBC	207	Re-located	Same as existing noise wall
NW-W-1005	7000 – 7200	RIDBC	245	Re-located	Same as existing noise wall
NW-W-1006	7500 – 7650	Boundary Road	120	Re-located	Same as existing noise wall
NW-W-2001	9600 – 10150	Lamorana Avenue	560	Re-located	Same as existing noise wall
NW-W-2002	10440 – 10450	Ferndale Road	16	Re-located	Same as existing noise wall
NW-W-2003	10550 – 11150	Murray Farm Road	634	Re-located	Same as existing noise wall
NW-W-2004	11300 – 11350	Kent Street Overpass	76	Re-located	Same as existing noise wall
NW-W-2005	12350 – 12500	West Tunnel Portal	144	Re-located	Same as existing noise wall
NW-W-2006	13250 – 13650	East Tunnel Portal	417	Re-located	Same as existing noise wall
NW-W-3001	14250 – 14400	Vimiera Road	140	New	3.0 m
NW-W-3002	15250 – 15350	Culloden Road	110	Re-located	Same as existing noise wall
NW-W-3003	15700 – 16050	Christie Road	368	Re-located	Same as existing noise wall

Note 1: Noise walls are to be built from modular 0.6 m panels, therefore the noise walls are specified in 0.6 m increments.

A discussion of the noise walls within the M2 Upgrade Project Area follows. **Appendix H**, which illustrates all noise walls affected by the project, should be consulted when considering this discussion.

9.7.4 Eastbound Noise Walls

NW-E-1001 (Relocated Noise Wall on New Off-Access Ramp to Windsor Road)

As part of the M2 Upgrade Project it is proposed to provide two new west-facing access ramps at the intersection of the M2 with Windsor Road (on-access to the M2 in the westbound direction and off-access in the eastbound direction).

As a result of this, the existing noise walls on the both sides of the carriageway, which are currently located at roadside, would be required to be removed and reinstated on the outer most edge of the new access ramps.

Although the new access ramps result in a closer noise source to the first row of houses (future distances of approximately 5 m to the nearest property to the eastbound off ramp and 25 m to the westbound on access ramp) on either side of the motorway, the future noise exposure of the houses on both sides of the carriageway is predicted to reduce. The reason for this has been discussed previously in **Section 5.5.1**.

The height of noise wall NW-E-1001 is approximately inline with existing noise wall at the western end, however, as a result of less future noise exposure to the properties behind the wall being apparent, the eastern end of the noise wall, which runs up the proposed off-access slip road, is able to be slightly reduced in height. The optimised height for this section of the noise wall is 2.4 m.

The proposed new noise wall also terminates slightly earlier than the existing wall, at a point just past the last affected property.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between -4.5 dBA and +1.0 dBA.

The single 2021 Future *Design* acute property which is behind noise wall NW-E-1001, as shown in **Appendix E**, is as a result of noise from Windsor Road.

NW-E-1002 (Relocated Noise Wall - Increased in Height in Middle Section)

This noise wall is required to be displaced as part of the upgrade works as the existing batter slope, on which the wall is currently located, requires modification. The majority of the new noise wall would be at the same height as the existing wall, however as a number of acute properties in the 2021 Future *Design* scenario were predicted immediately behind the section between approximate chainage 5400 and 5500, the height of the wall in this section was optimised. This analysis showed that the noise wall is required to be increased in height from 4.2 m to 4.8 m.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between 0 dBA and +2 dBA.

The five 2021 Future *Design* acute properties which remain after the optimisation process of this noise wall are eligible to be considered for architectural treatment. This is discussed in **Section 9.7.7** of this report.

NW-E-1003 (Relocated Noise Wall)

A relatively small (about 100 m) section of wall is required to be relocated at chainage 7600 – 7700. Although a number of acute properties on Westmore Drive are predicted in the Future *Design* 2021 scenario in the vicinity of this noise wall, increasing the height of this small section of wall would not be sufficient to adequately mitigate these receivers to below the criteria.

To mitigate the noise levels which are subject to these receivers, the entire noise wall (which runs from chainage 7300 to 7700) would be required to be increased in height. As this would require an existing noise wall which is not affected by the widening works to be increased, this is rejected on a cost-effectiveness basis. A discussion on the cost-effectiveness of increasing the height of existing walls which are not affected by the upgrade works is provided in **Section 9.7.6**.

Noise Wall NW-E-1003 has therefore been specified at 4.2 m high, which corresponds to the existing height of the noise wall.

The acute properties in the vicinity of this wall are eligible to be considered for architectural treatment.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +0.5 dBA and +1.0 dBA.

NW-E-2001 (Relocated Noise Wall

There are no acute properties in the vicinity of this noise wall, therefore the height of this relocated wall has been specified as being the same as the existing noise wall which it is replacing. The existing wall is 2.4 m high at the western end, which then rises to 4.2 m at the eastern end.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1 dBA and +1.5 dBA.

NW-E-2002 (Relocated Noise Wall)

As there are only two acute properties which are immediately affected by (ie directly behind) noise wall NW-E-2002 this wall does therefore not meet the minimum requirement of three properties to trigger the need to heighten the wall any further. This relocated wall has therefore been specified at the same height as the existing wall which it is replacing. The existing wall is 4.8 m high when on cutting and 5.4 m at roadside.

The two acute properties in the vicinity of this wall are eligible to be considered for architectural treatment.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-E-2003 (Relocated Noise Wall)

No acute properties are predicted in the 2021 Future *Design* scenario behind this noise wall, and as such this relocated wall is at the same height as the existing wall. The western end of the wall is 6.0 m high which then incrementally decreases to 3.2 m at the eastern end.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between 0 dBA and +1.5 dBA.

NW-E-3001 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 1.8 m high.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +0.5 dBA and +1.5 dBA.

NW-E-3002 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 3.0 m high for the majority of this wall, with the eastern rising up to 4.2 m high.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-E-3003 (New Noise Wall)

There is currently no noise wall on the exit ramp to Lane Cove Road. The Fontenoy Road development was recently constructed and therefore no noise walls were provided in the original design of the M2 Motorway.

As exceedances are predicted in the 2021 Future *Design* scenario at these receivers, there is therefore a requirement for a new noise wall in this area to mitigate noise levels. An optimised wall with a height of 2.4 m has been found for this new noise wall.

The new noise wall is located on top of the cutting, at the edge of the M2 exit ramp to Lane Cove Road, and runs for the length of the ramp.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between -3.0 dBA and 0 dBA.

The three 2021 Future *Design* acute multi-unit buildings which are adjacent to noise wall NW-E-3003, shown in **Appendix E**, are as a result of noise from Lane Cove Road.

9.7.5 Westbound Noise Walls

NW-W-1001 (Relocated Noise Wall on New On-Access Ramp to Windsor Road)

As part of the M2 Upgrade Project it is proposed to provide two new access ramps at the intersection of the M2 with Windsor Road (on-access to the M2 in the westbound direction and off-access in the eastbound direction).

The height of noise wall NW-W-1001 is approximately inline with existing noise wall at the western end, however, as a result of less future noise exposure to the properties behind the wall being apparent, the eastern end of the noise wall, which runs along the proposed on-access slip road, is able to be slightly reduced in height. The optimised height for this section of the noise wall is 2.4 m.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between -3.5 dBA and +1.0 dBA.

NW-W-1002 (Relocated Noise Wall)

No acute properties are predicted in the 2021 Future *Design* scenario for this noise wall, and as such this relocated wall is specified at the same height as the existing wall. The existing wall is 4.2 m high.

The acute property in the vicinity of this wall is eligible to be considered for architectural treatment.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between 0 dBA and +1.5 dBA.

NW-W-1003 (Relocated Noise Wall)

As only a single acute property is predicted behind this wall in the 2021 Future *Design* scenario, increasing the height of this wall is rejected for cost-effectiveness reasons. The relocated wall is therefore specified at the same height as the existing wall which is 3.0 m high at the western end, and 5.4 m when at roadside.

The acute property in the vicinity of this wall is eligible to be considered for architectural treatment.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-W-1004 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 7.2 m high for the majority of its length.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-W-1005 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 7.2 m high.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +0.5 dBA and +1.5 dBA.

NW-W-1006 (Relocated Noise Wall)

For this noise wall only a single acute property is predicted immediately behind it in the 2021 Future *Design* scenario, and as such this relocated wall is specified as being the same height as the existing wall. The existing wall is 5.4 m high.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +0.5 dBA and +1.0 dBA.

The two acute properties in the vicinity of this wall are eligible to be considered for architectural treatment.

NW-W-2001 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 3.6 m high at the western end of the wall and 4.2 m at the eastern end.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-W-2002 (Relocated Noise Wall)

NW-W-2002 is a short 16 m length of wall that requires displacement due to the widening process. This wall is the same as the existing wall, which is 6.0m high.

NW-W-2003 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 6.0 m at the western end and 4.2 m at the eastern end.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-W-2004 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 6.0 m high.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.5 dBA and +2.0 dBA.

NW-W-2005 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 5.4 m high.

The two acute properties in the vicinity of this wall are eligible to be considered for architectural treatment.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +0.5 dBA and +1.0 dBA.

NW-W-2006 (Relocated Noise Wall)

No acute properties are predicted in the vicinity of this noise wall, and as such this relocated wall is the same height as the existing wall. The existing wall is 6.0 m high for the majority of its length.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between 0 dBA and +1.5 dBA.

NW-W-3001 (New Noise Wall)

There is currently a section of the westbound carriageway, in the vicinity of Vimiera Road, where a gap in the existing noise wall is apparent (chainage 14250 to 14450). As three acute multi-unit residences are predicted in the 2021 Future *Design* scenario, it is necessary to mitigate these receivers by filling the gap in the noise wall. The optimisation height of this wall found to be 3.0 m.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between -4.5 dBA and 0 dBA.

NW-W-3002 (Relocated Noise Wall)

As no properties are situated behind this wall, the new wall is specified as being the same as the 2.4 m existing noise wall.

A comparison of the 2021 Future *Design* noise levels with the 2011 Future *Existing* levels at properties in this location shows a predicted sensitive receiver noise level change that varies between +1.0 dBA and +1.5 dBA.

NW-W-3003 (Relocated Noise Wall)

As no acute properties are situated behind this wall, the new wall is specified as being the same as the 2.4 m existing noise wall.

9.7.6 Increasing Height of Existing Walls Which are NOT Affected by the Widening Works

In all situations where three or more 2021 Future *Design* acute properties were located behind an existing noise wall that is not affected by the physical widening works, consideration has been given to increasing the height of these walls. This process included performing the cost-effectiveness analysis which was described in the preceding section.

In all cases, the cost-effectiveness analysis rejected any further increases to the height of these existing noise walls, primarily because of the very small additional noise benefit which is provided by increasing the size of already high noise walls vs the significant costs which the modifications would incur.

The ENMM requirement that for a noise walls to be considered acceptable it should generally provide a noise reduction of at least 5 dBA was also not met.

The locations of the existing noise walls which are not affected by the project but were considered to be increased are detailed below.

Eastbound Carriageway

- Existing Windsor Road on-access slip road (chainage 4000 – 4500)
- South of Westmore Drive (chainage 7300 – 7600)
- South of Austral Avenue (chainage 9800 – 10200)

Westbound Carriageway

- Existing Windsor Road off-access slip road (chainage 4200 – 4500)
- Darling Mills Creek Bridge[1] (chainage 4500 – 4700)
- North of Williams Road (chainage 5000 – 5200)
- North of Carmen Drive (chainage 7800 – 7900)

Note 1: In addition to being rejected on the standard cost-effectiveness reasons alone, the existing noise wall on Darling Mills Creek Bridge (which is currently 1.2 m high) could also not be substantially increased in height without the bridge structure itself being rebuilt. This is due to the extra wind loading forces which would be apparent should the height of this wall be increased.

9.7.7 Residual Architectural Property Treatments

At some locations where the noise criteria are exceeded as a result of the project, the feasibility and reasonableness considerations discussed above have concluded that the construction, or modification, of noise walls is not feasible, reasonable or cost-effective.

At such locations, where residual impacts remain after all feasible and reasonable approaches have been exhausted, noise mitigation in the form of acoustic treatment for existing individual dwellings is required to be assessed.

The details of all the property treatments related to the M2 Upgrade Project are summarised in **Table 41**, noting that a “n/a” means that a property has no first floor, and that grey text represents no exceedance of the criteria at ground floor level.

Table 41 2021 Exceedance Locations[1] and Residual Architectural Property Treatments

No.	Address	Approx. Chainage	Predicted Noise Level $L_{Aeq(9hr)}$ (dBA)			
			GROUND FLOOR		FIRST FLOOR	
			2011	2021	2011	2021
1	52 Junction Road, Baulkham Hills	3350	58	59	**60**	**60**
2	1 Watkins Road, Baulkham Hills	3400	59	**60**	n/a	n/a
3	4 Craig Avenue, Baulkham Hills	3450	**62**	**63**	n/a	n/a
4	10 Craig Avenue, Baulkham Hills	3500	57	58	**62**	**62**
5	5 Linton Street, Baulkham Hills	4100	56	57	**63**	**64**
6	14 Linton Street, Baulkham Hills	4200	57	57	**60**	**61**
7	4 Petrina Crescent, Baulkham Hills	4200	**60**	**60**	**63**	**64**
8	8 Petrina Crescent, Baulkham Hills	4250	**60**	**61**	n/a	n/a
9	10 Petrina Crescent, Baulkham Hills	4300	**61**	**62**	n/a	n/a
10	12 Petrina Crescent, Baulkham Hills	4300	**60**	**61**	n/a	n/a
11	14 Petrina Crescent, Baulkham Hills	4300	**60**	**61**	n/a	n/a
12	7 Petrina Crescent, Baulkham Hills	4350	**61**	**61**	n/a	n/a
13	266 Windsor Road, Winston Hills	4000	**63**	**66**	n/a	n/a
14	262 Windsor Road, Winston Hills	4000	**63**	**67**	n/a	n/a
15	258a Windsor Road, Winston Hills	4000	These three properties are newly built two-storey multi-unit dwellings. See discussion in **Section 9.7.11**			
16	258b Windsor Road, Winston Hills	4000				
17	258c Windsor Road, Winston Hills	4000				
18	254 Windsor Road, Winston Hills	4000	**64**	**66**	**66**	**68**
19	17 Russell Street, Northmead	4300	59	**60**	n/a	n/a
20	19 Russell Street, Northmead	4300	**60**	**60**	n/a	n/a

No.	Address	Approx. Chainage	Predicted Noise Level $L_{Aeq(9hr)}$ (dBA)			
			GROUND FLOOR		FIRST FLOOR	
			2011	2021	2011	2021
21	1 Russell Street, Northmead	4300	55	57	**67**	**68**
22	2 Russell Street, Northmead	4400	59	59	**65**	**66**
23	37 Dremeday Street, Northmead	4450	59	**60**	n/a	n/a
24	39 Dremeday Street, Northmead	4450	**60**	**61**	n/a	n/a
25	41 Dremeday Street, Northmead	4450	**60**	**61**	**62**	**62**
26	42-44 Dremeday Street, Northmead[2]	4500	**62**	**63**	n/a	n/a
27	46 Dremeday Street, Northmead	4500	**65**	**66**	n/a	n/a
28	46 Roland Avenue, Northmead	4500	**60**	**61**	**61**	**62**
29	48 Roland Avenue, Northmead	4500	**60**	**61**	**61**	**62**
30	41 Williams Road, North Rocks	4950	59	**60**	**60**	**61**
31	39 Williams Road, North Rocks	4950	59	**60**	n/a	n/a
32	33 Williams Road, North Rocks	5000	59	**60**	n/a	n/a
33	31 Williams Road, North Rocks	5000	59	**60**	n/a	n/a
34	29 Williams Road, North Rocks	5100	59	**60**	**61**	**62**
35	25 Williams Road, North Rocks	5100	**61**	**62**	n/a	n/a
36	23 Williams Road, North Rocks	5150	**60**	**61**	n/a	n/a
37	21 Williams Road, North Rocks	5200	**60**	**61**	**63**	**64**
38	11 Williams Road, North Rocks	5250	57	58	59	**60**
39	8 Rajola Place, North Rocks	5300	58	59	**60**	**61**
40	93 Barclay Road, North Rocks	5250	58	59	59	**60**
41	2 Mill Drive, North Rocks	5300	58	59	59	**60**
42	122 Barclay Road, North Rocks	5400	57	57	59	**61**
43	120 Barclay Road, North Rocks	5450	58	59	**61**	**62**
44	118 Barclay Road, North Rocks	5450	58	59	**61**	**62**
45	26 Hepburn Road, North Rocks	6000	55	57	58	**60**
46	24 Yale Close, North Rocks	6500	58	59	**60**	**62**
47	14 Virginia Place, West Pennant Hills	7000	58	59	59	**60**
48	15 Wilshire Avenue, Carlingford	7400	54	55	**62**	**63**
49	13 Wilshire Avenue, Carlingford	7400	57	57	**60**	**60**
50	96 Westmore Drive, West Pennant Hills	7400	58	59	59	**60**
51	86 Westmore Drive, West Pennant Hills	7400	58	59	59	**60**
52	82 Westmore Drive, West Pennant Hills	7500	59	**60**	**60**	**61**
53	80 Westmore Drive, West Pennant Hills	7500	**60**	**61**	n/a	n/a
54	78 Westmore Drive, West Pennant Hills	7550	59	**60**	n/a	n/a
55	76 Westmore Drive, West Pennant Hills	7600	58	59	59	**60**
56	74 Westmore Drive, West Pennant Hills	7600	58	59	59	**60**
57	2 Morton Avenue, Carlingford	7600	**60**	**60**	n/a	n/a
58	53 Carmen Drive, Carlingford	7650	**61**	**62**	n/a	n/a
59	52 Carmen Drive, Carlingford	7800	58	59	59	**60**
60	50 Carmen Drive, Carlingford	7850	58	59	59	**60**
61	33 Carmen Drive, Carlingford	7850	**60**	**61**	**67**	**67**
62	31 Carmen Drive, Carlingford	7850	**61**	**62**	n/a	n/a
63	29 Carmen Drive, Carlingford	7900	**60**	**61**	n/a	n/a
64	27 Carmen Drive, Carlingford	7900	58	59	**61**	**62**

No.	Address	Approx. Chainage	Predicted Noise Level $L_{Aeq(9hr)}$ (dBA)			
			GROUND FLOOR		FIRST FLOOR	
			2011	2021	2011	2021
65	20 Lamorna Avenue, Beecroft	9450	55	56	59	**60**
66	16 Lamorna Avenue, Beecroft	9450	57	58	**60**	**61**
67	16 Austral Avenue, Beecroft	9950	58	59	59	**60**
68	18 Austral Avenue, Beecroft	9950	58	59	59	**60**
69	20 Austral Avenue, Beecroft	10000	58	59	59	**61**
70	22 Austral Avenue, Beecroft	10000	58	59	59	**60**
71	24 Austral Avenue, Beecroft	10050	58	59	59	**60**
72	28 Austral Avenue, Beecroft	10050	58	**60**	59	**60**
73	30 Austral Avenue, Beecroft	10050	**60**	**61**	**61**	**62**
74	34-2/3 Austral Avenue, Beecroft	10100	59	**60**	n/a	n/a
75	36-1/2 Austral Avenue, Beecroft	10100	57	58	59	**60**
76	36-3 Austral Avenue, Beecroft	10100	59	**60**	**60**	**61**
77	6 Ferndale Road, Beecroft	10500	56	57	**61**	**62**
78	24 Barombah Road, Epping	11700	59	**60**	n/a	n/a
79	26 Dunmore Road, Epping	11800	58	58	**61**	**62**
80	13 Stewart Close, Cheltenham	12100	52	53	**61**	**62**
81	28 Old Beecroft Road, Cheltenham	12150	54	55	**62**	**62**
82	28A Old Beecroft Road, Cheltenham	12150	51	52	**62**	**63**
83	3 Constance Close, Epping	12500	57	58	59	**61**
84	5 Callistemon Close, North Epping	12600	57	58	59	**61**
85	3A Callistemon Close, North Epping	12650	**61**	**62**	**62**	**63**
86	27 Somerset Street, Epping	12650	**62**	**63**	**63**	**64**
87	16 Sussex Street, Epping	12650	57	58	59	**60**
88	21 Sussex Street, Epping	12650	56	56	59	**60**
89	83 Devon Street, North Epping	13150	55	56	59	**60**

Note 1: Exceedances are regarded as residential receivers that are subject to "acute" noise levels (ie ≥65 dBA $L_{Aeq,15hr}$ or ≥60 dBA $L_{Aeq,9hr}$) OR the incremental impact of the project is greater than 2 dBA (and the project noise goals are exceeded).

Note 2: This property consists of a number of units and will require further investigation during the detailed design phase to determine exactly how many of the units have exceedances.

9.7.8 Properties Outside of M2 Upgrade Project Area

The widening works associated with the M2 Upgrade Project start from approximately chainage 3500 and finish at around chainage 18000. As has previously been discussed in **Section 5.5.2**, in areas where no physical works are proposed, noise mitigation is only required to be considered where the noise level change as a result of the project is more than 2 dBA.

Reference to **Appendix F** shows that all properties in areas outside of the M2 Upgrade Project Area are predicted to be subject to a noise level increase which is less than 2 dBA and do therefore not trigger the need for further mitigation to be considered as part of the M2 Upgrade Project.

Properties which are outside of the extent of the upgrade works and which currently experience acute noise levels would however be subject to the original conditions of approval for construction of the M2 Motorway and will be considered accordingly. This process would be performed separately to the proposed M2 Upgrade Project.

9.7.9 Areas of New Housing Developments

There are a number of newly built, planned or currently under construction residential developments along the route of the M2 Motorway that were unable to be included in the noise modelling exercise that has been performed to date. These locations have not been able to be included in the model because no building data for any of these developments is currently available.

5 Petrina Crescent, Baulkham Hills

A new property is currently under construction at the eastern end of Petrina Crescent in a location adjacent to the M2 Motorway. The plot is situated behind an existing noise wall and is approximately 35 m away from the carriageway.

Although construction of this property was not complete at the time of writing, it is noted that the rear facade of the development, which faces the M2 Motorway, has two storeys.

Baden Powell Place, Carlingford

An area of land, accessed from Baden Powell Place, has been designated for residential use. It is located to the south of the M2 Motorway between Yale Close and the Royal Institute for Deaf and Blind Children School. The M2 Motorway runs immediately behind this location in cutting.

It is noted that at the time of writing this report all plots in this location were vacant. The ENMM notes that *“the selection and design of noise treatment(s) for vacant land should be based on the assumption that future development will be single storey and adjacent to the building line, regardless of the number of storeys that the zoning may allow”.* As such, noise mitigation for single storey dwellings is to be assessed at this location.

Devon Street, North Epping

An area of land situated above the eastern portal of the Norfolk tunnel, accessed from Devon Street, is designated for residential land use. There are currently six premises that are in a completed, or semi completed state, with space for approximately four more dwellings available.

The constructed dwellings are noted as having two storeys.

Waterloo Road, Marsfield

A new complex of three-storey apartment type buildings is nearing completion in Marsfield, situated at the corner of Waterloo Road and Crimea Road. The development is located at the top of a cutting and overlooks the M2 carriageway.

As no building data for any of these developments is currently available they have not been included in the noise model. The assessment of these areas has therefore been performed using free field grid noise contours predicted over the area in which the developments are situated.

A +2.5 dB correction factor has been included in all the contour data calculations to allow for the conversion of free field noise level to facade levels, as required by the ECRTN.

M2 noise contours for each development are illustrated in **Appendix I**. Noise contours have been predicted at both ground floor and first floor heights where appropriate (1.5 m and 4.3 m above the local ground respectively).

Future *Design* noise levels have been predicted for the 2021 night time $L_{Aeq(9hour)}$ scenario only, as the ECRTN criterion for this assessment period is the more stringent of the criteria. The 2021 scenario includes the upgrades to the noise walls as discussed in **Table 40**. The increase in L_{Aeq} noise levels as a result of the proposal are made on the basis of the Future *Existing* (Year 2011) versus Future *Design* (Year 2021) scenarios.

The assessment of the new areas of residential development is summarised in **Table 42**. Reference is to be made to the noise contours in **Appendix I**, where the red contours can be seen to represent the "acute" noise level boundary.

Table 42 New Residential Locations

No.	Location	Storey	Future Noise Levels Above ECRTN Criteria and Incremental Impact > 2dBA?	Future Noise Levels Acute? (≥60 dBA $L_{Aeq(9hour)}$)	Additional Mitigation Identified?
1	5 Petrina Crescent, Baulkham Hills	Ground	No	**Yes**	**Yes**
		First	No	**Yes**	**Yes**
2	Baden Powell Place, Carlingford[1]	Ground	No	No	No
		First	-	-	-
3	Devon Street, North Epping	Ground	No	No	No
		First	No	No	No
4	Waterloo Road, Marsfield[2]	Ground	No	No	No
		First	No	**Yes**	**Yes**

Note 1: These plots are currently vacant, therefore only ground floors require assessment.
Note 2: This is a multi-unit building.

Reference to the above table indicates that a further two properties require architectural treatment.

9.7.10 Sensitive Land Uses

The assessment of areas of sensitive land use (schools, churches, areas of active recreation and hospitals) is discussed in the following paragraphs.

When considering sensitive land uses, the same operational criteria scenarios that have been adopted for residential receivers are applicable. Additional noise mitigation is therefore required to be assessed when either:

Scenario 1

- The predicted 2021 Future *Design* noise level exceeds the ECRTN base criteria for redeveloped roads *and* the noise level increase due to the project is greater than 2 dBA.

or

Scenario 2

- The predicted 2021 Future *Design* noise levels are acute (≥65 dBA $L_{Aeq(15hour)}$ or ≥60 dBA $L_{Aeq(9hour)}$) regardless of the incremental impact of the project

It is noted that the ECRTN base criteria for these land uses is different to that applicable to residential properties. The appropriate assessment criteria for these uses are detailed in **Table 7**.

As has previously been discussed in **Section 5.5.2**, in areas where no physical works are proposed, noise mitigation is only required to be considered where the noise level change as a result of the project is more than 2 dBA.

The following assessment includes the predicted future noise levels at each of these land uses and details.

Reference is to be made to the various grid noise maps regarding sensitive lands uses that are presented in the following appendices:

- Existing Schools – **Appendix J**
- Churches – **Appendix K**
- Active Recreation – **Appendix L**
- Hospitals – **Appendix M**

Existing Schools

The ECRTN noise goal for existing schools is a daytime $L_{Aeq(1hour)}$ noise level of 45 dBA.

It is noted that this noise criterion is based on $L_{Aeq(1hour)}$ internal noise levels. Any "internal noise level" refers to the noise level at the centre of the habitable room that is most exposed to the noise source and applies with windows sufficiently open to provide adequate ventilation (notionally an open area equal to 5% of the floor area of the room).

When considering the correlation of internal noise criteria with externally predicted levels, the following table, as taken from the RTA's ENMM, should be considered.

Table 43 ENMM Table 4.2 - Indicative Noise Reduction (adapted from FHWA 1995)

Building type	Windows	Internal noise reduction
All	Open	10 dB(A)
Light frame	Single glazed (closed)	20 dB(A)
Masonry	Single glazed (closed)	25 dB(A)
	Double glazed (closed)	35 dB(A)

Therefore, as per the ENMM guidance, when assuming the typical (conservative) reduction of 10 dBA for a partially open window, to allow for natural ventilation on the noise exposed facade, the internal ECRTN noise criterion would correspond to an external $L_{Aeq(1hour)}$ noise level at the building facade of approximately 55 dBA.

This criterion may be considered slightly conservative, since the morning and afternoon peaks of traffic will typically occur outside normal teaching hours.

Assessment of all 1-hour noise levels contained within this report has been performed using the appropriate noise corrections as derived from the unattended noise logging noise data described in **Section 6.2**, averaged during the corresponding period of the day (ie day or night).

Table 44 Assessment of Existing Schools

School	ECRTN Criteria (dBA) Daytime	Future Noise Levels Above ECRTN Criteria and Incremental Impact > 2dBA?	Future Noise Levels Acute? (≥65 dBA LAeq(15hour)	Additional Mitigation Identified?
Model Farms High School[1]	LAeq(1 hr) 45 dBA (internal)	No	-	No
Winston Hills Public School[1]		No	-	No
Our Lady of Lourdes Primary School		No	No	No
Muirfield High School		No	No	No
Royal Institute for Deaf and Blind Children School		No	No	No
Epping Heights Public School		No	No	No
Macquarie University		No	No	No

Note 1: Located outside of the M2 Project Area, therefore only incremental impact required to be assessed.

Reference to **Table 44**, the noise contours in **Appendix J**, and the 2021 Future Design façade plots in **Appendix E** concludes the following.

Model Farm High School and Winston Hills Public School

At Model Farm High School and Winston Hills Public School, which are both outside of the M2 Upgrade Project Area, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels and as such, there is no requirement for additional mitigation to be investigated.

Acute 2021 Future *Design* noise levels are not required to be assessed at these schools.

Our Lady of Lourdes Primary School

At this school, where no modification to the existing noise walls are proposed, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels, neither are the 2021 Future *Design* noise levels predicted to be acute. As such, there is no requirement for additional mitigation to be investigated.

The Royal Institute for Deaf and Blind Children (RIDBC)

At the RIDBC, widening of the M2 is proposed and there is a requirement to relocate a number of the nearby noise walls. The heights of the proposed new noise walls are noted as being in-line with the heights of the existing noise walls (7.2 m for the noise walls immediately north of the school).

The 2021 Future *Design* noise levels at this school are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels, nor are the 2021 Future *Design* noise levels predicted to be acute. As such, there is no requirement for additional mitigation to be investigated.

Notwithstanding the above, an assessment of the change in noise impacts at the RIDBC with the relocated noise walls in this location being increased in height to 7.8 m has been performed. This assessment concluded that raising the height to 7.8 m resulted in only a marginal decrease in noise (less than 0.5 dBA) and that this small noise reduction was found to be insufficient to justify the extra cost.

Epping Heights Public School

At this school, where no modification to the existing noise walls are proposed, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels, neither are the 2021 Future *Design* noise levels predicted to be acute. As such, there is no requirement for additional mitigation to be investigated

Macquarie University

At this school, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels, neither are the 2021 Future *Design* noise levels predicted to be acute. As such, there is no requirement for additional mitigation to be investigated

It is noted that situated between the M2 corridor and the relevant Macquarie University campus buildings is a relatively busy section of Talavera Road, to the west of Christie Road. This section is not itself subject to upgrading as part of the new on/off ramps which form part of the M2 Upgrade Project.

Places of Worship

The ECRTN noise goal for places of worship is an internal $L_{Aeq(1hour)}$ noise level of 40 dBA. This applies to both the day and night-time periods.

Again, to adequately assess internal noise levels from those predicted externally, a conservative noise reduction of 10 dBA has been applied to allow for windows along the noise exposed facade being partially open (as defined within the ENMM). This corresponds to an external $L_{Aeq(1hour)}$ noise level at the building facade of approximately 50 dBA.

It is noted that, on average, the assessed 1-hour peak daytime noise levels are approximately 3 dBA higher than the night-time peak level and as such, the daytime is considered to be the governing criteria. This is as would be expected for road traffic generated noise, where the highest daytime peak hours (corresponding to either the morning or evening rush hours) experience far greater traffic volumes, and subsequently higher noise levels, than the night-time peak hours.

One place of worship has been identified as being affected by the M2 Upgrade Project. This is detailed in **Table 45** below. The relevant noise contours are presented in **Appendix K**.

Table 45 Assessment of Places of Worship

Place of Worship	ECRTN Criteria (dBA)		Future Noise Levels Above ECRTN Criteria and Incremental Impact > 2dBA?	Future Noise Levels Acute? (≥60 dBA $L_{Aeq(9hour)}$	Additional Mitigation Identified?
	Daytime	Night-time			
Our Lady of Lourdes Church	$L_{Aeq(1 hr)}$ 40 dBA (internal)	$L_{Aeq(1 hr)}$ 40 dBA (internal)	No	No	No

Note 1: The ECRTN defines the Daytime as 07.00 am to 10.00 pm and the Night-time as 10.00 pm to 07.00 am

At Our Lady of Lourdes Church, where no modification to the existing noise walls are proposed, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels, neither are the 2021 Future *Design* noise levels predicted to be acute. As such, there is no requirement for additional mitigation to be investigated

Inspection of the surrounding area to the church grounds also concludes that a 4.2 m noise wall is already in place along the site boundary on the sides that face towards the M2 motorway.

Areas of Active Recreation

A number of areas where active recreation occurs have been identified. These are listed in **Table 46**, and illustrated on the noise contours contained **Appendix L**.

Table 46 Assessment of Areas of Active Recreation

Area of Active Recreation	ECRTN Criteria (dBA) Daytime	Future Noise Levels Above ECRTN Criteria and Incremental Impact > 2dBA?	Future Noise Levels Acute? (≥65 dBA $L_{Aeq(15hour)}$)	Additional Mitigation Identified?
Gooden Reserve[2]	Freeway / Arterial Roads: $L_{Aeq(15 hr)}$ 60 dBA	No	-	No
Max Ruddock Reserve[2]		No	-	No
Muirfield Golf Course		No	No	No
Pennant Hills Golf Course		No	No	No
Cheltenham Oval		No	No	No
Epping Oval Athletics Track		No	No	No
Jim Campbell Field		No	No	No
Roger Sheeran Oval		No	No	No
Christie Park		No	No	No

Note 1: The ECRTN defines the Daytime as 07.00 am to 10.00 pm and the Night-time as 10.00 pm to 07.00 am

Note 2: Located outside of the M2 Project Area, therefore only incremental impact required to be assessed.

The assessment of areas of active recreation shows that at all locations, the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels. The 2021 Future *Design* noise levels at the locations which are within the M2 Project Area are also not predicted to be acute. As such, there is no requirement for additional mitigation to be investigated.

It is also noted that in these areas no alteration of the existing noise walls is proposed as part of the M2 Upgrade Project.

Hospital Wards

The ECRTN noise goal for hospital wards is an internal $L_{Aeq(1hour)}$ noise level of 35 dBA. This applies to both the day and night-time periods.

One hospital has been identified as being affected by the M2 Upgrade Project - the Macquarie University Hospital. At the time of writing, it is anticipated that Macquarie University Hospital will open in the first half of 2010.

As the hospital buildings at the Macquarie University Hospital will be newly constructed it has been assumed that mechanical ventilation will be provided to all ward rooms and hence there would be no requirement to open windows. A conservative external to internal noise reduction of 20 dBA has therefore been applied which results in an external $L_{Aeq(1hour)}$ noise level at the building facade of approximately 55 dBA.

The location of the hospital is highlighted in red in **Figure 22**

Figure 22 Location of Macquarie University Hospital

Image Courtesy of Google Earth

It is noted that the Macquarie University Hospital is located near to proposed upgrade of the Christie Road interchange. The upgrade works include:

- A new eastbound on-ramp to the M2 Motorway at Christie Road
- Widening of the Christie Road Bridge and Talavera Road (between Christie Road and Herring Road)

The assessment of Macquarie University Hospital is detailed in **Table 47**, and illustrated on the noise contours contained **Appendix M**.

It is noted that re-surfacing of the Christie Road and Talavera Road intersection would be completed as part of the upgrade works. To be consistent with the main operational assessment, no correction factor has been applied to the re-surfaced Future *Design* model.

Table 47 Assessment of Hospitals

Hospital Ward	ECRTN Criteria (dBA)		Future Noise Levels Above ECRTN Criteria and Incremental Impact > 2dBA?	Future Noise Levels Acute? (≥60 dBA $L_{Aeq(9hour)}$)	Additional Mitigation Identified?
	Daytime	Night-time			
Macquarie University Hospital	$L_{Aeq(1 hr)}$ 35 dBA (internal)	$L_{Aeq(1 hr)}$ 35 dBA (internal)	No	No	No

Note 1: The ECRTN defines the Daytime as 07.00 am to 10.00 pm and the Night-time as 10.00 pm to 07.00 am

The above assessment of the potential noise impacts at the Macquarie University Hospital indicates that the 2021 Future *Design* noise levels are not predicted to rise by more than 2 dBA over the 2011 Future *Existing* levels. As the 2021 Future *Design* noise levels are also not predicted to be acute, there is no requirement for additional mitigation to be investigated

9.7.11 Upgrade to Alignment at Windsor Road Intersection

As part of the M2 Upgrade Project it is proposed to add two additional on/off access ramp at the Windsor Road Intersection with the M2 Motorway. The current junction layout will therefore be required to be significantly altered to allow efficient access to and from the M2.

The properties that are located on Windsor Road in the vicinity of the proposed eastbound off-access ramp are of sufficient distance to not be affected to the realignment of this side of the intersection, however, the proposed layout for the westbound on-access ramp (to the immediate south of the junction) has the potential to impact on the residential receivers in this vicinity as they are situated much closer.

There are a number of properties of Windsor Road which are likely to be affected by the alignment change. Currently the buildings are set back by approximately 10 m to 15 m from Windsor Road. The proposed re-alignment would bring the road to within approximately 5 m to 10 m of some of the properties.

It is noted that three of the affected properties are multi-unit buildings (258 Windsor Road). These three multi-unit residencies are noted as being recently constructed and were not able to be included within the noise model. Assessment of noise impact due to the re-alignment of the Windsor Road junction has therefore been performed using noise contours at their footprint location.

The various contours are illustrated in **Appendix N**. Noise contours have been predicted at both ground floor and first floor heights (1.5 m and 4.3 m above the local ground respectively).

Future *Design* noise levels have been predicted for the 2021 night time $L_{Aeq(9hour)}$ scenario only, as the criterion for this assessment period is the more stringent of the criteria. The 2021 scenario includes the upgrades to the noise walls as discussed in **Table 40**.

A +2.5 dB correction factor has been included in all the contour data calculations to allow for the conversion of free field noise level into facade levels, as required by the ECRTN.

Reference to the grid noise within **Appendix N** shows that Future *Design* noise levels for six properties in the immediate vicinity of the re-alignment at Windsor Road are predicted to be acute (ie >60 dBA $L_{Aeq(9hour)}$). As these properties are directly accessed from Windsor Road and the construction of a noise wall is subsequently not feasible, these properties are therefore to be considered for property treatment mitigation (and have been include in **Table 41 – "2021 Exceedance Locations and Residual Architectural Property Treatments")**.

It is noted that 266 Windsor Road, which is affected by the re-alignment of the intersection, is a heritage listed building.

9.7.12 Secondary Roads – Potential Noise Impacts

As the M2 Upgrade Project has the potential to create additional traffic flows on the secondary roads which intersect with the M2, an assessment of the likely impacts resulting from this has been completed. The roads which form part of this assessment include:

- Windsor Road
- Pennant Hills Road
- Beecroft Road
- Lane Cove Road

It is noted that impacts from the alterations to Christie Road, Herring Road and Talavera Road form part of the main assessment.

A comparison of the 2011 Future *Existing* and the 2021 Future *Design* traffic volumes has been undertaken to determine the potential noise increase. This assessment found that the highest increase was apparent on Windsor Road (as a result of the new west facing access ramps) where a 14 % increase for the 2021 traffic flows is anticipated. This equates to a marginal noise level increase of around 0.6 dBA.

9.7.13 Sleep Disturbance Assessment

When assessing short term maximum noise levels from the M2 Upgrade Project, the current sleep disturbance guidelines used in NSW have been considered (refer to **Section 5.5.3**).

A review of research on sleep disturbance in the ECRTN indicates that in some circumstances, higher noise levels may occur without significant sleep disturbance. Based on studies into sleep disturbance, the ECRTN concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions.
- One or two noise events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

It is generally accepted, that internal noise levels in a dwelling, with the windows partially open, are 10 dBA lower than external noise levels (refer to **Table 43**). Based on a worst case minimum attenuation with windows partially open, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions.

The ENMM therefore defines a maximum noise event as any passby for which:

- The L_{Amax} noise level exceeds the $L_{Aeq(1hour)}$ noise level by at least 15 dBA *and* is in excess of 65 dBA.

As there is potential for heavy vehicles to use compression braking to slow upon exiting the M2 Motorway at the location of the proposed new eastbound Windsor Road off-access slip road, a maximum noise level assessment has been performed in this location.

Background noise monitoring to determine the existing amount of maximum noise events was completed at 3 Horwood Avenue, Baulkham Hills, on the evening of 9 February 2010. **Table 48** summaries the results of this noise monitoring.

Table 48 Maximum Noise Level Assessment

Date	Time Period	Measured Noise Level $L_{Aeq(1hour)}$ (dBA)	Number of Maximum Noise Events per Hour
09/02/2010	22:00 – 22:59	56.7	6
	23:00 – 23:59	56.1	12
10/02/2010	00:00 – 00:59	53.2	10
	01:00 – 01:59	53.9	9
	02:00 – 02:59	53.9	16
	03:00 – 03:59	55.6	3
	04:00 – 04:59	58.4	8
	05:00 – 05:59	60.1	4
	06:00 – 06:59	58.9	4
		TOTAL NUMBER OF MAXIMUM NOISE EVENTS	**72**

Results of the analysis of the maximum noise levels show that a maximum noise event (as defined within the ENMM) occurred a total of seventy two times at 3 Horwood Avenue, over the night of monitoring. The measured L_{Amax} maximum noise level events varied between 68 dBA and 81 dBA.

Maximum Noise Level Assessment - Discussion

The assessment of maximum noise levels which are subject to the receivers in the vicinity of the proposed eastbound Windsor Road off-access ramp concludes the following:

- The traffic data for the M2 Upgrade Project as supplied to Heggies shows an increase in traffic (2011 Future *Existing* and 2021 Future *Design*) on the M2 Motorway carriageway in this location which equates to a noise level increase of around 1 dBA. The mix of light and heavy vehicles is noted as remaining the same.
- However, the construction of the proposed new Windsor Road off-access ramp is expected to result in a reduction in L_{Aeq} noise levels at the sensitive receivers situated in the vicinity as a result of the proposed access ramp being required to be built up and hence effectively acting as a noise barrier to the road traffic on the main M2 carriageway (which is the dominant source of noise). This has previously been discussed in **Section 5.5.1** and **9.7.4**.
- Sensitive receiver L_{Aeq} noise level reductions of around 2 dBA to 4 dBA have therefore been predicted between the 2011 Future *Existing* and 2021 Future *Design* scenarios in this location.
- The noise barrier effect of the new Windsor Road (west-facing) ramps will induce a comparable reduction for 2021 Future *Design* L_{Amax} noise levels associated with road traffic on the main M2 Carriageway. As such, the number of maximum noise events associated with heavy vehicles travelling on the main carriageway in this location is anticipated to either remain the same or potentially reduce slightly as a result of the additional attenuation provided by the construction of the proposed off-access ramp.
- The proposed off-access ramp would however bring vehicles (using the off-access ramp) closer to the sensitive receivers in this location: 3 Horwood Avenue is currently ~25 m from the carriageway, the distance from the proposed access ramp to this property would be ~15 m. Although the heavy vehicles on the proposed off-ramp are predicted to be an order of magnitude less than the number of heavy vehicles on the main M2 carriageway, their proximity to the nearest receivers to the north suggests there is potential for the number of maximum noise level events associated with heavy vehicles exiting the M2 via the proposed eastbound off-access ramp to increase slightly compared to current conditions.

9.7.14 Staged Re-Opening of M2 – Operational Impacts

A staged re-opening process is anticipated for the M2 Upgrade Project, occurring in the following manner:

- New west-facing Windsor Road access ramps and tolls – to be operational 14 to 15 months after start of construction.
- New Christie Road and Herring Road access ramp and tolls, including Talavera Road widening – to be operational 21 months after start of construction.
- Widening of Western Zone (Zone 1) from Windsor Road to Pennant Hills Road (including the re-sheeting of the main carriageway) – to be operational 15 to 18 months after start of construction.

The remaining sections of the upgrade works are expected to be completed and then re-opened around 24 months after the construction works commence.

As indicated above, when the construction or upgrade of a particular section of the M2 Motorway is completed, it is expected that it will be fully re-opened to normal operational traffic flow.

Operational Impacts

As the re-opening of a particular section of the M2 would only occur after all the works associated with that section have been completed, it is therefore anticipated that no adverse sensitive receivers noise impacts will be apparent at locations where staged re-opening occurs. For example, in the case of the new Windsor Road west-facing access ramps, the proposed noise walls for these ramps will be in place at the time of the opening of this component of the upgrade works.

9.7.15 Signage to Limit Use Compression Braking by Heavy Vehicles

As the M2 Motorway is subject to significant volumes of heavy vehicles which have the potential to cause noticeable sensitive receiver noise impacts, a suitable strategy to help mitigate heavy vehicle noise may include the erection of signage which attempts to target the inappropriate use of engine/compression brakes.

Some success has previously been achieved on certain major arterial routes in NSW with the use of such signage to promote awareness of their use in residential areas. The newly proposed Windsor Road west-facing access ramps are locations where this could considered.

9.7.16 Bridge Expansion Joints

The M2 Upgrade Project would require modifications to several of the existing bridges which form part of the current alignment. As the impulsive noise from expansion joints in bridges can create significant localised impacts, it is therefore recommended that where expansion joints require replacement or modification as part of the M2 Upgrade Project, the selecting of suitable components should consider the potential noise generating characteristics in an attempt to minimise the impact on the sensitive receivers which are, in some location, situated in very close proximity to some of the bridge joints.

9.7.17 Norfolk Tunnel Widening - Operational Impacts

As part of the M2 Upgrade Project, it is proposed to widen both directions of the existing Norfolk Tunnel to provide an additional lane in the eastbound direction and upgraded lanes in the westbound direction.

Reference to the 2021 Future *Design* facade maps in **Appendix E** concludes that two ground floor and seven first floor properties are predicted to be acute and are therefore eligible for consideration for property treatment. All such properties have previously been identified in **Table 41 – "2021 Exceedance Locations and Residual Architectural Property Treatments"**.

In is however noteworthy that the difference plots in **Appendix F** show that these properties are not subject to an increase of more than 2 dBA as a result of the project.

It is further noted that no additional noise generating equipment (ie additional exhaust fans) is proposed as part of the tunnel upgrade works.

9.8 Stationary Noise Impacts from Mechanical Plant

The only mechanical plant items associated with the M2 Upgrade Project are the exhaust fans located in the Norfolk Tunnel. The exhaust fans are attached in pairs to the centre of the crown of the roof of each of the tunnels.

9.8.1 Noise Goals

Based on Industrial Noise Policy criteria as detailed in **Section 5.6**, **Table 49** presents the calculated RBL and ambient L_{Aeq} noise levels, along with the resulting intrusive and amenity noise goals for a representative residential receiver based on the “suburban area” classification.

The $L_{Aeq(15minute)}$ design noise goal is the *lower* of the intrusive and amenity goals and has been included in the table in bold face type.

Ambient noise level data was measured at both 4 Somerset Street and 56 Somerset Street, which are in the vicinity of the western and eastern tunnel portals respectively. The monitoring at 56 Somerset Street has been used in the following assessment as it was found to have lower ambient levels of noise.

Table 49 Calculated RBL and Ambient L_{Aeq} Noise Levels for Norfolk Tunnel Locations

Location	Period[1]	Recommended LAeq Noise Level[2]	Measured RBL[3]	Measured LAeq	Intrusive Criterion	Amenity Criterion
56 Somerset Street, Epping	Day	55	49	54	54	**49**
	Evening	45	45	51	50	**41**
	Night	40	33	49	**38**	39

Note 1: DECCW Governing Periods are - Day: 7.00 am to 6.00pm, Evening: 6.00pm to 10.00pm, Night: 10.00pm to 7.00 am

Note 2: Criteria are for Residences in a Suburban Area

Note 3: Rounded to nearest dB

The operation of the existing Norfolk Tunnel exhaust fans were noted by the Heggies Technician as not being audible at the logger location detailed above.

9.8.2 Noise Impact Assessment

Detailed noise emission calculations for the proposed exhaust fans have been performed and assessed against the EPA’s *“NSW Industrial Noise Policy”* (2000). The noise modelling of the mechanical plant has been carried out using the SoundPLAN V6.5 suite of acoustics software using the CONCAWE prediction model.

The assumptions used within this analysis include the following:

- A representative sound power level of approximately 85 dBA per (silenced) fan-pair has been assumed based on several previous studies carried out recently by Heggies.
- As each tunnel portal will have one fan-pair per carriageway, noise levels are assessed on the basis of two exhaust fan-pairs per carriageway.
- The exhaust fans will operate on a continuous basis for the 15 minute assessment period.
- The nearest affected residential receiver to either of the tunnel portals is 3A Constance Close and is approximately 60 m away from the end of the western portal.
- The noise model incorporates all the proposed changes which would form part of the M2 Upgrade Project (ie updated motorway alignment, altered cuttings and batter slopes, altered noise walls, etc), as described in the preceding sections of this report

Table 50 summaries the calculations related to exhaust fan noise emissions assessed at the nearest critical receiver to the tunnel portals.

Table 50 Norfolk Tunnel Noise Emission Calculations

Computation Item	LAeq Noise Level
Sound Power Level LAeq noise emission for a single fan (x2)	85 dBA
Noise level target (day, evening, night)	49 dBA, 41 dBA, 38 dBA
Predicted LAeq noise level at nearest receptor	31 dBA

Noise levels have been predicted to be below the target noise levels.

9.9 Vibration

Heggies has previously monitored vibration levels due to heavy vehicle traffic. Vibration levels of up to 0.4 mm/s were measured in a range of different geotechnical conditions (ie varying soil types) at a distance of approximately 10 m from the road.

Vibration generated from vehicles (in particular heavy vehicles) travelling along the M2 Motorway – main carriageway, on/off ramps and the Norfolk Tunnel – is therefore not expected to give rise to levels of vibration exceeding the daytime or night-time human comfort criteria recommended in AS 2670.

This is subject to regular maintenance of the roadway to repair any significant potholes, etc, as they occur.

10 CONCLUSION

The purpose of this report is to assess the potential noise and vibration emissions associated with the construction and operation of the proposal. Based on the proposed road alignment, this report identifies the principle areas where noise or vibration mitigation is considered likely to be required.

Construction Noise and Vibration

The M2 Upgrade Project represents a major infrastructure development project, constructed over two years, and as such there would be periods when impacts on the surrounding areas are expected. As it will be necessary for the motorway to, at least partly, remain open during the daytime, works would often be required to be conducted during the less busy night-time period.

At any particular location, the potential noise and vibration impacts can vary greatly depending on factors such as the relative proximity of noise-sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration emissions, the time at which the construction works are undertaken and the character of the noise or vibration emissions.

Notwithstanding the above, it is anticipated that compliance with the daytime Noise Management Levels (NMLs) is typically predicted as a result of the already high ambient noise environment along the route of the M2 Motorway. However, during the evening and night-time periods, higher exceedances are predicted, where sensitive receivers are situated in close proximity to the proposed construction works, as a result of the lower NMLs. Careful management will therefore be required at the nearest receivers.

In general, vibration produced by earthworks and road forming operations is expected to lie below structural damage criteria. Where vibration-intensive operations are being conducted in close proximity to the buildings nearest to the roadworks (eg construction of the Windsor Road Ramps), judicious selection of plant and equipment will be necessary.

At the locations of the Site Compounds, the predicted levels are expected to exceed the NMLs where receivers are situated close by and no natural shielding is apparent. To adequately mitigate the impacts, feasible mitigation measures could include the use of 3 m to 6 m high temporary perimeter noise walls. The exact requirement for these would be investigated in more detail as the project progresses.

During the widening of the Norfolk Tunnel both airborne and ground-borne noise has the potential to exceed the appropriate criteria at times. The potential noise impacts from the widening works which will be performed entirely within the tunnel will be mitigated with the use of acoustic sheds during the excavation of the tunnel, together with an acoustic curtain at either end of tunnel at other times. The acoustic shed will only be in place for the excavation phase of the widening. All other night-time works within the tunnels will have a noise curtain in place at the portal entrances.

For the early widening works (ie adjustment to the portal transition areas and breaking out of existing concrete barriers) there would be limited mitigation measures, as the options for physical noise attenuation devices and procedural management measures (such as scheduling of activities) would either not be effective or are not feasible.

It is recommended that where exceedances are indicated, suitable consultation with the affected land owners should take place to determine the appropriate feasible and reasonable management strategies, together with monitoring to confirm the predicted levels.

A detailed Construction Noise and Vibration Management Plan (CNVMP) would be appropriate to address the potential noise and vibrations impacts associated with construction of the proposed M2 Motorway Upgrade Project. The mitigations measures and strategies outlined in this assessment should be considered for inclusion in that management plan.

Operational Noise

The operational noise assessment was undertaken in accordance with the Environmental Criteria for Road Traffic Noise and the RTA's Environmental Noise Management Manual. These documents provide non-mandatory noise criteria for redevelopment of existing roads, and highlight processes for determining where the potential noise impacts would require the need for additional mitigation measures to be investigated.

With the incorporation of the mitigation measures as discussed in this report, the future noise levels resulting from the M2 Upgrade Project at the majority of sensitive locations do not exceed the criteria relevant to the project and consequently no further assessment of mitigation measures is required at these locations. Where residual exceedances are apparent, architectural building treatments would also be required.

When determining appropriate strategies to address potential operational noise issues, preference has been given to the use of noise walls, where feasible and reasonable, over architectural treatment of properties to mitigate sensitive receiver noise levels.

An optimisation process (including a cost-benefit analysis) has been undertaken when designing the noise walls for the M2 Upgrade Project using the approach outlined in the RTA's ENMM. All of the noise wall designs presented within this Report therefore reflect these RTA procedures. The need for architectural treatment to address residual exceedances of the adopted noise objectives has been considered as part of the optimisation process. A total of 91 properties have been identified as requiring consideration for architectural treatment. Architectural treatment would however be subject to feedback from the community consultation process which would be performed as part of the detailed design phase of the project.

Furthermore, the final mix of the selected noise mitigation strategies will be determined after the opinions of the local affected community have been consulted. The local affected community might prefer (on aesthetic grounds) a different option mix of noise barriers and property treatment than has been proposed in this assessment. The benefits of community preferred options would then need to be considered in light of additional factors such as future noise levels in the affected area and changes in land use in the local area.

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

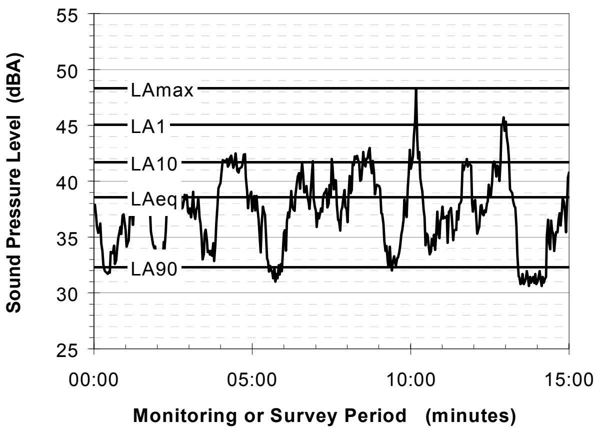
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as transportation noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

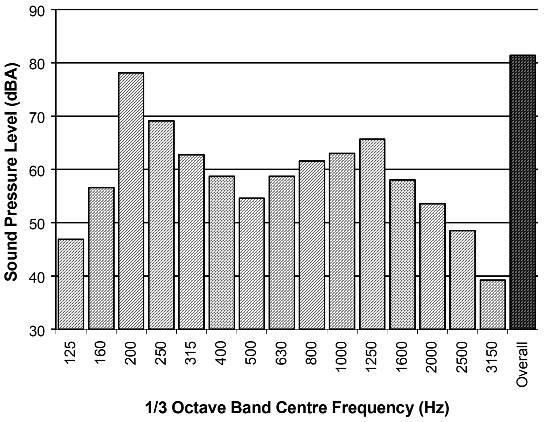
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

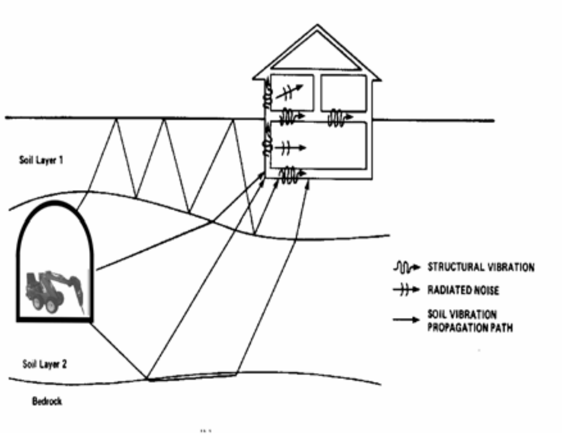
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

Appendix B
Report 10-7434R1

Site Plan

75 mm ON ORIGINAL

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

REV.	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	Jan 2010		ALW	PG

0 60 120
Scale = 1:6000

LEGEND:

S1-1 Noise Logger Location

01 Construction Noise Catchment Area

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

FILE NAME
10-7434R1 Appendix B - Site Plan.dwg

10-7434 M2 Upgrade Project
Site Plan
Page 1 of 4

DRAWING No.
10-7434_Site Plan

REVISION
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REV.	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	Jan 2010		ALW	PG

Scale = 1:6000 (0, 60, 120)

75 mm ON ORIGINAL

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- S1-1 Noise Logger Location
- 01 Construction Noise Catchment Area

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimile 02 9427 8200

FILE NAME: 10-7434R1 Appendix B - Site Plan.dwg

10-7434 M2 Upgrade Project
Site Plan
Page 2 of 4

DRAWING No.: 10-7434_Site Plan

REVISION: 0

75 mm ON ORIGINAL

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REV.	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	Jan 2010		ALM	PG

0 60 120

Scale = 1:6000

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Email address sydney@heggies.com.au
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FILE NAME
10-7434R1 Appendix B - Site Plan.dwg

10-7434 M2 Upgrade Project
Site Plan
Page 3 of 4

DRAWING No.
10-7434_Site Plan

REVISION
0

75 mm ON ORIGINAL

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REV.	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	Jan 2010		ALM	PG

Scale = 1:6000 (0, 60, 120)

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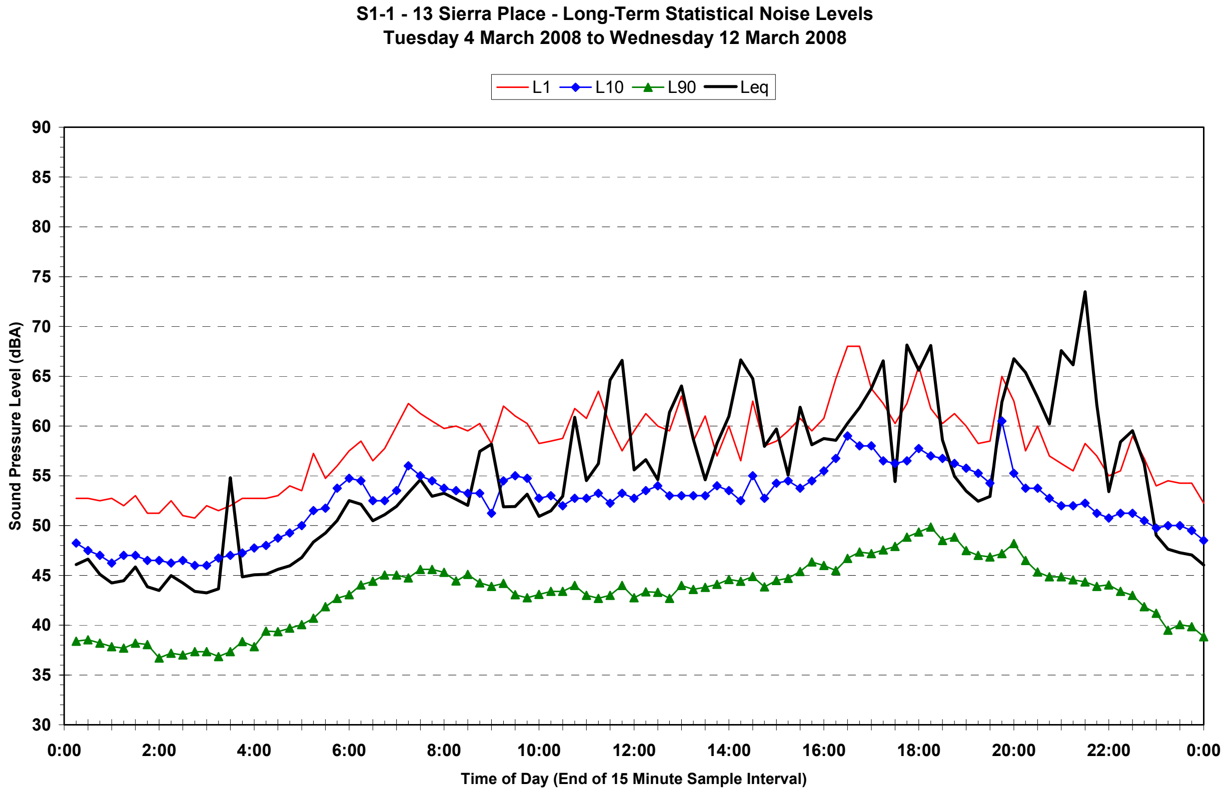
Site Plan
Page 4 of 4

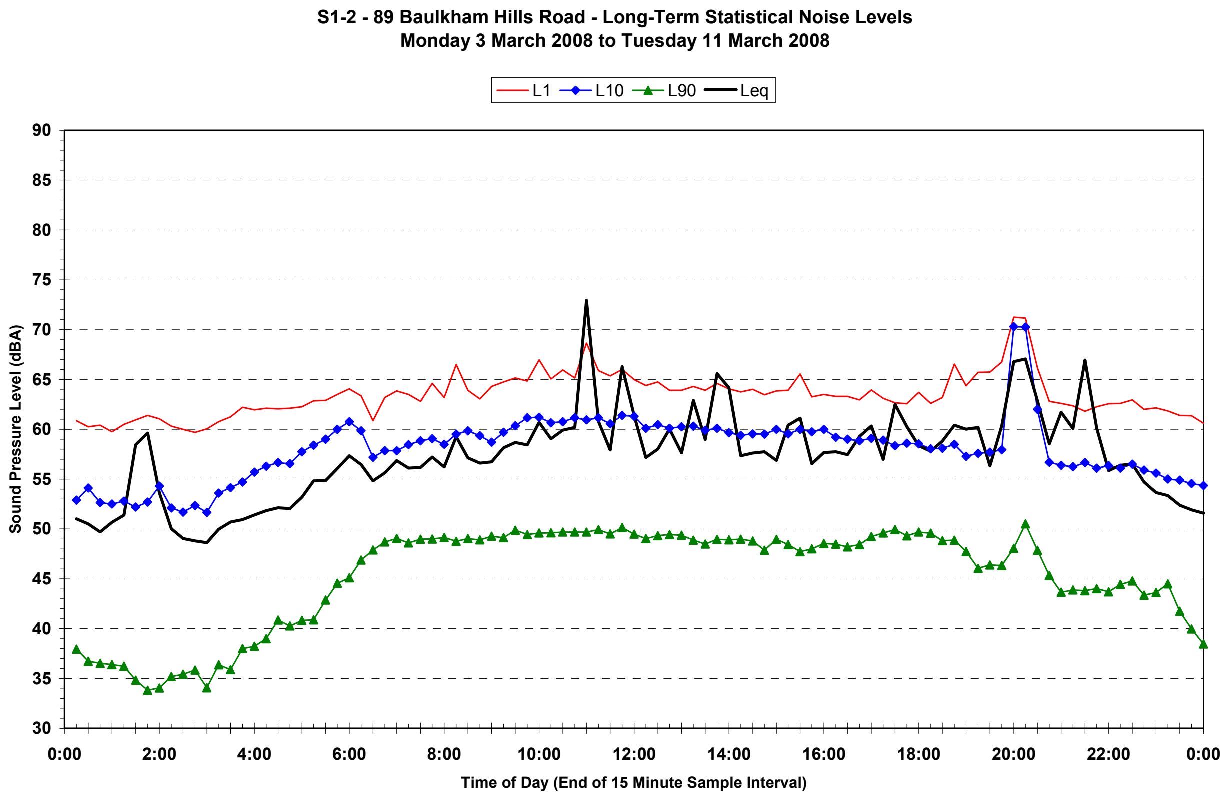
FILE NAME: 10-7434R1 Appendix B - Site Plan.dwg

DRAWING No.: 10-7434_Site Plan

REVISION: 0

Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)





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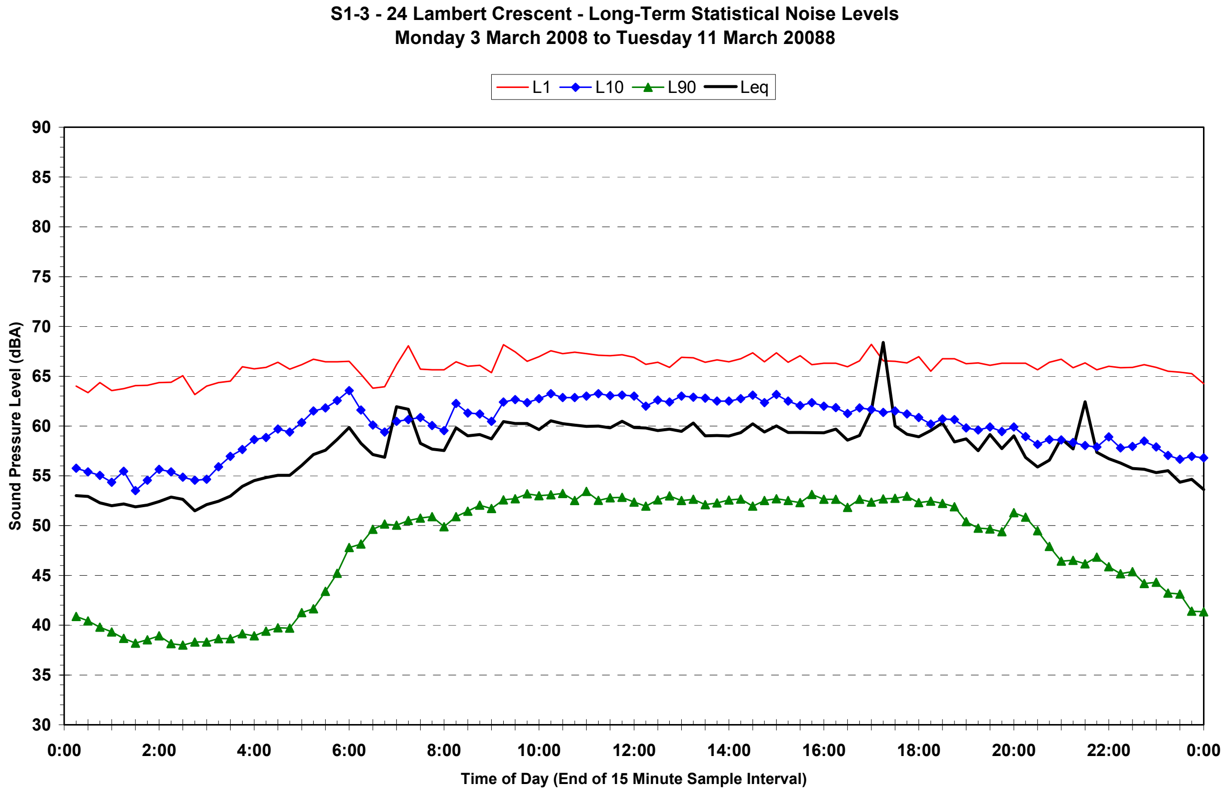
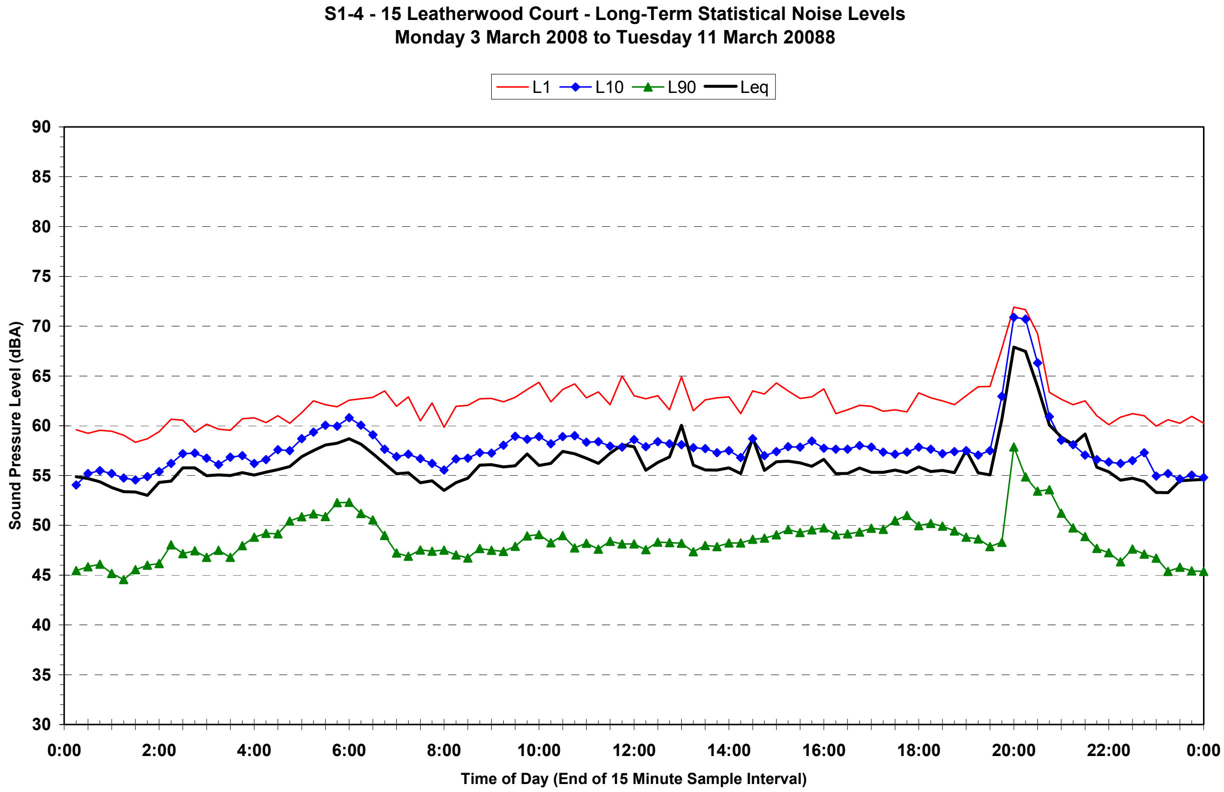
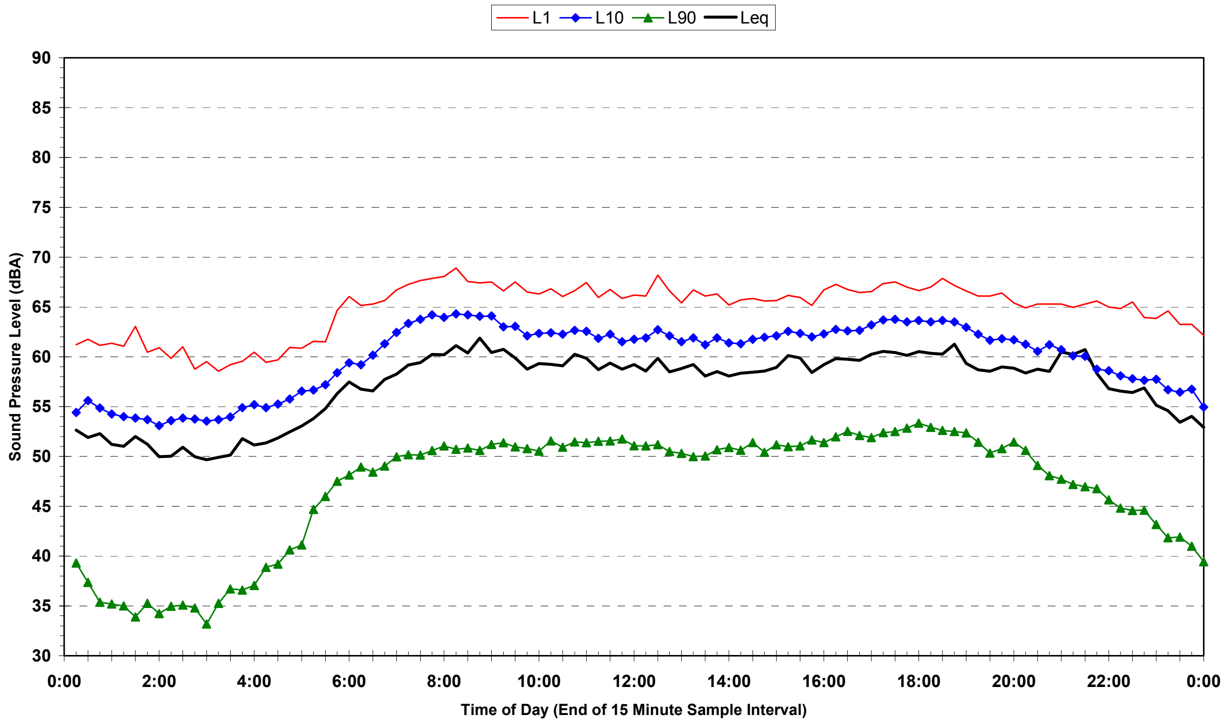


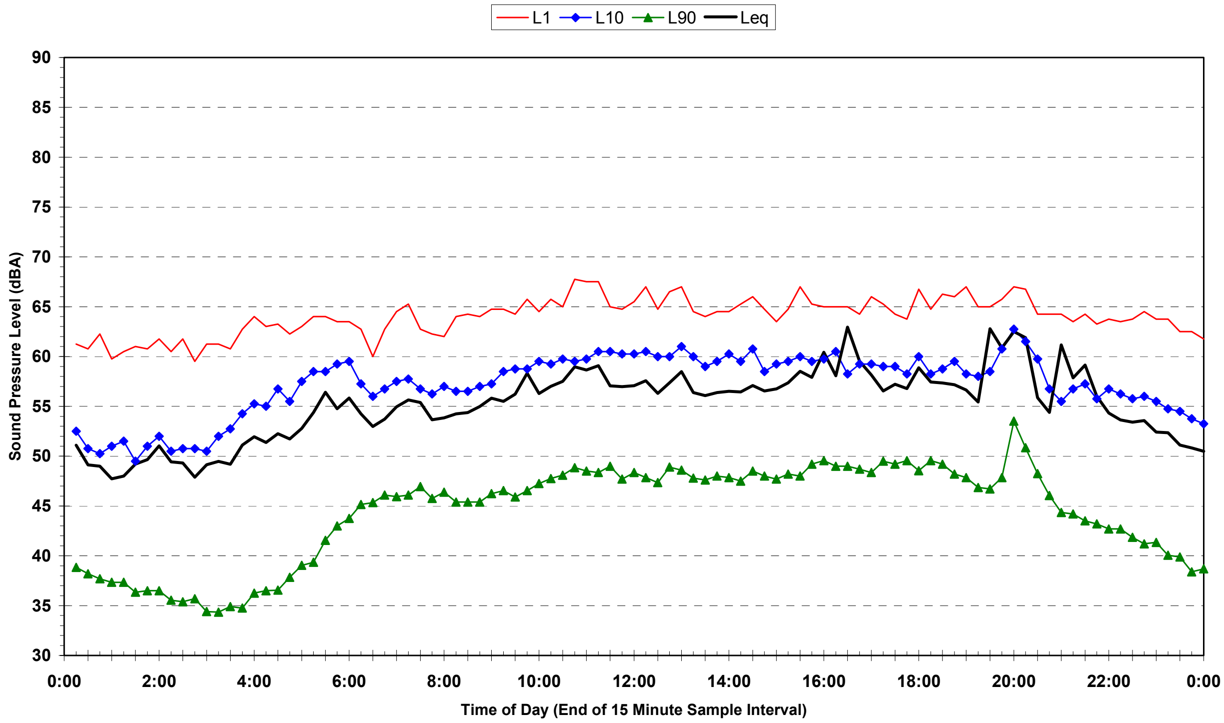


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

S1-5 - 108 Junction Road - Long-Term Statistical Noise Levels
Monday 3 March 2008 to Tuesday 11 March 2008



S1-6 - 17 Livingstone Avenue - Long-Term Statistical Noise Levels
Tuesday 4 March 2008 to Wednesday 5 March 2008



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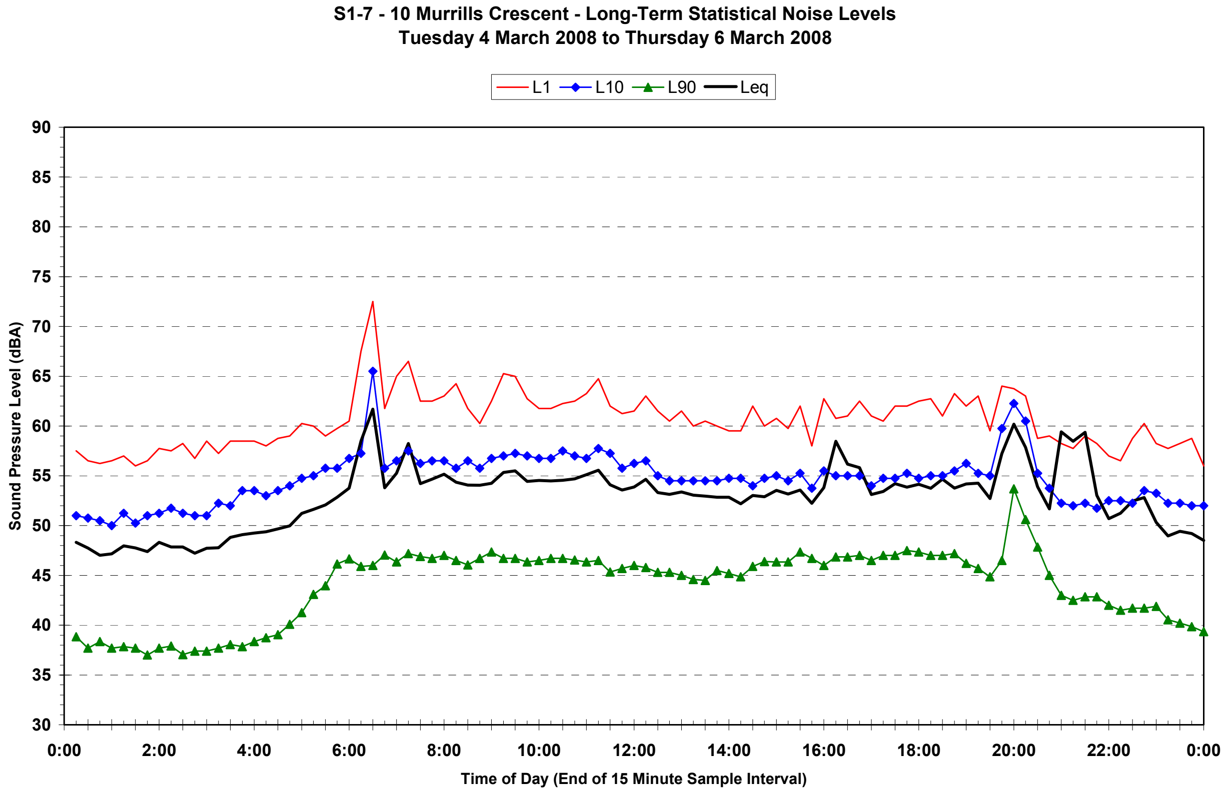

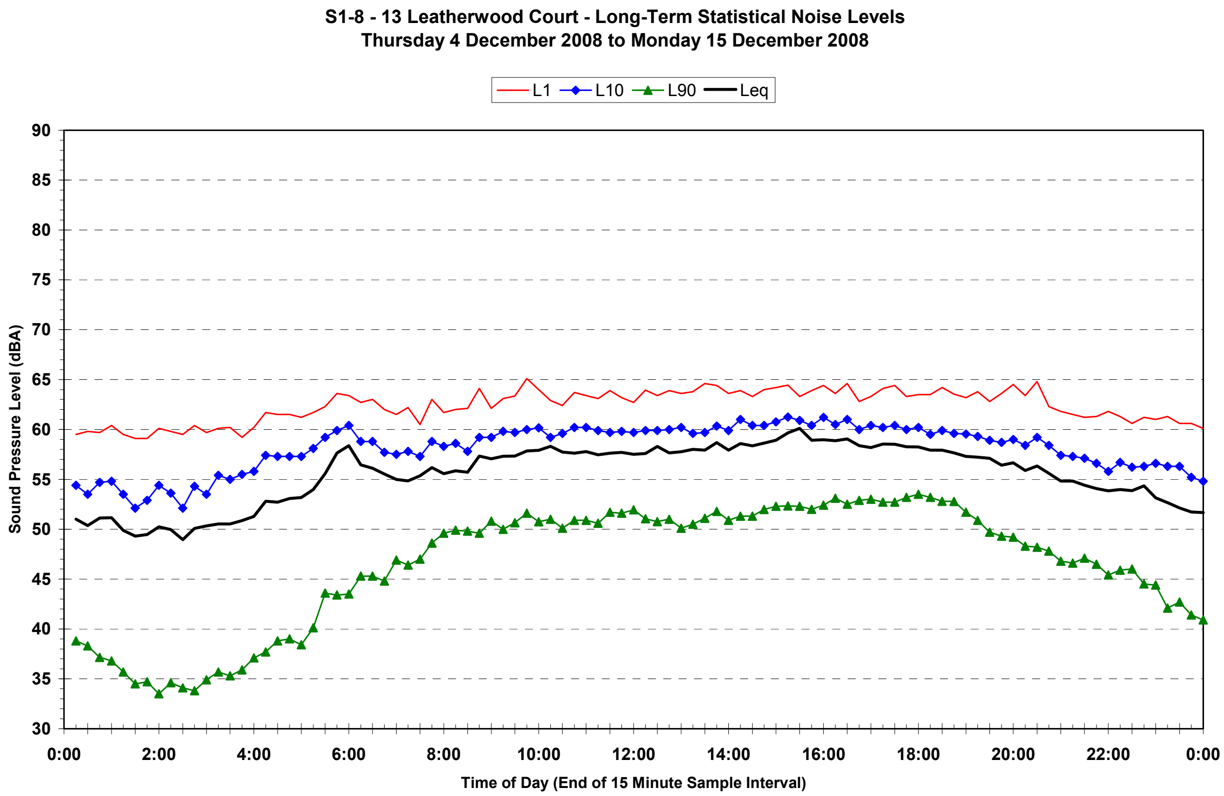

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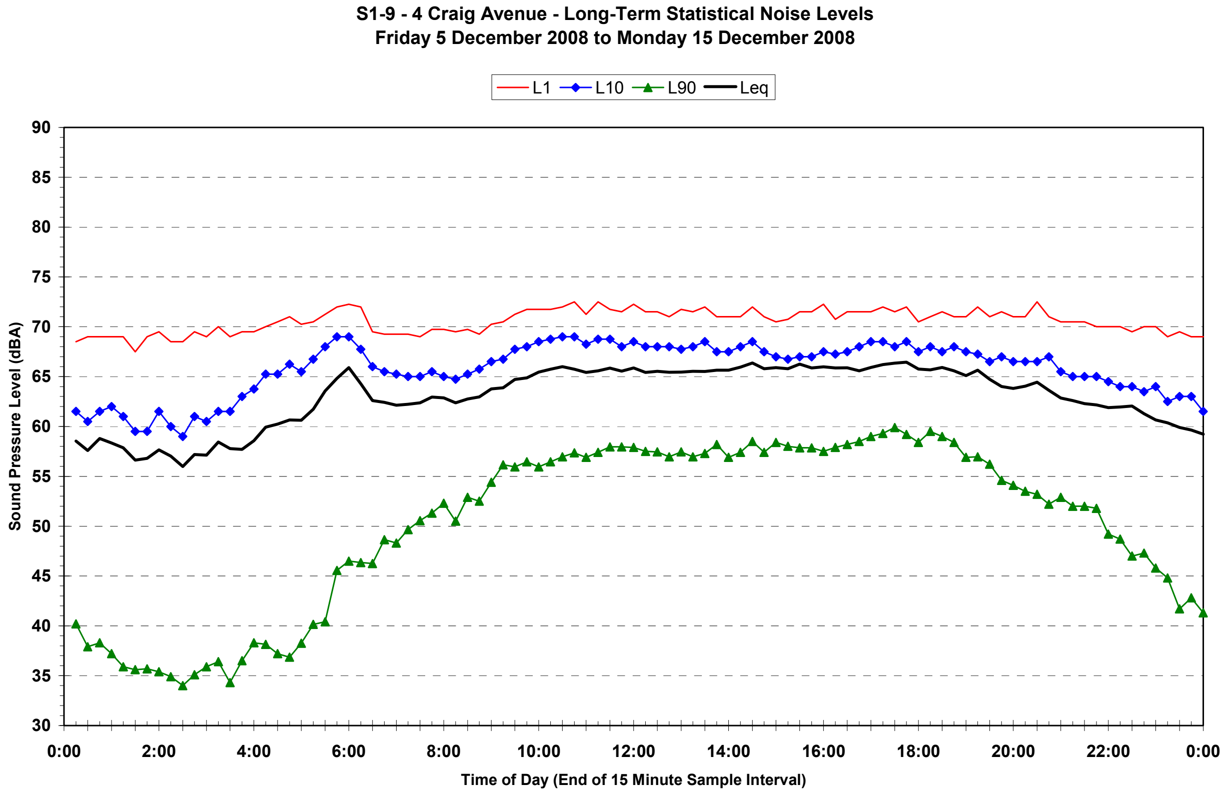
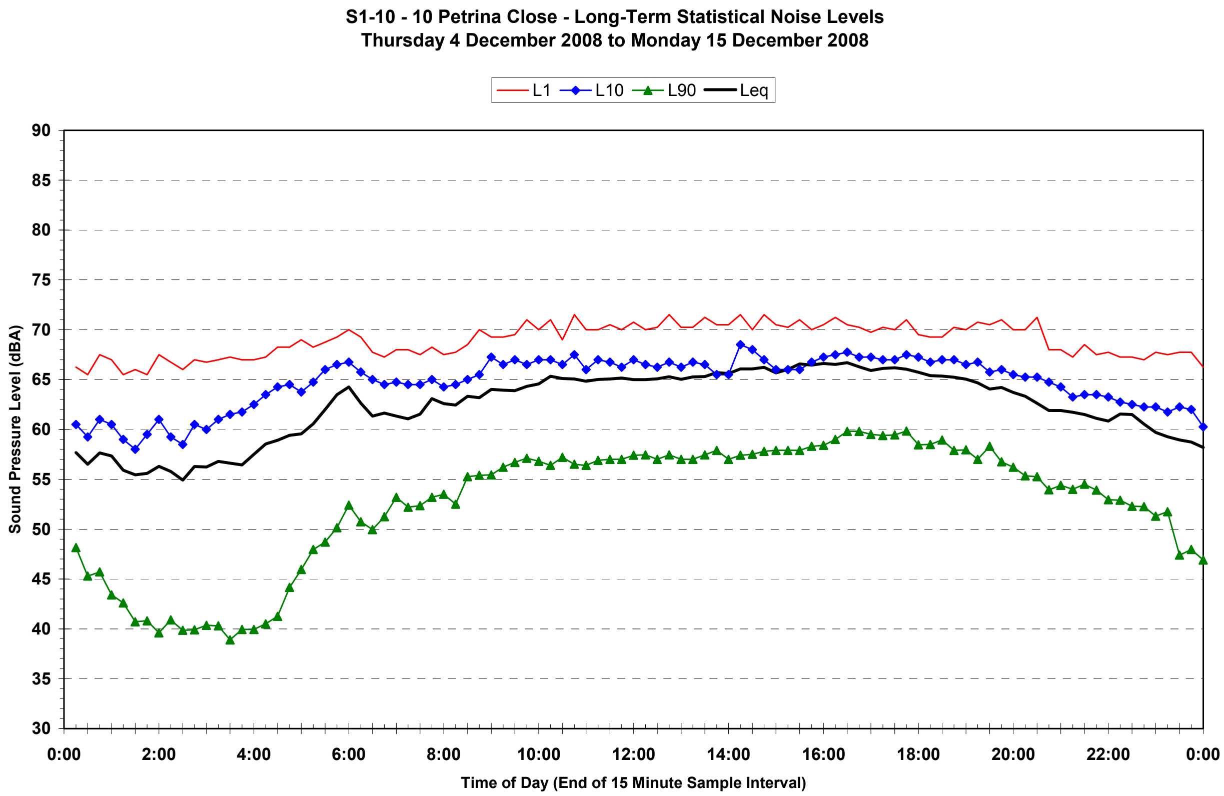
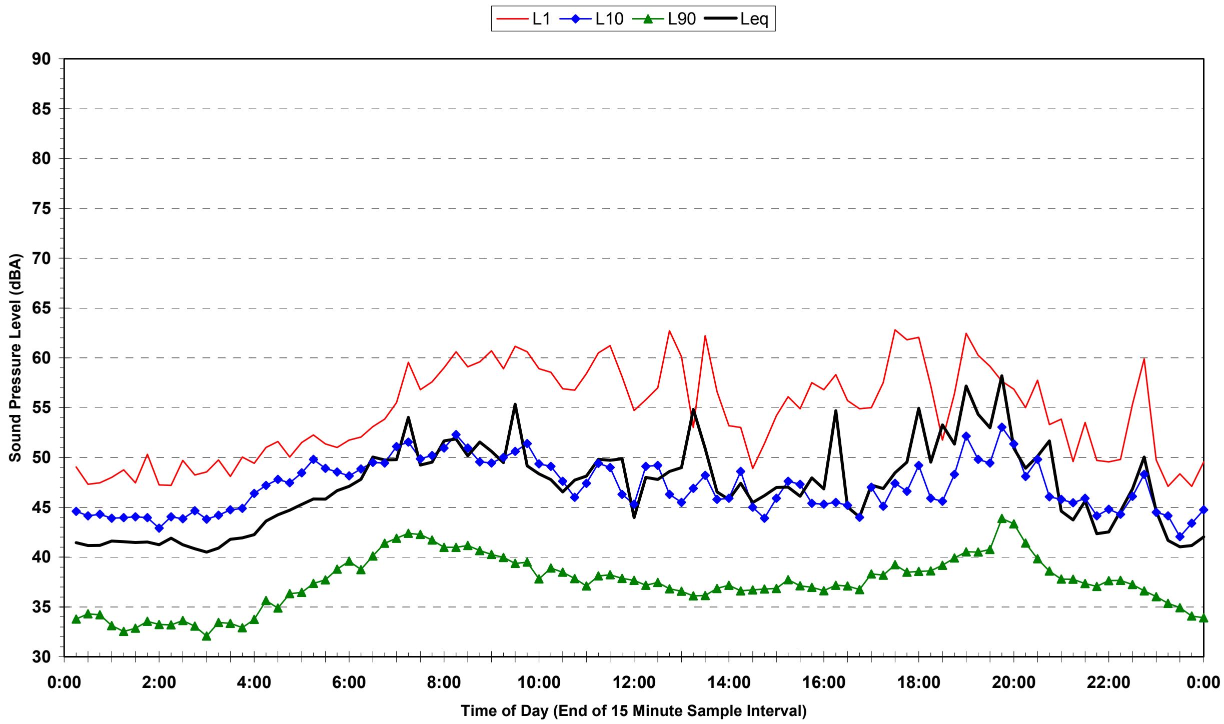


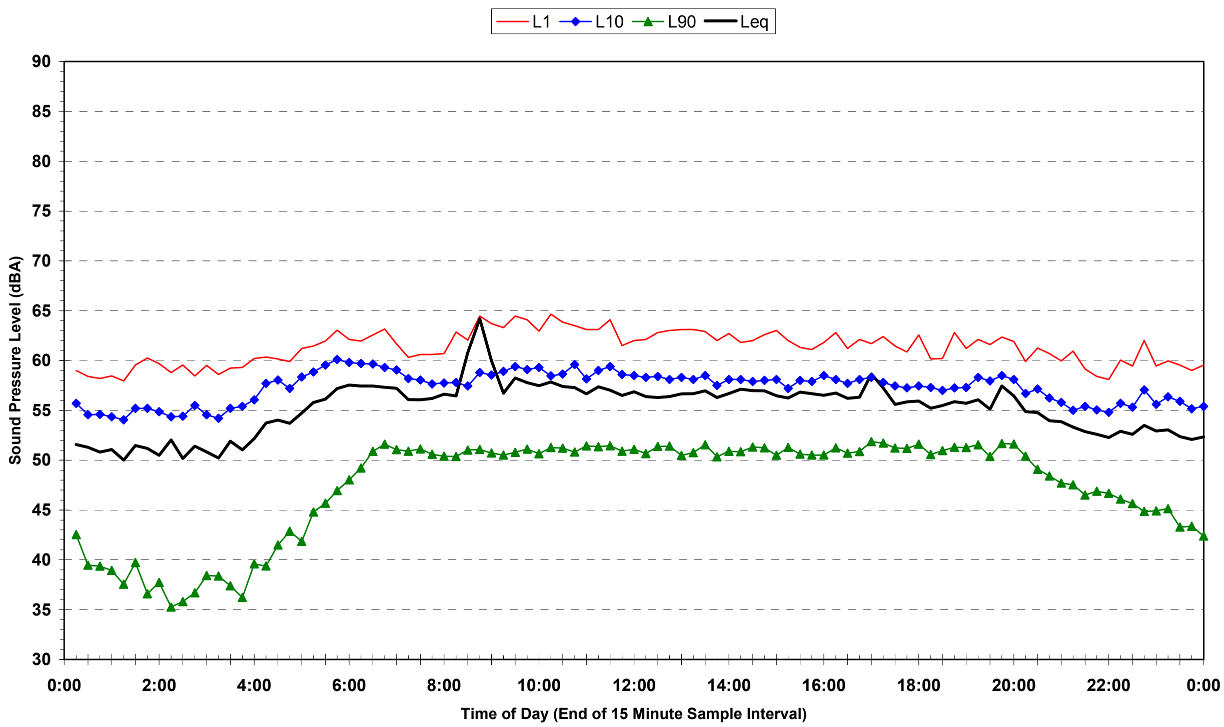


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

S2-1 - 12 Mill Drive - Long-Term Statistical Noise Levels
Wednesday 12 March 2008 to Thursday 20 March 2008

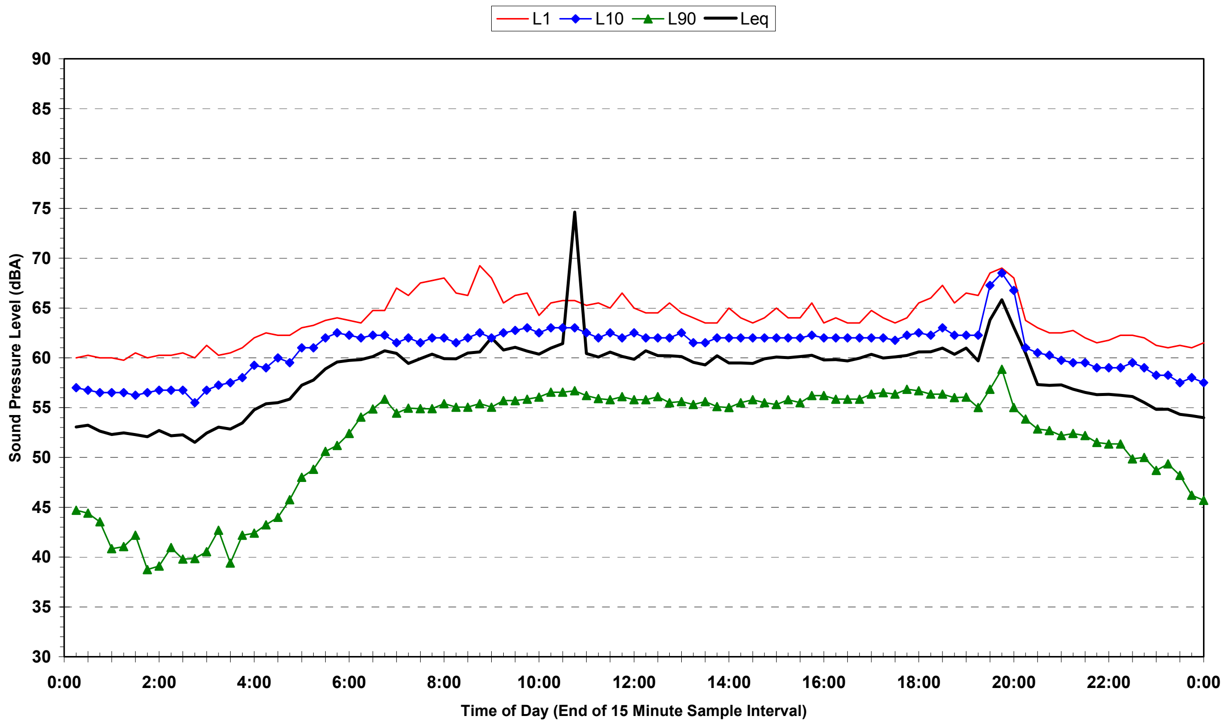


S2-2 - 10 Virginia Place - Long-Term Statistical Noise Levels
Wednesday 12 March 2008 to Friday 14 March 2008

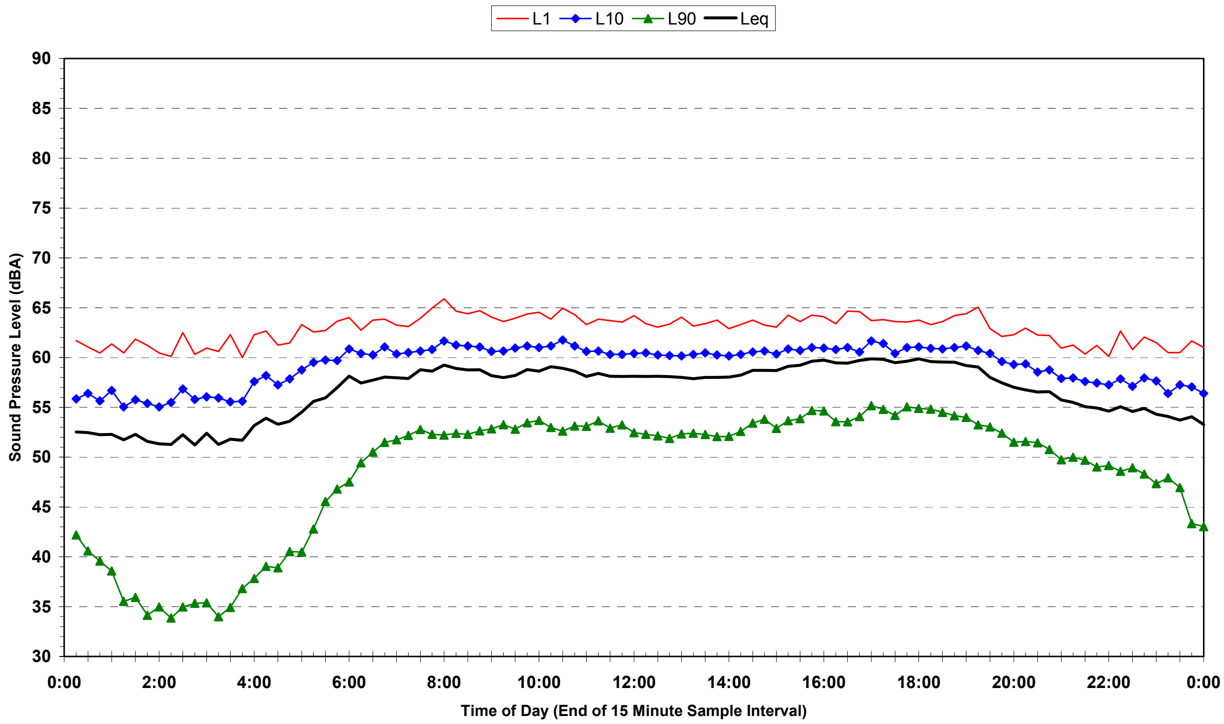


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

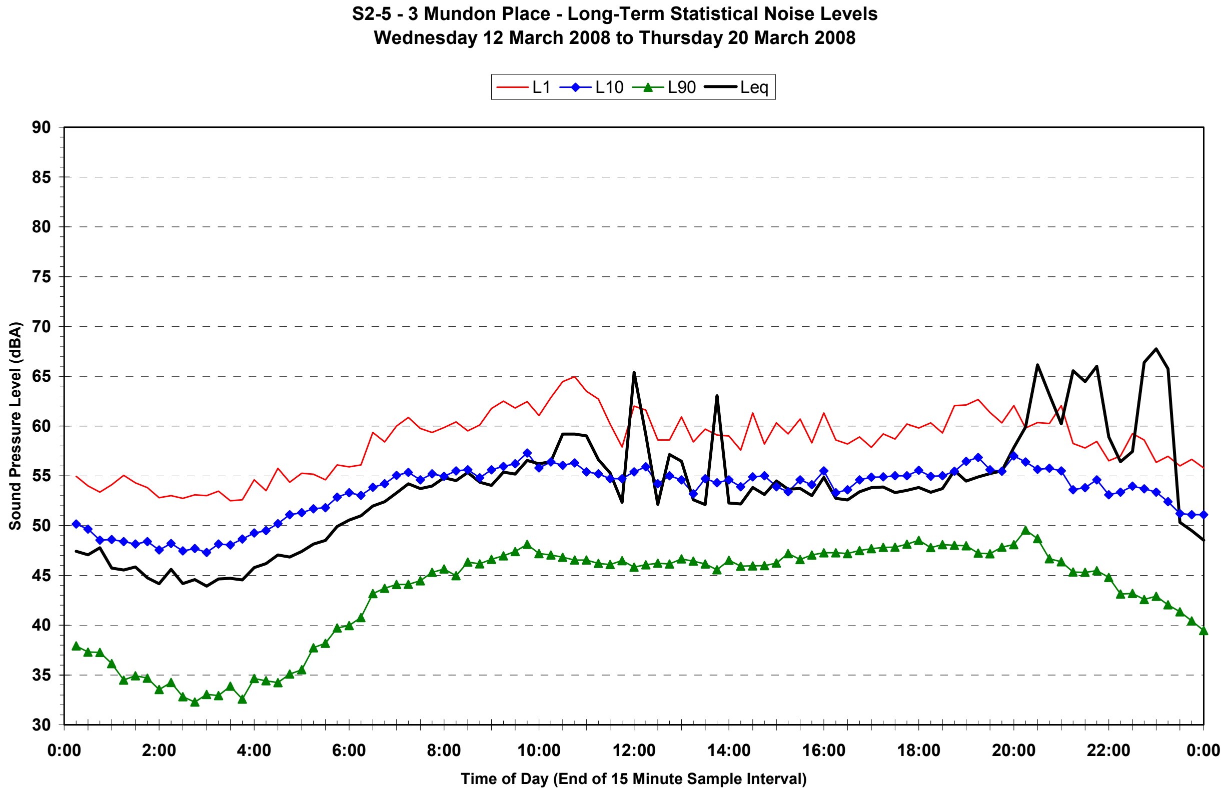
S2-3 - 11 Wilshire Avenue - Long-Term Statistical Noise Levels
Wednesday 12 March 2008 to Thursday 20 March 2008

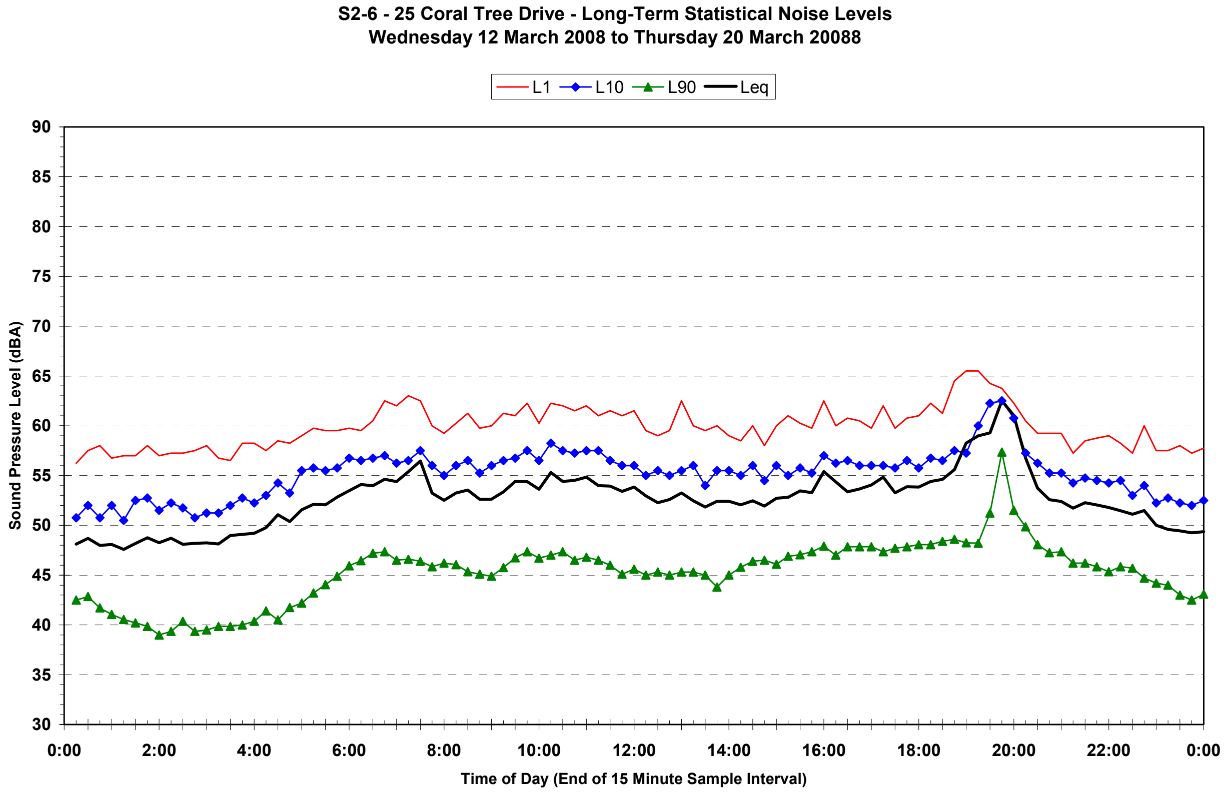


S2-4 - 70 Westmore Road - Long-Term Statistical Noise Levels
Wednesday 26 March 2008 to Thursday 3 April 2008



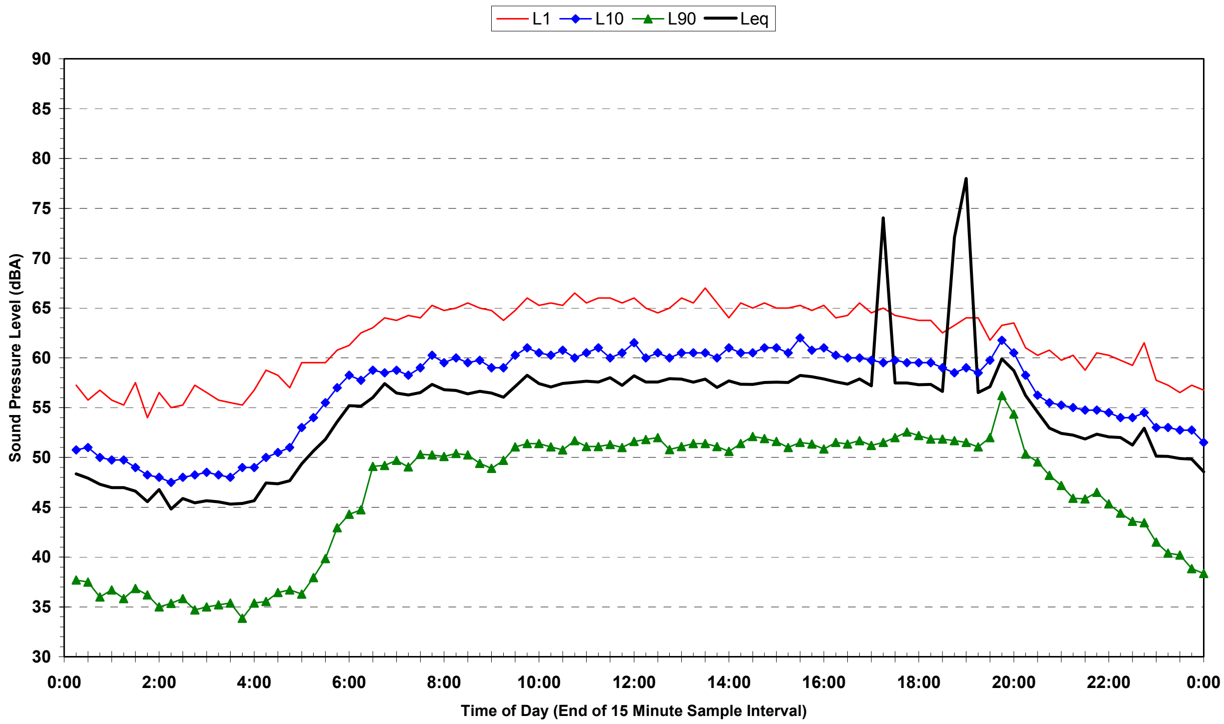
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)



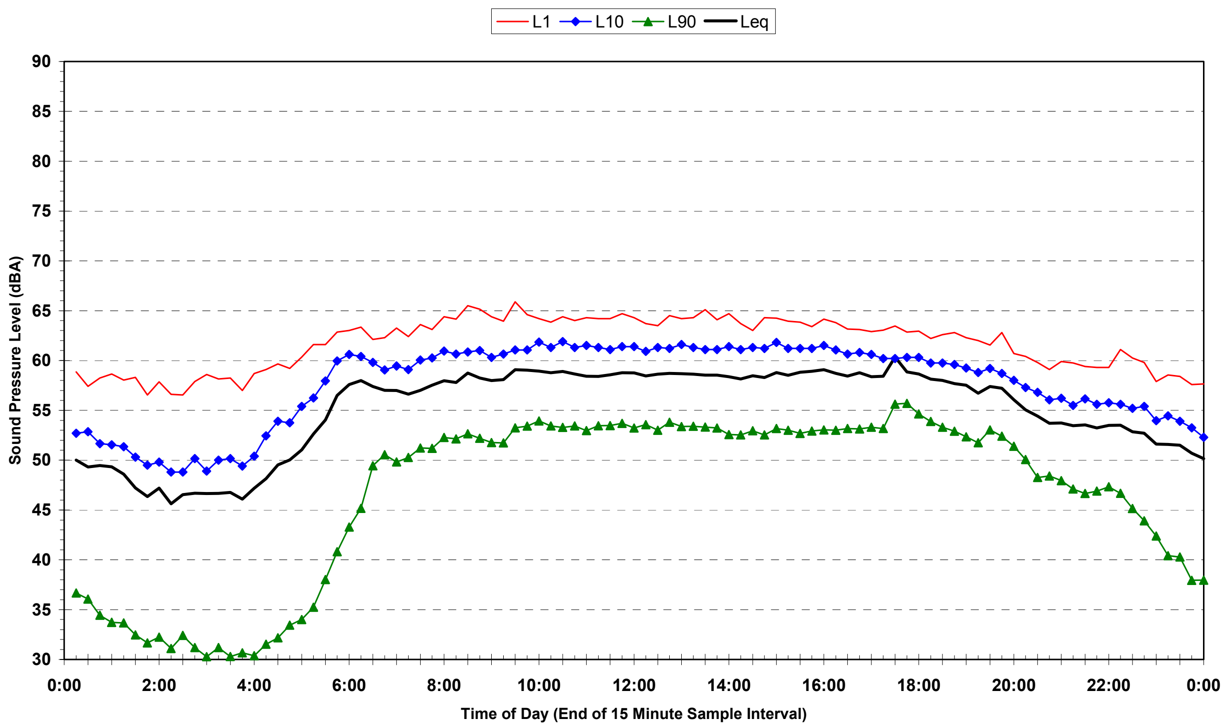


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

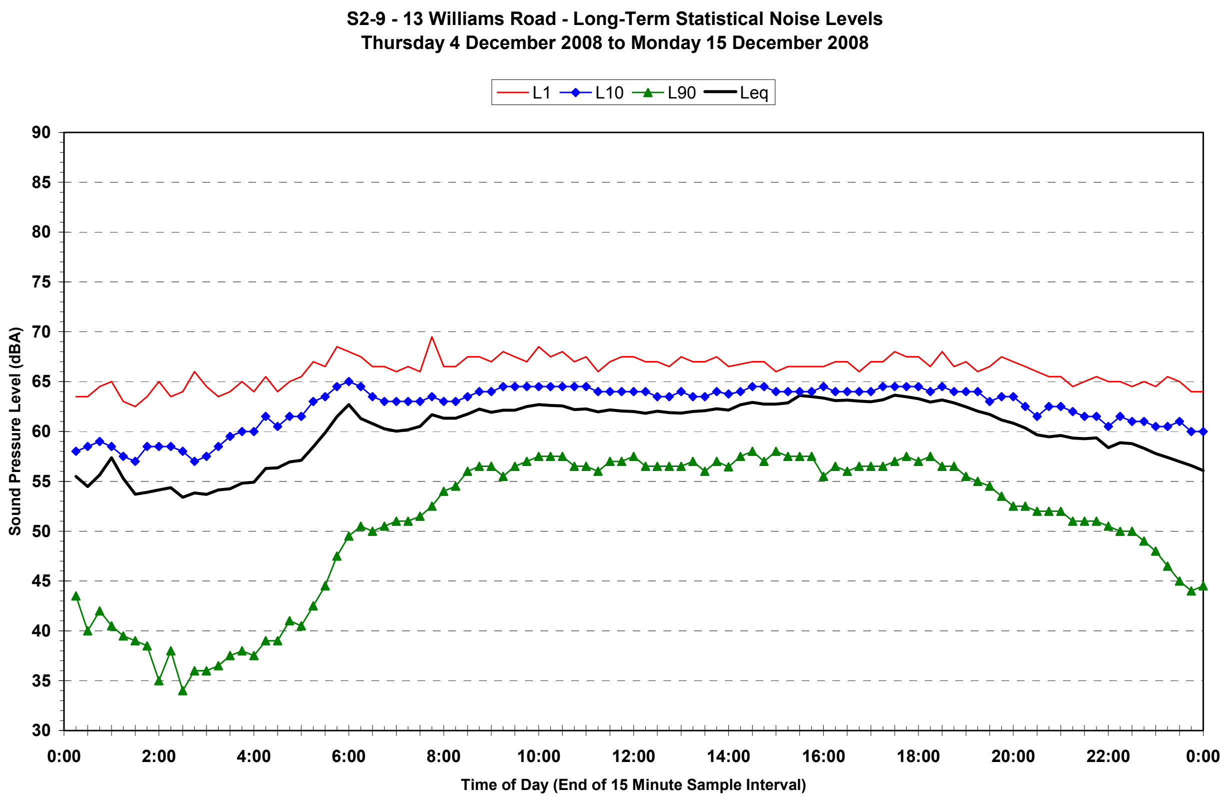
S2-7 - 5 Orchard Road - Long-Term Statistical Noise Levels
Wednesday 12 March 2008 to Friday 14 March 2008

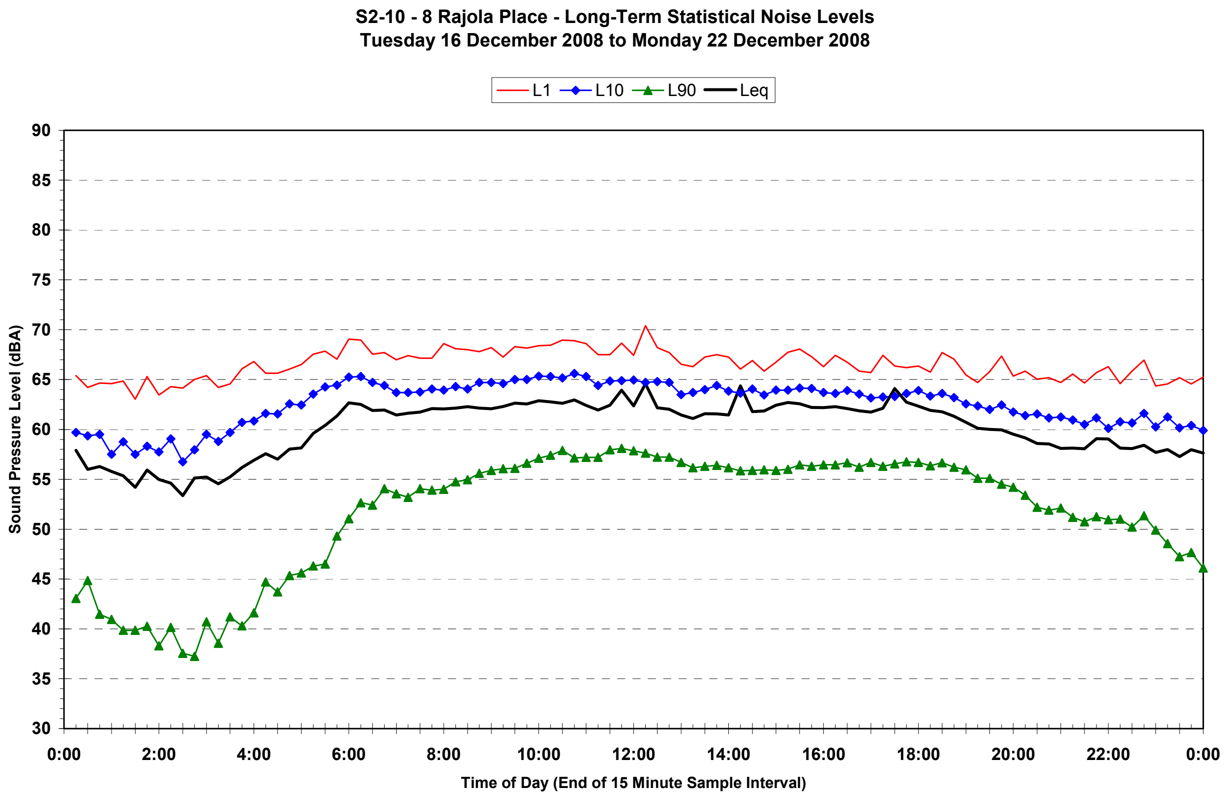


S2-8 - 24 A Castle Howard Road - Long-Term Statistical Noise Levels
Wednesday 12 March 2008 to Friday 14 March 2008

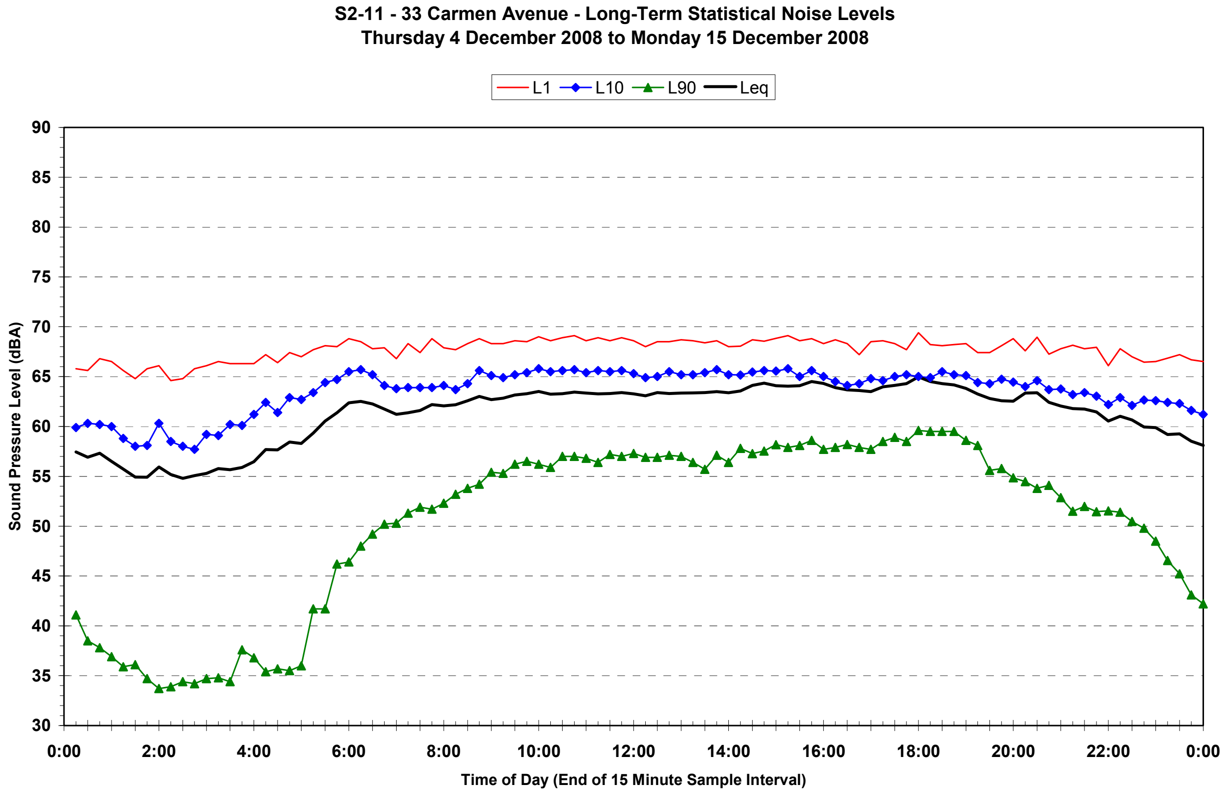


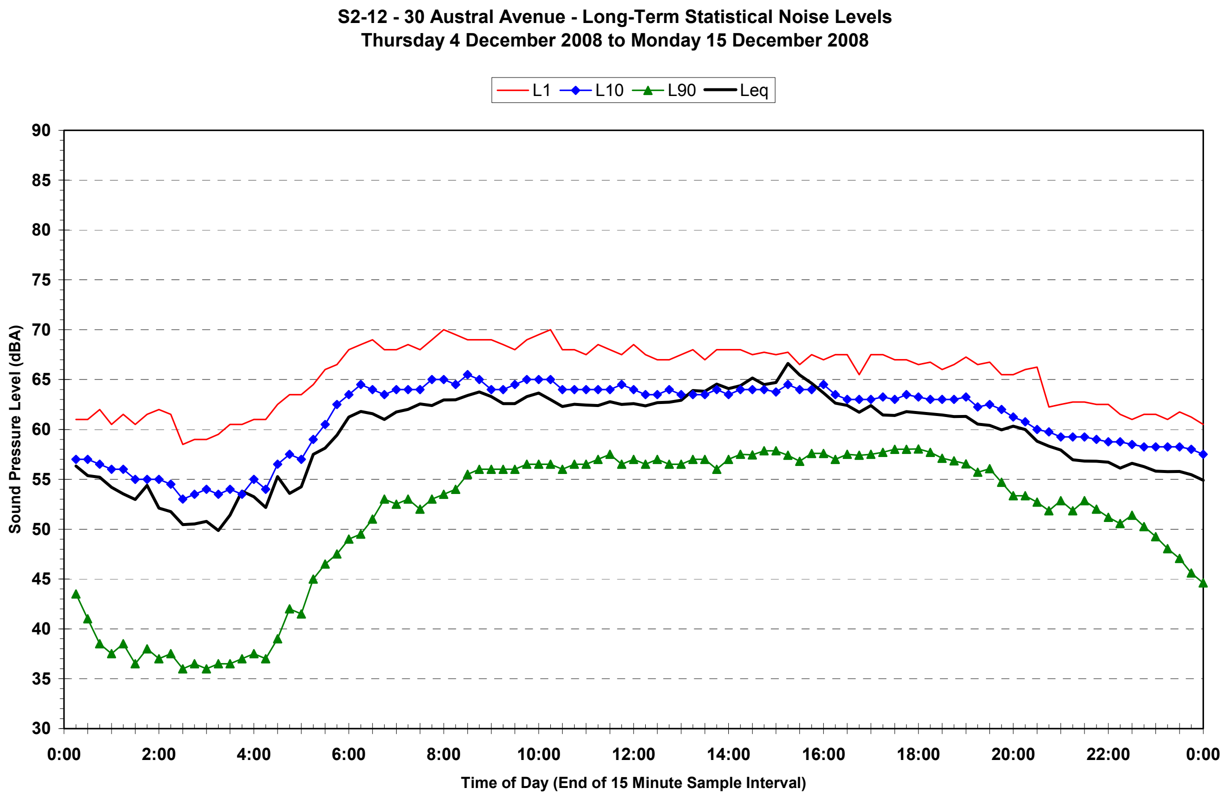
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)



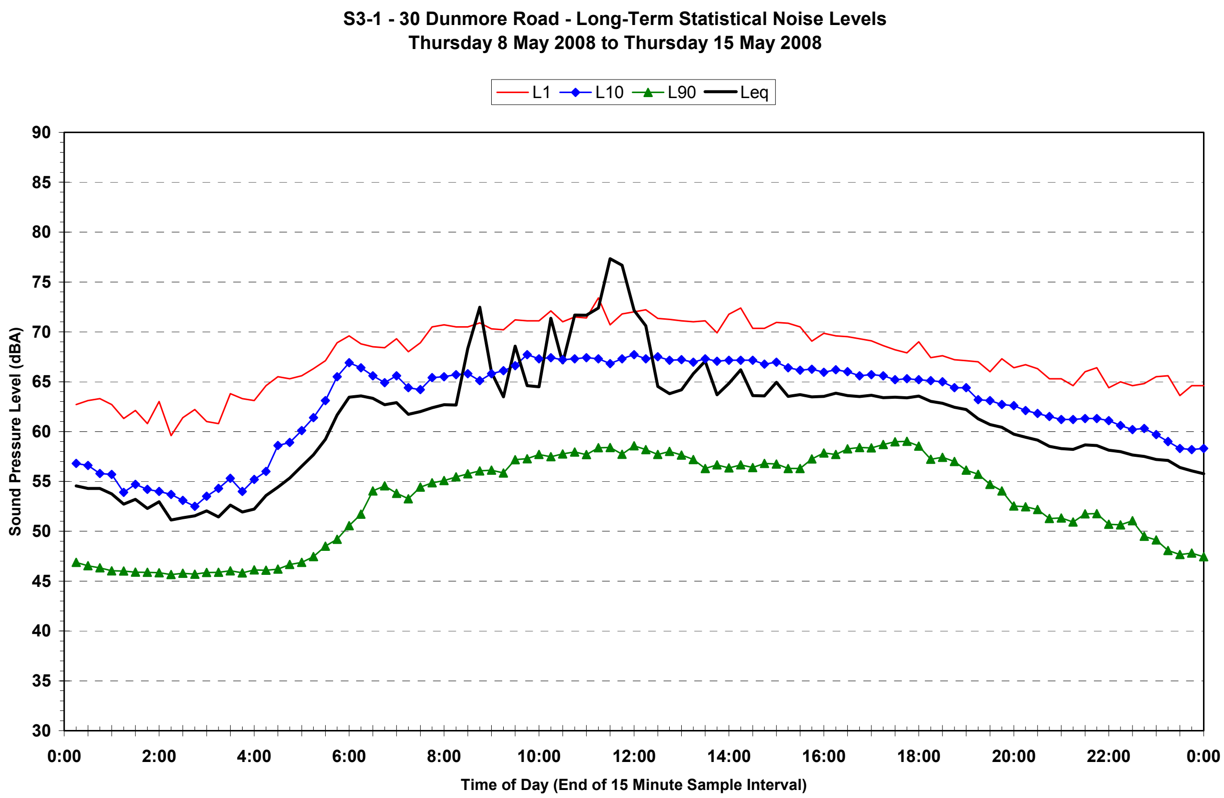


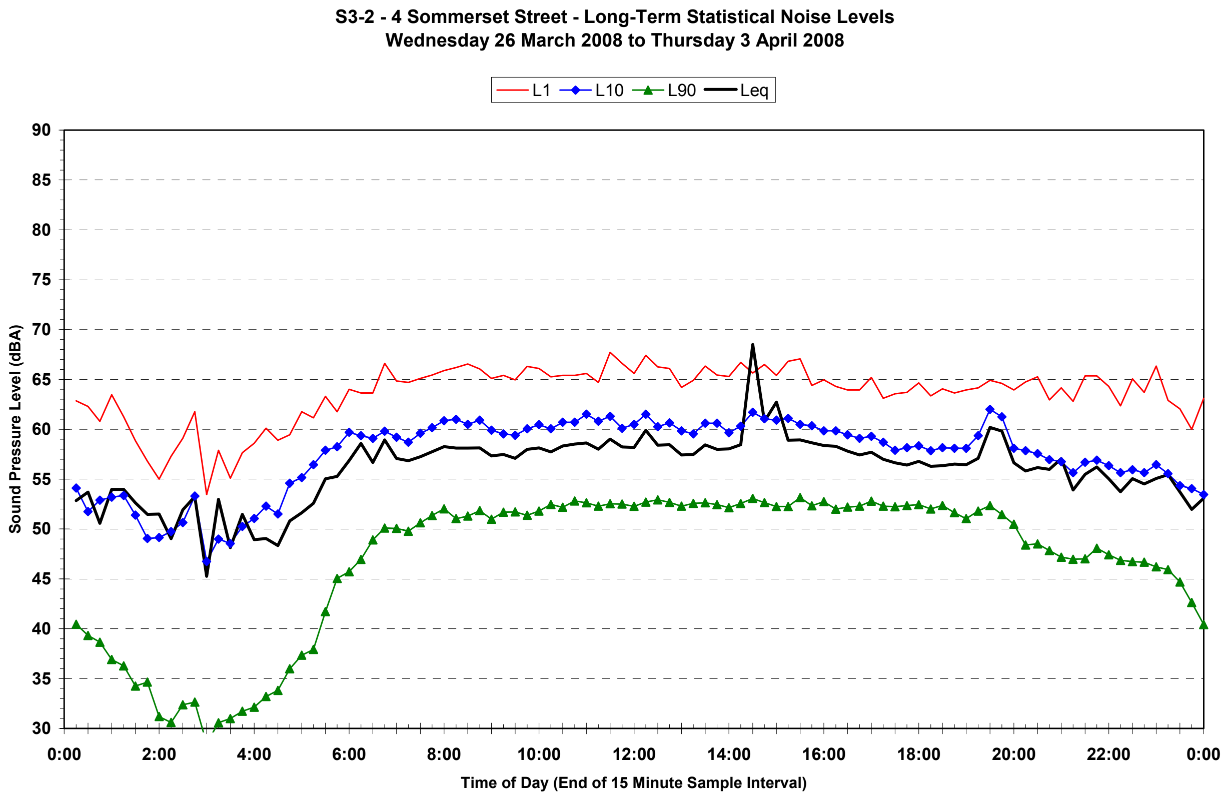
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)





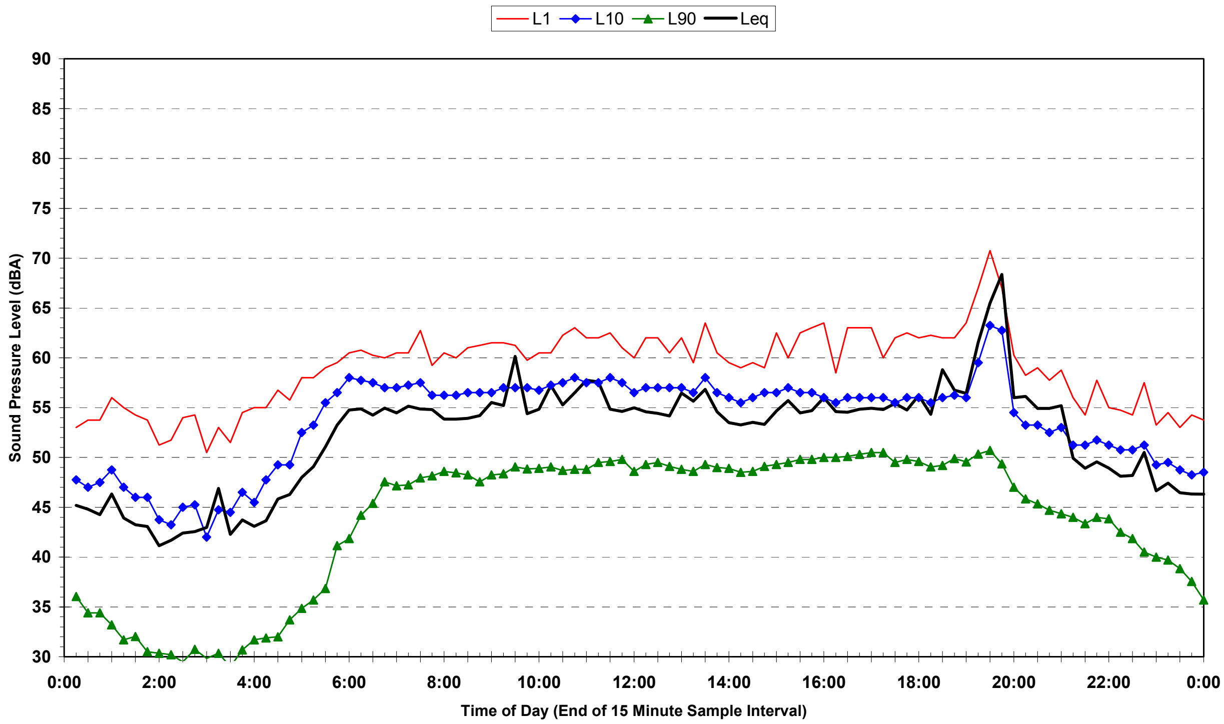
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)



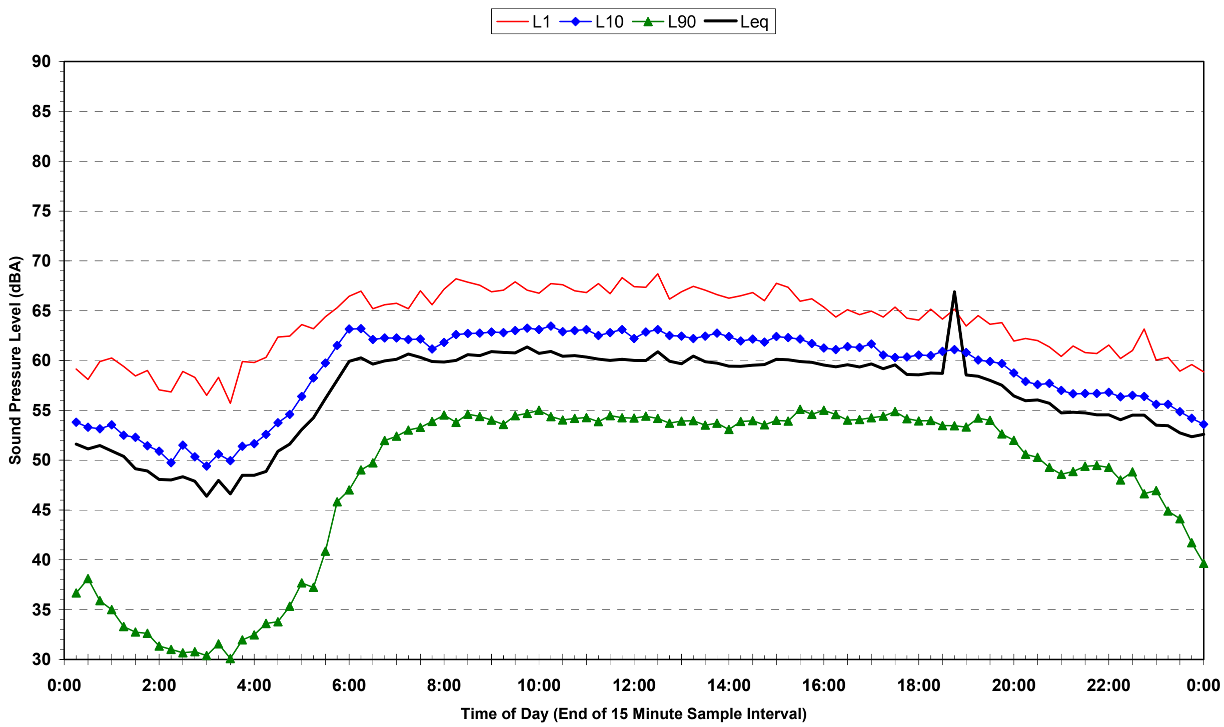


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

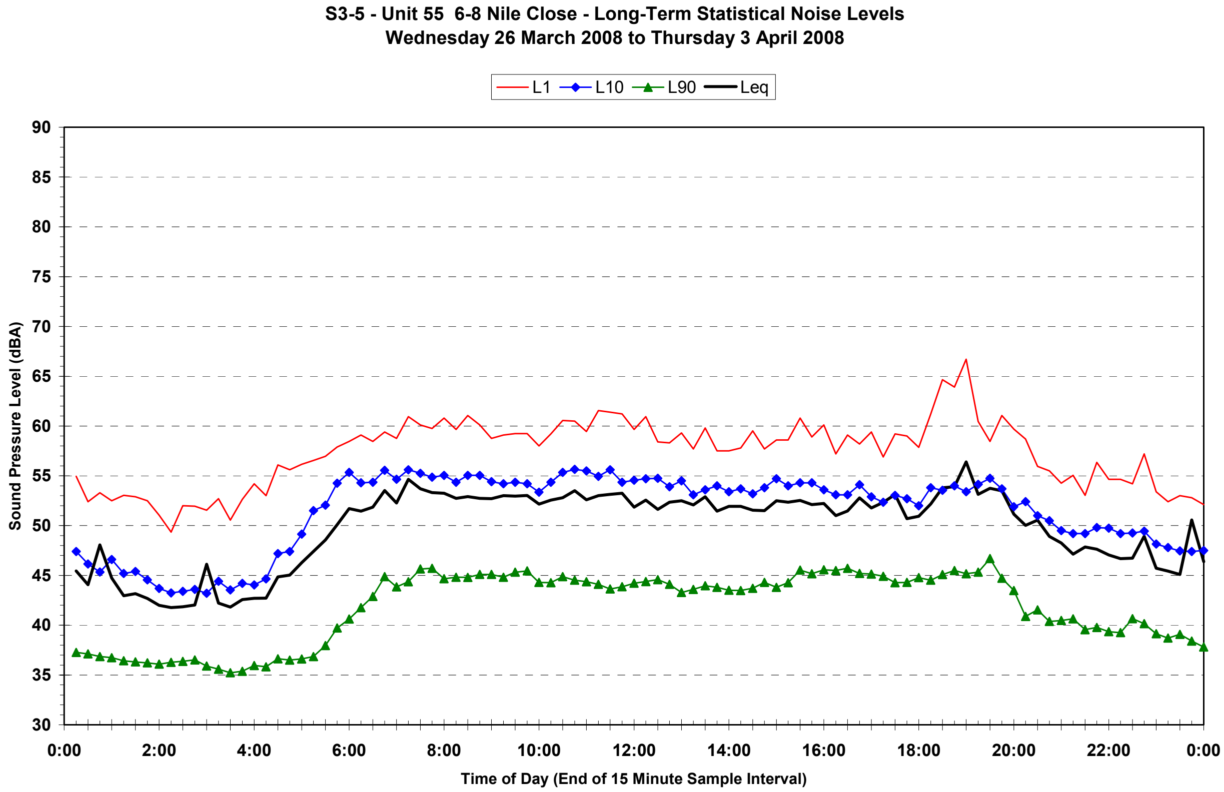
S3-3 - 56 Somerset Street - Long-Term Statistical Noise Levels
Wednesday 26 March 2008 to Thursday 3 April 2008

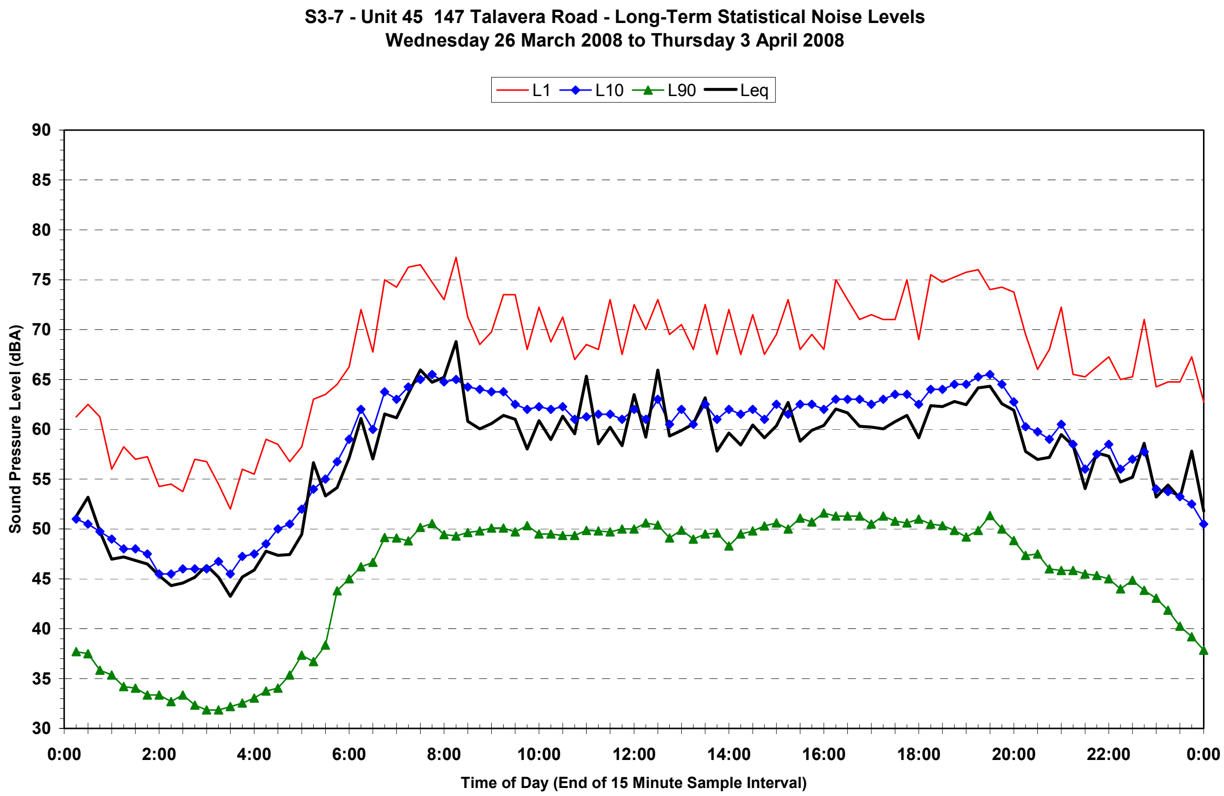


S3-4 - 19 Woodvale Avenue - Long-Term Statistical Noise Levels
Wednesday 26 March 2008 to Tuesday 1 April 2008



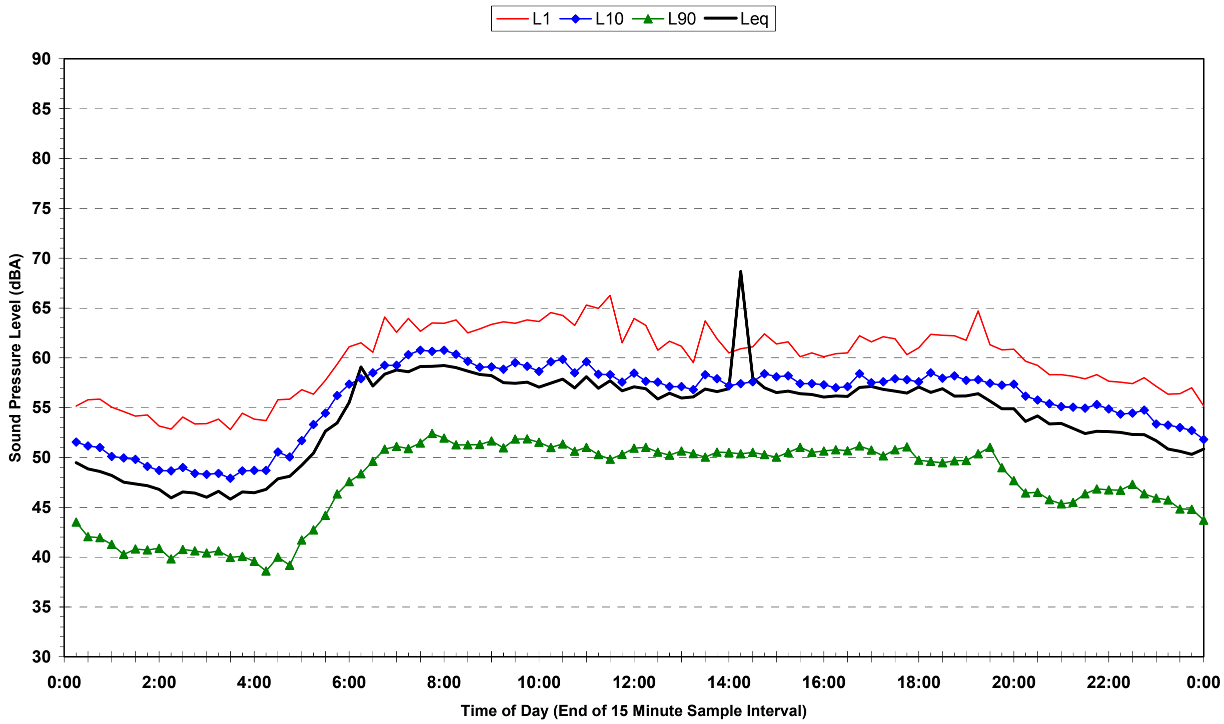
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)



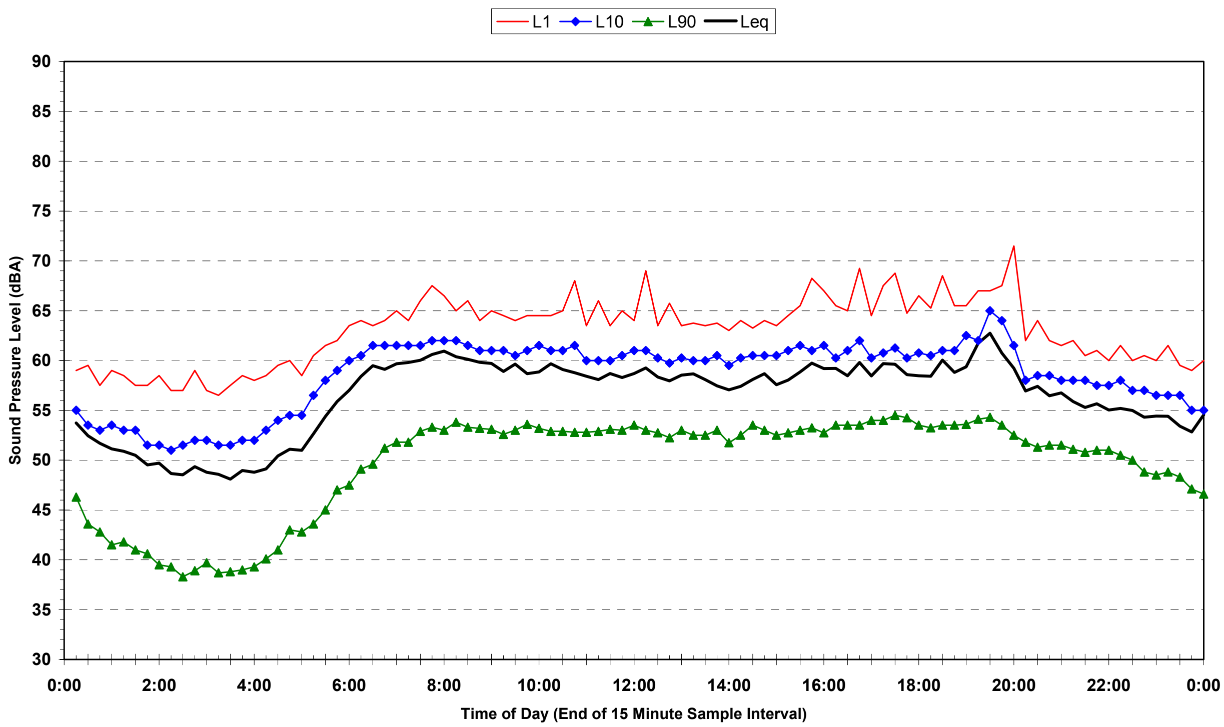


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

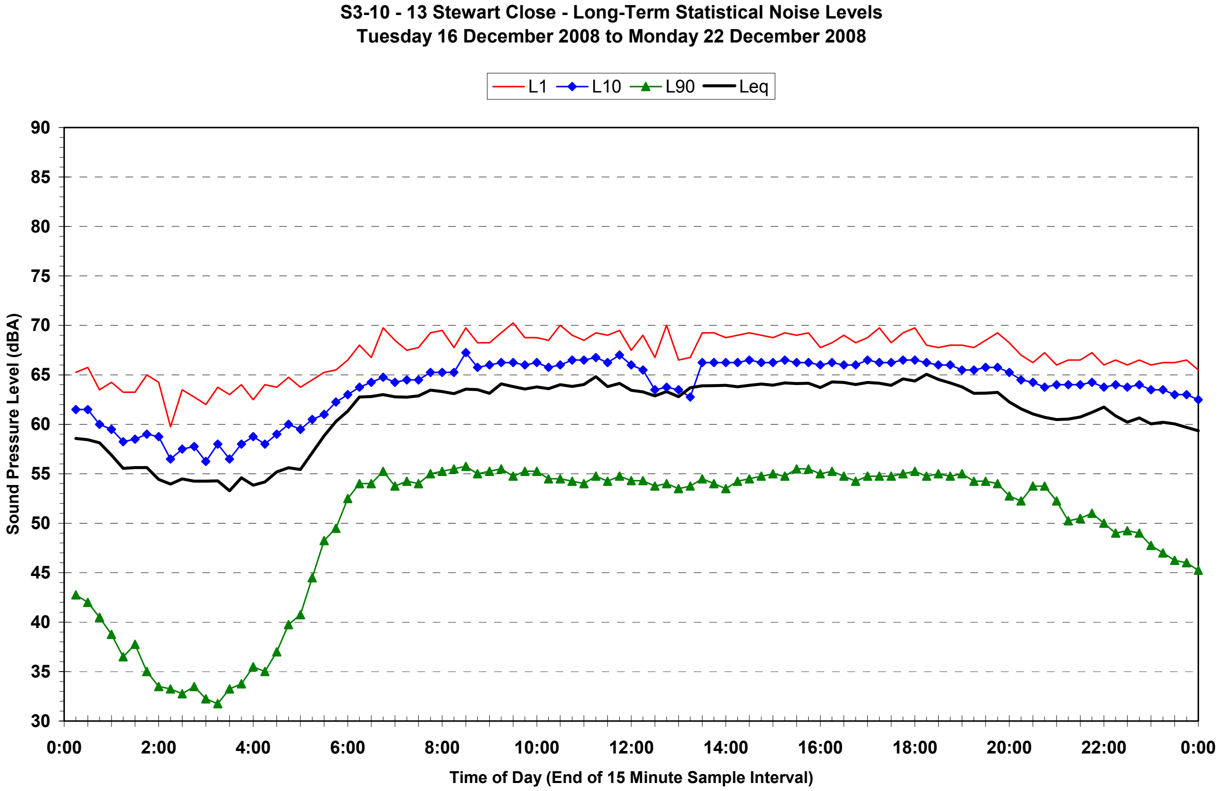
S3-8 - Unit 3 3 Tasman Place - Long-Term Statistical Noise Levels
Wednesday 26 March 2008 to Thursday 3 April 2008

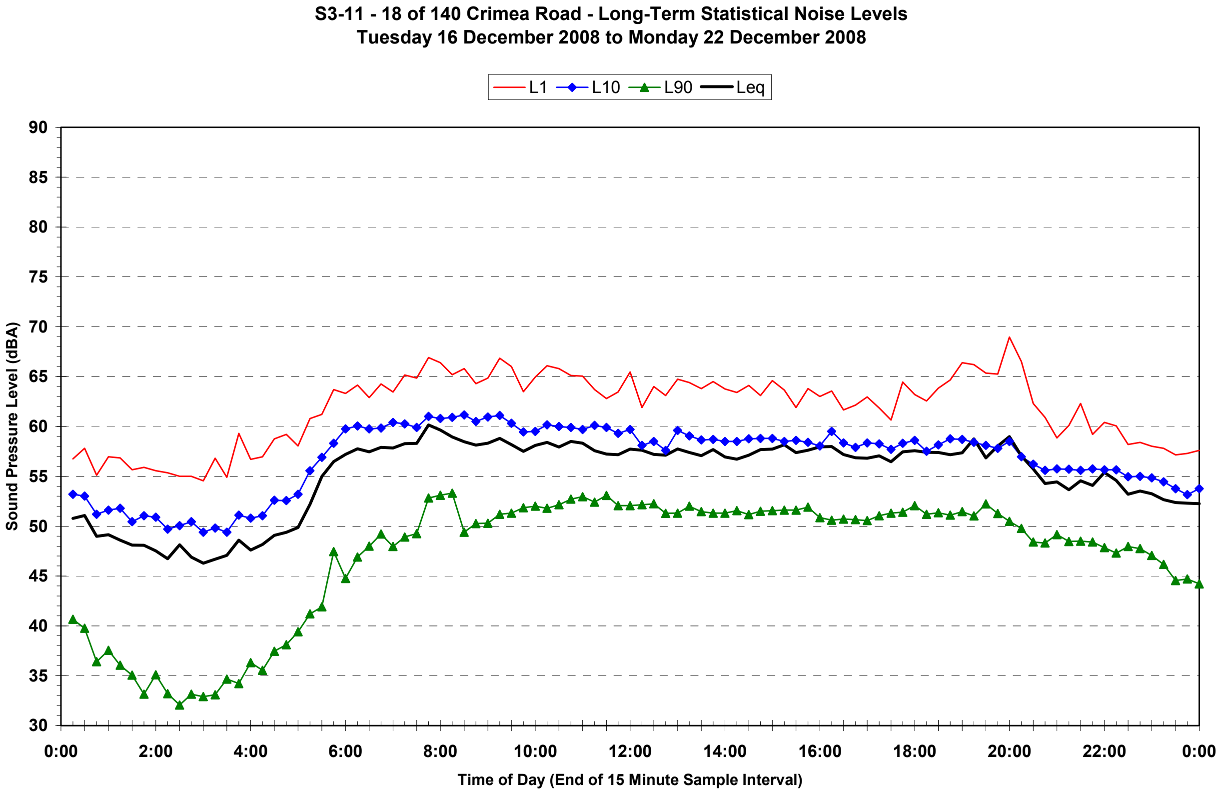


S3-9 - 21 Epping Road - Long-Term Statistical Noise Levels
Wednesday 26 March 2008 to Wednesday 2 April 2008



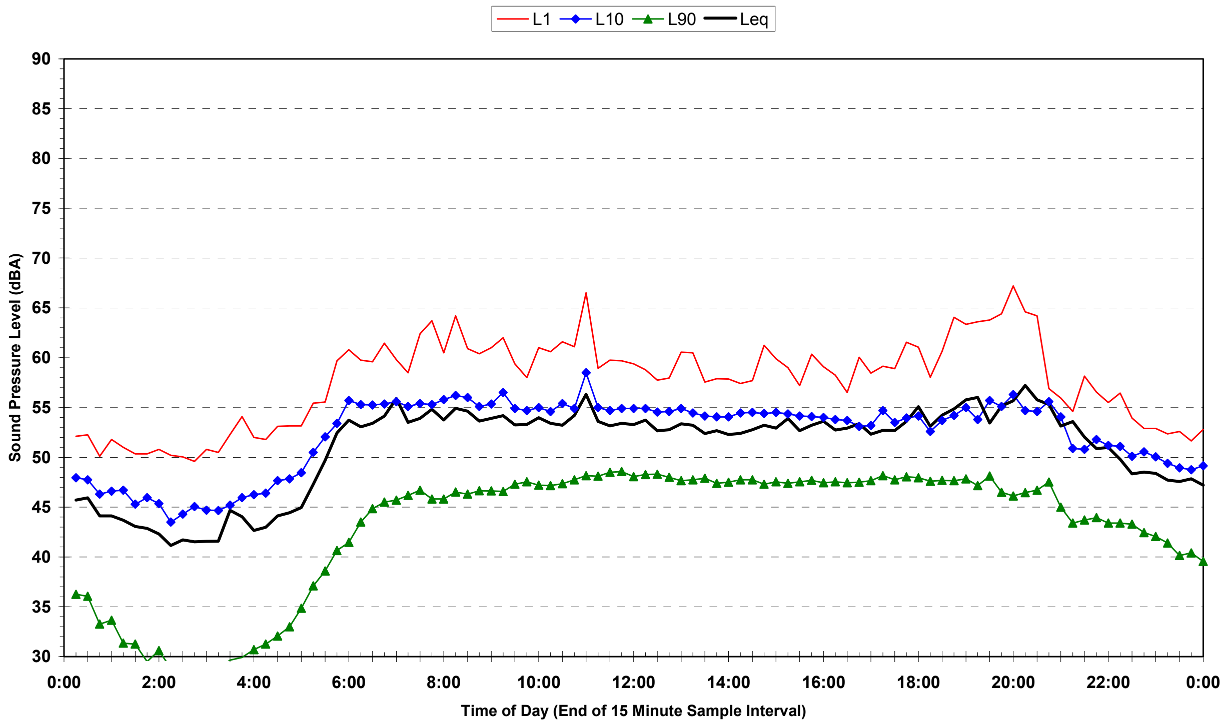
Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)



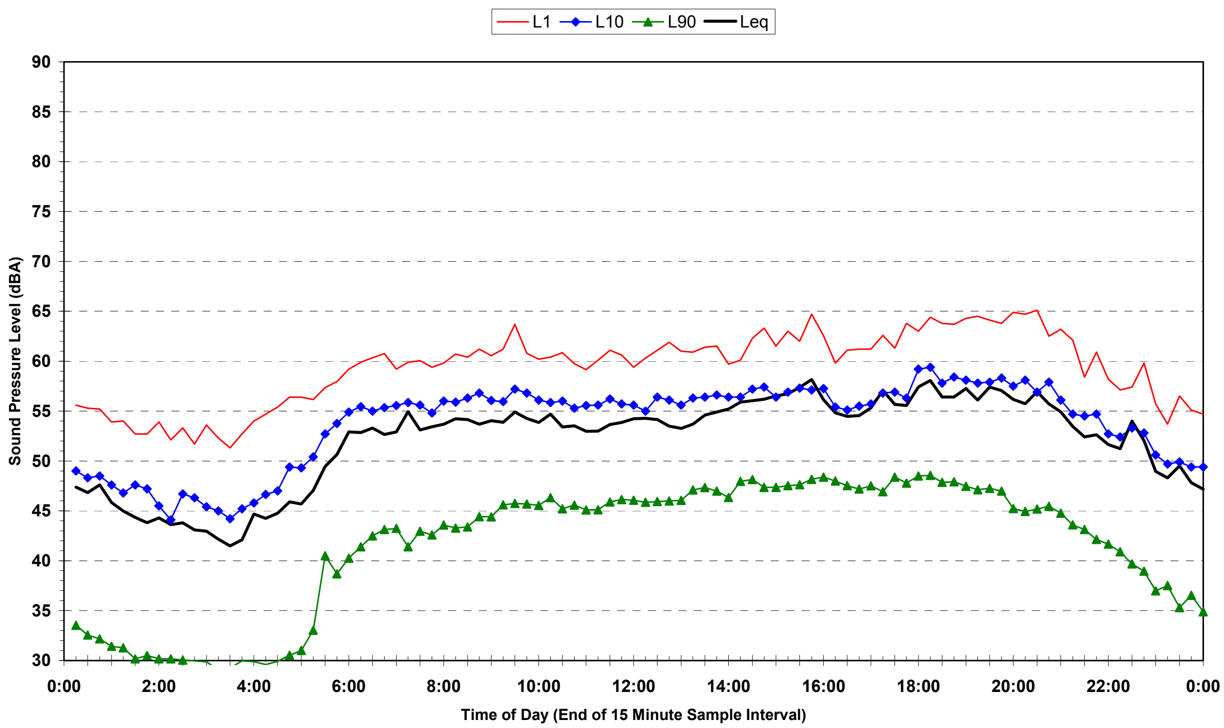


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

S3-12 - 8 of 150 Crimea Road - Long-Term Statistical Noise Levels
Tuesday 16 December 2008 to Monday 22 December 2008

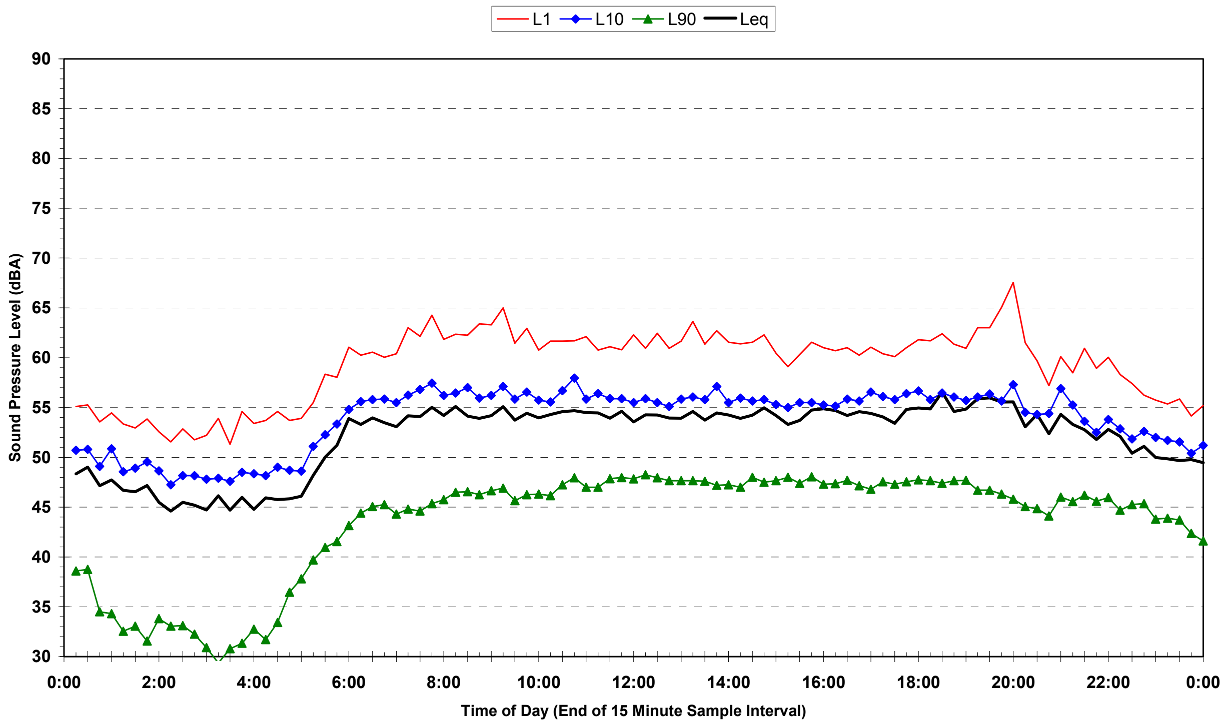


S3-13 - 24 of 2-4 Nile Close - Long-Term Statistical Noise Levels
Friday 5 December 2008 to Sunday 14 December 2008

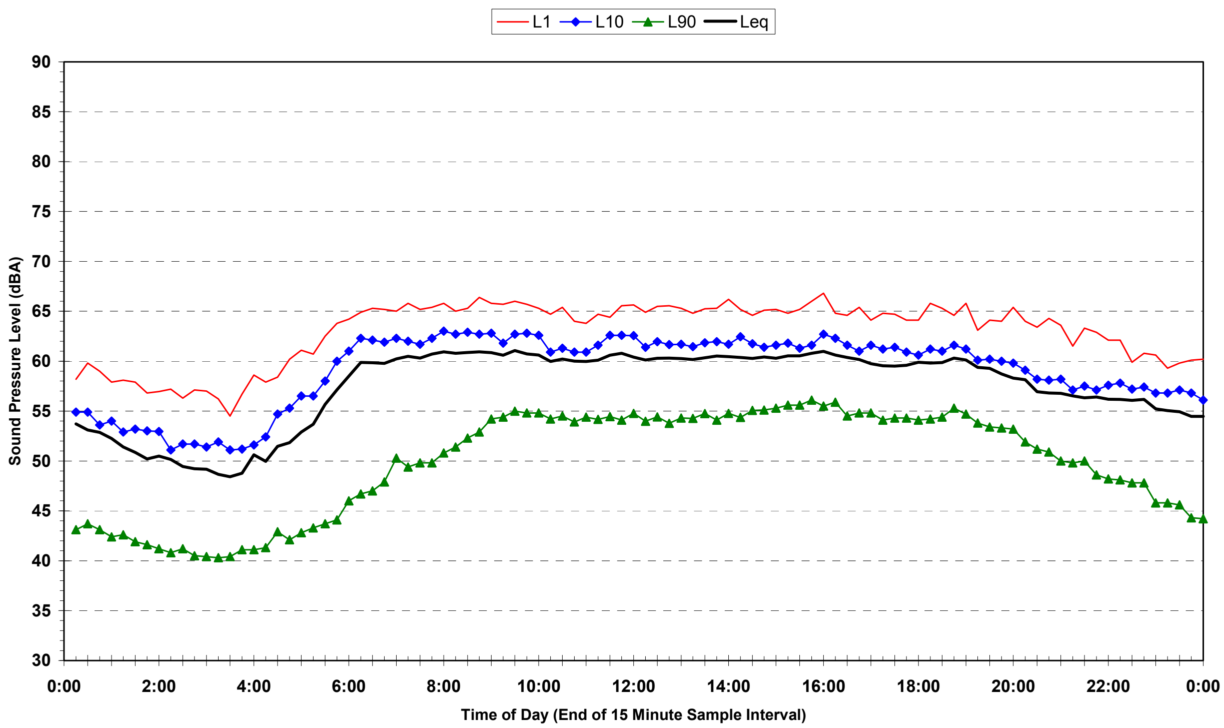


Noise Monitoring Data - 24 Hour Average Plots (Raw Data Before Filtering)

S3-14 - 21 of 1A Busaco Road - Long-Term Statistical Noise Levels
Tuesday 16 December 2008 to Monday 22 December 2008



S3-15 - 199 of 1 Fontenoy Road - Long-Term Statistical Noise Levels
Thursday 4 December 2008 to Monday 15 December 2008



Appendix D

Report 10-7434R1

Future Existing (2011) Facade Plots - Ground and First Floors

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 1/6

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

REVISION 0

50 mm ON ORIGINAL 0 10 20 30 40 50

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

50 mm ON ORIGINAL

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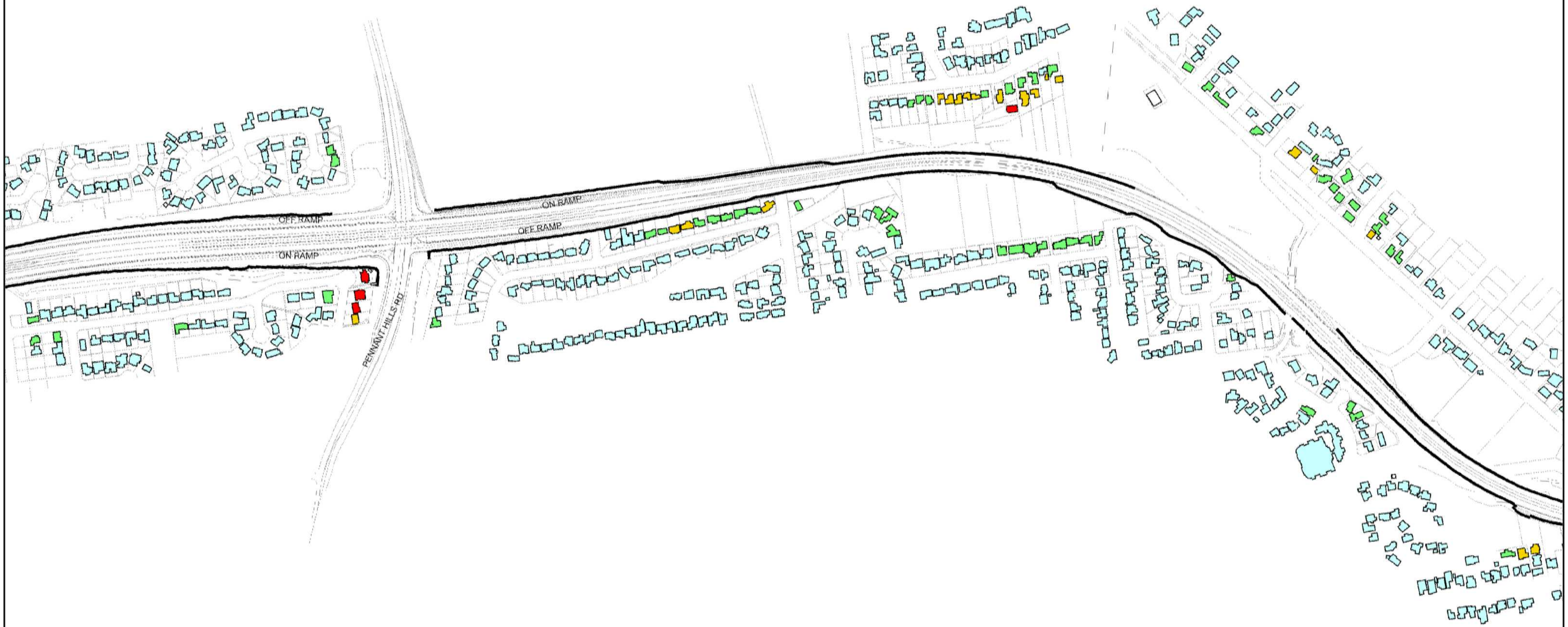
10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 2/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

REVISION 0



Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 3/6

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

REVISION 0

50 mm ON ORIGINAL 0 10 20 30 40 50

50 mm ON ORIGINAL

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Legend

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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 4/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

REVISION 0

Legend

- ≥ 65 dBA
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REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 5/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

REVISION 0

50 mm ON ORIGINAL

Legend

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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
Ground Floor Buildings
Page 6/6

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 1st.dwg

DRAWING No. 10-7434_2011_1st

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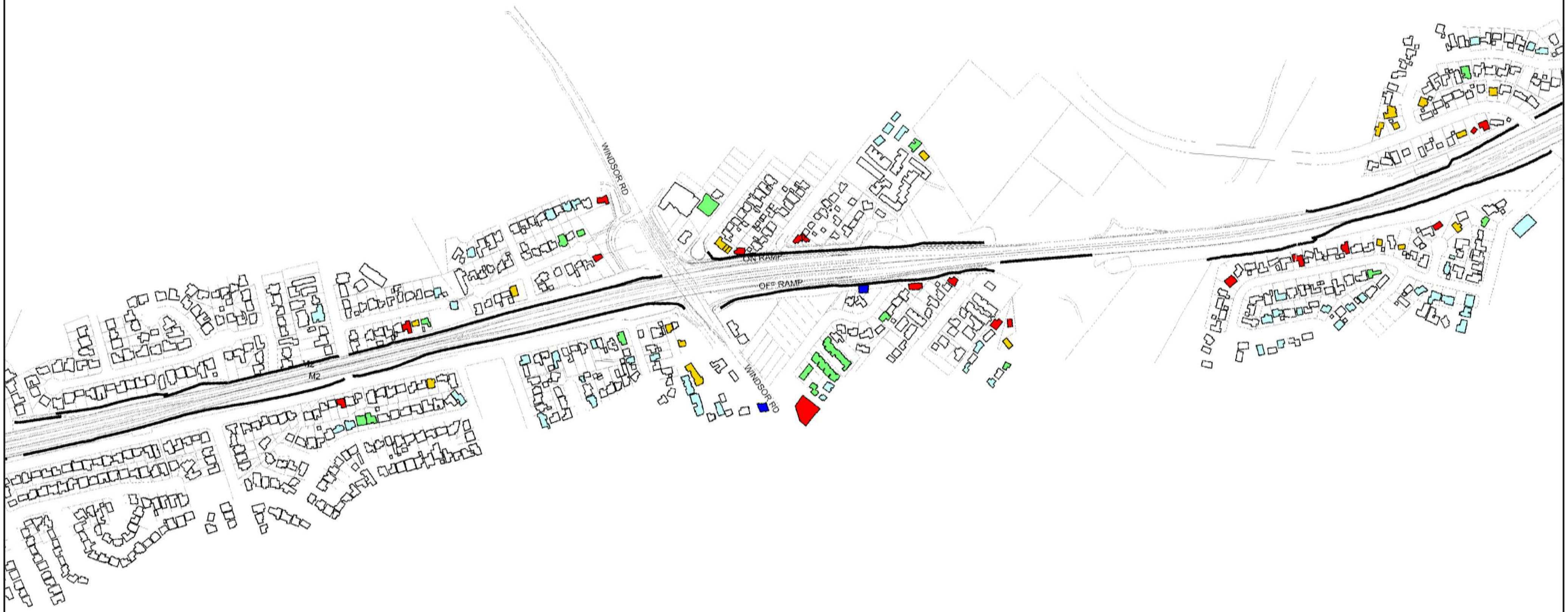

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Legend

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10-7434 M2 Upgrade Project

2011 Future Existing - LAeq(9hour)

First Floor Buildings

Page 1/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

DRAWING No. 10-7434_2011_2st

REVISION 0

50 mm ON ORIGINAL

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
First Floor Buildings
Page 2/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

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REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
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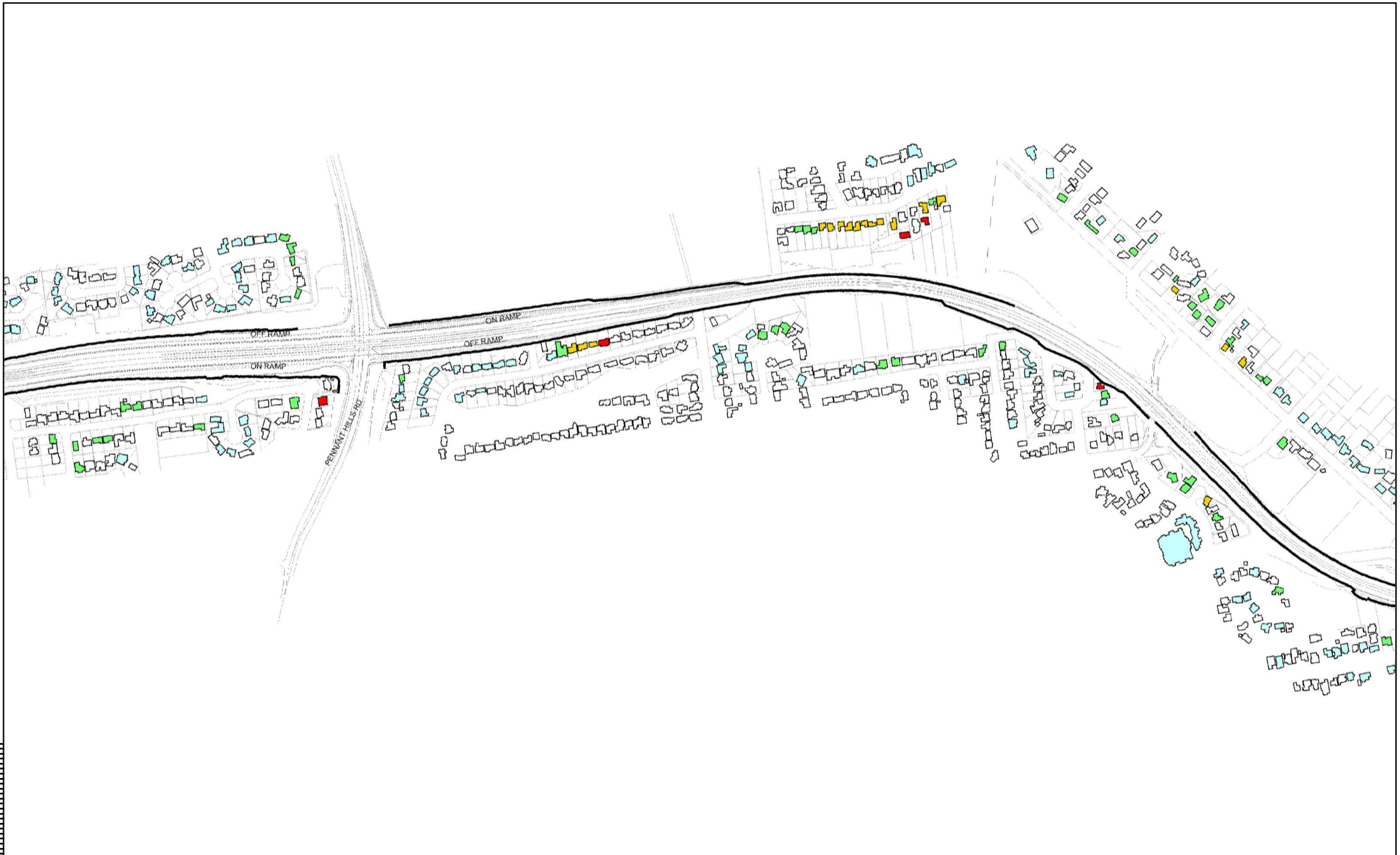
50 mm ON ORIGINAL



Legend

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10-7434 M2 Upgrade Project

2011 Future Existing - LAeq(9hour)

First Floor Buildings

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REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

DRAWING No. 10-7434_2011_2st

REVISION 0

50 mm ON ORIGINAL

Legend

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10-7434 M2 Upgrade Project

2011 Future Existing - LAeq(9hour)

First Floor Buildings

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REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

DRAWING No. 10-7434_2011_2st

REVISION 0

50 mm ON ORIGINAL

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0	18/12/09		ALW	PG

Legend

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- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
First Floor Buildings
Page 5/6

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

DRAWING No. 10-7434_2011_2st

REVISION 0

50 mm ON ORIGINAL

Legend

≥ 65 dBA	55 dBA to 56 dBA
60 dBA to 64 dBA	≤ 54 dBA
57 dBA to 59 dBA	

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10-7434 M2 Upgrade Project
2011 Future Existing - LAeq(9hour)
First Floor Buildings
Page 6/6

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

FILE NAME: 10-7434R1 App D - 2011 Future Existing - 2st.dwg

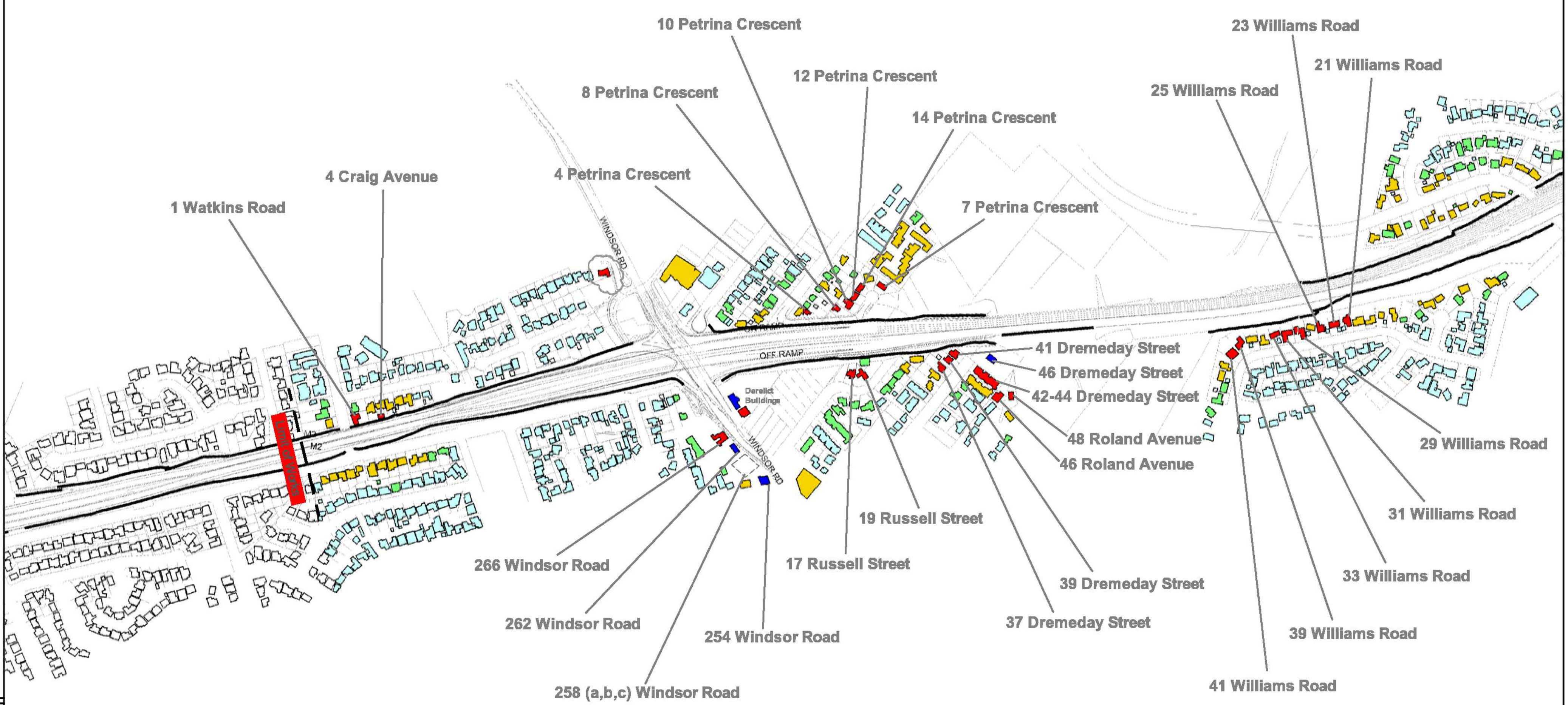
DRAWING No. 10-7434_2011_2st

REVISION 0

50 mm ON ORIGINAL 0 10 20 30 40 50

Appendix E
Report 10-7434R1

Future Design (2021) Facade Plots - Ground and First Floors



Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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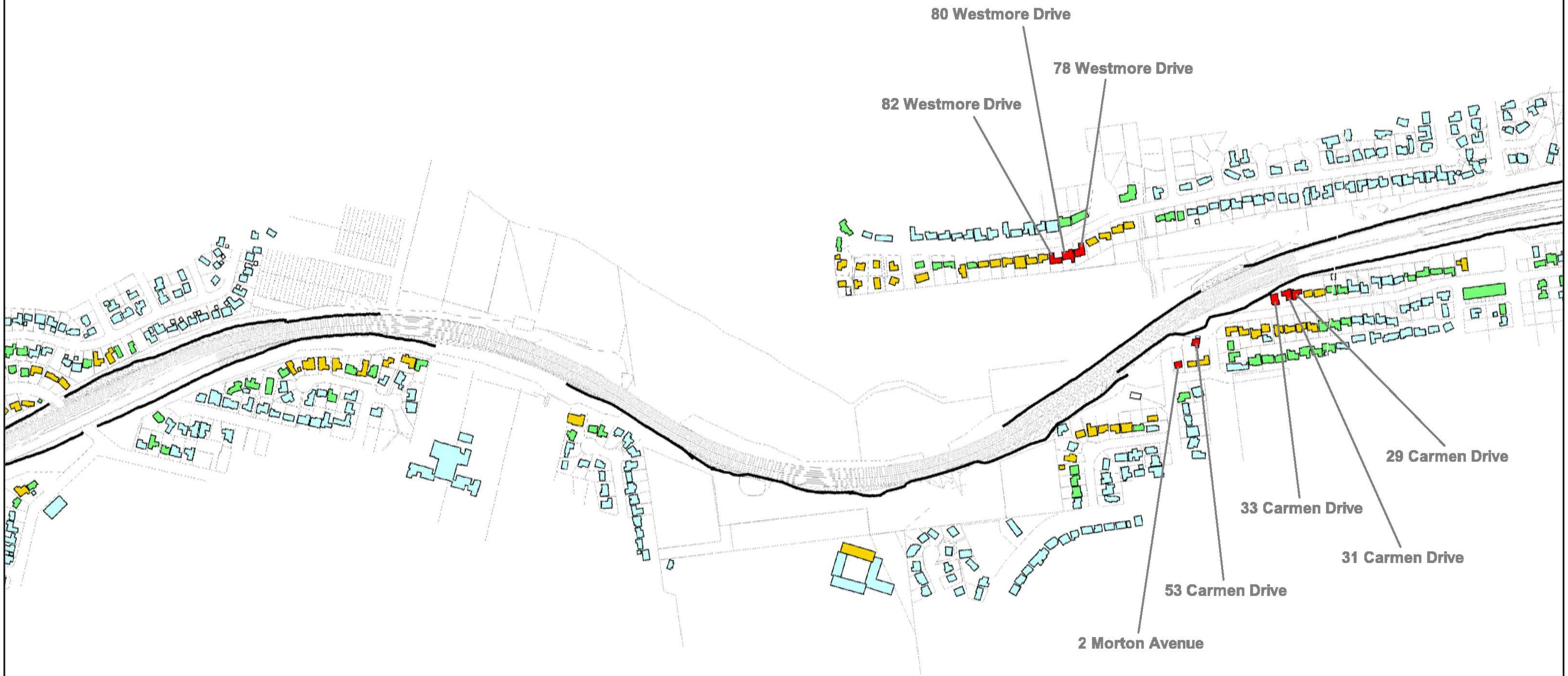
10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 1/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

50 mm ON ORIGINAL



Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

50 mm ON ORIGINAL

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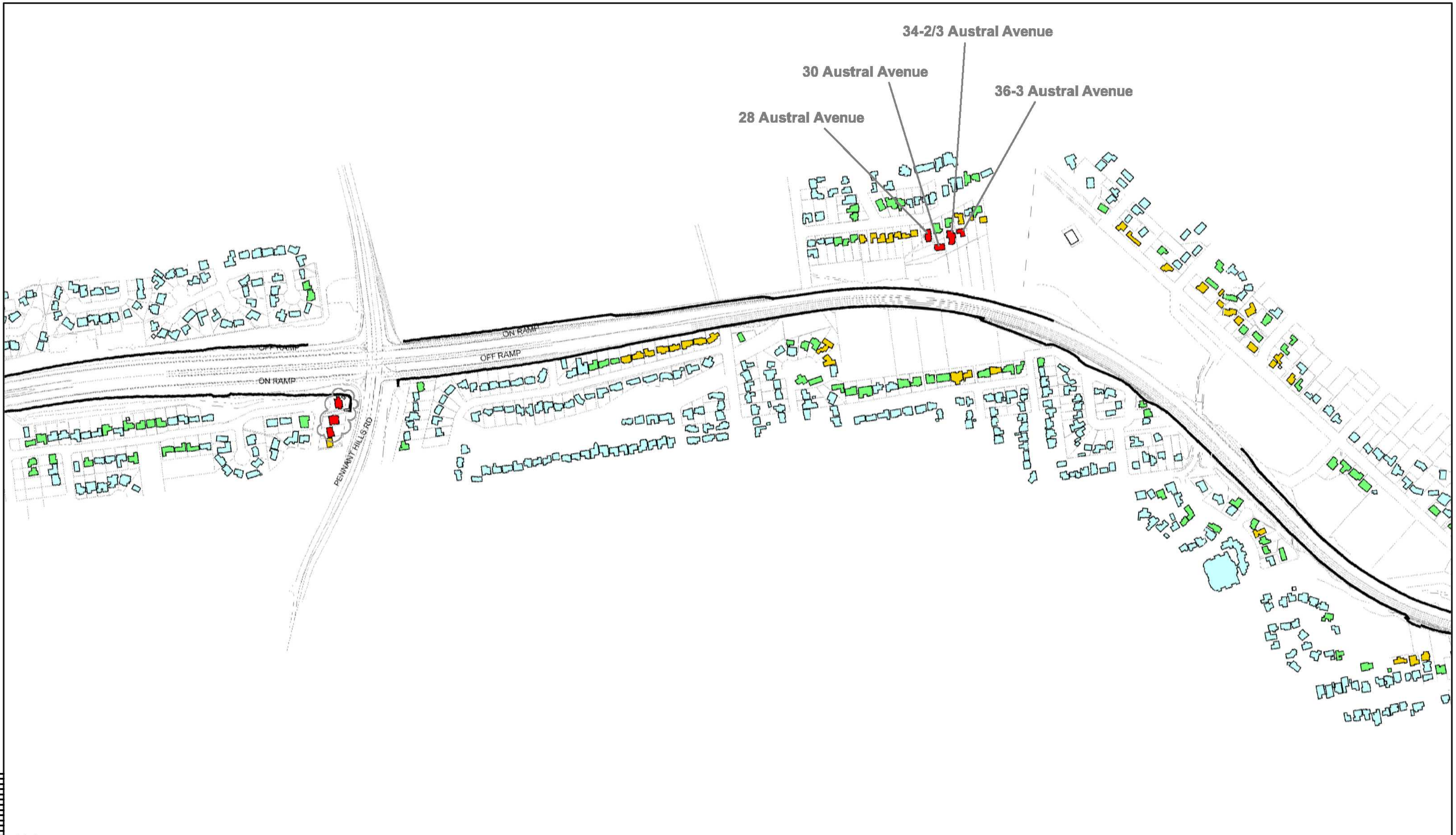
FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 2/6

DRAWING No. 10-7434_2021_1st

REVISION 0



Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Heggies Pty Ltd
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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 3/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

50 mm ON ORIGINAL

Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Heggies Pty Ltd
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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 4/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

50 mm ON ORIGINAL

Notes

(cloud symbol) = Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 5/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

50 mm ON ORIGINAL

Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

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REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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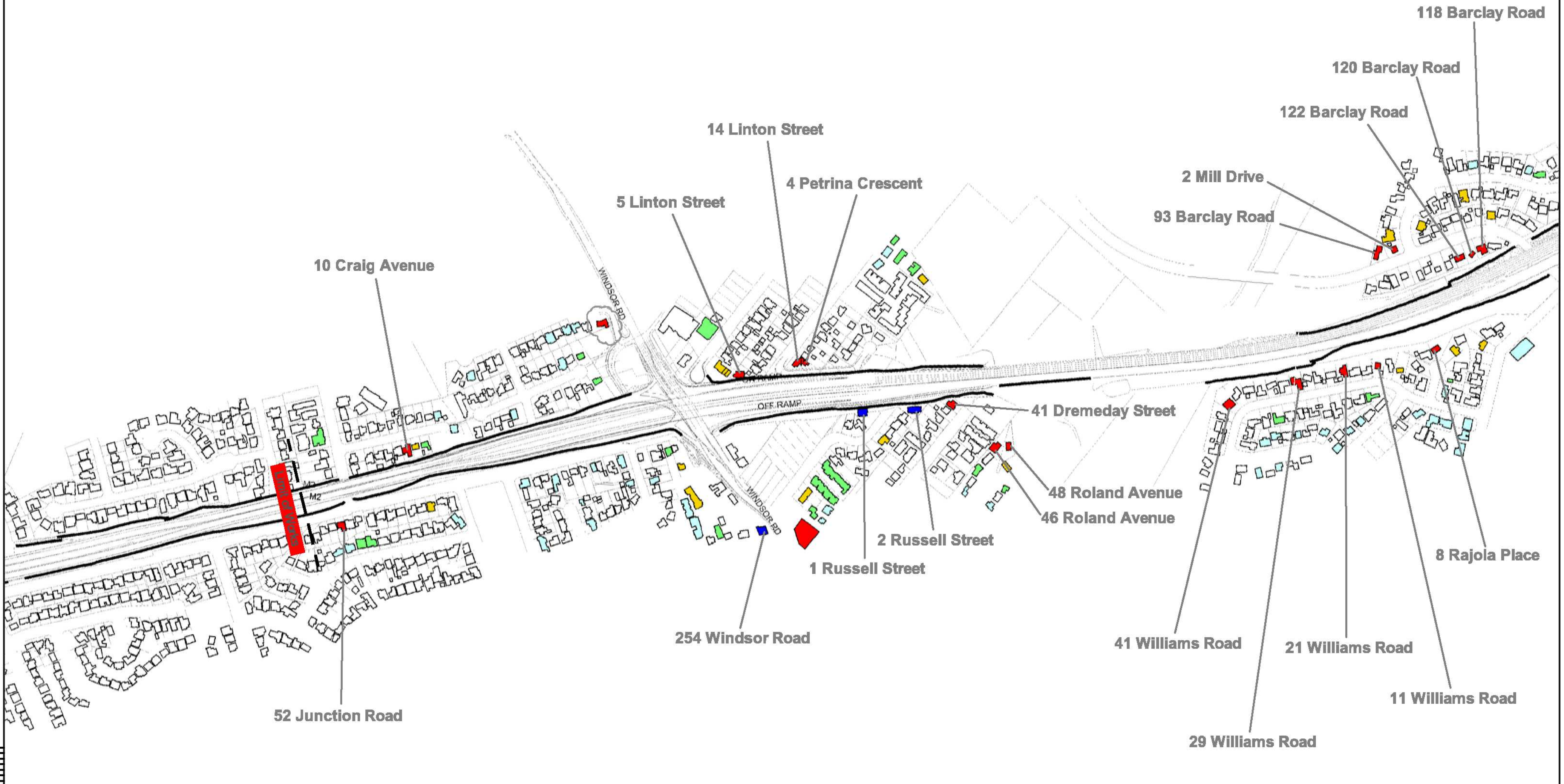
FILE NAME: 10-7434R1 App E - 2021 Future Design - 1st.dwg

10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Ground Floor Buildings
Page 6/6

DRAWING No. 10-7434_2021_1st

REVISION 0

50 mm ON ORIGINAL



Notes

= Exceedance is attributable to noise from Intersecting Roads

Legend

- ≥ 65 dBA
- 60 dBA to 64.9 dBA
- 57 dBA to 59.9 dBA
- 55 dBA to 56.9 dBA
- < 55 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
First Floor Buildings
Page 1/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 2st.dwg

DRAWING No. 10-7434_2021_1st

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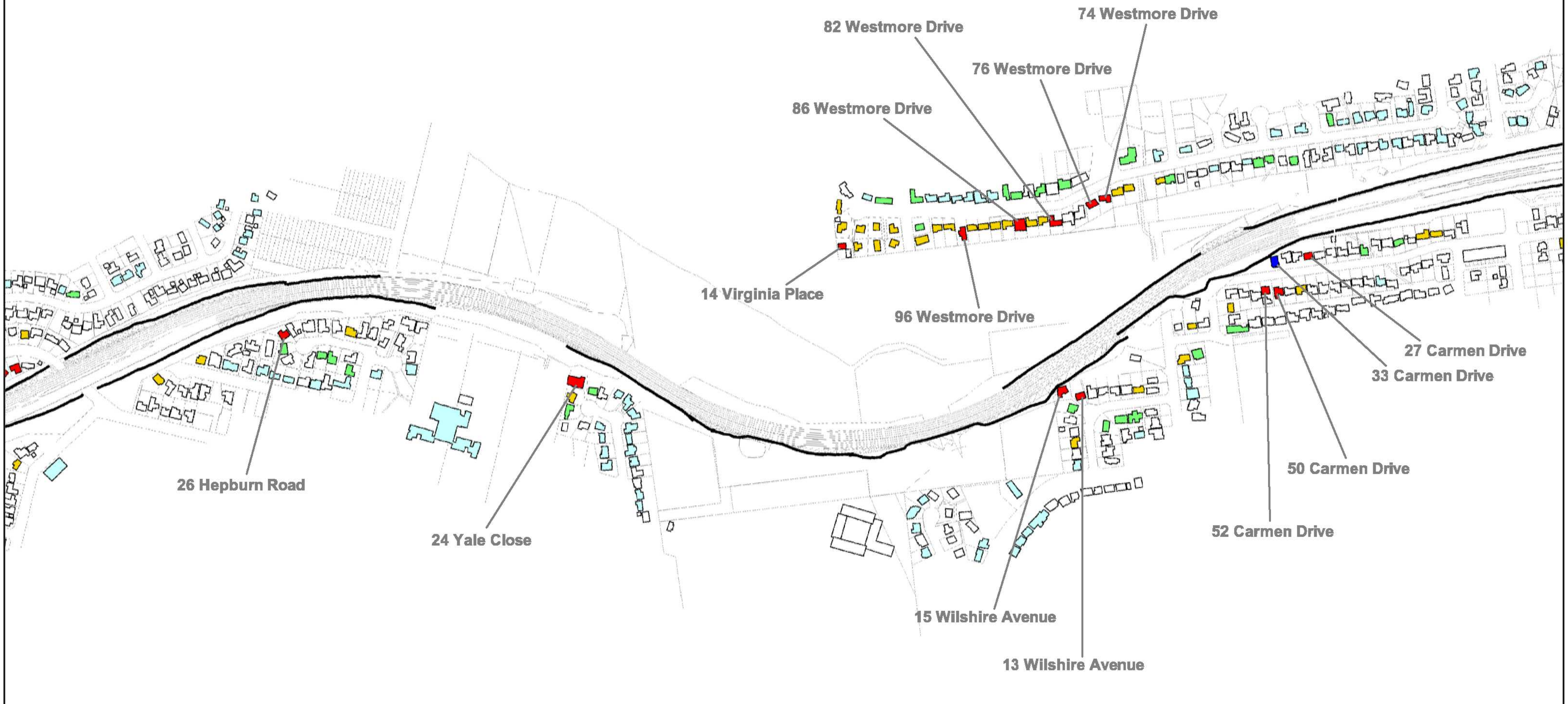

Notes

= Exceedance is attributable to noise from Intersecting Roads

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

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2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
First Floor Buildings
Page 2/6

FILE NAME: 10-7434R1 App E - 2021 Future Design - 2st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

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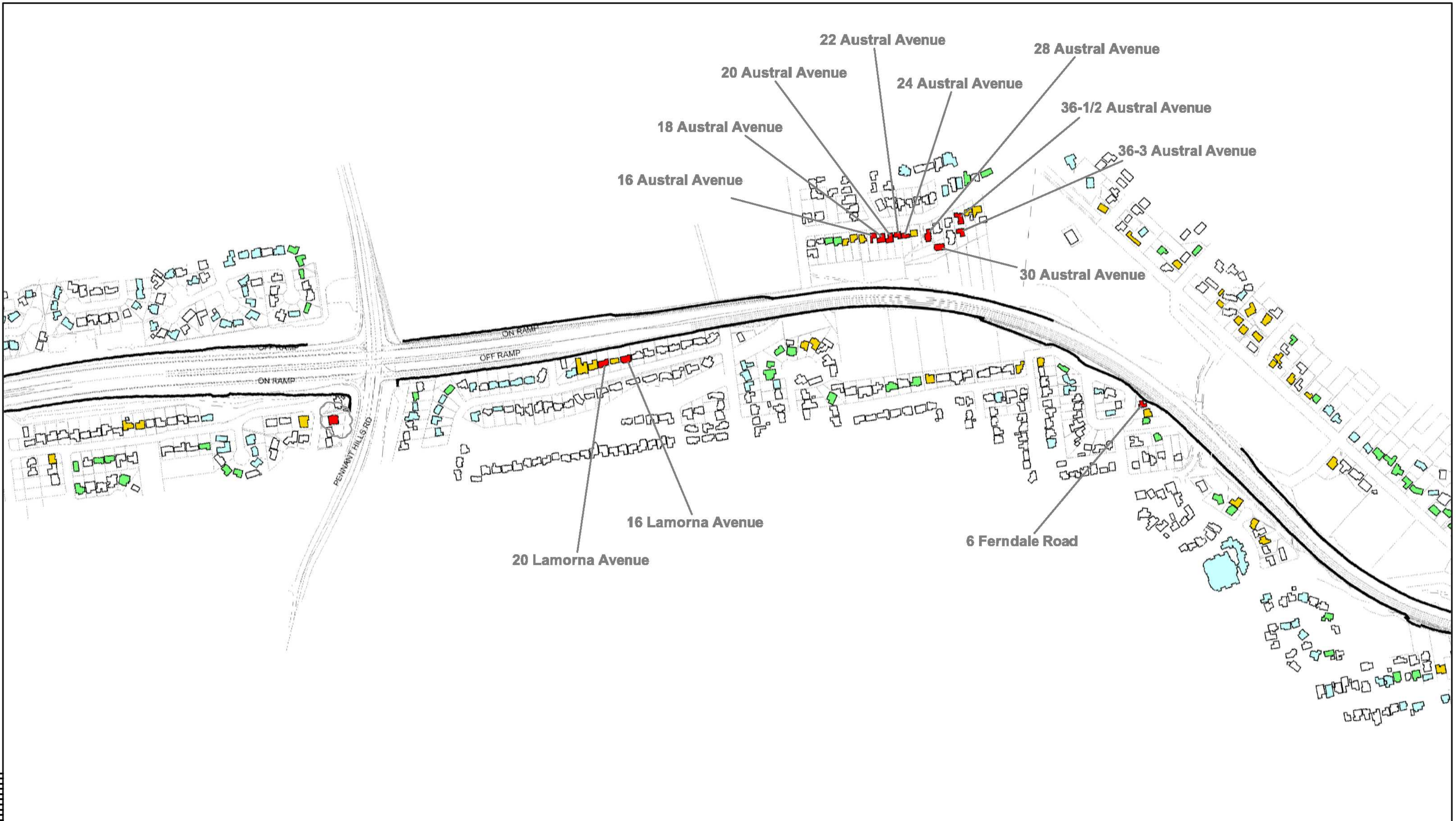

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
First Floor Buildings
Page 3/6

DRAWING No. 10-7434_2021_1st

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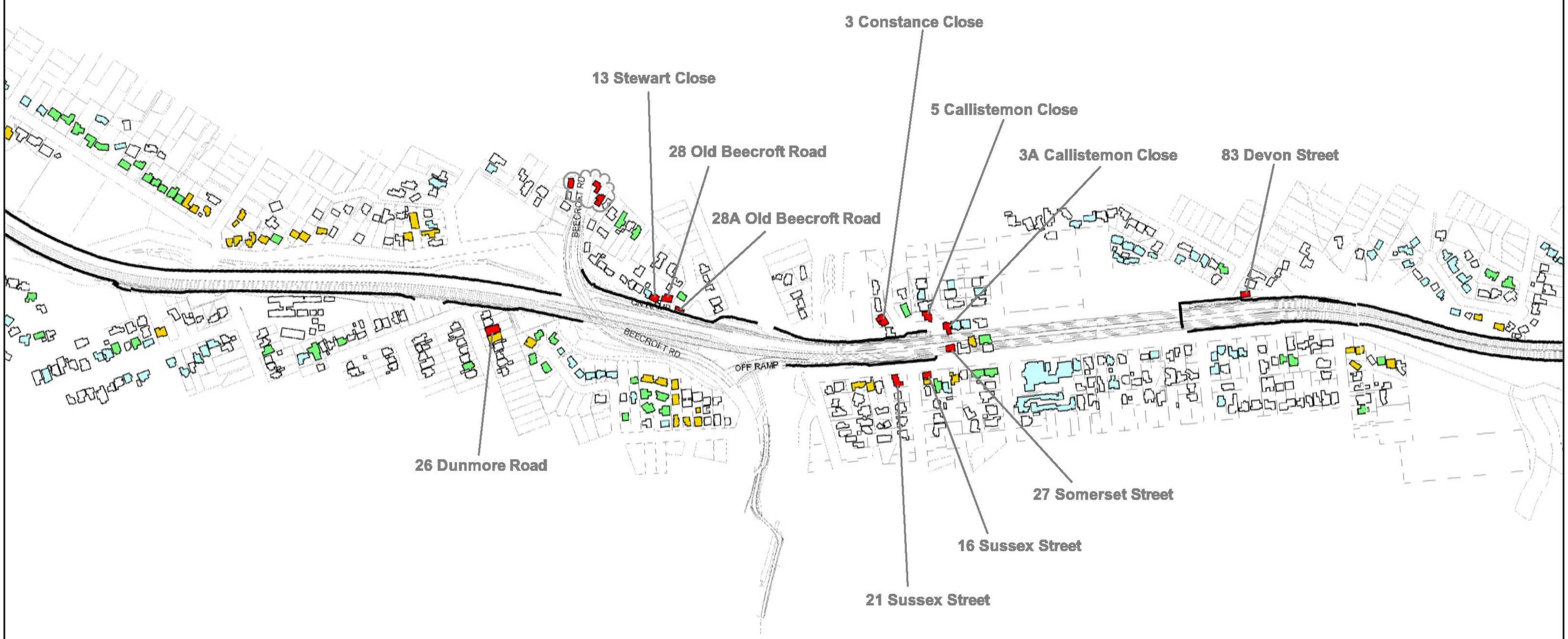

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
First Floor Buildings
Page 4/6

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FILE NAME: 10-7434R1 App E - 2021 Future Design - 2st.dwg

10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
First Floor Buildings
Page 5/6

DRAWING No. 10-7434_2021_1st

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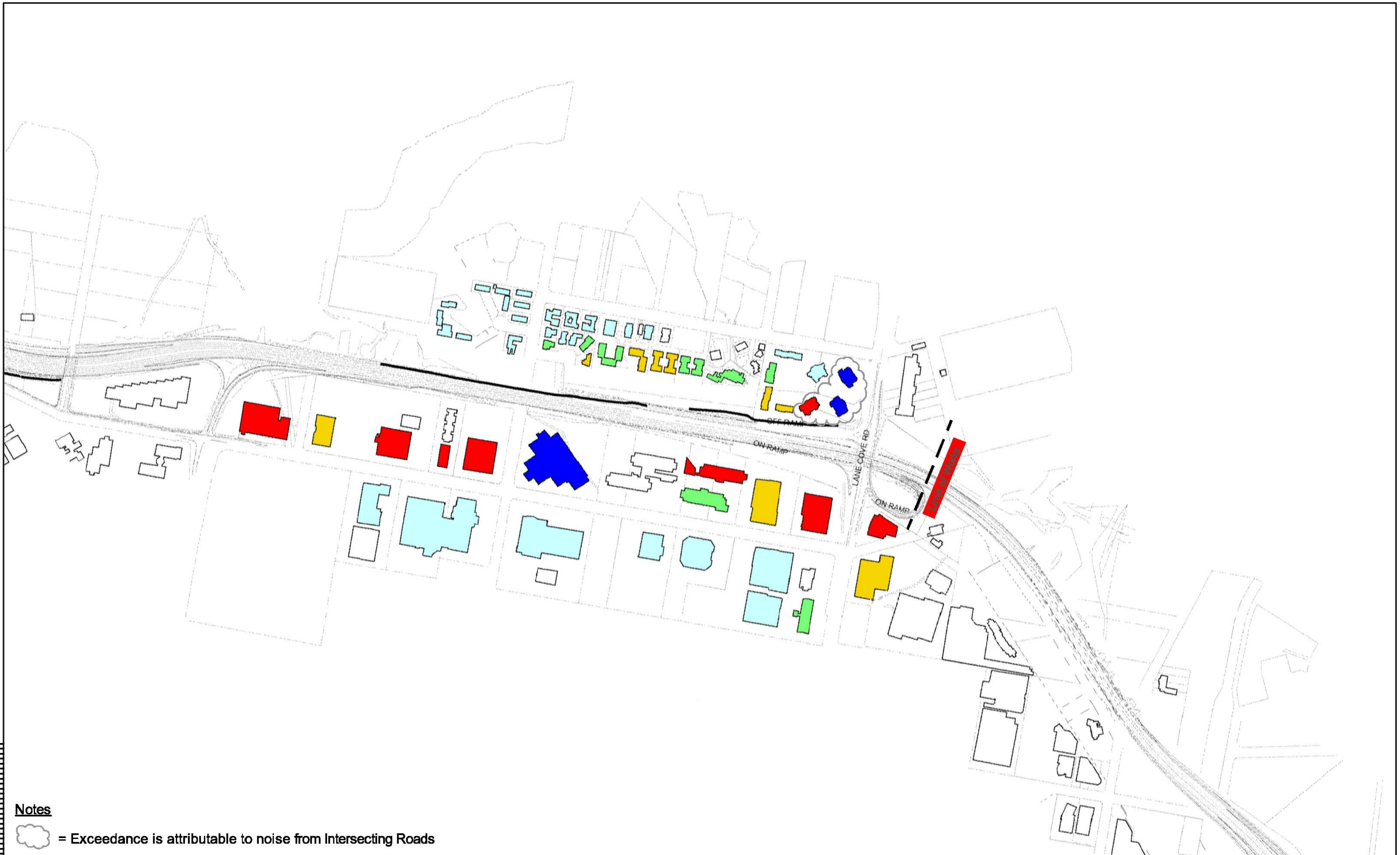

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2021 Future Design - LAeq(9hour)
First Floor Buildings
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FILE NAME: 10-7434R1 App E - 2021 Future Design - 2st.dwg

DRAWING No. 10-7434_2021_1st

REVISION 0

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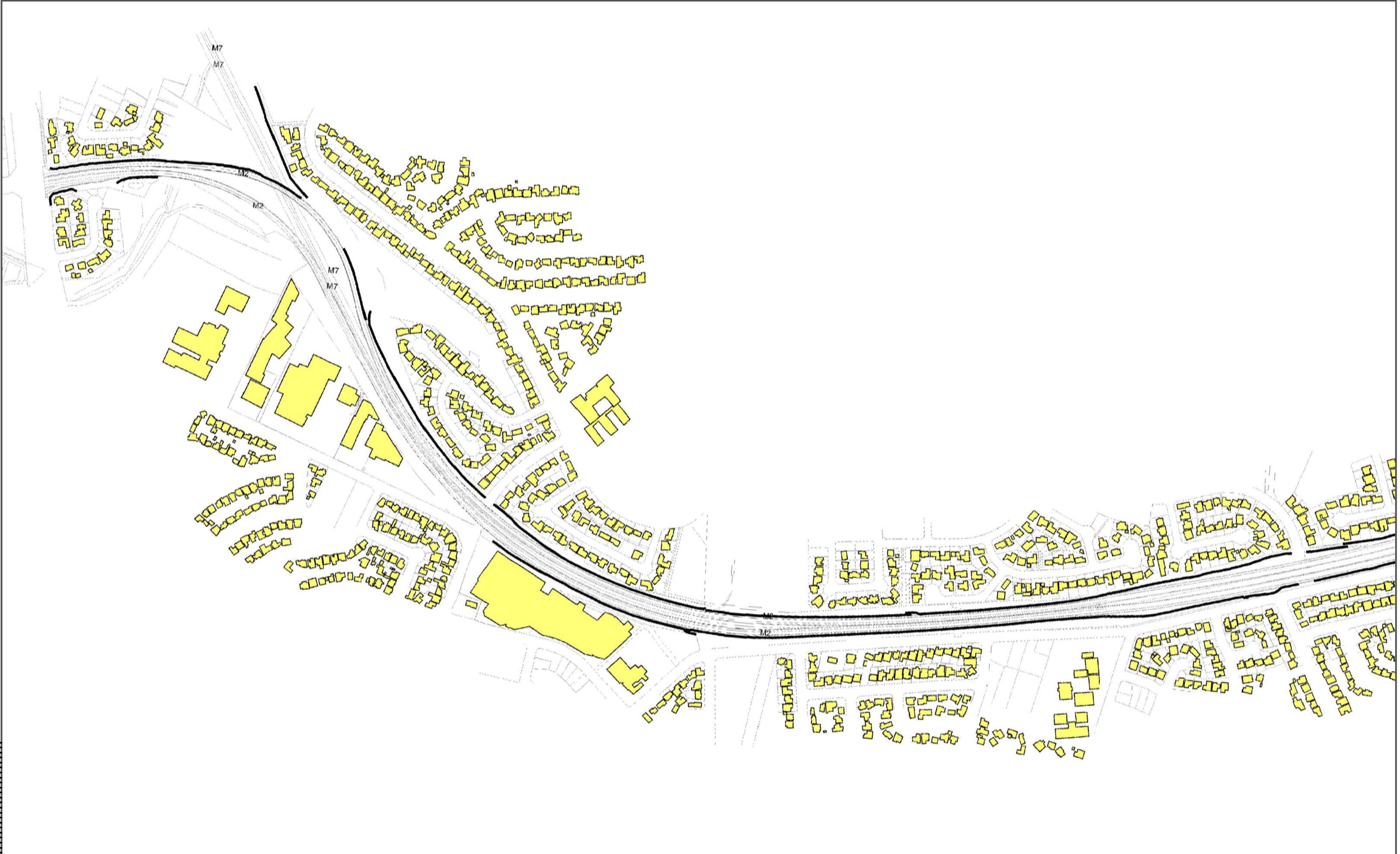
Future Design (2021) MINUS Future Existing (2011) Facade Plots - Ground and First Floors



Legend

> 2 dBA

< 2 dBA

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10-7434 M2 Upgrade Project

2021 MINUS 2011 Difference Plots

Ground Floor Buildings

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
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FILE NAME: 10-7434R1 App F - Difference Plots - 1st.dwg

DRAWING No. 10-7434_Difference_1st

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0 10 20 30 40 50

Legend

- > 2 dBA
- < 2 dBA

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2021 MINUS 2011 Difference Plots
Ground Floor Buildings
Page 2/7

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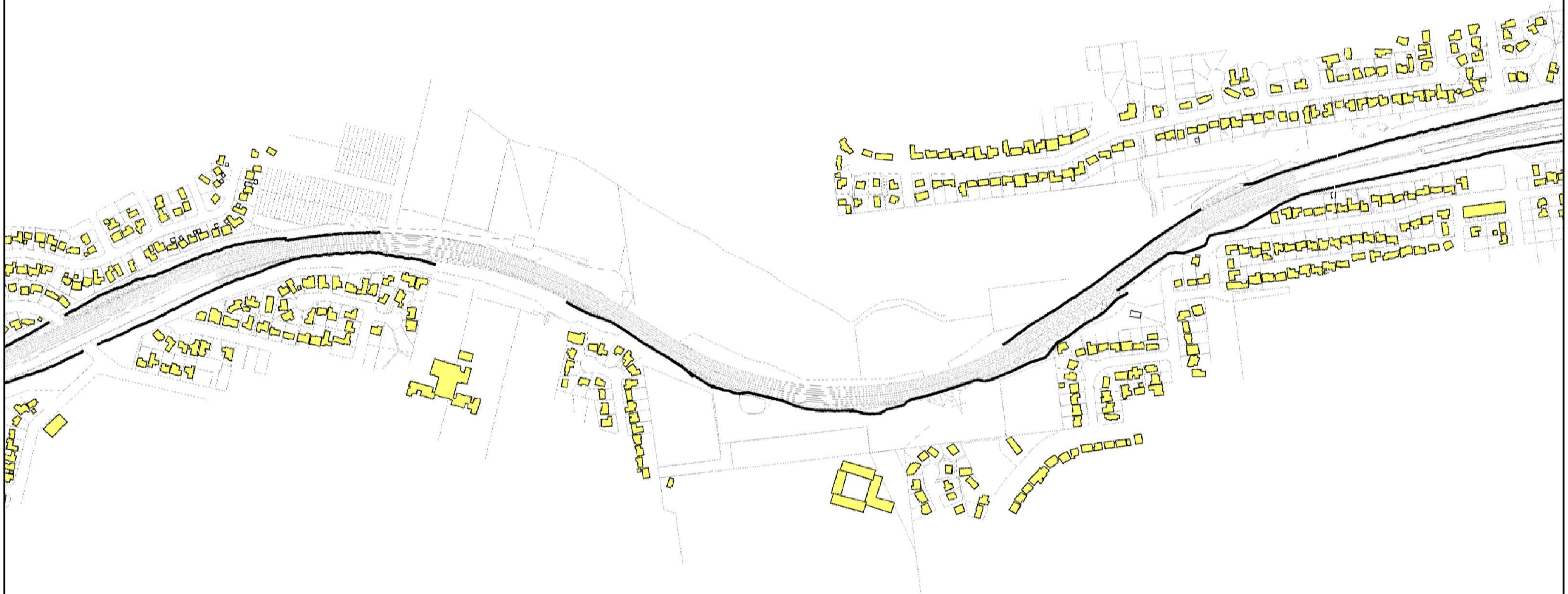

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10-7434 M2 Upgrade Project
2021 MINUS 2011 Difference Plots
Ground Floor Buildings
Page 3/7

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Ground Floor Buildings
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Page 6/7

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Ground Floor Buildings
Page 7/7

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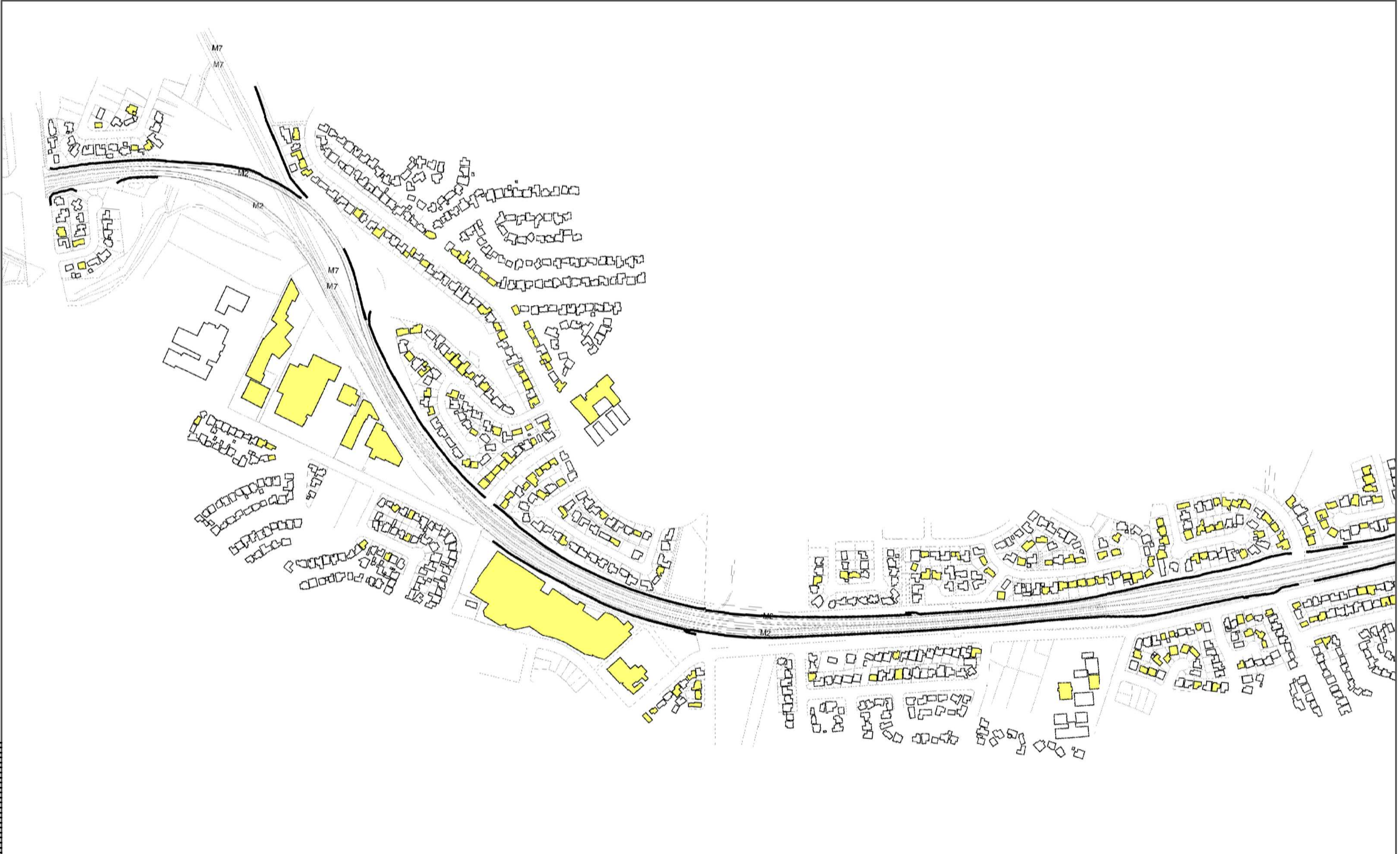

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■ < 2 dBA

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10-7434 M2 Upgrade Project
2021 MINUS 2011 Difference Plots
First Floor Buildings
Page 1/7

FILE NAME: 10-7434R1 App F - Difference Plots - 2st.dwg

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REVISION 0

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Legend

- > 2 dBA
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2021 MINUS 2011 Difference Plots
First Floor Buildings
Page 2/7

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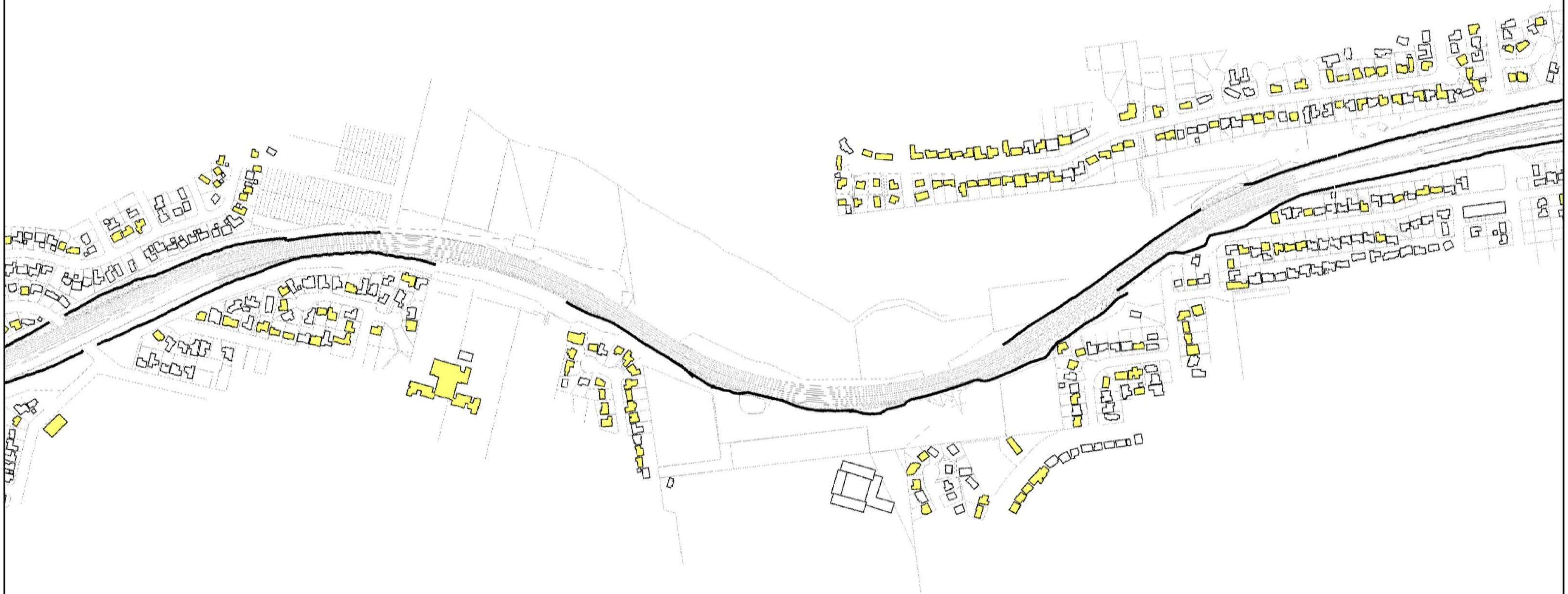

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10-7434 M2 Upgrade Project

2021 MINUS 2011 Difference Plots

First Floor Buildings

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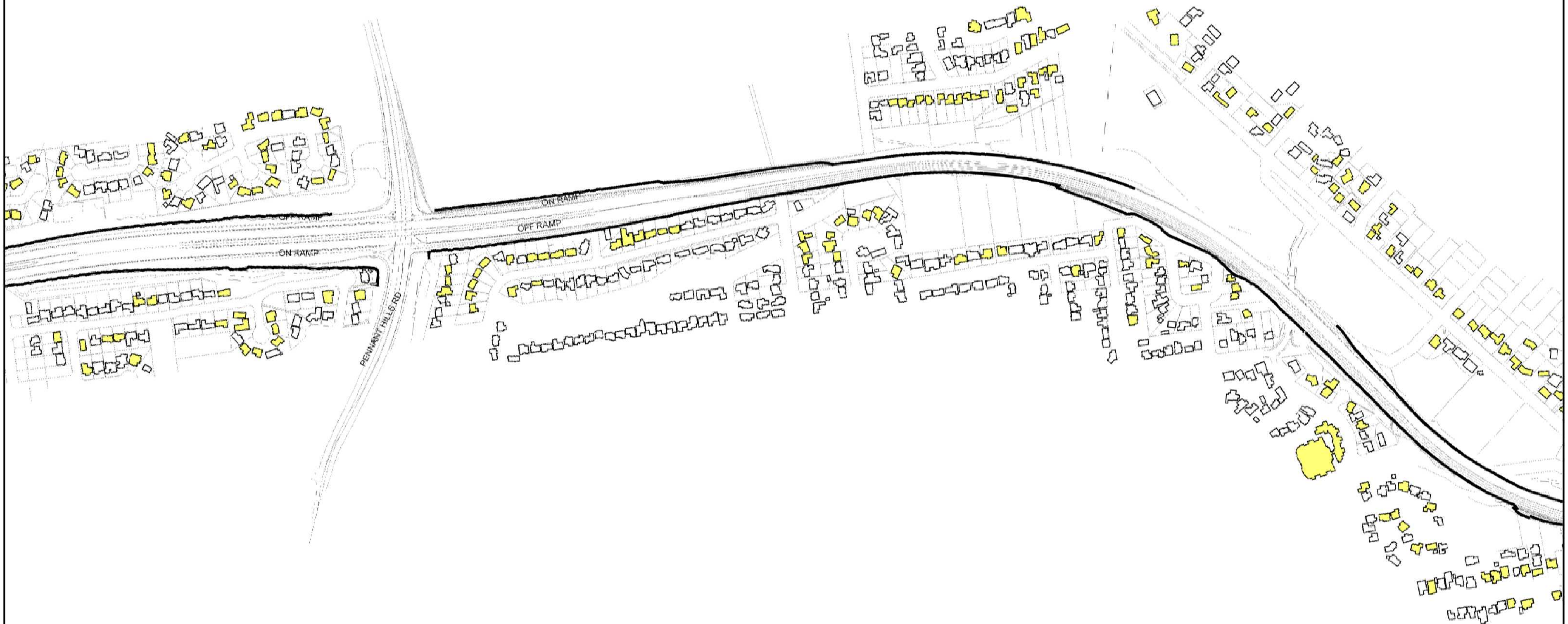

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First Floor Buildings
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10-7434 M2 Upgrade Project
2021 MINUS 2011 Difference Plots
First Floor Buildings
Page 5/7

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2021 MINUS 2011 Difference Plots
First Floor Buildings
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2021 MINUS 2011 Difference Plots
First Floor Buildings
Page 7/7

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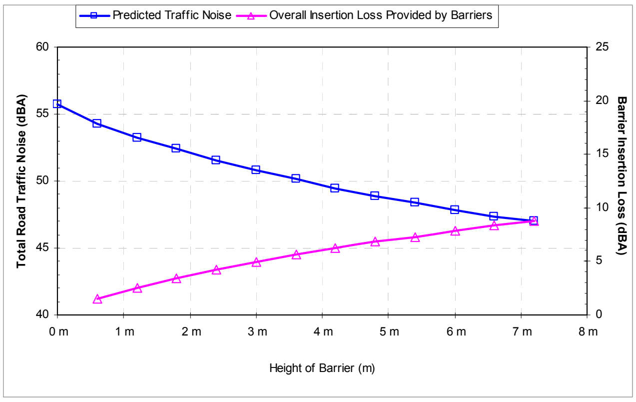
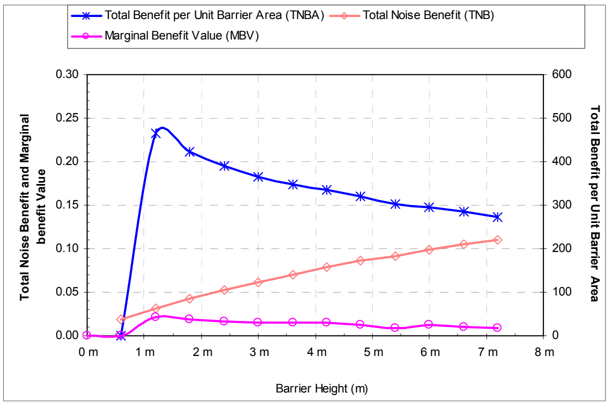
Optimisation of Noise Walls

NW-E-1001





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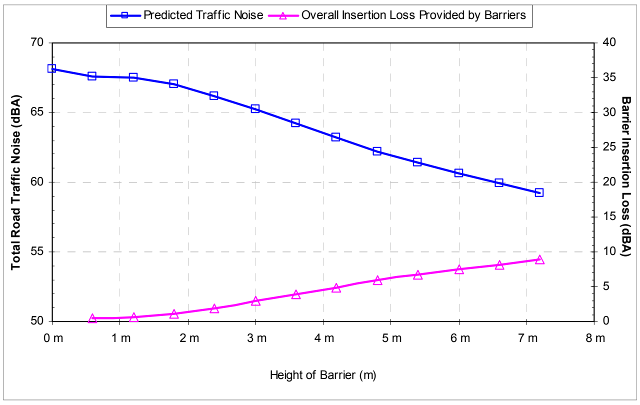

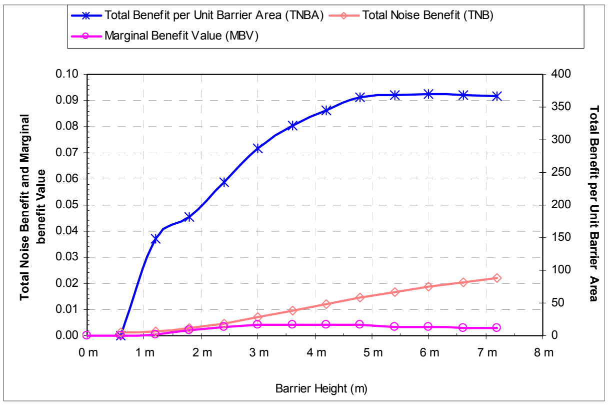

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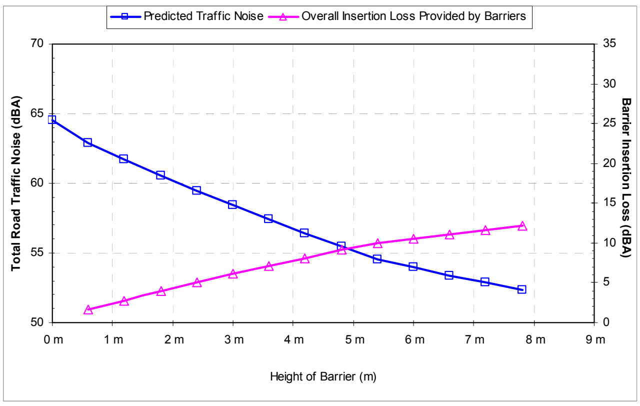
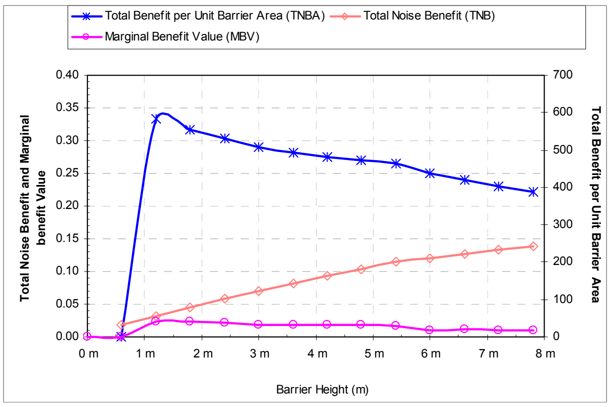
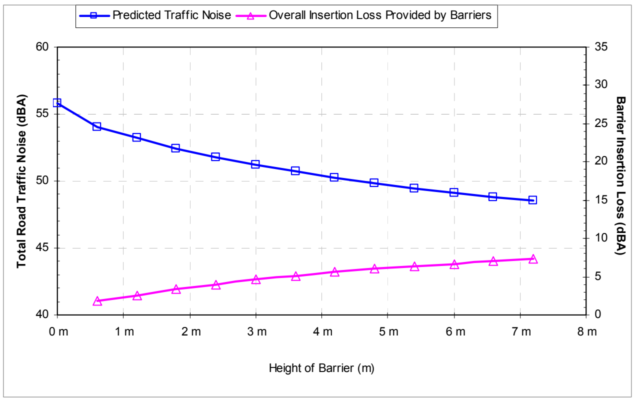
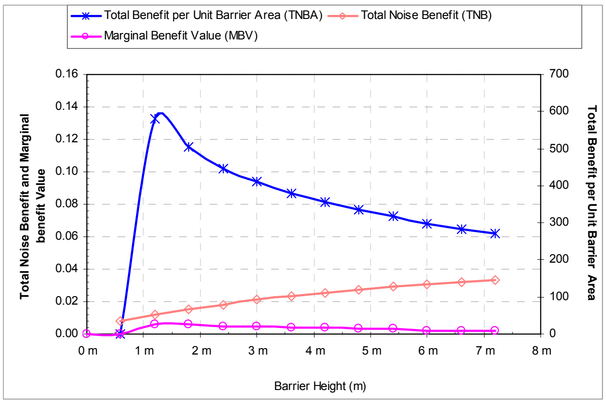




Optimisation of Noise Walls

NW-W-1001





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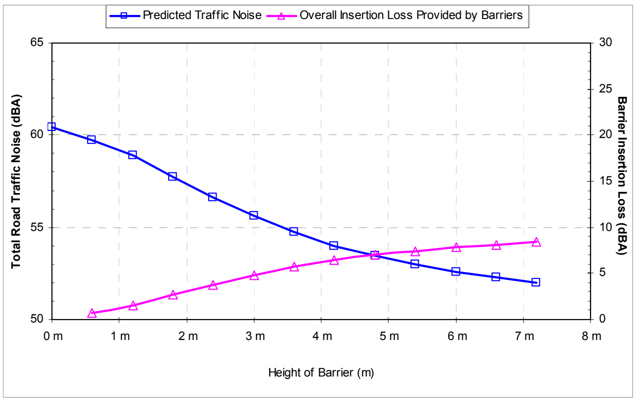
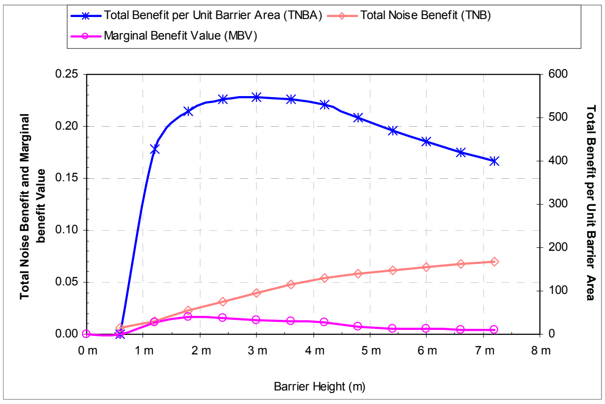




The **Total Noise Benefit** (TNB) for each barrier height option is the sum of the dBA reductions achieved (taking account of all road traffic noise sources) at all residences and other noise sensitive receivers within each segment for each barrier height.

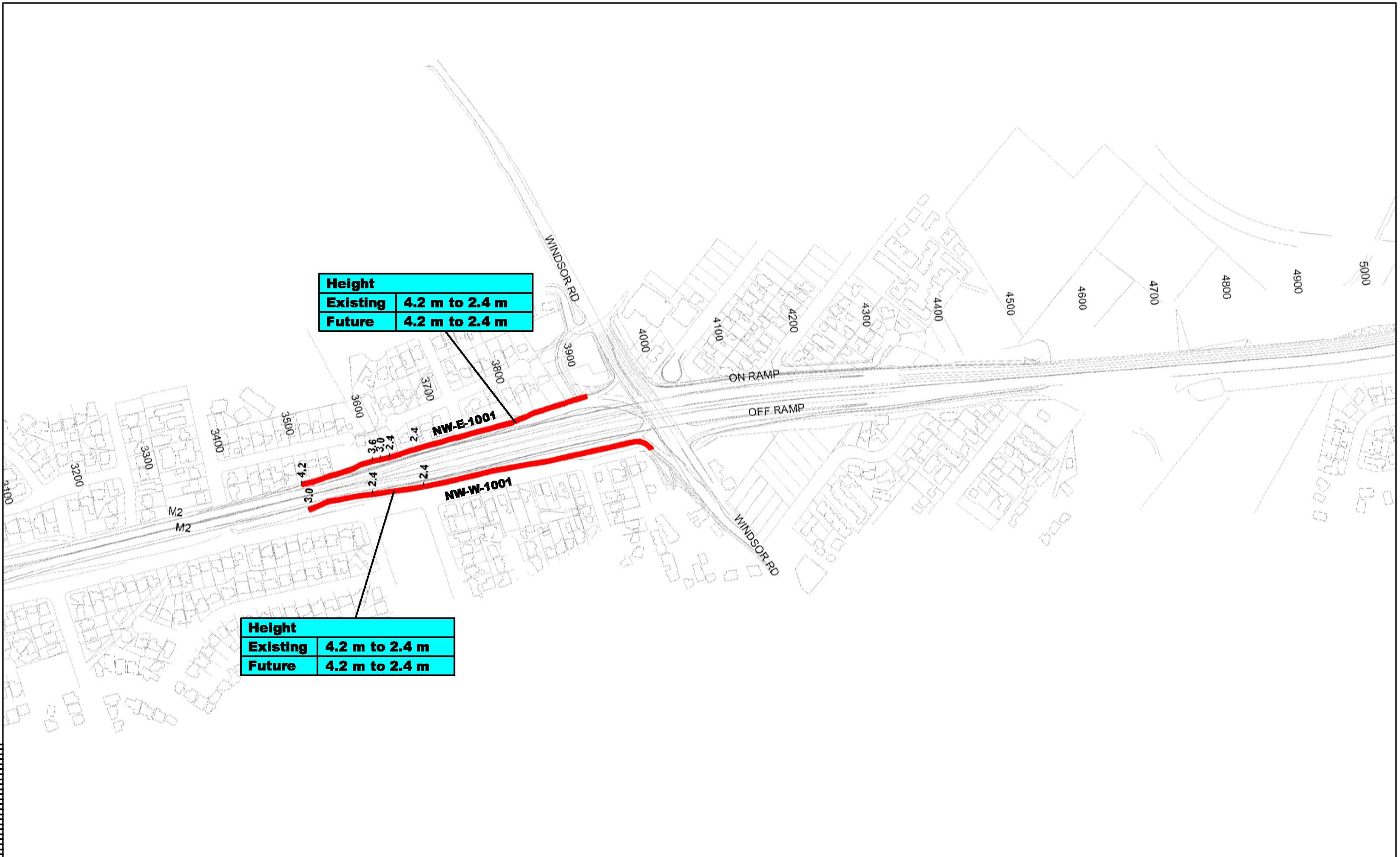
The **Marginal Benefit Value** (MBV) for a particular barrier height option is the increase in Total Noise Benefit (TNB) divided by the increase in barrier height or area. The methodology assumes barrier costs are proportional to barrier areas and are hence proportional to barrier heights, even though other factors such as barrier material will also have an influence on costs.

The **Total Benefit per Unit Barrier Area** (TNBA) is the Total Noise Benefit (TNB) divided by the total area of the barrier in the road section being examined.

Appendix H

Report 10-7434R1

Altered Noise Wall Locations



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0	18/12/09		ALW	PG

Legend

- Noise Wall Affected by Project
- Relocated Noise Wall
- Relocated and Heightened Noise Wall
- New Noise Wall

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2021 Future Design
Noise Wall Details
Page 1/8

FILE NAME: 10-7434R1 App H - Future Noise Walls.dwg

DRAWING No. 10-7434_Noise_Walls

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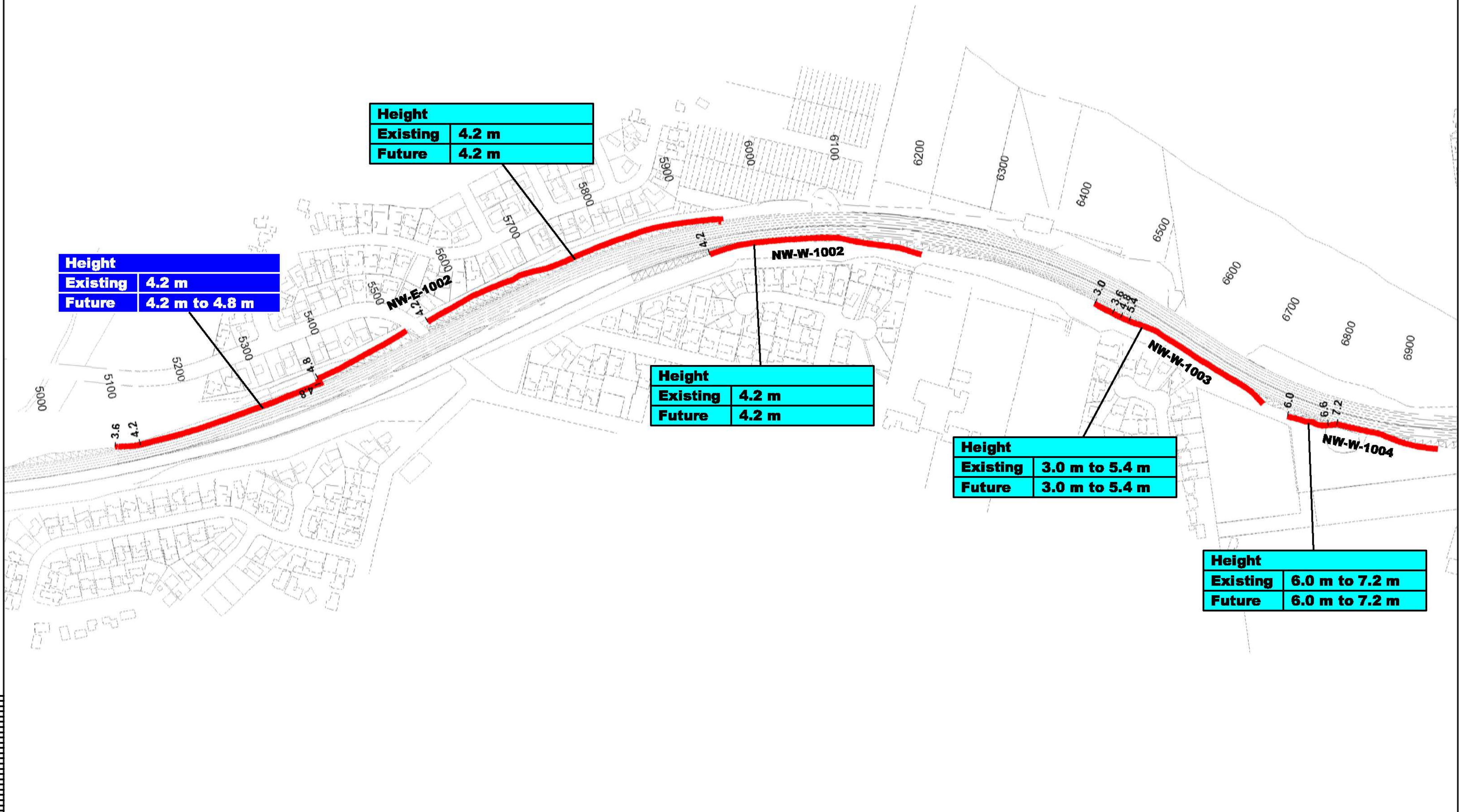

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10-7434 M2 Upgrade Project
2021 Future Design
Noise Wall Details
Page 2/8

DRAWING No. 10-7434_Noise_Walls

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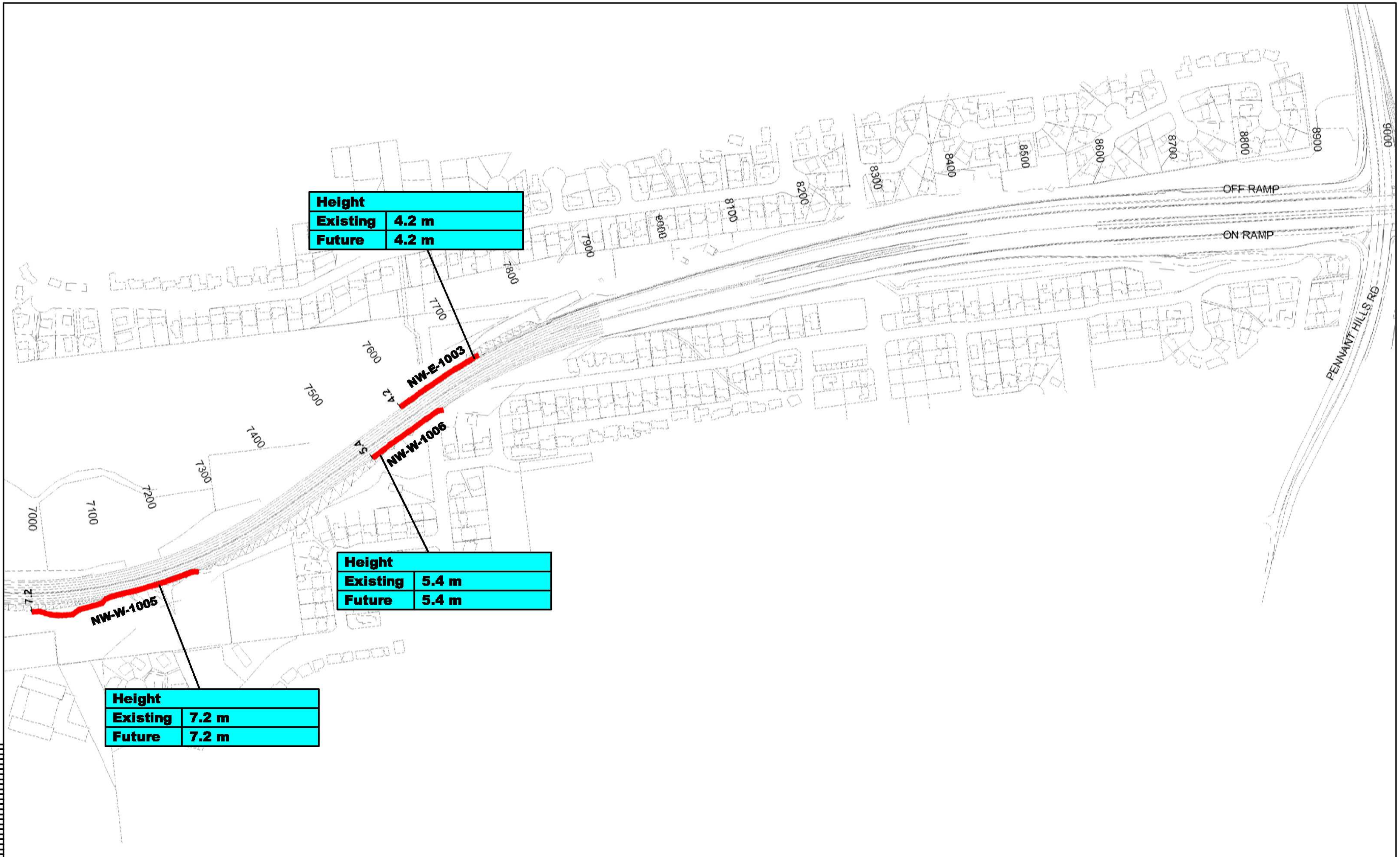

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Noise Wall Details
Page 3/8

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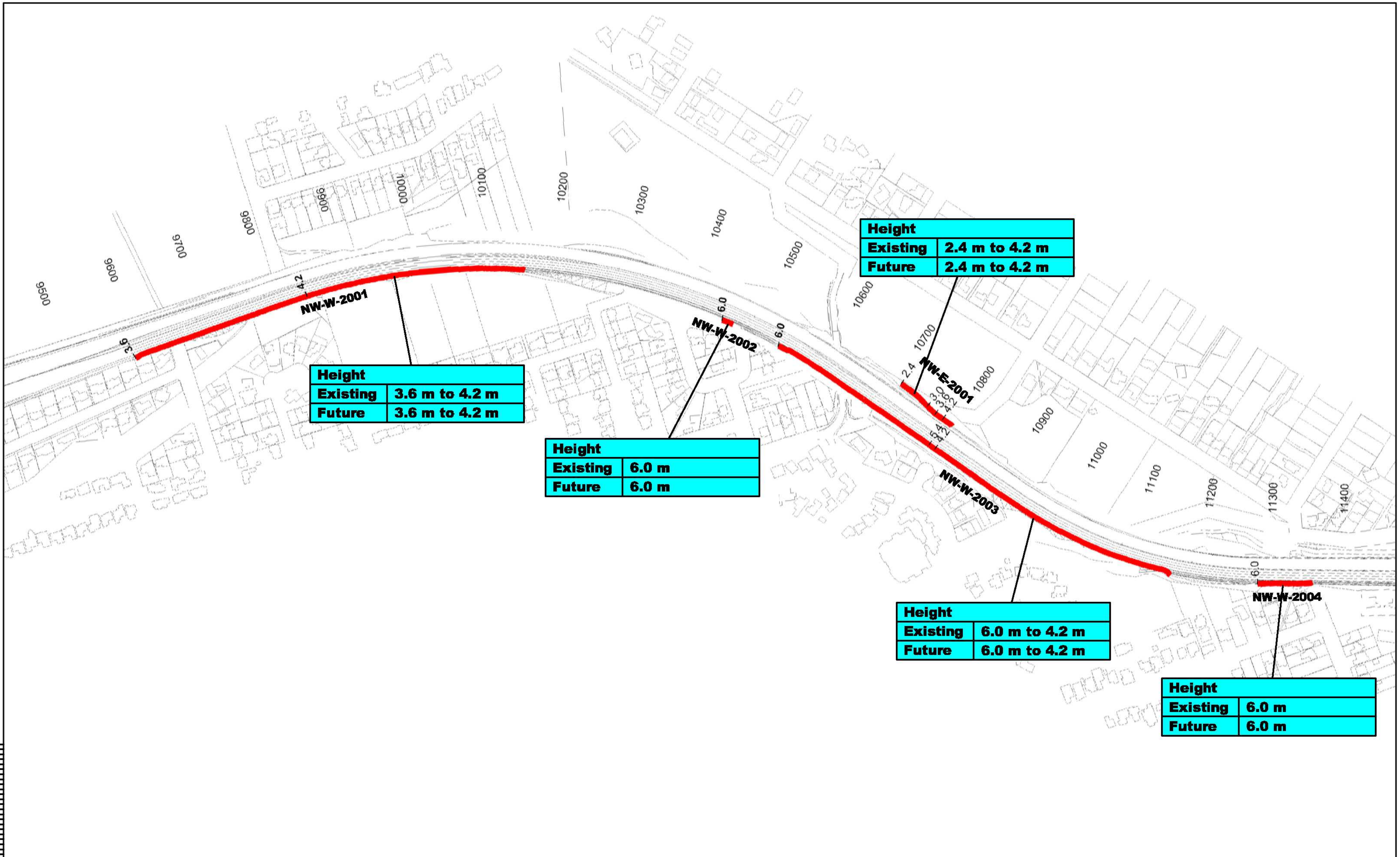

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Noise Wall Details
Page 4/8

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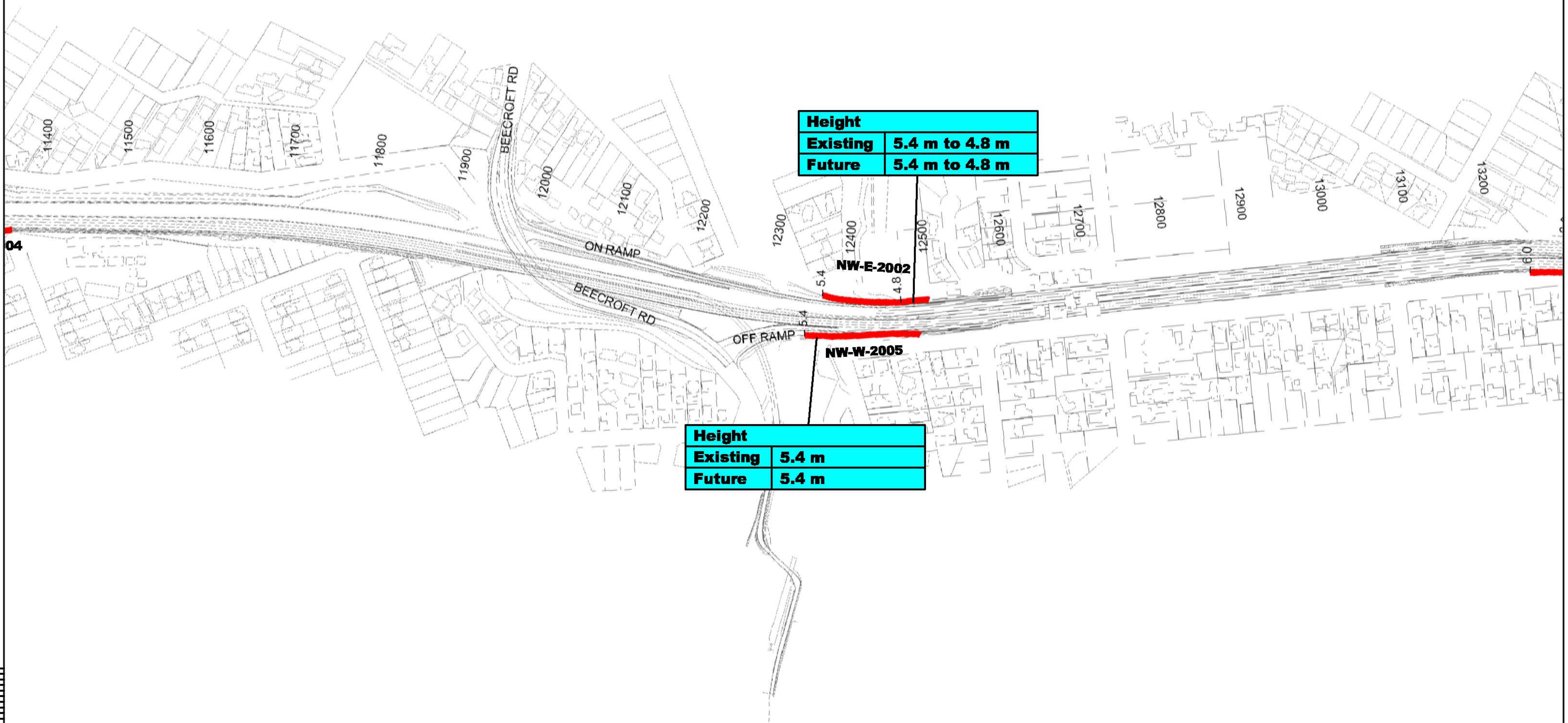

Height	
Existing	5.4 m to 4.8 m
Future	5.4 m to 4.8 m

Height	
Existing	5.4 m
Future	5.4 m

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
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Legend

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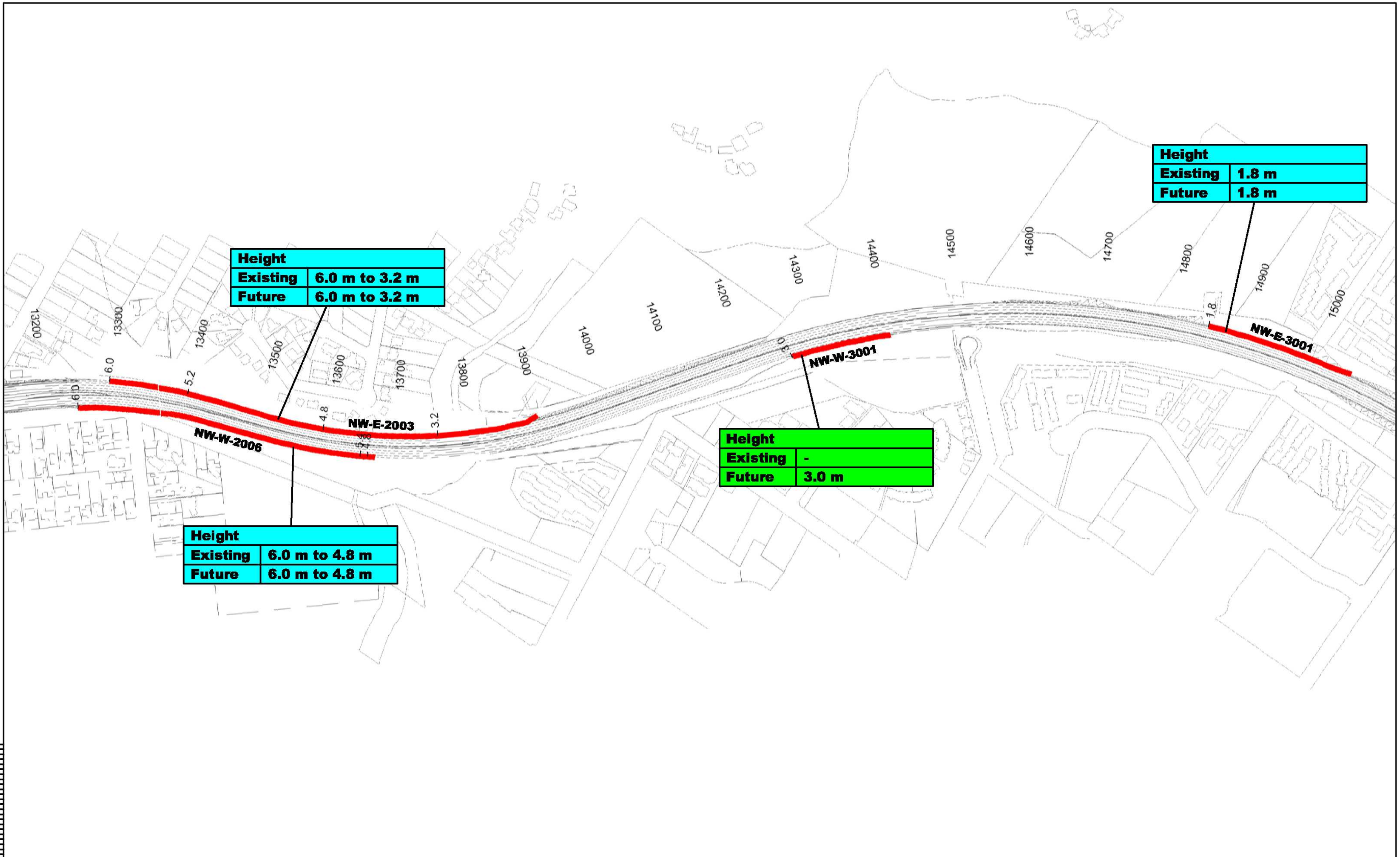
FILE NAME: 10-7434R1 App H - Future Noise Walls.dwg

10-7434 M2 Upgrade Project
2021 Future Design
Noise Wall Details
Page 5/8

DRAWING No. 10-7434_Noise_Walls

REVISION 0

50 mm ON ORIGINAL



Legend

- Noise Wall Affected by Project
- Relocated Noise Wall
- Relocated and Heightened Noise Wall
- New Noise Wall

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

10-7434 M2 Upgrade Project
2021 Future Design
Noise Wall Details
Page 6/8

FILE NAME: 10-7434R1 App H - Future Noise Walls.dwg

DRAWING No. 10-7434_Noise_Walls

REVISION 0

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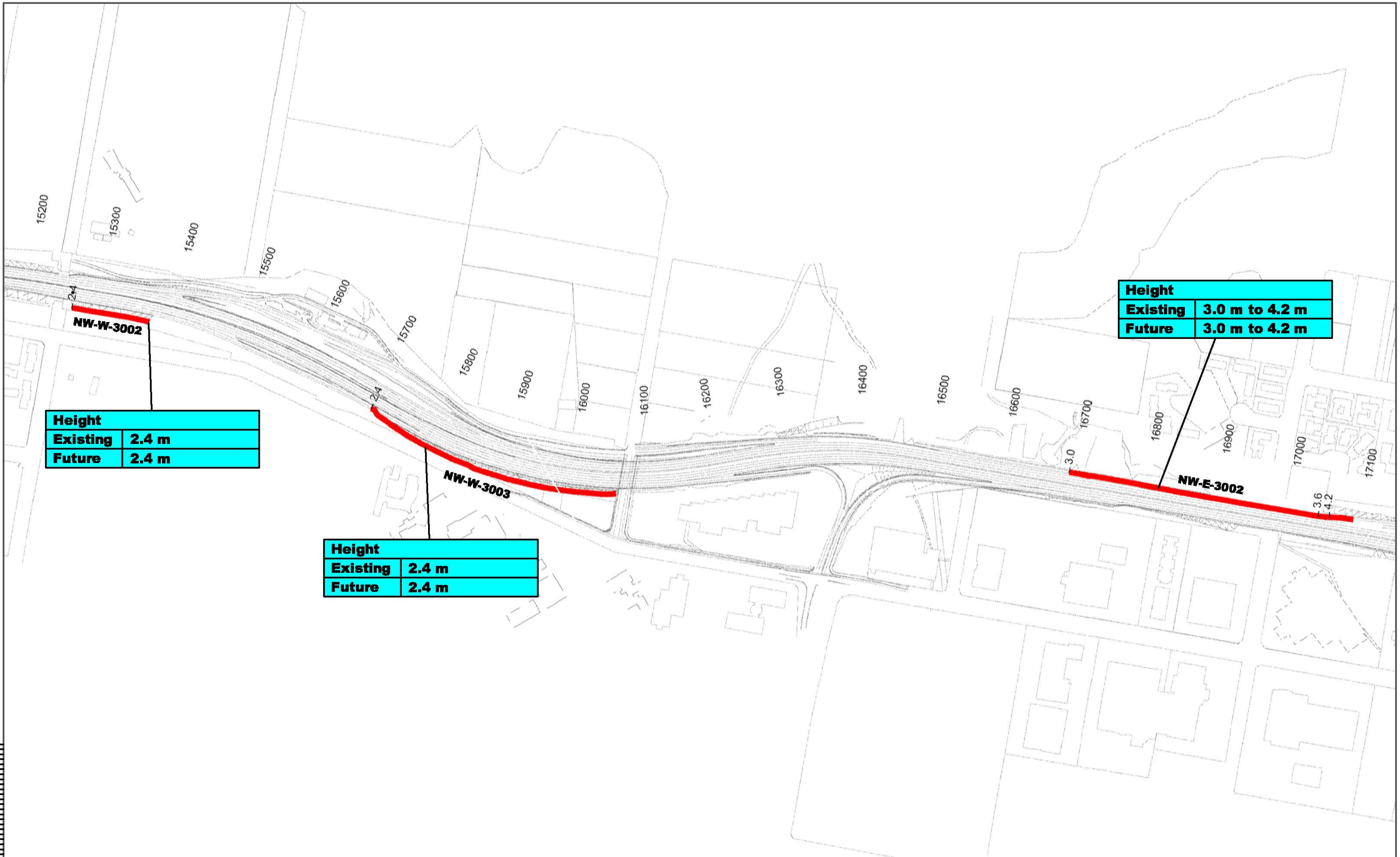

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0	18/12/09		ALW	PG

Legend

- Noise Wall Affected by Project
- Relocated Noise Wall
- Relocated and Heightened Noise Wall
- New Noise Wall

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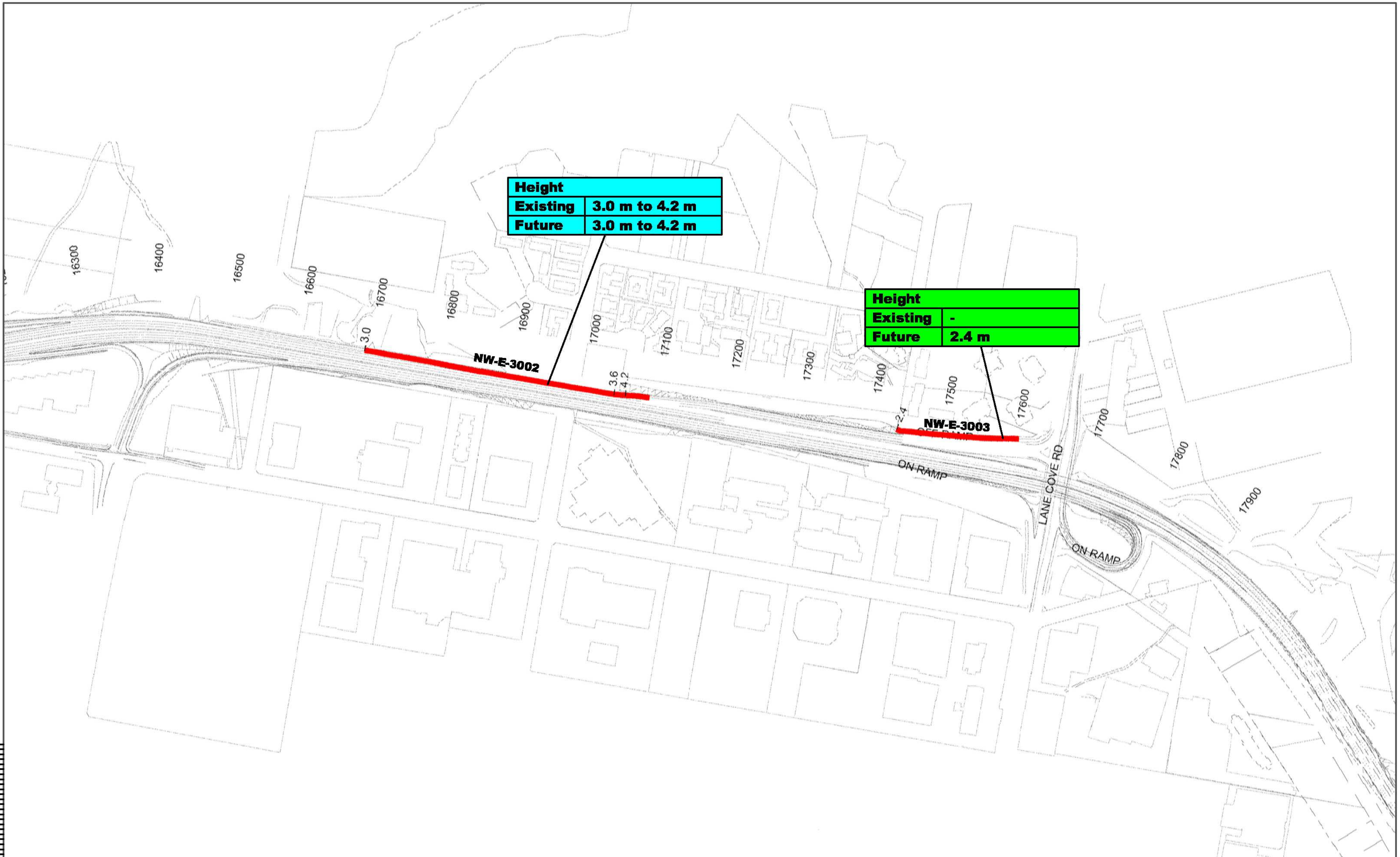
FILE NAME: 10-7434R1 App H - Future Noise Walls.dwg

10-7434 M2 Upgrade Project
2021 Future Design
Noise Wall Details
Page 7/8

DRAWING No. 10-7434_Noise_Walls

REVISION 0



REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Legend

- Noise Wall Affected by Project
- Relocated Noise Wall
- Relocated and Heightened Noise Wall
- New Noise Wall

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10-7434 M2 Upgrade Project
2021 Future Design
Noise Wall Details
Page 8/8

FILE NAME: 10-7434R1 App H - Future Noise Walls.dwg

DRAWING No. 10-7434_Noise_Walls

REVISION 0

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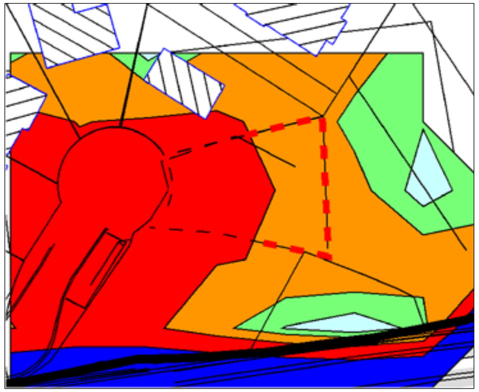
Appendix I

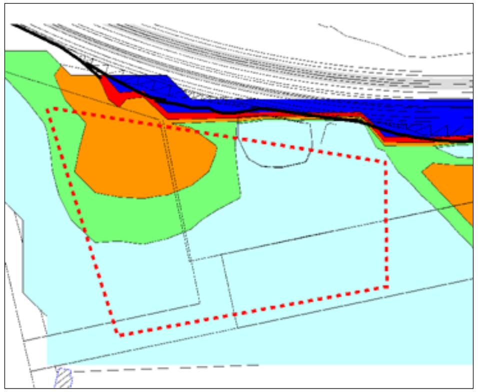
Report 10-7434R1

New Areas of Residential Development

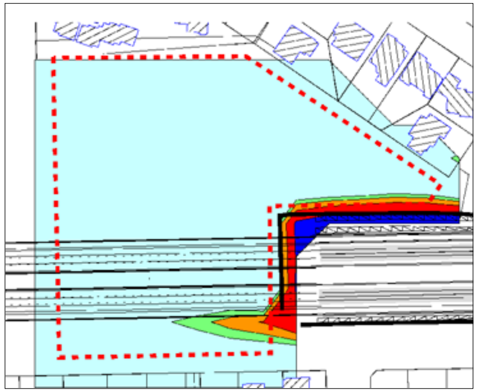
5 Petrina Close
Ground Floor (1.5 m)



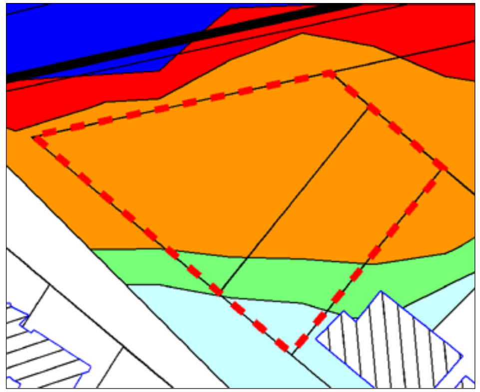
Baden Powell Place
Ground Floor (1.5 m)



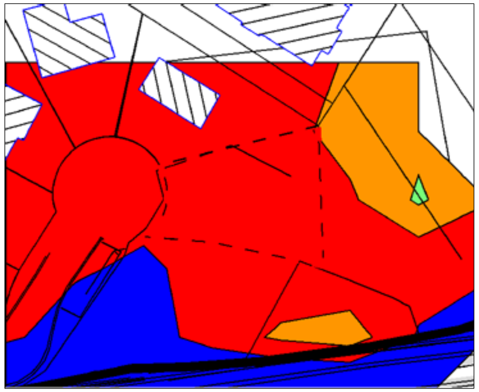
Devon Street
Ground Floor (1.5 m)



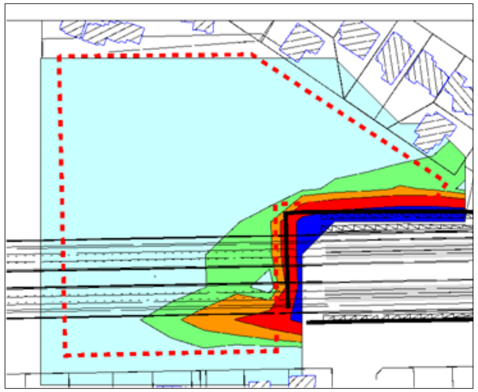
Waterloo Road
Ground Floor (1.5 m)



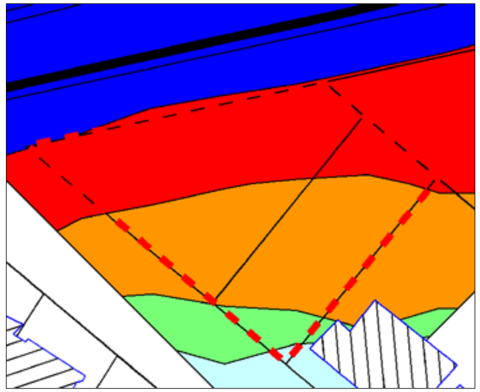
5 Petrina Close
First Floor (4.3 m)



Devon Street
First Floor (4.3 m)



Waterloo Road
First Floor (4.3 m)



Notes

Noise levels include a +2.5 dBA correction for facade reflections

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Areas of New Housing
Page 1/2

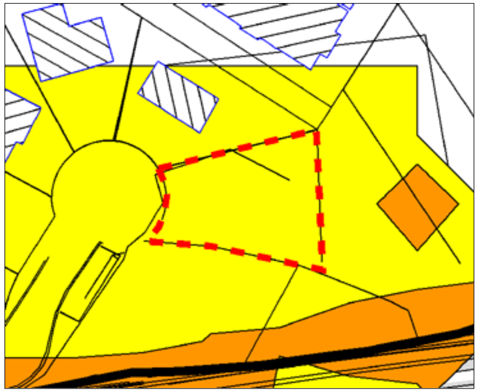
FILE NAME: 10-7434R1 Appendix I - New Housing.dwg

DRAWING No. 10-7434_New_Housing

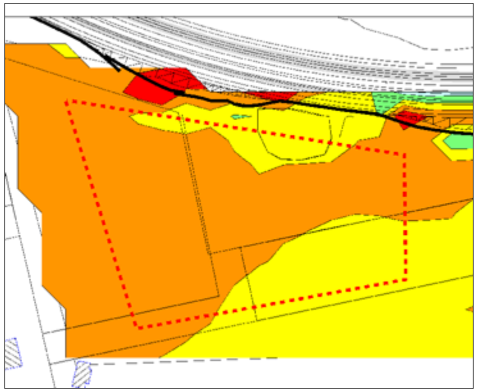
REVISION 0

50 mm ON ORIGINAL

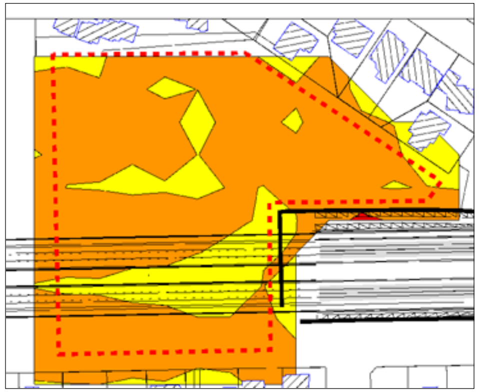
5 Petrina Close
Ground Floor (1.5 m)



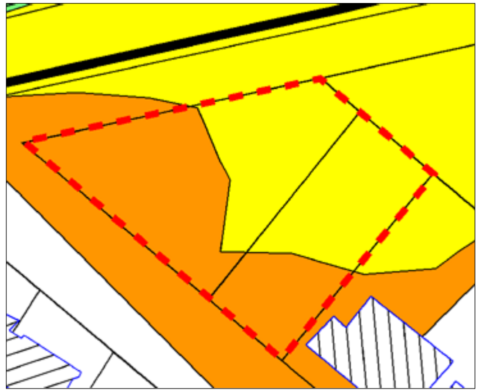
Baden Powell Place
Ground Floor (1.5 m)



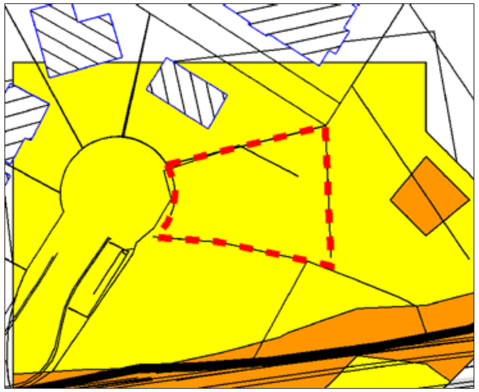
Devon Street
Ground Floor (1.5 m)



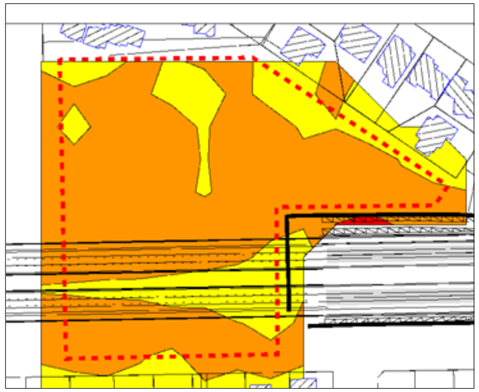
Waterloo Road
Ground Floor (1.5 m)



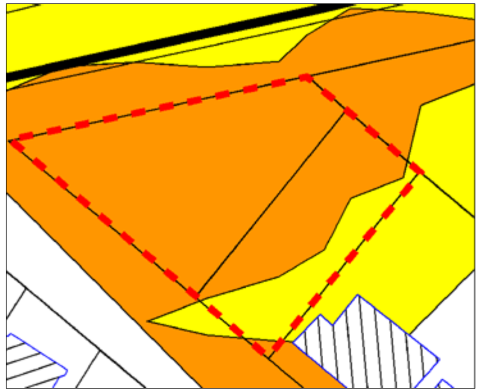
5 Petrina Close
First Floor (4.3 m)



Devon Street
First Floor (4.3 m)



Waterloo Road
First Floor (4.3 m)



Notes

Noise levels include a +2.5 dBA correction for facade reflections
Noise levels are the difference between 2021 Future Design and 2011 Future Existing

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

Legend

- > 2 dBA
- 1 dBA to 2 dBA
- 0 dBA to 1 dBA
- -1 dBA to 0 dBA
- < -1 dBA

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FILE NAME: 10-7434R1 Appendix I - New Housing.dwg

10-7434 M2 Upgrade Project
Difference Plots
Areas of New Housing
Page 2/2

DRAWING No. 10-7434_New_Housing

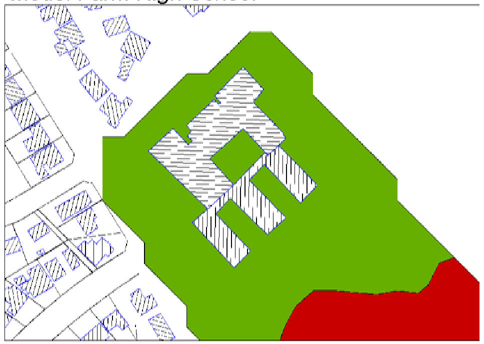
REVISION 0

Appendix J

Report 10-7434R1

Sensitive Land Uses (Schools)

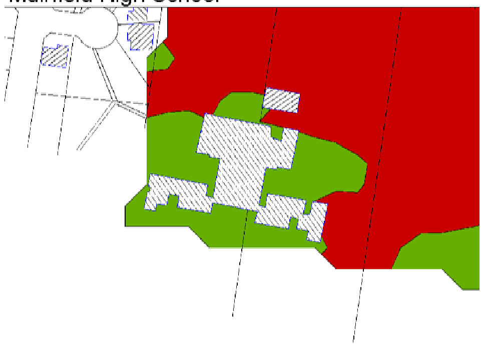
Model Farm High School



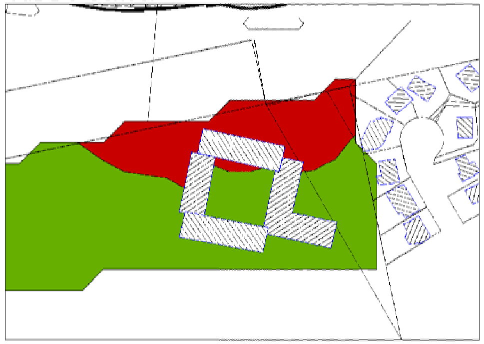
Winston Hills Public School

Our Lady of Lourdes Primary School

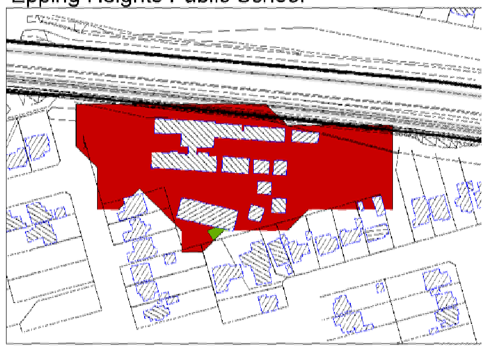
Muirfield High School



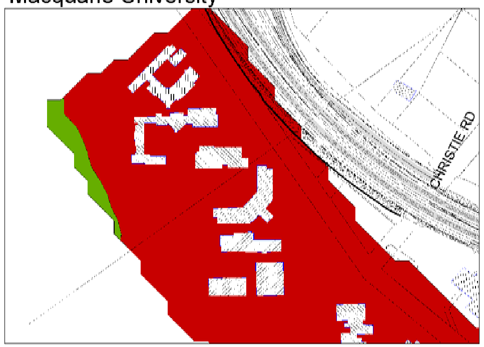
RIDBC School



Epping Heights Public School



Macquarie University



Notes

Criteria for Schools is an internal LAeq(1hr) of 45 dBA

A 10 dBA noise reduction from external to internal has been assumed

Legend

- > 55 dBA
- < 55 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(1hour)
Senstive Land Uses - Schools
Page 1/2

FILE NAME: 10-7434R1 Appendix J - Schools.dwg

DRAWING No. 10-7434_Schools

REVISION 0

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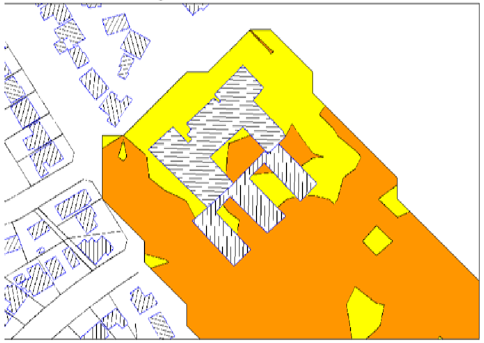
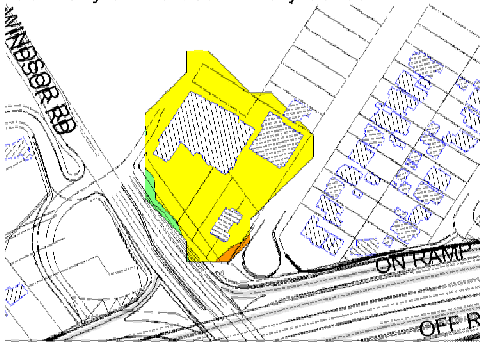
Model Farm High School

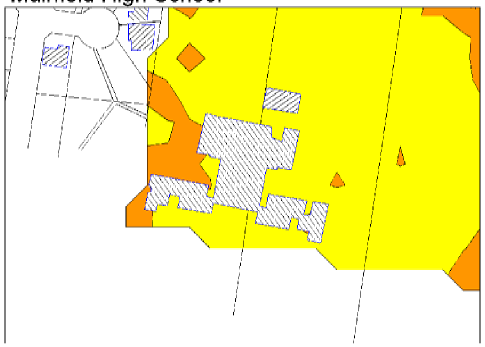


Winston Hills Public School

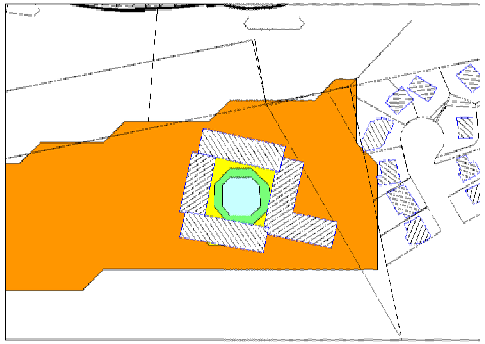
Our Lady of Lourdes Primary School



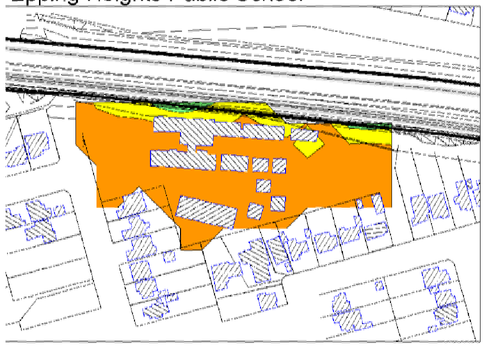
Muirfield High School



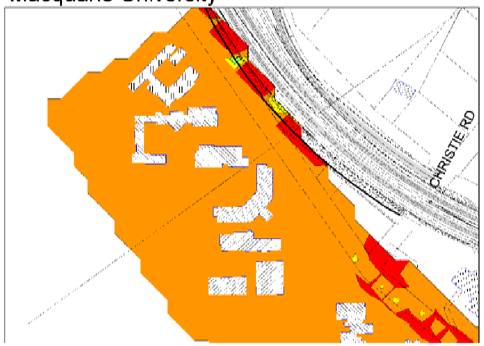
RIDBC School



Epping Heights Public School



Macquarie University



Notes

Noise levels are the difference between 2021 Future Design and 2011 Future Existing

Legend

- > 2 dBA
- 1 dBA to 2 dBA
- 0 dBA to 1 dBA
- -1 dBA to 0 dBA
- < -1 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
Difference Plots
Senstive Land Uses - Schools
Page 2/2

FILE NAME: 10-7434R1 Appendix J - Schools.dwg

DRAWING No. 10-7434_Schools

REVISION 0

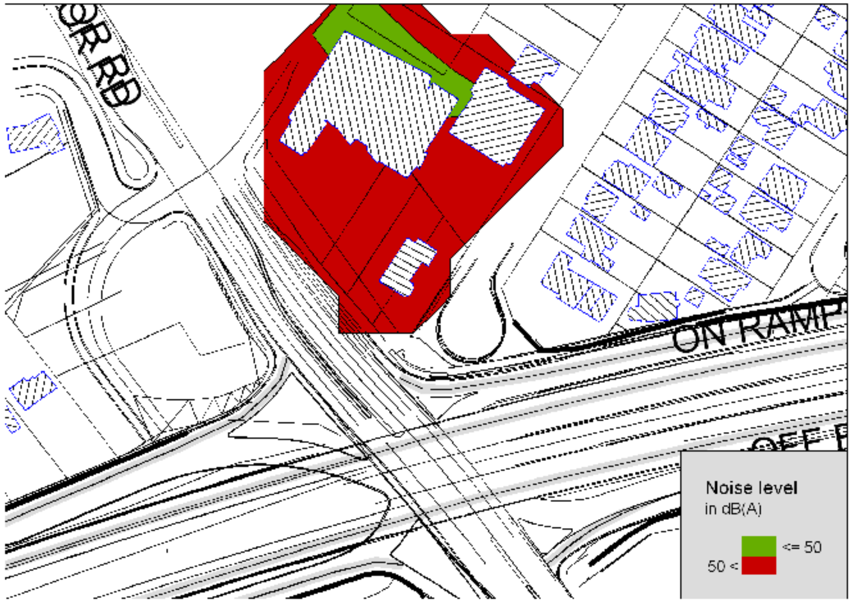
50 mm ON ORIGINAL

Appendix K

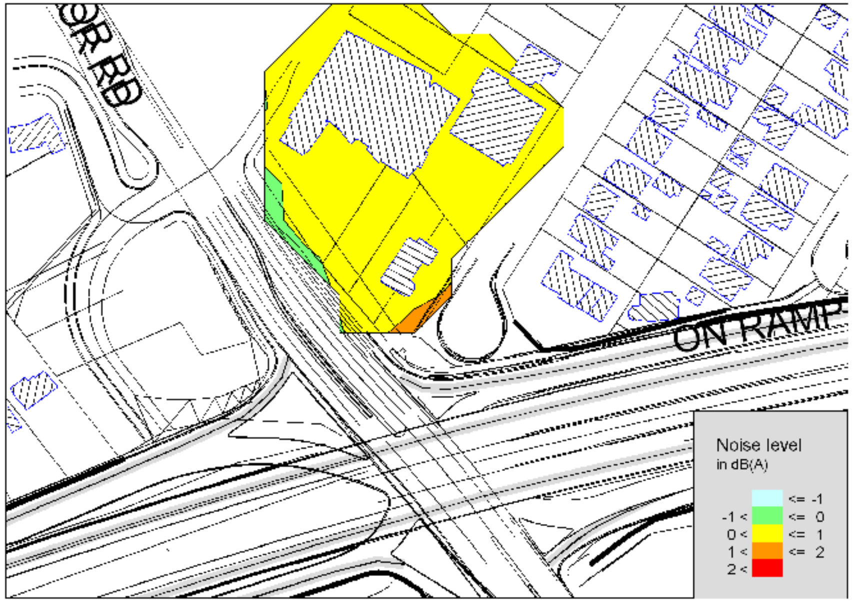
Report 10-7434R1

Sensitive Land Uses (Places of Worship)

Our Lady of Lourdes Church
2021 Future Design Scenario
Noise Level (Based on external 50 dBA LAeq,1hr Day ECRTN Criteria)



Our Lady of Lourdes Church
Difference Scenario
(2021 Future Design - 2011 Future Existing)



Notes
Criteria for Schools is an internal LAeq(1hr) of 40 dBA
A 10 dBA noise reduction from external to internal has been assumed

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design & Difference
Senstive Land Uses - Churches
Page 1/1

FILE NAME: 10-7434R1 Appendix K - Churches.dwg
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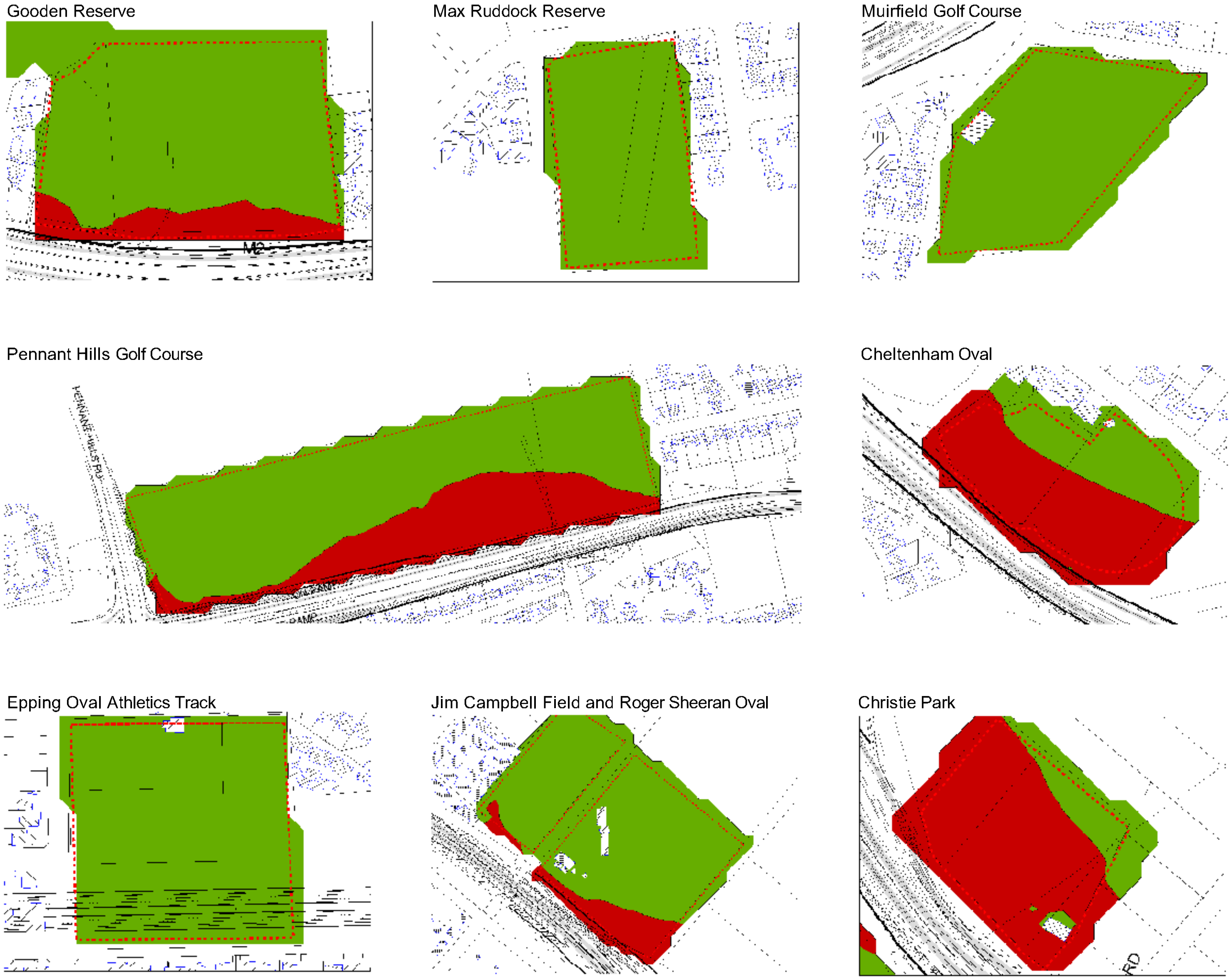
Appendix L

Report 10-7434R1

Sensitive Land Uses (Active Recreation)



Notes
Criteria for Active Recreation Areas is an external LAeq(15hr) of 60 dBA

Legend
- > 60 dBA
- < 60 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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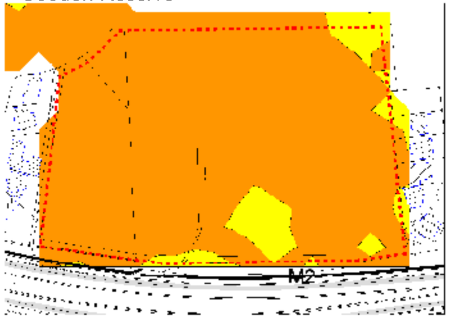
10-7434 M2 Upgrade Project
2021 Future Design
Senstive Land Uses - Active Rec
Page 1/2

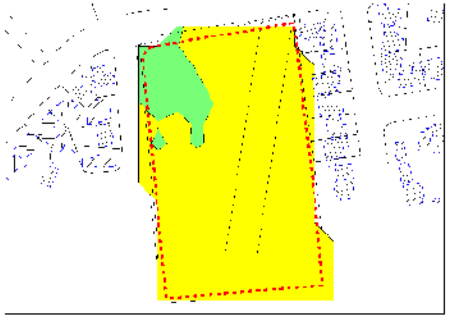
FILE NAME: 10-7434R1 Appendix L - Active Rec.dwg
DRAWING No. 10-7434_Active_Rec
REVISION 0

50 mm ON ORIGINAL

Gooden Reserve

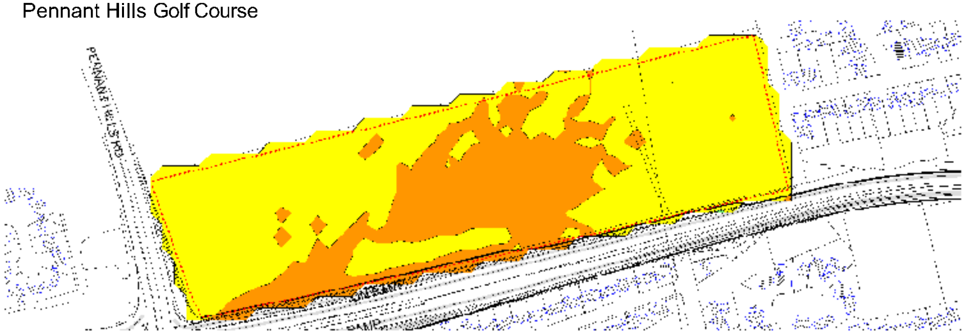


Max Ruddock Reserve

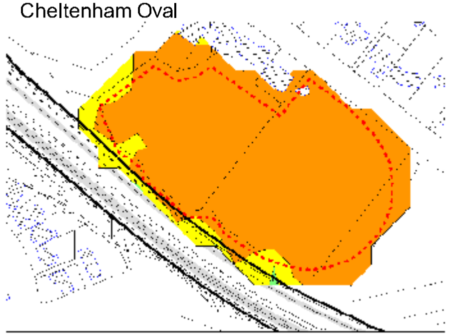


Muirfield Golf Course

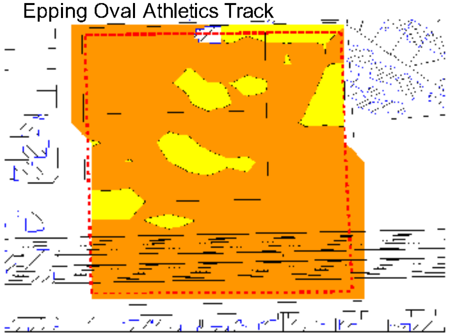
Pennant Hills Golf Course



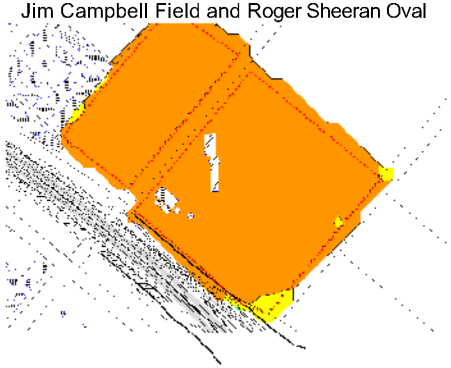
Cheltenham Oval



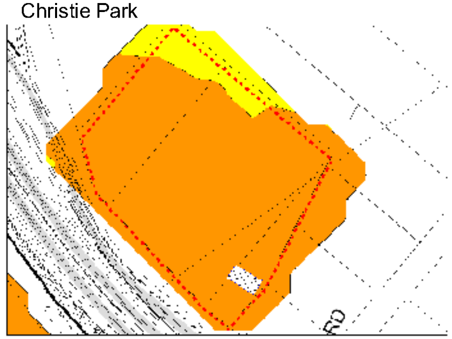
Epping Oval Athletics Track



Jim Campbell Field and Roger Sheeran Oval



Christie Park



Notes

Noise levels are the difference between 2021 Future Design and 2011 Future Existing

Legend

- > 2 dBA
- 1 dBA to 2 dBA
- 0 dBA to 1 dBA
- -1 dBA to 0 dBA
- < -1 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
Difference Plots
Senstive Land Uses - Active Rec
Page 2/2

FILE NAME: 10-7434R1 Appendix L - Active Rec.dwg

DRAWING No. 10-7434_Active_Rec

REVISION 0

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Appendix M
Report 10-7434R1

Sensitive Land Uses (Hospitals)

Macquaire University Hosptial

Notes
Criteria for Hospital Wards is an internal LAeq(1hr) of 35 dBA
A 20 dBA noise reduction from external to internal has been assumed

Legend
> 55 dBA
< 55 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design
Senstive Land Uses - Hospitals
Page 1/2

FILE NAME: 10-7434R1 Appendix M - Hospitals.dwg
DRAWING No. 10-7434_Hospitals
REVISION 0

50 mm ON ORIGINAL

Macquaire University Hosptial

Notes

Noise levels are the difference between 2021 Future Design and 2011 Future Existing

Legend

- > 2 dBA
- 1 dBA to 2 dBA
- 0 dBA to 1 dBA
- -1 dBA to 0 dBA
- < -1 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
Difference Plots
Senstive Land Uses - Hospitals
Page 2/2

FILE NAME: 10-7434R1 Appendix M - Hospitals.dwg

DRAWING No. 10-7434_Hospitals

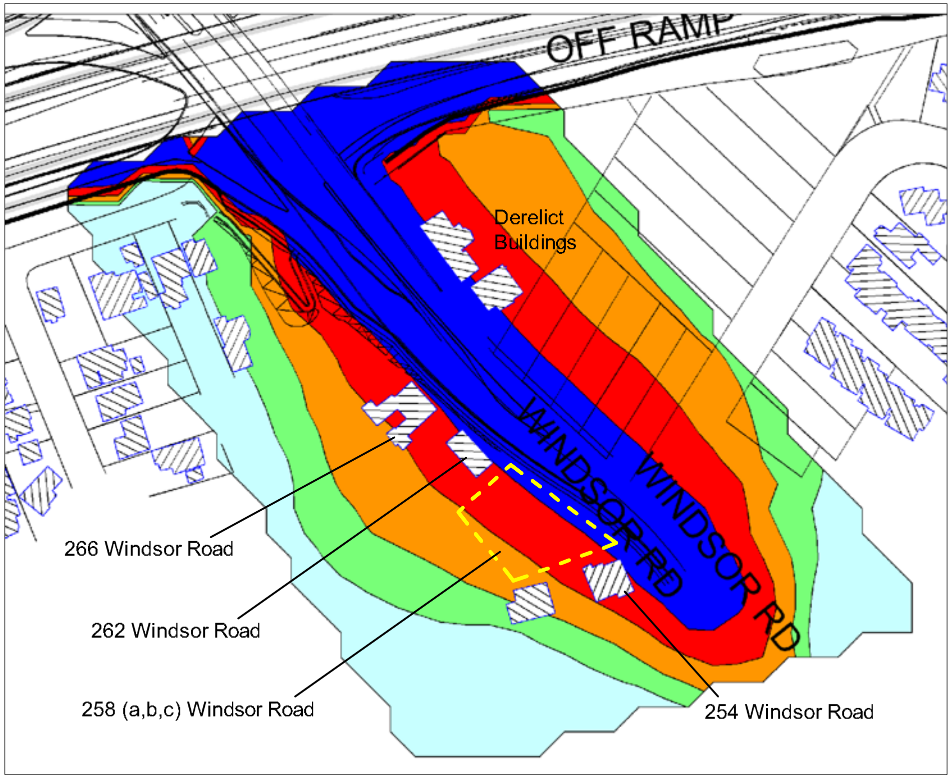
REVISION 0

Appendix N

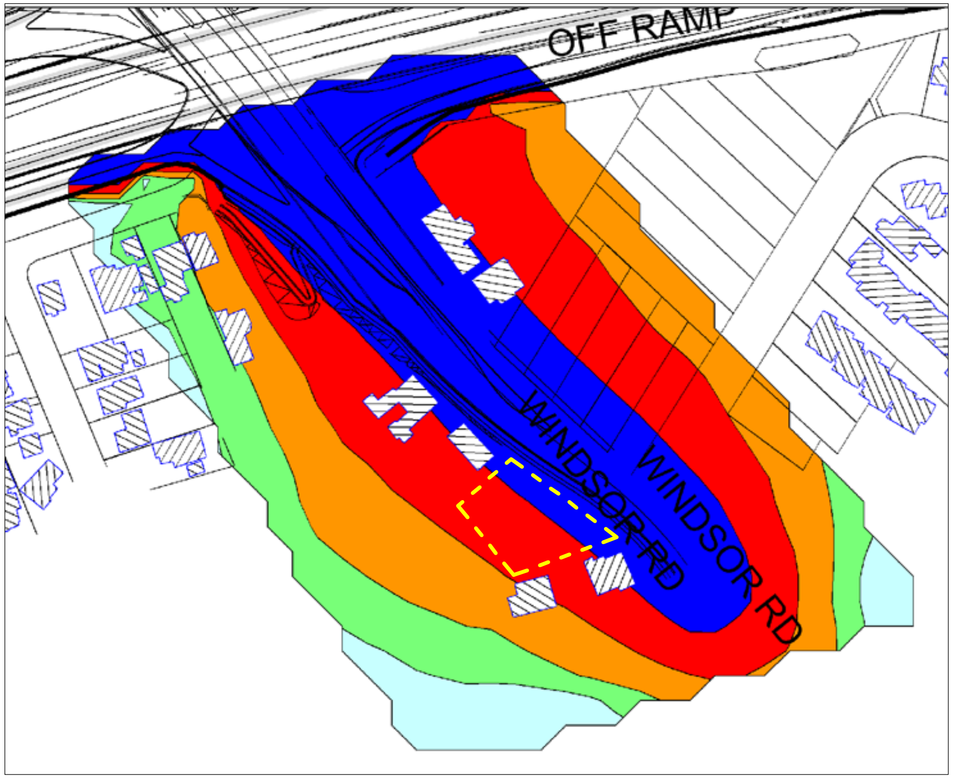
Report 10-7434R1

Windsor Road Re-Alignment

Windsor Road
Ground Floor (1.5 m)



Windsor Road
First Floor (4.3 m)



Notes

Noise levels include a +2.5 dBA correction for facade reflections
Three multi-unit properties are situated within the dashed yellow box

Legend

- ≥ 65 dBA
- 60 dBA to 64 dBA
- 57 dBA to 59 dBA
- 55 dBA to 56 dBA
- ≤ 54 dBA

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	18/12/09		ALW	PG

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10-7434 M2 Upgrade Project
2021 Future Design - LAeq(9hour)
Windsor Road Re-Alignment
Page 1/1

FILE NAME: 10-7434R1 Appendix N – Windsor Road.dwg
DRAWING No. 10-7434_Windsor_Road
REVISION 0

50 mm ON ORIGINAL

M2 Upgrade Project

05 May 2010

Flora and Fauna Assessment Report

M2 Motorway Upgrade

Flora and Fauna Assessment Report

Prepared for

M2 Upgrade Project

Prepared by

AECOM

May 2010

60143257

Quality Information

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Executive Summary

Introduction

The M2 Upgrade involves physical widening and associated works to improve the operational performance of the M2 Motorway. This Flora and Fauna Impact Assessment forms part of an Environmental Assessment and has been prepared to assess the potential impacts on ecological values associated with the proposed M2 Upgrade. The Assessment has been structured to comply with the Director General's Requirements. In particular, consideration is given to species, critical habitat, populations and ecological communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Threatened Species Conservation Act 1995* (TSC Act), *Threatened Species Conservation provisions of the Fisheries Management Act 1994* and the *Fisheries Management Amendment Act 1997*.

This flora and fauna Assessment also identifies suitable mitigation measures that would be implemented to ameliorate potential impacts on the environment.

Methods

The results of field surveys, a review of previous studies, a review of published information sources including the Commonwealth Government Species Profile and Threats (SPRAT) database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken in the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original Environment Impact Statements (EISs) for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992) as well as the Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area (DECC 2008).

Assessments of significance were conducted for threatened species listed under the TSC Act and followed the heads of consideration outlined in the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and the Department of Primary Industries, 2005) (now known as DECCW and I&INSW and referenced hereafter as the original document). For threatened species listed under the EPBC Act, assessments of significance were undertaken in accordance with the *Significant Impact Guidelines and Matters of National Significance* outlined by the Department of Environment and Heritage (DEH, 2006)(now known as DEWHA).

For the purposes of this assessment the 'M2 corridor' refers to the area bounded by the Hills M2 Motorway lease boundary, the study area was defined as the M2 corridor and any additional areas directly, or indirectly, affected by the proposed upgrade works and 'vicinity' refers to the surrounding neighbourhood areas adjacent to the project area.

Existing environment

The results of field surveys, a review of previous studies, a review of published information sources including the Commonwealth Government Species Profile and Threats (SPRAT) database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken in the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original Environment Impact Statements (EISs) for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992).

Much of the area surrounding the M2 corridor is highly urbanised and consists chiefly of residential properties, parkland, weed-infested areas and degraded riparian vegetation. Several larger areas of remnant native vegetation exist within and adjacent to the areas proposed to be directly, or indirectly, affected by the proposed upgrade works. The most significant of these include: Bidjigal Reserve; vegetation in the vicinity of Devlins Creek; vegetation surrounding Terrys Creek between Lucknow Park; Berriwerri Reserve and Sommerset Park and parts of Lane Cove National Park adjacent to the M2 corridor in Macquarie Park.

There are seven native vegetation communities mapped as occurring within the areas adjacent to the M2 Motorway (Coastal Sandstone Ridgetop Woodland, Coastal Sandstone Gully Forest, Hinterland Sandstone Gully Forest, Sydney Hinterland Transition woodland, Sandstone Riparian Scrub, Blue Gum High Forest and Sydney Turpentine-Ironbark Forest). Of these, Sydney-Turpentine Ironbark Forest and Blue Gum High Forest are listed as critically endangered ecological communities (EEC) under the TSC Act and EPBC Act. The M2 Upgrade has been designed to minimise vegetation clearing and in particular, to avoid any potential impacts to the Blue Gum High

Forest community identified adjacent to the M2 Motorway by the alignment of the proposed M2 Upgrade away from the community.

The areas of vegetation within and adjacent to the M2 corridor that have been mapped as Sydney Turpentine–Ironbark Forest were inspected and found to be less than one hectare in area, highly disturbed and consistent with the floristic composition of the larger patches of the adjacent Hinterland Sandstone Gully Forest vegetation community, which is not listed as an EEC. The dominant canopy species in these areas are Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*). No ironbark species were detected within these areas.

Neither the TSC Act nor EPBC Act Threatened Species Scientific Committee's advice regarding this community includes Blackbutt (*Eucalyptus pilularis*) as a dominant or frequently occurring species. While the understorey and ground layer vegetation observed shows a resemblance to that of Sydney Turpentine-Ironbark Forest, its composition and structure are more closely aligned with the Hinterland Sandstone Gully Forest community. Therefore, this EEC is not considered to occur within the areas to be affected by the M2 Motorway Upgrade.

Potential impacts

Approval under the EPBC Act is required where the Department of Environment, Water, Heritage and the Arts (DEWHA) determines if there is likely be a significant impact on a matter of NES. A referral has been submitted to DEWHA for their determination. The referral illustrates that there are unlikely to be any significant impacts on any matters of NES and therefore it recommends to DEWHA that the project is not a controlled action. DEWHA's final determination is currently pending.

Of the threatened terrestrial plant species that are considered to have potential to occur within the areas adjacent to the M2 Motorway, only *Epacris purpurascens var. purpurascens* was recorded during the field investigations conducted for the preparation of this report. This species is listed as vulnerable under the TSC Act. Within the M2 corridor, this species is restricted to translocated soils including earth mounds and rock armoured batter slopes. An assessment of significance (which followed the heads of consideration as outlined in the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) concluded the potential loss of approximately 20 individuals (observed within flora survey plots) is considered unlikely to significantly affect the viability of a local population of this species.

Habitat for a variety of fauna species exists within the remnant vegetation occurring within the M2 corridor and surrounding bushland areas. Threatened species that are known to use these areas include Grey-headed Flying-fox (*Pteropus poliocephalus*), Gang-gang Cockatoo (*Callocephalon fimbriatum*) and Powerful Owl (*Ninox strenua*).

Two migratory nectar-feeding birds Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) may use this resource sporadically or on a seasonal basis but are not considered likely to be regular or frequent visitors to the area based upon database records. In addition to the above, several threatened insectivorous bat species may forage in the air spaces within and around the vegetation adjacent to the M2 Motorway.

Based on assessments of significance conducted for the above threatened species, the proposed M2 Upgrade is not considered to have a significant adverse affect on these threatened species.

Vegetation removal for the M2 Upgrade would be required for the following areas: areas occupied by the widened Motorway and fill batters, construction access roads, site compounds, materials storage areas, new detention basins and access to detention basins.

The amount of native and exotic vegetation estimated to be cleared is approximately 21 ha in total. Of this, a conservative estimate of the amount of vegetation considered to be in good condition within the study area is approximately 10 ha. Approximately 11 ha of this total are considered to be poor condition as these areas are highly modified and characterised by high levels of weed invasion. Whilst removal of vegetation within the development footprint would be permanent, clearing for access and compound areas would be temporary. Approximately 3 hectares would be subsequently rehabilitated post-construction. The 10 ha of native vegetation required to be removed is chiefly found within the Hinterland Sandstone Gully Forest vegetation community that occurs throughout the M2 corridor. This vegetation community is not listed as an EEC under the EPBC Act or TSC Act and is widespread in the vicinity of the proposed M2 Upgrade.

The final construction methodology for access and compound sites will be determined during the detailed design phase. As the widening of the M2 Motorway is alongside the existing Motorway, vegetation fragmentation is not likely to be significantly increased.

Some of the areas with the largest potential impact by the proposal are chiefly areas near waterways. These areas are located within the Sandstone Riparian Scrub vegetation community that occurs along all creeks within and adjacent to the M2 corridor. Due to the restriction of this vegetation community to the edges of watercourses, it is considered to be regionally significant. These communities are currently infested with exotic vines and scramblers. Earthworks have the potential to spread these species to a greater extent. The proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation.

The presence of impervious surfaces such as roads within the catchments of the study area has resulted in alteration of the flow regime of creeks adjacent to the M2 Motorway. Detention basin works proposed are being designed with capacity for the additional stormwater from the Motorway therefore the increased road surface as a result of the works is not considered likely to further alter the natural flow regime of the creeks of the study area.

Mitigation measures

An Environmental Management Plan (EMP) would be developed that describes in detail how each of the management measures prescribed would be implemented during construction (CEMP) and operation (OEMP) of the works. This plan would be developed in consultation with Department of Environment, Climate Change and Water (DECCW), Industry and Investment (I&INSW) and other relevant stakeholders.

The EMP would include measures to minimise impacts on flora and fauna including weed management in areas affected by construction throughout the extent and duration of the project and vegetation rehabilitation and revegetation in areas bordering natural bushland. The extent of clearing for construction compounds will be minimised by retaining mature trees and other vegetation of conservation significance where feasible within compound sites.

Revegetation of disturbed areas as a result of construction activities adjacent to the construction areas and bordering natural bushland will be conducted by suitably qualified and experienced persons, using local provenance plant species that are representative of the relevant vegetation communities. This strategy would be documented in a landscape plan or bushland rehabilitation section of the CEMP. In areas bordering adjacent urban development, revegetation works would be undertaken in accordance with the principles of the RTA Landscape Guidelines.

Where available, seeds will be collected from local understorey and ground layer vegetation prior to clearing and where feasible, from felled trees and branches following clearing for use in revegetation.

Potentially hollow-bearing trees will be identified and marked and targeted measures to minimise potential harm to fauna during clearing will be implemented.

A revegetation strategy would be developed that takes into account the availability of light, moisture and the most suitable plant species.

Works around waterways would be managed to retain bank stability and prevent erosion. Water quality will be protected through the implementation of suitable sediment control measures in all relevant work areas.

Conclusion

It is not considered likely that the proposed works will have a significant effect on ecological communities, threatened flora or threatened fauna species. No threatened ecological communities, as listed under the EPBC Act or TSC Act will be impacted by the proposed works. This has been achieved through the design and alignment of the M2 Motorway Upgrade. Through the implementation of the mitigation measures proposed, there is an opportunity to provide a positive impact by improving habitat connectivity to larger areas of bushland through vegetation rehabilitation in areas suffering from habitat modification and high levels of weed invasion.

1.0 Background

The M2 Upgrade involves physical widening and associated works to improve the operational performance of the M2 Motorway. A detailed project description is provided in Section 6 of the Environmental Assessment. A summary is provided below.

The M2 Upgrade works will include the following:

- Widening eastbound from Windsor Road on-ramp to the Pennant Hills Road off-ramp by one additional lane.
- Widening eastbound and westbound from Pennant Hills Road to Beecroft Road by one additional lane in each direction. This will involve the removal of the Beecroft Road bus on/off ramp.
- Widening eastbound and westbound from Beecroft Road to Lane Cove Road by one additional lane in each direction. The widened lane east of Terry's Creek will be marked as a transit lane.
- Widening of Norfolk Tunnel just east of Beecroft Road eastbound and westbound by one additional lane in each direction.
- Provision of new west facing on/off-ramps at Windsor Road. Windsor Road will be widened to accommodate turning movements.
- Provision of new east facing on-ramp at Christie Road.
- Provision of new east facing off-ramp at Herring Road.
- Improvement and widening of Talavera Road between Christie Road and Alma Road to provide two through lanes in each direction.
- Widening of Christie Road Bridge to 5 lanes over the M2 Motorway including the provision of new traffic control signals on Christie Road.
- Bridge modifications on the M2 between Windsor Road and Christie Road to accommodate the widening works.
- Intelligent Traffic System (ITS) upgrades along the corridor including upgrade to the cableway.

Widening of the M2 Motorway has been designed to minimise the amount of vegetation removal required. Design options have been considered to reduce the amount of excavation and intensive earthworks that would be required and therefore minimise the potential impacts to the surrounding environment. Wherever practicable the proposed widening has been designed within the existing footprint of the M2 Motorway. This involves compound locations and proposed access and egress routes. At the Devlins Creek viaduct, approximately 60% of the additional road width requirements are proposed to be provided by joining the two adjacent bridge decks. This would minimise disturbance in the riparian zone. An already stripped site previously used as a construction compound has been chosen for the proposed main construction compound, within the Macquarie Park precinct.

This flora and fauna assessment considers the potential impacts on ecological values associated with the proposed M2 Upgrade. In particular, species, populations and ecological communities listed as threatened under NSW State and Commonwealth environmental legislation are assessed for potential significant impacts. The assessment is based on an examination of vegetation mapping, aerial photography, field investigations and desktop studies.

For the purpose of this report, the 'M2 corridor' refers to the area bounded by the Hills M2 Motorway lease boundary, the 'study area' refers to the M2 corridor and any additional areas directly, or indirectly, affected by the proposed upgrade works, and the 'vicinity' refers to the surrounding neighbourhood areas adjacent to the project area.

1.1 Objectives of the Flora and Fauna Assessment

The objectives of the flora and fauna assessment are to:

- Produce an impact assessment of proposed works with respect to terrestrial and aquatic ecology based on existing information and additional field surveys.
- To assess potential impacts on flora and fauna in the area and determine the most appropriate mitigation measures to address flora and fauna impacts.
- Give particular attention to the impact on critical habitat, threatened species, populations and ecological communities, or their habitats (as defined under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the *Threatened Species Conservation Act* 1995 (TSC Act), the Threatened Species Conservation provisions of the *Fisheries Management Act* 1994 and the *Fisheries Management Amendment Act* 1997 (FM Act).
- To comply with the Director General's Requirements (DGR) (refer to section 2.1.1).
- To follow the heads of consideration as outlined in the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) and the *Significant Impact Guidelines and Matters of National Significance* (DEH, 2006).

2.0 Legislative Requirements

2.1.1 Director General's Requirements

DGRs were issued for the project in April 2009 (see **Appendix A**), which identified the key impacts on ecology to be addressed in the environmental assessment, including:

- *The Environmental Assessment must include an assessment of the potential impacts of the project, with specific reference to the need for vegetation clearing, habitat and connectivity implications, edge effects, and stormwater and watercourse implications.*
- *The Environmental Assessment must make specific reference to impacts on threatened species, populations and communities, including the Sydney Turpentine-Ironbark Forest and Blue Gum High Forest Endangered Ecological Communities, and the native fauna that may utilise those communities.*
- *The Environmental Assessment shall demonstrate that the extent of vegetation clearing has been minimised through the design of the project, and shall include details of any off-set measures proposed.*

These issues are subject to specific assessment requirements as detailed in the DGRs. The issues relating to impacts on ecology are addressed in this report.

2.2 NSW Legislation

2.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) provide the statutory framework for the assessment of the proposal. The EP&A Act is supplemented by a number of Environmental Planning Instrument's (EPIs) including:

- State Environmental Planning Policies (SEPPs).
- Local Environmental Plans (LEPs).
- Other planning instruments such as Development Control Plans (DCPs).

2.2.2 Threatened Species Conservation Act 1995

The TSC Act outlines the protection of threatened species, communities and critical habitat in NSW. The Act is administered by the Department of Environment Climate Change and Water (DECCW). Section 91 of the TSC Act requires that a licence be obtained should a development result in one or more of the following:

- *Harm to any animal that is of, or is part of, a threatened species, population or ecological community.*
- *The picking of any plant that is of, or is part of, a threatened species, population or ecological community.*
- *Damage to critical habitat.*
- *Damage to habitat of a threatened species, population or ecological community.*

A Seven Part Test to determine the significance of the effect on a particular species or Endangered Ecological Community (EEC) is not required under Part 3A. However, assessments of significance for threatened species, populations or ecological communities (listed under the TSC Act) with a moderate to high likelihood of occurrence within the study area were carried out. These were in accordance with department of Environment, Climate Change and Water's *Draft Guidelines for Threatened Species Assessment under Part 3A* (DECCW, 2005).

2.2.3 National Parks and Wildlife Act 1974

The purpose of this the *National Parks and Wildlife Act* 1974 (NPW Act) is to provide the primary basis for protection and unwarranted destruction of relics of high cultural significance – both Indigenous and non-Indigenous value. In addition, the NPW Act also provides a framework to conserve native terrestrial flora and fauna species and manage areas of conservation value such as Nature Reserves and National Parks.

Under the NPW Act, it is an offence to harm, trade, possess or damage critical habitat or the habitat of any threatened species without obtaining a Section 120 licence.

2.2.4 Fisheries Management Act 1994

The FM Acts provide for the conservation, protection and management of fisheries, aquatic systems and habitats in NSW. Permits are required for any dredging or reclamation works, any harm to marine vegetation or any obstruction to fish passage. The proposal will not significantly affect aquatic ecosystems or block fish passage and no permits are required under either of these Acts.

2.2.5 Noxious Weeds Act 1993

The *Noxious Weeds Act* 1993 (NW Act) establishes a system for the identification and control of noxious weeds in NSW. The Act divides noxious weeds into four categories which determine the level of control required. Responsibility for the control of noxious weeds lies with the owner and/or occupier of private land and Crown land, local councils and other public authorities on land they occupy. Under the NW Act, the Minister for the Industry and Investment NSW (I&INSW) may declare a plant to be a noxious weed. Control notices can be issued by the Minister and local control authorities to ensure obligations are met.

2.3 Commonwealth Legislation

2.3.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act governs the Commonwealth Environmental Assessment process and provides protection for matters of National Environmental Significance (NES), which include:

- Nationally threatened species and ecological communities.
- Australia's World heritage properties.
- Ramsar wetlands of international importance.
- Migratory species listed under the EPBC Act (species protected under international agreements).
- Commonwealth marine areas.
- Nuclear actions, including uranium mining.
- National heritage.

Approval under the EPBC Act is required where the Department of Environment, Water, Heritage and the Arts (DEWHA) determines that there will or likely be a significant impact on a matter of NES. A referral has been submitted to DEWHA for their determination. The referral illustrates that there are no significant impacts on any matters of NES and therefore it recommends to DEWHA that the project is not a controlled action. DEWHA's final determination is currently pending.

3.0 Methodology

3.1 Overview

The information presented in this report is based on new field surveys, a review of previous studies, a review of published information sources including the SPRAT database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken for the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original EISs for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992).

Field surveys undertaken for this assessment included targeted searches for threatened species and were conducted in areas considered to contain suitable habitat for flora and fauna. Areas considered to contain suitable flora and fauna habitat include waterways, streamside vegetation and larger areas of remnant native vegetation that provide habitat connectivity (refer to Section 3.2)

3.2 Desktop Investigation and Review of Prior Studies

The M2 corridor is within an area of Sydney that has been extensively studied. The previous studies conducted within and adjacent to the M2 corridor that informed this assessment include the following:

- North West Transport Links Western Section Flora and Fauna Evaluation Mount King Ecological Surveys (1992a).
- North West Transport Links East Environmental Impact Statement Working Paper Flora and Fauna Evaluation (Bushland Effect and Management) Report (Eastern Section) Mount King Ecological Surveys (1992b).
- M2 Hills Motorway Fauna Monitoring Report (Gunninah 2000).

Searches of the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened flora or fauna species listed under the TSC Act or EPBC Act have been recorded or predicted to occur within a 10 km radius of the M2 corridor.

Information on fauna habitat contained in the Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area (DECC 2008) has been incorporated into this study where relevant.

The DECCW threatened species profiles (DECCW, 2009) and entries in the SPRAT database for threatened species, populations and ecological communities were reviewed and relevant information was extracted. This information was used to determine which threatened species, population and communities have potential to occur on the site based on a comparison of the habitat attributes observed within the study area and their known habitat associations. A complete list of threatened species, populations and ecological communities potentially occurring within the study area is provided in **Appendix C**.

3.3 Field Survey

3.3.1 Flora

Flora surveys were conducted between 26 November 2008 and 24 March 2009 by two AECOM ecologists. The purposes of the surveys were to assess the likely impact of the proposed action on the vegetation communities and significant flora species present or likely to occur within the study area. Survey sites were selected based on a preliminary investigation of the study area using aerial photography, topographic maps, vegetation mapping undertaken by Tozer *et al.* (2006) and the existing threatened species database searches (refer to Section 2.1). Flora surveys involved the recording of the structure, condition and composition of vegetation communities present and a targeted search for threatened flora species throughout the study area, targeting areas of greatest potential for the species to occur. The distribution of vegetation communities as per existing mapping (Tozer *et al.* 2006) was ground-truthed.

Plant species were identified within eight 20 m x 20 m survey plots and a random meander search for threatened flora species (refer to Section 4.4.3 for a list of targeted species) were conducted in the vicinity of each plot. Random meander transects targeting threatened flora species was also undertaken throughout the entire length of bushland potentially impacted.

3.3.2 Fauna

Fauna surveys were conducted between November 2008 and March 2009 by AECOM ecologists. The field survey methods used to detect and assess habitat for fauna species are listed in Table 1. The survey effort complies with the minimum survey effort based on the study area size, habitat types available on the site and seasonal factors, as recommended by the *Draft Guidelines for Threatened Species Assessment under Part 3A* (DEC and DPI, 2005).

Extensive fauna surveys including trapping surveys were conducted during the preparation of the environmental impact assessment reports for the existing M2 Motorway and were not repeated in this study. Field survey methods for the project were chosen in order to ensure that adequate information is available to fully assess the potential impacts of the proposal on fauna species of conservation significance. Fauna survey methods such as cage-trapping of mammals, pitfall trapping and detailed aquatic surveys were not undertaken.

In addition to fauna surveys, the following habitat assessments were undertaken:

- Observation of the location, extent and density of key habitat features such as mature, potentially hollow-bearing trees, waterways, seepages, rocky outcrops, vegetation types and soils.
- Assessment of the condition of aquatic habitats through noting factors including turbidity, rubbish, exotic fish species, surface films, submerged and emergent vegetation and substrates.
- Assessment of the condition of vegetation as habitat for fauna species through observation of factors including weed infestation, structural layering, species composition, nectar and fruit resources and maturity and condition of trees.

Table 1 Field survey methods and survey effort for fauna

Fauna Group	Survey Techniques Employed	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current Study (person hours)
Frogs (no area specified)	Systematic day habitat search	Conducted but effort unspecified	Conducted but effort unspecified	48 hours (8 hours per survey period)	3 hours in 3 locations
	Night habitat search of damp and watery sites	-	-	-	2 hours on 2 nights
	Nocturnal call playback	-	-	-	2 call playback sessions on separate nights at 2 locations
	Night watercourse search	Conducted but effort unspecified	Conducted but effort unspecified	-	2 hours
Reptiles (100 ha)	Habitat search	Conducted but effort unspecified	Conducted but effort unspecified	48 hours (8 hours per survey period)	1.5 hours
	Spotlighting	Conducted but effort unspecified	Conducted but effort unspecified	-	2 hours
Diurnal Birds (no area specified)	Area search	6 transect sites – number of inspections not specified	5 transect sites – number of inspections not specified	16 survey stations – (64 hours over six survey periods)	20 minute surveys conducted at each of 6 sites
Nocturnal Birds (no area specified)	Call playback	-	-	-	Three sites surveyed – 2 nights each
	Day habitat search	-	-	-	All potential riparian vegetation roost areas searched
	Spotlighting	Conducted but effort unspecified	Conducted but effort unspecified	Conducted as part of spotlighting targeting mammals	Conducted as part of spotlighting targeting mammals
Mammals (Excluding Bats) (50 ha)	Small Elliott traps – 100 trap nights over 3-4 consecutive nights	1200 trap nights	700 trap nights	-	-
	Wire cage traps – 24 trap nights	24 traps utilised – trap nights not specified	24 traps utilised – trap nights not specified	-	-

Fauna Group	Survey Techniques Employed	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current Study (person hours)
	Spotlighting on foot	6 transects	5 transects	8 transects (surveys twice yearly for 3 years)	3 transects each surveyed twice on separate nights for 1 hour each with two staff
	Call playback – 2 sites per stratification unit up to 200 hectares, plus an additional site per 100 hectares above 200 hectares. Each playback site must have the session conducted twice, on separate nights	-	-	-	Three sites surveyed – 2 nights each
	Search for scats and signs	Conducted but effort unspecified	Conducted but effort unspecified	-	Six sites specifically searched – opportunistic recordings throughout
	Track search – 1km of track search with emphasis on where substrate is soft	Conducted but effort unspecified	Conducted but effort unspecified	-	-
Bats (100 ha)	Harp trapping – Four trap nights over two consecutive nights (with one trap placed outside the flyways for one night)	-	-	-	Four harp trap nights in two locations
	Ultrasonic call recording – Two sound activated recording devices utilised for the entire night, starting at dusk for two nights	-	-	-	Two anabat devices used for static recording for 4 nights & four walking transects of 1 hour duration with two anabat devices
All Fauna	Opportunistic observations	Conducted but effort unspecified	Conducted but effort unspecified	Conducted but effort unspecified	Approximately 40 hours

3.3.3 Staff undertaking survey

The field survey, desktop investigations and impact assessment were conducted by Calliope Adamos and Paul Rossington.

Paul Rossington has completed a Bachelor of Science Degree, majoring in botany, zoology and ecology and a Post-graduate Diploma of Wildlife Management and has over five years experience in bushland restoration and wildlife management. Paul holds a current DECCW Scientific Licence for flora and fauna studies.

Calliope Adamos has completed a Bachelor of Environmental Science Degree and a Diploma of Natural Resource Management and has over five years experience in bushland restoration.

3.3.4 Survey Limitations

The environmental field surveys and assessments conducted are based on environmental conditions at the time of survey and therefore the absence of threatened species recorded is not indicative of the lack of threatened species inhabiting the study area. For those threatened flora species that are difficult to detect outside of their flowering time (such as *Tetratheca glandulosa*, which flowers July to November and *Hibbertia superans*, which flowers July to December) a precautionary approach was taken and species were assumed to be present if suitable habitat was observed. Therefore, assessments of significance are based on the appropriateness of habitats on the site for threatened flora and fauna species and the presence of key habitat features as listed in the relevant DECCW species profiles.

3.3.5 Impact Assessment Approach

Fauna surveys were conducted in areas that were considered potential habitat for threatened species, populations and communities. The M2 corridor is within an area of Sydney that has been extensively studied. Ecological survey efforts conducted over the years have not necessarily been specifically related to the M2 Motorway but rather have been conducted to gather accurate and relevant database information relating to bushland and biodiversity in the various LGAs, National Parks and Reserves in the locality. Hence, the database information is considered to be relatively reliable and reflective of the current ecological context of the study area.

3.4 Assessment of Significance

Assessments of significance for threatened flora and fauna species listed under the TSC Act were undertaken following the heads of consideration outlined in the *Draft Guidelines for Threatened Species Assessment under Part 3A* ((DEC and DPI, 2005). For threatened species listed under the EPBC Act, assessments of significance were undertaken in accordance with the *Significant Impact Guidelines and Matters of National Significance* outlined by the Department of Environment and Heritage (DEH, 2006). Ecological communities and flora and fauna species considered potentially sensitive to the impacts of the project were assessed in terms of the potential to have a significant impact on the survival of the species or community at the local scale.

4.0 Results

4.1 Overview

A description of the ecological context of the study area is provided in the following sections below. Included is a description of the various vegetation communities occurring within the study area. These include:

- Coastal Sandstone Ridgetop Woodland.
- Coastal Sandstone Gully Forest.
- Hinterland Sandstone Gully Forest.
- Sydney Hinterland Transition Woodland
- Sandstone Riparian Scrub.
- Blue Gum High Forest.
- Sydney Turpentine-Ironbark Forest.

Sydney Turpentine-Ironbark Forest and Blue Gum High Forest are both critically endangered ecologically communities listed under the TSC Act and EPBC Act. The condition of the vegetation communities listed above is described in Section 4.4.

Threatened flora and fauna species which are considered to have a moderate to high likelihood of occurring within the study area on the basis of distribution and habitat requirements is summarised in Section 4.4.3. Of the listed species, the following flora species have been recorded in the vicinity of the proposed upgrade works:

- *Callistemon linearifolius*
- *Darwinia biflora*.
- *Epacris purpurascens var. purpurascens*.
- *Pimelea curviflora var. curviflora*.
- *Tetratheca glandulosa.*

Threatened fauna species likely to occur within the study area include:

- Green and Golden Bell Frog
- Red-crowned Toadlet
- Swift Parrot
- Regent Honeyeater
- Gang-gang Cockatoo
- Glossy Black Cockatoo
- Powerful Owl
- Grey-headed Flying-Fox
- Eastern Freetail-bat
- Yellow-bellied Sheathtail-bat
- Greater Broad-nosed Bat
- Eastern Bentwing-bat
- Large-footed Myotis
- Large-eared Pied Bat.

A variety of noxious weeds occur within the M2 corridor. The species recorded and the control requirements required for each weed class under the NW Act are shown in Section 4.4.4. Fauna species of conservation significance and the likelihood of occurrence of these species based on previous records and habitat attributes is summarised in Section 4.5.5. Whilst aquatic habitat of the study area is described (Section 4.7), no aquatic plant species of conservation significance were recorded or considered likely to occur within the M2 corridor or surrounds.

4.2 Topography, Geology and Soils

The M2 Motorway is chiefly located on a series of plateaux that are dissected by eroded sandstone-dominated valleys. The relatively deep and fertile soil of the plateaux is chiefly clay derived from the weathering of Wianamatta shales. These flat areas have been almost entirely cleared for urban development and little native vegetation remains. The valleys that dissect these plateaux are moderately to extremely steep. Valley soils vary from moderately deep sandy soils in areas of shallower slope to shallow, skeletal sands and rock outcropping in steeply sloping locations.

Near the boundary between these plateaux and valleys, there exists a zone of sandstone-derived soil which is enriched with clay from the adjacent shale-derived soils.

4.3 Ecological Context of the Study Area

4.3.1 Urban areas and the urban bushland interface

Much of the area surrounding the study area is highly urbanised and consists chiefly of residential properties, parkland, bushland areas with varying levels of weed infestation and riparian vegetation. Fauna habitat within these areas of the route is largely limited to streams and streamside vegetation and the canopies of remnant and planted trees. Only native and exotic fauna species that are able to utilise highly modified habitat are likely to exist in these parts of the route.

Due to their mobility and ability to cope with habitat fragmentation, highly mobile native fauna species typical of open environments such as birds and bats would be able to exploit feeding, nesting and roosting opportunities that exist within these habitats. Highly adaptable native mammal species which are capable of utilising a wide variety of habitats such as the Brush-tailed Possum (*Trichosurus vulpecula*) and Common Ring-tailed Possum (*Pseudocheirus peregrinus*) persist here. Several bat species, such as the White-striped Mastiff Bat (*Tadarida australis*), Chocolate Wattle Bat (*Chanlinolobus morio*) and the threatened Grey-headed Flying Fox (*Pteropus poliocephalus*), are also found in these environments.

A larger diversity of native bird species inhabits urban areas such as the Noisy Miner (*Manorina melanophrys*), Pied Currawong (*Strepera graculina*), Laughing Kookaburra (*Dacelo novaeguineae*), Sulphur-crested Cockatoo (*Cacatua galerita*), Rainbow Lorikeet (*Trichoglossus haematodus*), Red Wattlebird (*Anthochaera carunculata*), Australian Magpie (*Gymnorhina tibicen*) and Tawny Frogmouth (*Podargus strigoides*). The threatened Powerful Owl (*Ninox strenua*) is also sometimes seen in urban areas in the vicinity of bushland.

Exotic mammal species such as the European Rabbit (*Oryctolagus cuniculus*), Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), European Red Fox (*Vulpes vulpes*) and feral Domestic Cat (*Felis catus*) are found in the study area, along with exotic bird species such as Common Myna (*Acridotheres tristus*), Spotted Turtle-dove (*Streptopelia chinensis*), Starling (*Turdus merula*) and Red-whiskered Bulbul (*Pycnonotus jocosus*).

As a result of habitat loss and competition, and predation by exotic and over-abundant native species, fauna species that require a diverse understorey, disturbance-sensitive species, species which are susceptible to predation by pets and feral animals, and species with very specific habitat requirements are unlikely to exist in urban environments.

A combination of small area, isolation and high edge-to-area ratio of many small remnants within the urban areas has left these areas particularly susceptible to weed invasion, altered fire regimes and local extinctions of flora and fauna species.

The waterways in the vicinity of the study area are degraded as a result of a number of factors including increased erosion due to the concentration of stormwater flows, weed invasion, polluted catchment runoff and the presence of exotic fish species (such as *Gambusia holbrooki*). As a result, frogs, fish and aquatic invertebrates that are sensitive to disturbance are unlikely to persist in the waterways. Nonetheless, a variety of disturbance tolerant frog species (e.g. Striped Marsh Frog (*Limnodynates peronii*), Common Eastern Froglet (*Crinia signifera*), Eastern Dwarf Tree-frog (*Litoria fallax*), Green Stream Frog (*Litoria phyllochroa*) and Peron's Tree Frog (*Litoria peronii*)) are likely to use these habitats. A number of native fish species are also likely to persist.

Vegetated wildlife corridors within the urban environment are chiefly confined to these waterways which connect the bushland remnants that are largely located in the steep sandstone valleys.

4.3.2 Larger vegetation remnants

Several larger areas of remnant native vegetation exist within and adjacent to the study area. The most significant of these include:

- Bidjigal Reserve (formerly Excelsior Reserve and Darling Mills State Forest).
- Vegetation in the vicinity of Devlins Creek including Beecroft Reserve, Beecroft Reserve South, Chilworth Reserve and Cheltenham Park.
- Vegetation surrounding Terrys Creek between Lucknow Park, Berriwerri Reserve and Sommerset Park.
- Parts of Lane Cove National Park adjacent to the M2 corridor in Macquarie Park.

These areas have greater potential as habitat for a wider variety of fauna species due to their larger size, greater habitat diversity, more natural vegetation condition and connectivity to other areas of wildlife habitat. These areas have more potential to support viable populations of flora and fauna species as they are larger and better connected. These features make these areas more resistant to local extinction of flora and fauna species due to events such as fires and disease outbreaks and processes such as changing vegetation characteristics and predation by feral animals.

As a result of the size, connectivity and complexity of these areas, populations eliminated from part of their range may become re-established from refugia that were unaffected. The conservation and management of these areas and the corridors that connect them is important to the conservation of biodiversity in the locality.

4.4 Terrestrial Vegetation of the Study Area

4.4.1 Vegetation communities

There are seven native vegetation communities that occur within the study area. Each community and its conservation significance are described below.

The distribution of these vegetation communities, as well as the other vegetation communities occurring in the region (as described in the predictive vegetation mapping datasets) is shown in Figure 1.

Appendix B shows detailed vegetation mapping for the entire M2 Upgrade route in ten maps. The vegetation maps in **Appendix B** are derived from the existing vegetation mapping for the area (Figure 1) and field survey efforts. A summary of the conservation significance for each vegetation community to be impacted is provided below.

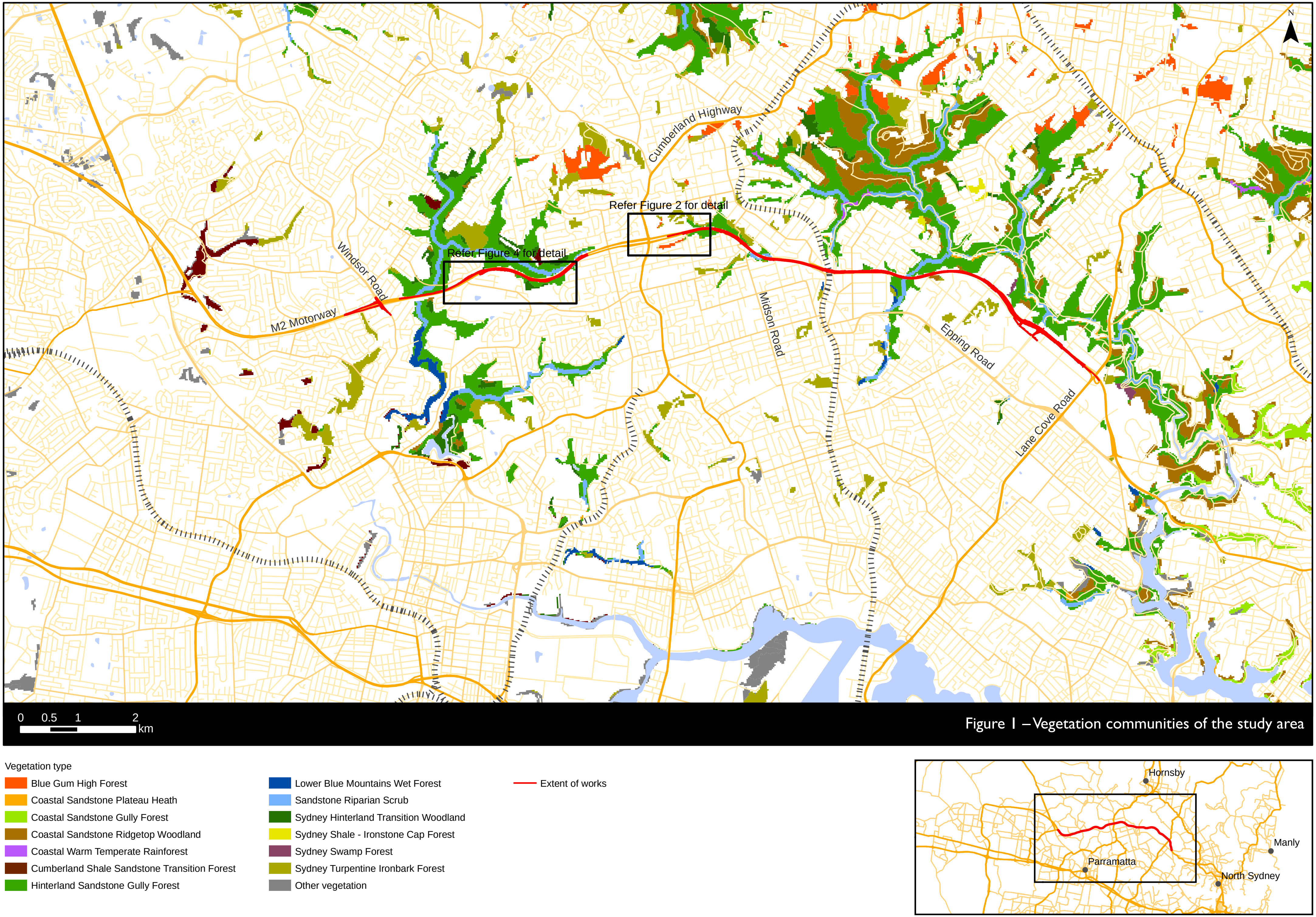


Figure 1 – Vegetation communities of the study area

Source: RTA (2009), Tozer et. al. (2006) The vegetation extents shown in these maps are from predictive vegetation mapping datasets and may not represent the vegetation actually present at these locations

Coastal Sandstone Ridgetop Woodland

The shallow sandy soil of ridgetops and dry exposed slopes in the locality support an open dry sclerophyll vegetation type known as Coastal Sandstone Ridgetop Woodland (unit p131) in Tozer *et al*. (2006). This community is mapped as Sydney Sandstone Ridgetop Woodland (unit 10ar) in Benson and Howell (1994). This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

The structure of this vegetation is quite variable, ranging from open woodland, open scrub to heathland. Coastal Sandstone Ridgetop Woodland is composed of a diverse array of species and substantial floristic variation also exists within this complex of vegetation types (Smith and Smith 2008).

A number of vegetation communities within this vegetation type have been described by Smith and Smith (2008). These communities have not been mapped consistently across the region and hence these communities are all considered under the label Coastal Sandstone Ridgetop Woodland. The distribution of this vegetation type is quite restricted within the M2 corridor and consists chiefly of the small patches of Bloodwood-Scribbly Gum Woodland. The characteristic species of this variant are listed in Table 2.

Table 2 Coastal Sandstone Ridgetop Woodland Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
Narrow-leaved Apple	*Angophora bakeri*
Smooth-barked Apple	*Angophora costata*
Red Bloodwood	*Corymbia gummifera*
Scribbly Gum	*Eucalyptus haemastoma*
Sydney Peppermint	*Eucalyptus piperita*

Within the M2 corridor, Coastal Sandstone Ridgetop Woodland is found as thin bands of vegetation, transitional with Hinterland Sandstone Gully Forest on or near the ridgetops north of the M2 Motorway between Darling Mills Creek in the west and Oakes Road in North Rocks. Patches of the community are also found to the east of Terrys Creek in Marsfield. While much of this vegetation is continuous with that of Bidjigal Reserve, narrow bands of this vegetation also occur between the M2 Motorway and adjacent residential properties in this area.

In areas that are adjacent to broad bands of intact vegetation, minimal disturbance and weed invasion is evident. The narrow bands of this vegetation adjacent to urban areas and some areas that were subject to disturbance during construction of the M2 Motorway show moderate to high levels of disturbance, particularly weed invasion.

Coastal Sandstone Ridgetop Woodland is a common vegetation community in the Sydney region and is represented in local conservation reserves such as Lane Cove National Park, Garigal National Park, Berowra Valley Regional Park and Ku-ring-gai Chase National Park.

Coastal Sandstone Gully Forest

Coastal Sandstone Gully Forest (unit p140) in Tozer *et al.* (2006) is found in coastal areas where the erosion of overlying solids has exposed the underlying sandstone resulting in the formation of thin sandy soils. In the Sydney region this vegetation has been mapped as a part of a single variable vegetation type, including a number of variants as Sydney Sandstone Gully Forest (Benson and Howell 1994) but has been classified as a separate vegetation community in Smith and Smith (2008) and in the Southeast NSW Native Vegetation Classification and Mapping Project (SCIVI) mapping (Tozer *et al.* 2006). This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

The local occurrence of this vegetation type is an open forest in which the dominant tree species are Sydney Peppermint (*Eucalyptus piperita*) and Smooth-barked Apple (*Angophora costata*) with a variety of other tree species occurring at lower frequency. A typically sparse sub-canopy of small trees and large shrubs such as *Allocasuarina littoralis*, *Banksia serrata*, *Ceratopetalum gummiferum* is found over a diverse understorey of shrubs that varies from sparse (particularly where rock outcropping is abundant) to dense. The structure and composition of this understorey layer is variable and reflects localised soil conditions (particularly moisture and nutrient levels) and disturbance events such as fires, weed invasion and mechanical disturbance. Typical understorey species include *Acacia suaveolens*, *Dillwynia retorta*, *Dodonaea triquetra*, *Grevillea linearifolia*, *Leptospermum trinervium*, *Persoonia levis, Platysace linearifolia* and *Pultenaea flexilis*.

The ground layer vegetation also varies in structure and composition due to soil conditions and disturbance events, tending to be less diverse and less dense in areas of thicker understorey. Typical understorey species include *Actinotus minor*, *Caustis flexuosa*, *Dianella caerulea*, *Entolasia stricta*, *Lomandra longifolia*, *Pteridium esculentum*, *Stylidium productum*, *Xanthosia pilosa* and *X. tridentata*.

This vegetation is typically found on the upper to lower slopes of gullies often immediately down slope of Coastal Sandstone Ridgetop Woodland. In areas with more productive soils, this variant may grade into Hinterland Sandstone Gully Forest and often grades into Sandstone Riparian Scrub in the vicinity of waterways.

Within and in the vicinity of the M2 corridor, Coastal Sandstone Gully Forest is found as small patches in the vicinity of Devlins Creek and on the gully slopes between Terrys Creek and Busaco Road in Marsfield where it is transitional with Hinterland Sandstone Gully Forest and Sandstone Riparian Scrub.

This variant of Coastal Sandstone Gully Forest is a common vegetation community in the Sydney region which is represented in local conservation reserves such as Lane Cove National Park, Garigal National Park, Berowra Valley Regional Park and Ku-ring-gai Chase National Park.

The characteristic tree species of this community are listed in Table 3.

Table 3 Coastal Sandstone Gully Forest Variants and Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Sydney Peppermint	*Eucalyptus piperita*
+Smooth-barked Apple	*Angophora costata*
*Turpentine	*Syncarpia glomulifera*
*Red Bloodwood	*Corymbia gummifera*
#Grey Gum	*Eucalyptus punctata*
#Blackbutt	*Eucalyptus pilularis*
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Hinterland Sandstone Gully Forest

In the Sydney region, this vegetation type has been mapped as Hinterland Sandstone Gully Forest (unit p142) by Tozer *et al.* (2006) has been classified as Blackbutt Gully Forest in Smith and Smith (2008).

This vegetation is a subset of the Sydney Hinterland Dry Sclerophyll Forests vegetation class of Keith (2004). Most of the native vegetation within the project area conforms to the description of this community.

This vegetation type is a tall open forest in which Blackbutt (*Eucalyptus pilularis*), Smooth-barked Apple (*Angophora costata*) and in some locations, Turpentine (*Syncarpia glomulifera*) are usually the dominant species. This variant occurs in gullies on Hawkesbury Sandstone with enriched soils as a result of influence from nearby Wianamatta Group shales or shale lenses within the sandstone bedrock (Smith and Smith 2008).

This vegetation type typically has a moderately dense sub-canopy of small trees and large shrubs such as *Allocasuarina littoralis*, *A. torulosa*, *Banksia serrata*, *Ceratopetalum gummiferum* and *Elaeocarpus reticulatus*. The sparse to moderately dense understorey of this variant often includes *Acacia linifolia*, *Dodonaea triquetra*, *Elaeocarpus reticulatus*, *Grevillea linearifolia*, *Leptospermum trinervium*, *Persoonia linearis*, *Pittosporum undulatum* and *Pultenaea flexilis*.

The ground layer vegetation also varies in structure and composition due to soil conditions and disturbance events, tending to be less diverse and less dense in areas of thicker understorey. Typical understorey species include *Calochlaena dubia*, *Dianella caerulea*, *Entolasia stricta*, *Lomandra longifolia*, *Microlaena stipoides*, *Pratia purpurascens*, *Pteridium esculentum* and *Xanthosia pilosa*.

Within and in the vicinity of the M2 corridor, Hinterland Sandstone Gully Forest is chiefly found within the eastern arm of Bidjigal Reserve and on the valley slopes and valley floors around Blue Gum Creek in Carlingford. It is also found around Devlins Creek in Beecroft and Cheltenham.

This vegetation type is considered by Campbell (2006) to be locally significant as, although it is relatively common in the Hornsby Shire, it is not common or well-represented in conservation reserves in other parts of the Sydney region.

The characteristic tree species of this community are listed in Table 4.

Table 4 Hinterland Sandstone Gully Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Blackbutt	*Eucalyptus pilularis*
+Smooth-barked Apple	*Angophora costata*
*Turpentine	*Syncarpia glomulifera*
*Red Bloodwood	*Corymbia gummifera*
*Sydney Peppermint	*Eucalyptus piperita*
*Red Mahogany	*Eucalyptus resinifera*
#Grey Gum	*Eucalyptus punctata*
#Sydney Blue Gum	*Eucalyptus saligna*
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Sydney Hinterland Transition Woodland

Sydney Hinterland Transition Woodland (unit p146) in Tozer *et al.* (2006) and has been described as Upper Georges River Sandstone Woodland (Tozer *et al.* 2003).This community has also been described elsewhere as Hinterland Sandstone Transition Grey Gum Forest (DECCW, 2009a), with the most extensive stands occurring within the Campbelltown and Liverpool LGAs. This vegetation type is part of the Sydney Hinterland Dry Sclerophyll Forest Class (DECCW, 2009) and is primarily found on the broad ridges associated with Mittagong Formation sandstone. The presence of shale soil is not obvious as sites often include sandstone benching or outcropping (DECCW, 2009b).

Dominant canopy trees include Red bloodwood (*Corymbia gummifera*) and Grey Gum(*Eucalyptus punctata*) with a number of stringybarks such as Narrow-leaved Stringybark (*E.oblonga*) common., In sheltered gullies *Angophora costata* (Sydney red gum), *Eucalyptus agglomerata* (blue-leaved stringybark), *E. deanei* (mountain blue gum), *E. pilularis* (blackbutt) and *Syncarpia glomulifera* (turpentine) may be common (DECCW, 2009).

Dominant shrub species include Prickly Moses (*Acacia ulicifolia suaveolens*), Sunshine Wattle (*Acacia terminalis*), Broad-leaved Geebung (*Persoonia levis*), Narrow-leaved Geebung (*P. linearis*),Hair-pin Banksia (*Banksia spinulosa var. spinulosa*), Flaky-barked Teatree (*Leptospermum trinervium*).

The ground layer species such as Common Ground Fern (*Calochlaena dubia*) and Bracken (*Pteridium esculentum*) are common in sheltered sites,

Within and in the vicinity of the M2 corridor, Sydney Hinterland Transition Woodland is mapped as occurring on the western edge of Bidjigal Reserve and opposite Bidjigal Reserve however due to a lack of characteristic canopy trees, these areas closely resemble Hinterland Sandstone Gully Forest.

The characteristic tree species of this community are listed in Table 5.

Table 5 Hinterland Sandstone Gully Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
*Blackbutt	*Eucalyptus pilularis*
*Smooth-barked Apple	*Angophora costata*
#Turpentine	*Syncarpia glomulifera*
+Red Bloodwood	*Corymbia gummifera*
+Narrow-leaved Stringybark	*Eucalyptus oblonga*
+Grey Gum	*Eucalyptus punctata*
#Black She-oak	Allocasuarina littoralis
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Sandstone Riparian Scrub

Sandstone Riparian Scrub (unit p58) in Tozer *et al.* (2006) is found along creeks within sandstone gullies. In the Sydney region this vegetation has been mapped as a part of a single variable vegetation type, including a number of variants as Sydney Sandstone Gully Forest (Benson and Howell 1994) but has been classified as a separate vegetation community in Smith and Smith (2008) and in the Southeast NSW Native Vegetation Classification and Mapping Project (Tozer *et al.*. 2006) mapping. This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

This low closed forest variant occurs in small patches and narrow bands along creeks in sandstone gullies. In its natural state, the dominant canopy species usually includes Coachwood (*Ceratopetalum apetalum*), Water Gum (*Tristaniopsis laurina*), Black Wattle (*Callicoma serratifolia*) and Pittosporum (*Pittosporum undulatum*) with a variety of other chiefly mesophilic shrub and small tree species. The understorey is composed largely of ferns species including *Adiantum aethiopicum*, *Blechnum ambiguum*, *Calochlaena dubia*, and *Sticherus flabellatus* with additional fern species (*Hymenophyllum cupressiforme* and *Pyrrosia rupestris*) often growing on rocks and tree trunks. *Lomandra longifolia* is also a common element of the understorey.

This vegetation type occurs along all creeks within and adjacent to the M2 corridor with the most intact occurrences at Darling Mills Creek and Terrys Creek. Much of this vegetation is highly modified as a result of alteration to natural flow regimes, increased nutrients and especially weed invasion. Riparian vegetation is of most value in stabilising waterways, rather than contributing to the biodiversity of the site.

Due to the restricted distribution of this vegetation community to the edges of watercourses, the tendency of these areas to be affected by altered hydrology, pollution and weed invasion, and the scarcity of this vegetation type in the Sydney region, it is considered to be regionally significant (Campbell 2006).

The characteristic tree species of this community is listed in Table 6.

Table 6 Sandstone Riparian Scrub Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Coachwood	*Ceratopetalum apetalum*
+River Gum	*Tristaniopsis laurina*
*Black Wattle	*Callicoma serratifolia*
*Pittosporum	*Pittosporum undulatum*

Native Canopy Species	
Common Name	**Botanical Name**
*Water Gum	*Tristaniopsis laurina*
#Lilly Pilly	*Acmena smithii*
#Christmas Bush	*Ceratopetalum gummiferum*
#Crabapple	*Schizomeria ovate*
The Sandstone Riparian Scrub vegetation type often also includes emergent trees typical of the other Sandstone Gully Forest vegetation types that adjoin it.	
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Blue Gum High Forest

This community is listed as a critically endangered ecological community (CEEC) under the TSC Act as Blue Gum High Forest and under the EPBC Act as Blue Gum High Forest of the Sydney Basin Bioregion.

This is a moist tall open forest community in which Sydney Blue Gum (*Eucalyptus saligna*) is a dominant species together with a combination of other species including Smooth-barked Apple (*Angophora costata*), Grey Ironbark (*Eucalyptus paniculata*), Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*). This vegetation is referred to as Blue Gum High Forest (unit p153) in Tozer *et al.* (2006).

Trees within this vegetation community can form large hollows. Threatened fauna species known to occur in remnant Blue Gum High Forest include Sugar Glider (*Petaurus breviceps*), Powerful owl (*Ninox strenua*), Grey-headed Flying-fox (*Pteropus poliocephalus*), Glossy Black Cockatoo (*Calyptorhynchus lathami*), Swamp Wallaby (*Wallabia bicolour*) and Brush-turkey (*Alectura lathami*) (DECC 2008).

This vegetation type is restricted to ridgetop plateaus and upper slopes on clay soils derived from Wianamatta shales. Prior to clearing for urban development and road construction, a number of areas along the M2 corridor may have contained this vegetation community or the closely allied Sydney Turpentine-Ironbark Forest. The extent and condition of this community has been verified through on ground inspection and the present distribution within the study area is restricted to a narrow band between the M2 Motorway and Pennant Hills Golf Course to the north. This area is approximately 1.36 ha in area and in moderate to poor condition (Figure 2).

The species composition of this patch shows affinities with Turpentine-Ironbark Forest. The dominance of Sydney Blue Gum and Grey Ironbark, the lack of Turpentine and the composition of the understorey and ground layers suggest that this vegetation patch is more closely aligned with the definition of Blue Gum High Forest. A gradation into vegetation more similar to Turpentine-Ironbark Forest occurs at the western extent of the patch as indicated by a drier understorey and an increasing dominance by Rough-barked Apple (*Angophora floribunda).*

The characteristic species of this community are listed in Table 7.

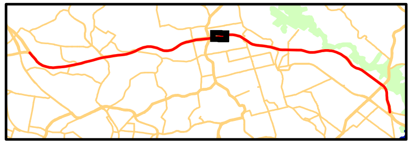
Table 7 Blue Gum High Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Smooth-barked Apple	*Angophora costata*
+Grey Ironbark	*Eucalyptus paniculata*
+Blackbutt	*Eucalyptus pilularis*
+Sydney Blue Gum	*Eucalyptus saligna*
+Turpentine	*Syncarpia glomulifera*
#Grey Gum	*Eucalyptus punctata*
#Red Mahogany	*Eucalyptus resinifera*
+ = dominant canopy species, *, # = less frequent species	

Figure 2 – Blue Gum High Forest at Pennant Hills Golf Course

Blue Gum High Forest

Proposed Design



Source: MapData Sciences 2009

Sydney Turpentine-Ironbark Forest

Sydney Turpentine-Ironbark Forest is listed as a critically endangered ecological community (CEEC) (Turpentine–Ironbark Forest of the Sydney Basin Bioregion) under both the EPBC Act and the TSC Act.

EPBC Act Definition

Sydney Turpentine-Ironbark Forest is an open-forest of mixed and varying canopy species composition in which Turpentine (*Syncarpia glomulifera*) and ironbarks (*Eucalyptus* spp.) are dominant. Other tree species include Red Bloodwood (*Corymbia gummifera*), Sydney Blue Gum (*E. saligna*), Grey Gum (*E. punctata*), Narrow-leaved Ironbark (*E. crebra*), Mountain Grey Gum (*E. cypellocarpa*), Round-leaved Gum (*E. deanei*) and Red Ironbark (*E. fibrosa*) (DEWHA 2009).

Low tree and shrub species include *Acacia parramattensis*, *Breynia oblongifolia*, *Dodonaea triquetra*, *Leucopogon juniperinus, Notelaea longifolia, Ozothamnus diosmifolius, Pittosporum revolutum, P. undulatum, Polyscias sambucifolia* and *Maytenus silvestris*. Ground layer species include *Adiantum aethiopicum, Austrostipa pubescens, Dianella caerulea, Dichondra repens, Entolasia stricta, Lomandra longifolia, Poa affinis, Pseuderanthemum variabile* and *Themeda australis*. Climbers include *Eustrephus latifolius, Glycine clandestina* and *Pandorea pandorana* (DEWHA 2009).

The Commonwealth listing for the CEEC includes vegetation in the following condition:

- The vegetation contains some characteristic components from all structural layers (tree canopy, small tree/shrub midstorey, and understorey).
- Tree canopy cover is greater than 10% and remnant size is greater than one hectare. These areas have the greatest conservation value and their high quality and size makes them most resilient to disturbance.
- Remnants with tree canopy cover less than 10% are also included in the ecological community, if the fragments are greater than one hectare in size and occur in areas of native vegetation in excess of 5 hectares in area. These areas enhance the potential for connectivity and viability of the ecological community. They support native flora and fauna species by facilitating gene flow among remnants and buffering against disturbance (DEH 2005).

Areas mapped as Sydney-Turpentine Ironbark Forest within the M2 corridor were inspected and found to be:

- Less than one hectare in area, highly disturbed and lacking an intact ground layer or understorey; and/or
- Consistent with the floristic composition of the larger patches of the adjacent Hinterland Sandstone Gully Forest vegetation community.

TSC Act Definition

Under the NSW definition, Sydney Turpentine-Ironbark Forest is an open forest community and the dominant canopy trees are Turpentine (*Syncarpia glomulifera*) and Grey Ironbark (*Eucalyptus paniculata*). Common understorey shrubs include Sweet Pittosporum (*Pittosporum undulatum*), Hop Bush (*Dodonaea triquetra*), Elderberry Panax (*Polyscias sambucifolia*) and Sickle Wattle (*Acacia falcata*).

Sydney Turpentine-Ironbark Forest occurs on fertile soils in an area of moderate rainfall. It is transitional between Cumberland Plain Woodland in drier areas and Blue Gum High Forest on adjacent higher rainfall ridges. As a transitional community, the species composition varies according to the influence of sandstone and aspect.

The areas of vegetation within and adjacent to the M2 corridor that have been mapped as Sydney Turpentine–Ironbark Forest under the alternative vegetation classifications described below have all been inspected and were subject to detailed flora surveys. The soil on which this vegetation is growing is sandy and contains frequent outcropping of sandstone and also shows a relatively minor yet noticeable clay influence in upper slope areas. The dominant canopy species in these areas are Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*) with only occasional specimens of other tree species including Smooth-barked Apple (*Angophora costata*) and Red Bloodwood (*Corymbia gummifera*) present. No ironbark species were detected within these areas.

The moderately dense understorey in these areas consists of a mix of sclerophyllous and mesophilic shrubs of a range of species that are found in a variety of soil types and vegetation communities. The patterns in the relative abundance of the shrub species observed appear to be correlated with the variation in moisture levels due to aspect. The sparse to moderately dense ground layer vegetation here is a mixture of low shrubs, herbs, grasses and sedges.

Vegetation Mapping Schemes

In the mapping of Tozer *et al.* (2006) as shown in Figure 1, small isolated occurrences of this community are mapped in the Beecroft and Carlingford North areas.

Other vegetation mapping schemes have labelled vegetation as Sydney Turpentine-Ironbark Forest inconsistently across the locality of the M2 corridor. The Native Vegetation of the Cumberland Plain maps (NPWS 2002) show extensive areas (including developed areas such as roads, residences) as this community, however these maps have limitations in their applicability to fine scale assessment of vegetation due to a number of factors described in the associated interpretation guidelines (NPWS 2002).

A recently released draft vegetation community mapping scheme for the Sydney metropolitan catchment area (DECCW 2009 a) shows some areas as Sydney Turpentine–Ironbark Forest which are mapped as Hinterland Sandstone Gully Forest by Tozer *et al.* (2006) and as Blackbutt Gully Forest by Smith and Smith (2008). The new mapping scheme is currently a draft open to comment and subject to change and the Sydney Metropolitan CMA provides the following advice regarding its status:

> *The product is a draft, and therefore is subject to change. For that reason, the product is not intended to be used for planning or decision making purposes until the review period has ceased and the final version of the product has been released.*

Neither the TSC Act nor EPBC Act Threatened Species Scientific Committee's advice regarding this community includes Blackbutt (*Eucalyptus pilularis*) as a dominant or frequently occurring species. While the understorey and ground layer vegetation observed shows a resemblance to that of Sydney Turpentine-Ironbark Forest, its composition and structure are more closely aligned with the Hinterland Sandstone Gully Forest community.

In light of these factors, this vegetation within the study area is considered to be Hinterland Sandstone Gully Forest with a slightly higher than typical clay soil influence and not Sydney Turpentine-Ironbark Forest.

The results from flora surveys conducted within areas mapped as Sydney Turpentine-Ironbark Forest adjacent to the M2 Motorway is presented in **Appendix D** and summarised below in Table 8.

Table 8 Flora survey data within the M2 corridor

Native Canopy and Shrub Species		Location of flora quadrat		
Common Name	**Botanical Name**	**5- (Bidjigal Reserve)**	**11- (Devlins Creek, Cheltenham)**	**12- (Devlins Creek, North Epping)**
Narrow-leaved Apple	*Angophora bakeri*	X		
Smooth-barked Apple	*Angophora costata*	X	X	X
Forest Oak	*Allocasuarina torulosa*	X		
Old Man Banksia	*Banksia serrata*	X		
Blackbutt	*Eucalyptus pilularis*	X	X	X
*Lantana	*Lantana camara*	X	X	X
Paperbark Tea-tree	*Leptospermum trinervium*	X		
*Broad-leaf Privet	*Ligustrum lucidum*		X	
*Small-leaf Privet	*Ligustrum sinense*	X	X	X
Sweet Pittosporum	*Pittosporum undulatum*	X		
Turpentine	*Syncarpia glomulifera*	X		
*=exotic species				

4.4.2 Highly disturbed and artificial vegetation

Highly disturbed, weed-dominated vegetation within the corridor is chiefly found in:

- Areas that have been subjected to a high degree of mechanical disturbance (e.g. fill batters, fill mounds, scalped areas, some detention basins) and subsequent weed invasion.
- The vicinity of waterways that receive nutrient-rich stormwater and weed seeds from urban areas.
- The interface between bushland and residential areas affected by nutrient-rich runoff, dumping of green waste and encroachment of garden plants.

Modified vegetation consists of exotic grasslands (mown areas) and revegetated areas created after the completion of the M2 Motorway. The exotic grasslands contain little if any native vegetation.

Revegetated areas adjacent to the Motorway have canopies composed of immature to semi-mature native trees (chiefly eucalypts) with a sparse to moderate density shrub layer. This shrub layer consists of a mixture of locally indigenous native plants, other native species which would not naturally occur in the locality and woody weeds such as Lantana (*Lantana camara*) and Blackberry (*Rubus* spp). The ground layer in revegetated areas is dominated by introduced grasses, perennial and annual herbs and occasional specimens of native species such as *Lomandra longifolia*.

These areas have very low plant species diversity, simplified vegetation structure and minimal natural seedling recruitment and are not of conservation significance.

These areas do have some value as fauna habitat however they contain a very low density of important habitat features such as tree hollows and large mature heavily-flowering trees and have low structural diversity. These areas are therefore considered to be marginal habitat for the threatened species with potential to occur in the locality and are unlikely to be important to the long-term viability and recovery of local populations of these species.

4.4.3 Terrestrial plant species of conservation significance

Searches of the NPWS Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened plant species listed under the TSC Act or EPBC Act are likely to occur in the vicinity of the project. The database search revealed that there are a number of threatened species recorded in the vicinity of the site (Figure 3). The conservation status of the listed flora and fauna species is provided in **Appendix C**.

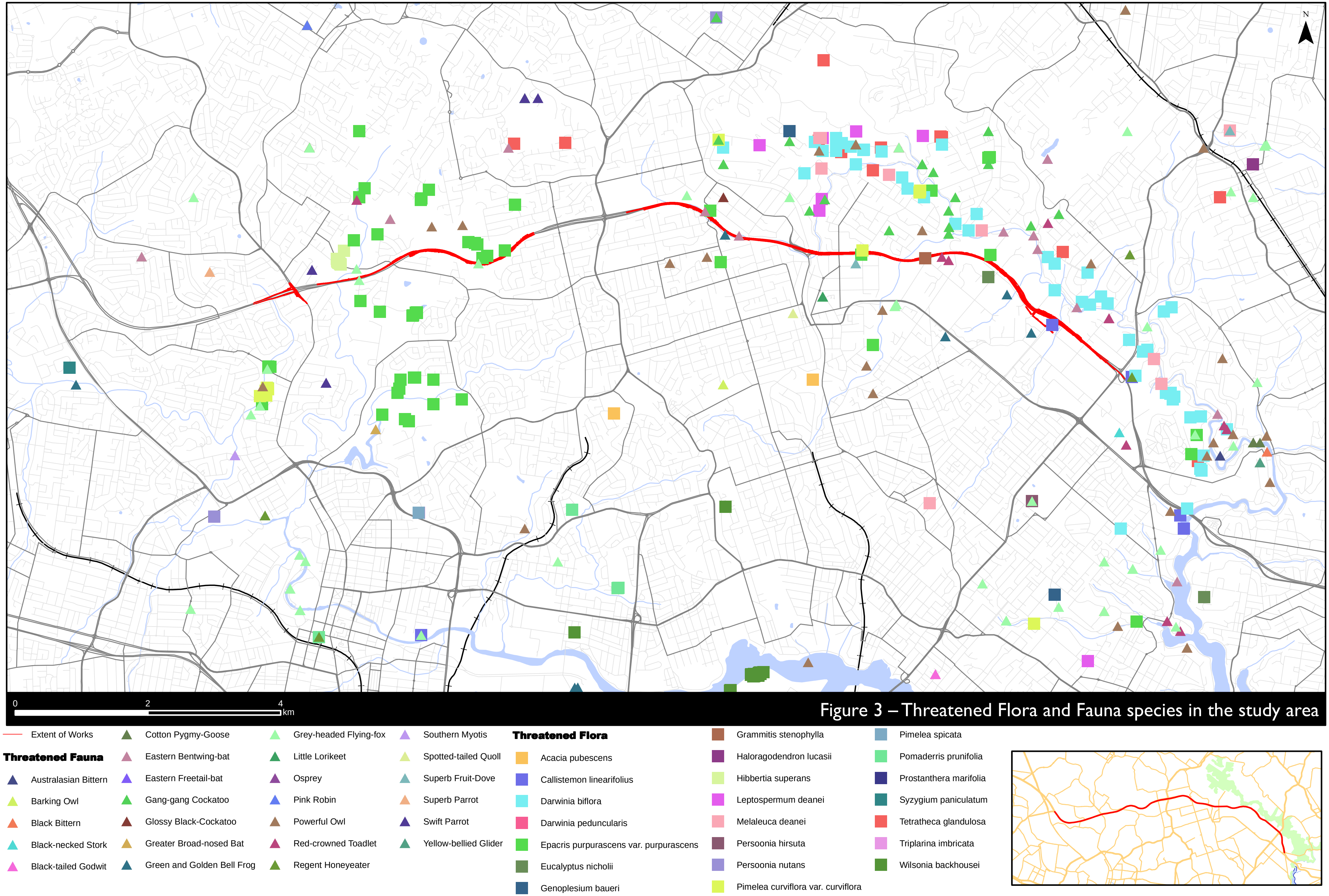


Figure 3 – Threatened Flora and Fauna species in the study area

Source: DECC, 2009; MapData Sciences 2009; Tozer et.al (2006) Native vegetation of southeast NSW

The likelihood of occurrence of these species based on previous records and habitat attributes is summarised in **Appendix C**. Those species which were considered to have a moderate to high likelihood of occurring within the study area on the basis of distribution and habitat requirements are shown in Table 9. Assessments of significance for these species are presented in **Appendix F**.

Table 9 Threatened flora species with potential to occur in the M2 Corridor

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
Acacia bynoeana	Bynoe's Wattle	Shrub	E	V	Moderate
Callistemon linearifolius		Shrub	V	-	High
Darwinia biflora		Shrub	V	V	Moderate-High
Epacris purpurascens var. *purpurascens*		Shrub	V	-	High-recorded
Persoonia hirsuta	Hairy Geebung	Shrub	E	E	Moderate
Pimelea curviflora var. *curviflora*		Shrub	V	V	High
Tetratheca glandulosa		Shrub	V	V	Moderate
V = Vulnerable, E = Endangered, - = Not listed					

The threatened terrestrial plant species that are considered to have potential to occur within the study area are chiefly those species which are associated with sandstone soils, particularly where these soils are somewhat enriched due to their proximity to areas of shale-derived soil.

Of the above-listed species, the following species have been recorded in the locality and are associated with woodland or open forest on clay-enriched sandstone soils:

- *Callistemon linearifolius.*
- *Darwinia biflora.*
- *Epacris purpurascens* var. *purpurascens.*
- *Pimelea curviflora* var. *curviflora.*
- *Tetratheca glandulosa*.

Of these species, only *Epacris purpurascens* var. *purpurascens* was recorded during the field investigations conducted for the preparation of this report. *Epacris purpurascens* var. *purpurascens* is an erect shrub, 50-180 cm high that is found in a range of habitat types, most of which have a strong shale soil influence (DECCW 2009). Within the M2 corridor, individuals of this species are located in translocated soils including earth mounds and rock armoured batter slopes.

Pimelea curviflora var. *curviflora* was recorded during the EIS for the western section of the M2 Motorway (Mount King 1992). However the specific location and the population size of this species were not reported. The species has been recorded in Lane Cove National Park and in Epping near the M2 corridor (DECCW 2009). The species was not recorded during recent flora surveys within the M2 corridor however it is possible that this species may exist within the M2 corridor.

Callistemon linearifolius is known to occur in the Hornsby, Lane Cove and Ryde local government areas and has been recorded near the M2 corridor at Marsfield (DECC, 2001). The species usually grows in dry sclerophyll forest on the coast and adjacent ranges. The species was not recorded during the flora survey of the M2 corridor however there is a high likelihood that it occurs here.

Darwinia biflora grows in heath on sandstone or in the understorey of woodland on shale-capped ridges. There are records of this species occurring in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai local government areas. The bushland of the M2 corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove Valley) are not included in the lists of known important populations.

The species was not recorded during flora surveys however it is possible that this species may exist within the M2 corridor.

Tetratheca glandulosa grows in sandy or rocky heath or scrub. The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor.

Several parts of the M2 Motorway are located on ridgetop areas on or adjacent to areas underlain by shale-derived soils. *Persoonia hirsuta* and *Acacia bynoeana* are associated with woodland or open forest on sandstone soils but are not particularly associated with soils which have a clay influence. Important populations of these species are not considered likely to exist within the M2 corridor.

4.4.4 Introduced flora

A wide variety of introduced plant species are found within the M2 corridor and within adjacent urban and bushland areas. The most abundant and detrimental types of weeds include woody weeds (e.g. *Lantana camara*, *Rubus* spp., *Ligustrum* spp.), vine weeds (e.g. *Cardiospermum grandiflorum*, *Ipomoea* spp.) grasses (e.g. *Eragrostis curvula*, *Chloris gayana*) and herbs (e.g. *Tradescantia fluminensis*, *Bidens pilosa*). A variety of aquatic weeds are also found in the waterways of the study area, particularly within Devlins Creek. See **Appendix D** for a list of species recorded during field surveys.

Highly weed-infested vegetation within the corridor is chiefly found in:

- Areas that have been subjected to a high degree of mechanical disturbance (e.g. fill batters, fill mounds, scalped areas).
- The vicinity of waterways that receive nutrient-rich stormwater from urban areas.
- The interface between bushland and residential areas.

A variety of noxious weeds occur within the M2 corridor. The species recorded are shown in Table 10 with the control requirements for each weed class under the NW Act shown in Table 11.

Table 10 **Noxious weeds noted within the M2 Corridor and adjacent lands and weed class**

Noxious Weed Species		Weed Class for each Local Government Area			
Scientific Name	**Common Name**	**Hills Shire**	**Hornsby**	**Ryde**	**Parramatta**
Acetosa sagittata	Turkey rhubarb	-	4	-	-
Ageratina adenophora	Crofton weed	4	-	-	-
Anredera cordifolia	Madeira vine	-	4	4	4
Arundo donax	Giant reed	-	4	4	4
Asparagus aethiopicus	Asparagus fern	-	4	4	4
Asparagus asparagoides	Bridal creeper	5	4	4	4
Asparagus plumosus	Climbing asparagus fern	-	4	4	4
Bryophyllum species and hybrids	Mother-of-millions	3	-	-	-
Cardiospermum grandiflorum	Balloon vine	-	4	4	4
Cestrum parqui	Green cestrum	3	3	3	3
Chrysanthemoides monilifera subsp. *monilifera*	Boneseed	-	-	3	3
Cinnamomum camphora	Camphor laurel	-	4	4	-
Cortaderia species	Pampas grass	3	3	3	3
Delairea odorata	Cape ivy	-	4	4	4
Genista monspessulana	Cape broom	-	3	3	3

Noxious Weed Species		Weed Class for each Local Government Area			
Scientific Name	Common Name	Hills Shire	Hornsby	Ryde	Parramatta
Ipomoea indica	Morning glory (purple)	-	4	4	4
Lantana species	Lantana	5	4	4	4
Ligustrum lucidum	Privet (Broad-leaf)	4	4	4	4
Ligustrum sinense	Privet (Narrow-leaf/Chinese)	4	4	4	4
Ludwigia longifolia	Long-leaf willow primrose	3	3	3	3
Ludwigia peruviana	Ludwigia	3	3	3	3
Ochna serrulata	Ochna	-	4	4	-
Olea europaea subsp. *cuspidata*	African olive	-	-	4	-
Parietaria judaica	Pellitory	4	4	4	4
Phyllostachys species	Rhizomatous bamboo	-	4	4	4
Ricinus communis	Castor oil plant	-	4	4	4
Rubus fruticosus aggregate species	Blackberry	4	4	4	4
Sagittaria platyphylla	Sagittaria	5	5	5	5
Senna pendula	Senna	-	-	4	-
Toxicodendron succedaneum	Rhus tree	4	4	4	4
Tradescantia fluminensis	Trad	-	4	4	-
Xanthium species	Bathurst/Noogoora/Californian/cockle burrs	4	-	-	-

Table 11 Control requirements for each weed class under the Noxious Weeds Act 1993

Weed Class	Control requirements
1	The plant must be eradicated from the land and the land must be kept free of the plant
2	The plant must be eradicated from the land and the land must be kept free of the plant
3	The plant must be fully and continuously suppressed and destroyed
4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with

4.5 Terrestrial Fauna and Fauna Habitat of the Study Area

4.5.1 Large patches of native vegetation

Habitat for a variety of fauna species exists within the remnant vegetation occurring within the M2 corridor and surrounding bushland areas. Trees (e.g. *Eucalyptus* spp., *Angophora* spp., *Syncarpia* spp. and *Corymbia* spp.), Wattles (*Acacia* spp.) and Banksias (*Banksia* spp.) in particular provide a food source in the form of leaves, sap, nectar, pollen and seed for a number of bird, mammal and insect species. Threatened species known to use these resources include Grey-headed Flying-fox (*Pteropus poliocephalus*) and Gang-gang Cockatoo (*Callocephalon fimbriatum*). The migratory nectar-feeding birds Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) may use this resource sporadically or on a seasonal basis but are not considered likely to be regular or frequent visitors to the area based upon database records.

The Powerful Owl (*Ninox strenua*) is also known to hunt and roost in the bushland of the study area and contiguous areas of bushland in the locality and may nest in large tree hollows in the locality. Nest sites are considered most likely to be located in areas containing very large mature hollow-bearing trees, particularly in core bushland areas which are less subject to human disturbance.

Large and medium-sized tree hollows are likely to exist within the larger, more mature trees particularly in mature Blackbutt (*Eucalyptus pilularis*). These larger trees are chiefly found on lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material that are not considered likely to be affected by the proposed works. Small hollows, fissures and decorticating bark exist within the trees of the study area. These hollows provide potential den, nest and roost sites for a number of small bird, mammal and reptile species.

Smaller hollows may be used by threatened hollow-roosting microbats including Eastern Freetail-bat (*Mormopterus norfolkensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*).

In addition to the microbat species listed above, several other threatened, non hollow-roosting species may forage in the air spaces within and around the vegetation including Large-eared Pied Bat (*Chalinolobus dwyeri*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Large-footed Myotis (*Myotis adversus*).

The leaf-litter, fallen logs and ground layer vegetation of the ecology study area form potential habitat for ground-dwelling fauna including Echidna (*Tachyglossus aculeatus*), Long-nosed Bandicoot (*Perameles nasuta*), Swamp Wallaby (*Wallabia bicolor*) and a variety of reptile species. These habitat features are also likely to be used for sheltering and foraging for some locally occurring frog species.

4.5.2 Rocky outcrops

Rocky outcrops provide potential sheltering sites for reptiles (lizards and snakes), frogs and small terrestrial mammals. If environmental conditions are conducive, crevices within larger rock outcrops may provide roosting habitat for some species of cave-roosting microbats. Large rock outcrops are abundant within Bidjigal Reserve including some locations on the edge of the M2 corridor. Microbats are also known to use the bridge abutments and culverts associated with the M2 Motorway as roosting habitat.

4.5.3 Wildlife corridors

The bushland of the Darling Mills Creek corridor is considered to be the most significant regional habitat link with Berowra Bushland Park in Hornsby and further on to Ku-ring-gai Chase National Park and Brisbane Waters (Upper Parramatta River Catchment Trust, 1999).

Due to its relatively large size and its connectivity with other bushland areas, the bushland of the Darling Mills Creek corridor retains high biodiversity value and potential for fauna movements and genetic exchange.

The more intact bushland areas of the sandstone valleys are likely to have the greatest importance as corridors for terrestrial fauna, particularly for species which are less tolerant of disturbed environments.

Despite extensive weed invasion, the narrow bands of riparian vegetation that persist along creeks within cleared areas, are also important as they provide the continuous vegetation cover that is required by some fauna species which do not readily cross cleared lands.

Narrow bands of vegetation, such as those often found along roadways, also have some value as movement corridors for more mobile fauna species.

The following disturbance events within the bushland of the corridor may have had negative impacts on wildlife corridors:

- Increased residential development, which results in altered hydrology, increased nutrient loads and weed invasion along waterways.
- The installation of mains sewerage lines along the creek, including overflow points, which results in water pollution during high rainfall events.
- The construction of roads, which creates disturbance to soils and vegetation and barriers to wildlife movement within the corridor (Upper Parramatta River Catchment Trust, 1999).

The main wildlife corridors within the M2 corridor include the bushland and disturbed vegetation surrounding Blue Gum Creek, Devlins Creek, Darling Mills Creek and Terrys Creek.

Where bridges span Darling Mills Creek, Devlins Creek and Terrys Creek, the vegetation underneath forms the only habitat connection between bushland areas on opposite sides of the Motorway. These areas are considered to be of particular importance to fauna movement. The vegetation underneath these structures is somewhat degraded due to previous earthworks and the impacts of shading and the interception of rainfall by the roadway overhead.

Patches of bare soil are apparent under these bridges. Around the abutments, in particular, the soil lacks vegetation cover and is loose and dry. Shading, a lack of suitable soil covering post-construction and low water availability may be the cause of this condition. The dry soil and lack of vegetation cover here is likely to limit the use of these areas as movement corridors by species (e.g. frogs) that require cover from predators or moist conditions (e.g. frogs).

The vegetation between Blue Gum Creek and the intersection of the M2 Motorway and Pennant Hills Road, and the vegetation along the southern boundary of Pennant Hills Golf Course also provides some connectivity between Bidjigal reserve and bushland areas to the east.

4.5.4 DECC Rapid Fauna Habitat Assessment

Part of the M2 corridor comprises four sites considered to be moderate to very high in fauna value (DECC 2008). The vegetation north of the M2 Motorway to the Cumberland Highway is part of the Lane Cove Valley (Figure 1). Darling Mills Creek is to the north-west (Bidjigal Reserve area), Devlins Creek is to the north of the M2 at the Chilworth Recreation Reserve, Cheltenham and Quarry Branch Creek is south west of the M2 at Winston Hills. In the DECC study, the fauna significance of a site was determined by the following features:

- Habitat connectivity;
- Habitat state or condition;
- Presence of tree hollows;
- Below canopy structural attributes;
- Habitat present considered to comprise priority fauna habitat;
- Future prospects;
- Presence of threatened species and regionally significance species;
- Potential presence of further significant fauna;
- Presence of feral bird species; and
- Presence of additional fauna attributes.

Lane Cove Valley (very high habitat value)

Table 12 shows the scores assigned by DECC for the Lane Cove Valley site for each of the above features.

Table 12 Rapid Fauna Habitat Assessment for Lane Cove Valley (DECC 2008)

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	0	0-20	Not connected
Habitat State	10	0-15	Little Bisected
Tree Hollows	15	0-20	Moderate
Below Canopy Attributes	10	0-15	Moderately Modified

Fauna Habitat Feature	Score	Score Range	Criteria
Priority Fauna Habitat	15	0-30	Moderate
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	10	0-30	Moderate
Threatened Species	150	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	160	5 per species	
Feral Bird Species	2	0-5	Moderate
Additional fauna Values	20	Various	
Total	392	(Very High)	

DECC's Lane Cove Valley site contains six priority fauna habitats: forested wetland, rainforest, alluvial forest and woodland, grassy woodland, freshwater wetland and saltwater wetland. These habitats are known to support 231 native fauna species, including ten endangered fauna species and one endangered population. The following threatened fauna have been recorded in the Lane Cove Valley site:

- Red-crowned Toadlet (*Pseudophryne australis*);
- Black Bittern (*Ixobrychus flavicollis*);
- Osprey (*Pandion haliaetus*);
- Gang-gang Cockatoo (*Callocephalon fimbriatum*) (endangered population);
- Glossy Black-cockatoo (*Calyptorhynchus lathami)*
- Swift Parrot (*Lathamus discolour*);
- Powerful Owl (*Ninox strenua*);
- Barking Owl (*Ninox connivens*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- East-coast Freetail-bat (*Mormopterus norfolkensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Little Bentwing-bat (*Miniopterus australis*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

Darling Mills Creek (high habitat value)

Table 13 shows the scores assigned to the Darling Mills Creek site for each of the above features.

Table 13 Rapid Fauna Habitat Assessment for Darling Mills Creek (DECC 2008)

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	0	0-20	Not connected
Habitat State	5	0-15	Moderately Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	5	0-15	Mostly Modified
Priority Fauna Habitat	5	0-30	Little
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	20	0-30	High
Threatened Species	70	10 per Vulnerable sp	

Fauna Habitat Feature	Score	Score Range	Criteria
		30 per Endangered sp	
Regionally Significant Species	90	5 per species	
Feral Bird Species	0	0-5	Widespread
Additional fauna Values	0	Various	
Total	210	(High)	

The site supports three priority fauna habitats: rainforest, alluvial forest and woodland and grassy woodland. There have been six threatened species recorded at the site, including:

- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- East-coast Freetail-bat (*Mormopterus norfolkensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

These species are assessed in **Appendix C** for their potential to occur within the M2 corridor.

Devlins Creek (moderate fauna value)

Table 14 shows the scores assigned to the Devlins Creek site for each of the above features.

Table 14 Rapid Fauna Habitat Assessment for Devlins Creek

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	5	0-20	Little connected
Habitat State	0	0-15	Highly Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	10	0-15	Moderately Modified
Priority Fauna Habitat	0	0-30	Nil
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	30	0-30	Very High
Threatened Species	60	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	5	5 per species	
Feral Bird Species	2	0-5	Moderate
Additional fauna Values	40	Various	
Total	162	(Moderate)	

The site supports no priority fauna habitats. The endangered population of Gang-gang Cockatoo in the Hornsby and Ku-ring-gai LGAs was recorded near this site, but its actual status within the site is uncertain. The following threatened species have been recorded at the site:

- Powerful Owl (*Ninox strenua*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*); and

- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

Quarry Branch Creek (moderate fauna value)

Table 15 shows the scores assigned to the Quarry Branch Creek site for each of the above features.

Table 15 Rapid Fauna Habitiat Assessment for Quarry Branch Creek

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	5	0-20	Little connected
Habitat State	10	0-15	Little Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	10	0-15	Moderately Modified
Priority Fauna Habitat	0	0-30	Nil
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	20	0-30	High
Threatened Species	40	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	10	5 per species	
Feral Bird Species	0	0-5	Widespread
Additional fauna Values	20	Various	
Total	125	(Moderate)	

The site supports no priority fauna habitats. Four threatened species are recorded within the habitat at the site:

- Powerful Owl (*Ninox strenua*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Southern Myotis (*Myotis macropus macropus*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

4.5.5 Fauna Species of Conservation Significance

Searches of the NPWS Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened fauna species listed under the TSC Act or EPBC Act have been recorded or are likely to occur in the vicinity (Figure 3). The database revealed that there are a number threatened species recorded or predicted to occur within 10 km of the site. The likelihood of occurrence of these species based on previous records and habitat attributes is summarised in **Appendix C**. Those species which are assessed to have a moderate to high likelihood of occurring on the site on the basis of distribution and habitat requirements are shown in Table 16. Assessments of Significance for these species are presented in **Appendix F**.

Table 16 Potential threatened fauna species and populations in the M2 Corridor

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
Anthochaera phrygia	Regent Honeyeater	Bird	E	E	Moderate
Callocephalon fimbriatum	Gang-gang Cockatoo	Bird	V	-	High - recorded
Callocephalon fimbriatum	Gang-gang Cockatoo population in the Hornsby	Bird	E	-	High - recorded

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
	and Ku-ring-gai Local Government Areas				
Calyptorhynchus lathami	Glossy Black-cockatoo	Bird	V	-	Moderate
Chalinolobus dwyeri	Large-eared Pied Bat	Mammal	V	V	Moderate
Lathamus discolor	Swift Parrot	Bird	E	E	Moderate – seasonal migrant
Litoria aurea	Green and Golden Bell Frog	Frog	E	V	Moderate
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Mammal	V	-	Moderate to High
Mormopterus norfolkensis	Eastern Freetail-bat	Mammal	V	-	Moderate to High
Myotis adversus	Large-footed Myotis	Mammal	V	-	Moderate to High
Ninox strenua	Powerful Owl	Bird	V	-	Moderate to High
Pseudophryne australis	Red-crowned Toadlet	Frog	V	-	Moderate to High
Pteropus poliocephalus	Grey-headed Flying-fox	Mammal	V	V	High - recorded
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Mammal	V	-	Moderate
Scoteanax rueppellii	Greater Broad-nosed Bat	Mammal	V	-	Moderate to High
V = Vulnerable, E = Endangered, - = Not listed					

The threatened fauna species listed in Table 16 above are discussed in further detail in Section 5.2.

4.5.6 Feral animals and over-abundant native species

Introduced feral and domestic predatory mammal species such as the European Red Fox (*Vulpes vulpes*), Domestic Cat (*Felis catus*) and Black Rat (*Rattus rattus*) compete with and prey upon native fauna and may have lead to the local depletion or extinction of small to medium-sized terrestrial mammals, ground-foraging birds and reptile species.

Other introduced species such as the European Rabbit (*Oryctolagus cuniculus*) may damage plants and fauna habitat through their feeding and digging activities. A number of introduced birds such as the Red-whiskered Bulbul (*Pycnonotus jocosus*), Spotted Turtle Dove (*Streptopelia chinensis*) and Common Myna (*Acridotheres tristis*) spread the seeds of environmental weeds.

Common Myna (*Acridotheres tristus*), Starling (*Turdus merula*) and European Honey Bee (*Apis mellifera*) compete with native species for nesting hollows.

Several native bird species are believed to have increased markedly in their abundance and have been implicated in the decline in some common native species due to competition and predation. Noisy Miner (*Manorina melanophrys*), Rainbow Lorikeet (*Trichoglossus haematodus*) and Red Wattlebird (*Anthochaera carunculata*) are aggressive nectar-feeding species which may exclude other nectar-feeding birds from flowering trees and shrubs. Pied Currawong (*Strepera graculina*) have been implicated in the decline of populations of small birds as a result of the predation, particularly of eggs and nestlings and also spread the seeds of environmental weeds. Parrots such as Sulphur-crested Cockatoo (*Cacatua galerita*) and Rainbow Lorikeet (*Trichoglossus haematodus*) compete with other birds for scarce nesting opportunities in tree hollows.

Many of these species have been able to establish and proliferate in bushland areas as a result of human-induced changes to the environment such as vegetation clearing and the cultivation of introduced plant species.

4.6 Aquatic Vegetation of the Study Area

4.6.1 Vegetation communities and condition

The Sandstone Riparian Scrub vegetation type occurs along all creeks within and adjacent to the M2 corridor with the most intact occurrences at Darling Mills Creek and Terrys Creek. Much of this vegetation is highly modified as a result of alteration to natural flow regimes, increased nutrients and especially weed invasion.

Native aquatic submerged and emergent vegetation is not abundant within the creeks of the study area. This is likely to be as a result of the chiefly rocky substrate found here, high water velocity during heavy rainfall and competition from introduced species.

The only commonly encountered native aquatic plants were Bull Rush (*Typha orientalis*) and knotweeds (*Persicaria* spp.) which were found in small patches along the creeks, chiefly in disturbed areas.

The detention basins within the M2 corridor contain an artificial assemblage of emergent native aquatic plants including *Eleocharis sphacelata*, Marsh Club-rush (*Bolboschoenus fluviatilis*) and Jointed Twig-rush (*Baumea articulata*) which were planted when the basins where constructed.

No assemblages of native aquatic plants were found that could be described as native vegetation communities.

4.6.2 Aquatic plant species of conservation significance

No aquatic plant species of conservation significance were recorded or considered likely to occur within the M2 corridor or surrounds.

4.6.3 Introduced flora

A variety of aquatic weeds (e.g. Water Milfoil (*Myriophyllum aquaticum*) and Watercress (*Rorippa nasturtium-aquaticum))* are found along the waterways of the study area. Of these, three species are listed as noxious weeds. Noxious aquatic species recorded include:

- Long-leaf willow primrose (*Ludwigia longifolia*).
- Ludwigia (*Ludwigia peruviana*).
- Sagittaria (*Sagittaria platyphylla*).

4.7 Aquatic Fauna Habitat

4.7.1 Waterways

Prior to residential development in surrounding areas, the creeks of the locality are likely to have supported a diverse community of insects, fish, frogs, birds and mammals. The creeks are degraded to varying degrees as a result of a number of factors including increased erosion due to the concentration of stormwater flows, weed invasion, polluted catchment runoff and the presence of exotic fish species. As a result of this condition, frogs, fish and aquatic invertebrates that are sensitive to these forms of disturbance are unlikely to persist in these waterways. Nonetheless, a variety of disturbance tolerant fauna species remain.

The present condition of the creeks of the M2 corridor varies from highly modified to near-natural. Classification of the creeks within the study area is listed below in Table 17.

Table 17 Classification of waterway crossings within the study area

Classification	Characteristics of waterway type	Creek/drainage line
Class 2 – Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.	Darling Mills Creek
Class 3 – Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (for example, fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Blue Gum Creek, Devlins Creek and Terry's Creek

Source: Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road?

The section of Darling Mills Creek crossed by the M2 corridor appears to be in relatively moderate condition, with low turbidity, little evidence of sedimentation and a low level of weed invasion. This area is likely to be inhabited by all of the native fish species listed in **Appendix D**. It is also likely to be inhabited by the introduced Plague Minnow (*Gambusia holbrooki*), though the population density of this species is likely to be relatively low due to the higher water quality and intact riparian vegetation which favour native fish species. The Eastern snake-necked Tortoise (*Chelodina longicollis*) is also likely to be found here.

Recent frog surveys conducted along this section of Darling Mills Creek detected the Green Stream Frog (*Litoria phyllochroa*), Peron's Tree Frog (*Litoria peronii*), Striped Marsh Frog (*Limnodynates peronii*) and Common Eastern Froglet (*Crinia signifera*).

The threatened Red-crowned Toadlet (*Pseudophryne australis*) usually lives close to non-perennial streams but previous ecological assessments conducted have recorded the Red-crowned Toadlet between Wicks Road and Epping Road, North Ryde, adjacent to the M2 corridor (Eco Logical Australia, 2009; Biosphere, 2007), and also at Nile Close, Marsfield. The North Ryde area is occupied by Transport Infrastructure Development Corporation (TIDC) and is currently proposed as a compound site for the M2 Upgrade.

The other creeks of the study area are more disturbed and are likely to contain a lower diversity and abundance of fish and frog species with the Plague Minnow becoming increasingly dominant in more disturbed areas.

Due to the low abundance of emergent aquatic vegetation along these creeks, little habitat for aquatic birds exists here.

A number of fish species likely to be found within the creeks of the study area are catadromous, meaning they spend their lives in freshwater and return to the ocean to spawn. Catadromous species likely to found in the creeks of the study area include:

- Shortfinned Eel (*Anguilla australis*).
- Longfinned Eel (*Anguilla reinhardtii*).
- Common Jollytail (*Galaxias maculatus*).

These species need to be able to move between freshwater and marine environments and thus may be susceptible to the obstruction of waterways. Other fish species which move into the smaller tributaries of river systems during the juvenile phase of their life cycles may also be susceptible. Fish species that have been previously recorded or considered likely to occur within the study area are listed below in Table 18.

Table 18 Fish species considered likely to occur within the study area

Scientific name	Common name	Conservation status (NSW)
Anguilla australis	Short-finned Eel	P
Anguilla reinhardtii	Long-finned Eel	P
Carassius auratus	Goldfish	U
Cyprinus carpio	Common carp	U
Gobiomorphus australis	Striped Gudgeon	-
Gobiomorphus coxii	Cox Gudgeon	-
Hypseleotris compressus	Empire Gudgeon	-
Hypseleotris galii	Firetail Gudgeon	-
Philypnodon grandiceps	Flathead Gudgeon	-
Galaxias maculatus	Common Jollytail	-
Gambusia affinis	Mosquito fish	U
Retropinna semoni	Australian Smelt	-
Anguilla australis	Short-finned Eel	P
Anguilla reinhardtii	Long-finned Eel	P

Note: P: Protected; U: Unprotected; –: Not classified.

Obstructions to fish movement within the M2 corridor exist where waterways pass beneath the Motorway via culverts. During low flow conditions, the streams of water flowing through the culverts are broad but very shallow and may limit the passage of some fish species. Higher water velocity and turbulence during rainfall events and a lack of pooled areas for fish to rest between bouts of swimming may also limit fish movement through the culverts. The extremely low light level within culverts may also create a nonphysical barrier for some fish species that may avoid dark areas during daylight hours (Fairfull and Witheridge, 2003).

Larger in stream structures (e.g. the retarding basin wall near Loyalty Road, North Rocks and weirs on the Lane Cove River) lower in the catchments of these creeks are also potential barriers to fish passage.

Prior to the 1980's the Platypus (*Ornithorhynchus anatinus*) was regularly observed within Darling Mills Creek in Bidjigal Reserve but has not been seen in recent times. The Water Rat (*Hydromys chrysogaster*) has been previously been recorded and may still occur in the waterways of the study area.

4.7.2 Constructed water bodies (detention basins)

When constructed, the detention basins of the M2 corridor were planted with emergent aquatic native plants with the intention of providing wildlife habitat. This was in addition to the primary purpose of slowing stormwater flows to minimise water pollution and impacts to the hydrology of adjacent waterways.

Emergent aquatic plants currently found growing in the detention basins include *Eleocharis sphacelata, Bolboschoenus fluviatilis*, and *Typha orientalis*. Four frog species were recorded within the detention basins; *Litoria peronii, L. fallax, Limnodynastes peronii* and *Crinia signifera*.

The detention basins vary somewhat in the characteristics of the aquatic vegetation found within them, some having an almost complete cover of emergent vegetation whilst others have larger areas of open water. The height and structure of the vegetation surrounding the basins also varies with some overshadowed by tree regrowth and others in relatively open sunlit conditions. Water levels within these basins are likely to increase after rainfall and decrease during extended dry periods though it is likely that water is continually present in most if not all of these basins.

Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface. Basins that are isolated from other water bodies are unlikely to be inhabited by fish though other aquatic fauna such as tortoises, snakes and wading birds may be found in these locations. It is unknown whether or not the

Amphibian Chytrid Fungus is found in any of these basins but it is possible that it may have been introduced there by colonising frogs.

4.7.3 Aquatic fauna species of conservation significance

No threatened or protected aquatic invertebrate or fish species have been recorded in the waterways of the M2 corridor. In their pre-development condition, the creeks of the study area may have provided potential habitat for the Australian Grayling (*Prototroctes maraena*) but this species has not been recorded in either of the river systems of the study area and is considered unlikely to exist there due to historical and ongoing pressures on these waterways.

4.7.4 Introduced aquatic animals

Introduced fish species recorded in the locality include Goldfish (*Carassius auratus*), Common Carp (*Cyprinus carpio*) and Plague Minnow (*Gambusia holbrooki*). Goldfish and Common Carp are not likely to be abundant in the small rocky streams of the study area however the Plague Minnow is found in all of the creeks, especially in disturbed areas. This species is listed as a Key Threatening Process due to its detrimental impacts upon tadpoles and frog eggs.

5.0 Impact Assessment

5.1 Impacts on Flora

5.1.1 Vegetation removal

Vegetation removal for the M2 Upgrade would be required for:

- Areas occupied by the widened M2 Motorway and fill batters.
- Construction access roads.
- Site compounds.
- Materials storage areas.
- New detention basins.
- Access to detention basins.

The nature of these impacts is summarised in Table 19.

Table 19 Direct impacts on vegetation

Element of proposal	Nature of impact
Widened M2 Motorway including fill batters	Permanent removal of vegetation would occur in areas occupied by the widened M2 Motorway. Permanent alteration of the soils of the batter slopes would occur.
Construction access roads and materials storage areas	Partial clearing of vegetation would occur in the areas identified for construction access roads. Construction access areas are largely located within areas dominated by native vegetation. Vegetation removal would be limited to that necessary for access. Mature trees and other fauna habitat features such as waterways and rock outcrops would be avoided where practicable. Access roads to compound sites and work locations associated with bridges over Darling Mills Creek, Devlins Creek and Terrys Creeks will be required. • Darling Mills Creek will be accessed via access tracks off the M2 Motorway. Entry to the site compound will be via eastbound lanes and exits will be via westbound lanes. • Devlins Creek will be accessed via Allerton Road (entry and exit) • Terrys Creek will be accessed via access tracks provided off Somerset Street (entry and exit) • Areas under the bridges will be utilised for access. Construction methodology will determined during the detailed design phase. Cleared areas would be rehabilitated post construction as described in Section 6.0.
Site compounds	Clearing of vegetation would occur in the areas identified for site compounds. The larger site compounds are located on filled areas. Vegetation in these areas is composed of trees and shrubs planted after the construction of the M2 Motorway with the ground layer consisting almost entirely of introduced species. Cleared areas would be rehabilitated post construction as described in Section 6.0.
New detention basins including access roads	Permanent removal of vegetation in areas occupied by the new detention basins and access roads. Detention basins would be planted with emergent native aquatic plant species.
Access to existing detention basins	Permanent removal of vegetation for permanent access roads to access new and existing detention basins. Works will involve permanent removal of vegetation, much of which is weedy regrowth from the original construction of the basins.

The amount of vegetation (native and exotic) estimated to be cleared is approximately 21 ha in total. A conservative estimate of the amount of vegetation considered to be in good condition within the study area is approximately 10 ha. These areas are characterised by having a relative intact understorey, shrub and canopy layer and are consistent with the floristic composition of the vegetation community as defined by the relevant native vegetation classification for each community.

Approximately 11 ha of this total are considered to be in poor condition as these areas are highly modified and characterised by high levels of weed invasion. Although dominated by exotic species, these areas are still considered to be part of the vegetation communities as identified in Table 20.

Table 20 shows the breakdown of clearing required in each vegetation community (as described by the predictive vegetation mapping datasets) within the M2 corridor. The local occurrence of the vegetation communities is defined as the ecological community that occurs within and adjacent to the study area.

Table 20 Vegetation clearing within the M2 corridor

Vegetation Community	Approximate local occurrence (ha)	Approximate amount of vegetation removal (ha)	Approximate amount of disturbed /exotic vegetation (ha)
Coastal Sandstone Ridgetop Woodland	25.2	0.4	0.16
Hinterland Sandstone Gully Forest	379.6	17.5	9.3
Sydney Hinterland Transition Woodland	24.4	0.1	0.08
Sandstone Riparian Scrub	64.5	3	1.3
Total		21	10.84

Potential impacts to threatened flora species considered to have a moderate to high likelihood of occurrence are summarised below.

Acacia bynoeana

Acacia bynoeana occurs in heath or dry sclerophyll forest on sandy soils and seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leafed Apple. The total population is estimated to be only a few hundred plants. The closest records of the species to the M2 corridor are within 2 km in Gordon and near the northern boundary of Bidjigal Reserve. No individuals of this species were recorded within the M2 corridor during recent flora surveys.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Acacia bynoeana*. As the potential habitat here is isolated from habitat containing known populations in the region as a result of urban development it is considered unlikely that any population here would be considered a key source population either for breeding or dispersal.

Callistemon linearifolius

Callistemon linearifolius has been recorded within the M2 corridor at Marsfield (DECCW, 2001). The species was not detected during the flora survey of the M2 corridor. An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Callistemon linearifolius* and with the implementation of the mitigation measures provided in section 5 (such as pre-clearance surveys prior to construction), potential impacts to this species will be minimised.

Darwinia biflora

There are 20 populations of *Darwinia biflora* within the Sydney Region that are not currently covered by the reserve system and have been identified as important and suitable to be targeted for conservation. The bushland of the M2 corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove National Park) are not included in these lists of important populations.

The species was not recorded during flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a large population exists here.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Darwinia biflora* as it is considered unlikely that a large population exists here.

Epacris purpurascens var.purpurascens

Epacris purpurascens var. *purpurascens* habitats which remain (particularly on ridgetops) are under increasing threat of clearance or habitat modification (DECCW, 2009).

A conservative estimate of potential habitat for *Epacris purpurascens* var. *purpurascens* within the M2 corridor is approximately 30 ha. Approximately 20 individuals of this species (observed in flora plots during flora surveys) are likely to be removed (refer to Figure 4). As these individuals of the species are located in translocated soils and earth mounds within the M2 corridor, further regeneration of the species from soils translocated during the proposed project is considered likely.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. Based on the above considerations and assessment conducted the M2 Upgrade is unlikely to have a significant impact on a local population of *Epacris purpurascens* var. *purpurascens.*

Persoonia hirsuta

Persoonia hirsuta was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, the closest recent (post 1980) record of the species is approximately 5 km from the M2 corridor and the species has not been detected within the adjacent bushland reserves.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The proposed works are unlikely to have a significant impact on this species as a potentially important population is not considered likely to exist within the M2 corridor.

Pimelea curviflora var. curviflora

Pimelea curviflora var. *curviflora* was recorded during the EIS for the western section of the M2 Motorway (Mount King 1992) however the specific location and the population size of this species were not reported. It is found in two fairly small populations in Lane Cove National Park, North Ryde and a few plants were recorded in the Pages Creek area. The Field of Mars Reserve population was estimated to be greater than 300 plants. The species is known to also occur at Epping Oval (DECCW, 2001).

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Pimelea curviflora* var. *curviflora.*

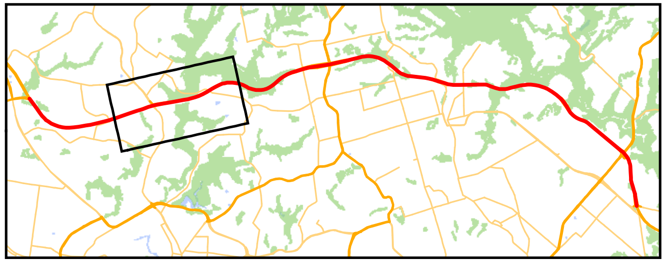
Tetratheca glandulosa

Tetratheca glandulosa is associated with areas of shale-sandstone transition habitat. The vegetation varies from heaths and scrub to woodlands/open woodlands, and open forest. The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the development footprint due to the level of disturbance occurring in these areas.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Tetratheca glandulosa.*

Figure 4 – Approximate locations of *Epacris purpurascens* var. *purpurascens* found within the study area

Lease boundary
Proposed Design
Epacris purpurascens var. *purpurascens*



Source: RTA (2009)

5.1.2 Ecological communities

The project is not considered to have any impact on the EPBC Act and TSC Act listed threatened ecological communities. Sydney Turpentine–Ironbark Forest is listed as a CEEC under the TSC Act and the EPBC Act. Site surveys conducted reveal that vegetation mapped as Sydney Turpentine-Ironbark Forest is not consistent with either the EPBC Act or TSC Act definitions of this community. This vegetation is consistent with the floristic composition of the larger patches of adjacent Hinterland Sandstone Gully Forest vegetation community.

No other EECs are considered in the impact assessment.

5.1.3 Indirect impacts

The Blue Gum High Forest community is listed as a CEEC under the TSC Act and the EPBC Act. The extent and condition of this community has been verified through on ground inspection and the present distribution within the M2 corridor is restricted to a narrow band between the M2 Motorway and Pennant Hills Golf Course to the north. This area is approximately 1.36 hectares in area and in moderate to poor condition.

The design option for the proposed widening of the M2 Motorway was specifically chosen to avoid vegetation clearing or modification to this ecological community, however indirect impacts are possible.

The earthworks required for the construction of the M2 Upgrade have the potential to spread weed seeds between locations along the length of the M2 corridor in soil adhered to vehicles and construction equipment and on the clothing of construction workers. Soil disturbance as a result of earthworks activities may also create a favourable environment for the proliferation of weed species already present.

Shading and the reduction in soil moisture due to the interception of rainfall by overbridges may result in alteration to or loss of native vegetation underneath these structures.

An assessment of significance for the potential impact on Blue Gum High Forest has been undertaken and is presented in **Appendix F**.

5.1.4 Threatening processes

The Key Threatening Processes (KTPs) listed under the TSC Act that are known or considered likely to affect the biodiversity of the study area and the interaction of the proposed works with these processes is summarised in Table 21.

Table 21 KTPs and potential impacts on flora and fauna within the M2 corridor

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands (TSC)	The flow regime of Darling Mills Creek is altered due to the presence of the flood retarding basin upstream of the study area. The presence of impervious surfaces such as roads within the catchments of the study area has resulted in alteration of the flow regime of these creeks. Altered moisture levels in the soils of riparian areas, erosion and sediment deposition affect the health of native vegetation and may promote weed invasion. The alteration to riparian habitat, increased turbidity and barriers to fish passage affect aquatic and terrestrial fauna species.	The increased road surface as a result of the works could further alter the natural flow regime of the creeks of the study area however the detention basin works proposed are being designed with capacity for the additional stormwater from the Motorway. The flow patterns within the waterways may be altered by the construction of piers in or adjacent to the waterway. It may be necessary to build one or two piers in or adjacent to Darling Mills Creek or its tributary (chainage 4750) and a tributary of Devlins Creek (chainage 9770).

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
	The vegetation underneath existing bridge structures is degraded due to previous earthworks, the impacts of shading and the interception of rainfall by the roadway overhead. Around existing abutments, the soil is loose and dry. A lack of suitable soil cover post-construction and low water availability has resulted in a lack of vegetation cover.	The potential impact of the piers includes localised increases in flow velocities around the piers however these are not considered significant for flood flows (see Surface Water Assessment, AECOM 2010). Construction of additional piers may also result in localised changes to flow patterns and localised scour. Due to the sandy nature of soil under bridges, the construction of piers may result in increased erosion and sedimentation during the construction phase however erosion control plans will be implemented and these areas will be remediated (revegetated) or stabilised post-construction. The lack of vegetation cover under bridges is likely to limit the use of these areas as movement corridors by fauna species which require cover from predators or moist conditions (e.g. frogs).
Bushrock Removal (TSC)	Rock outcropping exists in within the sandstone valleys and ridgetops of the study area. Bushrock removal can be detrimental to the habitat of some fauna species, particularly reptiles and frogs (e.g. Red-crowned Toadlet (*Pseudophryne australis*)).	Some areas of bushrock would be removed during construction. The area of forest with abundant rock outcropping that would be removed is approximately 0.5 ha.
Clearing of native vegetation (TSC) Land clearance (EPBC)	Much of the original vegetation of the study area has been cleared for residential development and road construction. This has also resulted in fragmentation of the remaining vegetation. Clearing reduces the habitat available to fauna species, affects ecosystem function through the loss of pollinators and seed dispersal vectors in isolated remnants and creates opportunities for weed invasion and feral animals.	The proposal would result in additional vegetation removal and disturbance as described in section 5.1.1. As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased.
Competition and grazing by the feral European rabbit (TSC) Competition and land degradation by rabbits (EPBC)	The feral European rabbit have been recorded within the study area but do not appear to be present in large numbers at present or to have had significant impact on vegetation. Grazing by feral rabbits can inhibit seedling recruitment thereby degrading native vegetation and fauna habitat.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that rabbits would be likely to increase in abundance or in their impact on native species.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Competition from feral honeybees (TSC)	Feral honeybees are likely to form hives in hollow trees within the study area. Competition from feral honeybees reduces the availability of nesting and roosting resources for hollow-dependent fauna such as species of owls, parrots, possums and microbats. Feral honeybees also compete with native fauna for nectar and pollen resources.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral honeybees would be likely to increase in abundance or in their impact on native species. Any nest boxes installed for native fauna may become inhabited by feral honeybees. Regular monitoring of nest boxes should be conducted to ensure that any bees that infest the boxes are removed.
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (TSC) Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC)	Chytridiomycosis caused by Amphibian Chytrid Fungus has been implicated in severe population declines and species extinctions of frogs in the past 20 years (DEH 2006). Chytridiomycosis is a threat to populations of threatened frog species such as the Green and Golden Bell Frog *Litoria aurea*. Amphibian chytrid fungus *Batrachochytrium dendrobatidis* is widespread in the Sydney region and it is considered likely to occur in the waterways of the M2 corridor. It is also possible that the fungus may have been introduced to some or all of the detention basins of the M2 corridor by frog species that inhabit both still and flowing water bodies.	With the use of equipment in wet environments in several locations within the M2 Corridor, there is a risk that amphibian chytrid fungus could be spread in wet mud. With the implementation of the proposed mitigation measures, this risk of spreading this disease to uninfected water bodies is considered to be low.
Infection of native plants by *Phytophthora cinnamomi* (TSC)	The pathogen (*Phytophthora cinnamomi*) appears to be widespread in coastal forests. The pathogen has been recorded in the nearby Lane Cove National Park and Garigal National Park (DECCW 2008). The presence or absence of this pathogen within the study area is unknown. This pathogen can result in the loss of susceptible plant species from affected areas, causing an alteration to vegetation composition and structure thereby altering habitat characteristics for fauna species.	The proposed works have some potential to introduce this pathogen in soil or water on equipment and footwear and in soils and plant material brought into the corridor during the works. Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens. The importation of soil and mulch into bushland areas would be minimized through the use of in situ materials wherever feasible.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Invasion and establishment of exotic vines and scramblers (TSC)	Several species of exotic vines and scramblers are found in the M2 corridor, chiefly along the creeks and in moist environments. Affected vegetation has a decreased ability to regenerate and is of lower value to fauna due to reductions in vegetation structural complexity and food resources.	Some of the areas affected by the proposal (chiefly areas near waterways) are currently infested with exotic vines and scramblers. Earthworks have the potential to spread these species. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of exotic vines and scramblers is not likely to be increased significantly.
Invasion, establishment and spread of *Lantana camara* (TSC)	*Lantana camara* (Lantana) is abundant in several locations within the M2 corridor where vegetation has been disturbed by earthworks. Affected vegetation is reduced in its ability to regenerate and has lower value to fauna due to reductions in vegetation structural complexity and food resources.	Some of the areas affected by the proposal are currently infested with Lantana. Earthworks have the potential to spread this species and to create opportunities for existing infestations to expand. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of Lantana is not likely to be increased significantly.
Loss of Hollow-bearing Trees - key threatening process (TSC)	Hollow-dependent fauna such as species of owls, parrots, possums and microbats are known or considered likely to occupy the M2 corridor. The density of mature, potentially hollow-bearing, trees within the M2 corridor is lower than would be expected to occur in undisturbed forest. Previous land use activities such as timber-getting and forestry (e.g. in the former Darling Mills State Forest) and clearing for infrastructure and residential development are likely to have reduced the local abundance of tree hollows.	The proposed works would require the permanent removal of approximately 7 ha of eucalypt forest and woodland. A further 3 ha would need to be removed for access and compound sites though this area would be rehabilitated post-construction and mature trees would be avoided where practicable. No tree hollows of sufficient size to provide nesting opportunities for larger species, such as the Powerful Owl, were observed within the areas potentially affected by clearing activities. Most of the trees removed are immature or semi-mature and are likely to contain chiefly small to medium-sized hollows that are potential habitat for smaller species of birds and mammals. These trees also have the potential to develop hollows as they mature, providing opportunities for populations of hollow-dependent fauna to recover. The loss of hollow-bearing trees would be offset by the proposed installation of nest boxes of a variety of designs.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Predation by feral cats (TSC) Predation by feral cats (EPBC)	Predation by feral and domestic cats, in association with predation by the feral cats and other factors, is likely to have caused the local extinction of a number of native ground-dwelling mammals, birds and reptiles.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral cats would be likely to increase in abundance or in their impact on native species.
Predation by the European Red Fox (TSC) Predation by European red fox (EPBC)	Predation by the European Red Fox, in association with predation by feral and domestic cats and other factors, is likely to have caused the local extinction of a number of native ground-dwelling mammals, birds and reptiles.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that the European Red Fox would be likely to increase in abundance or in its impact on native species.
Predation by the Plague Minnow (*Gambusia holbrooki*) (TSC)	The Plague Minnow is a small introduced fish that preys on and competes with native fish, aquatic invertebrates and the tadpoles of frogs. This species has been implicated in the decline of populations of the Green and Golden Bell Frog (*Litoria aurea)*. The Plague Minnow is present in all of the creeks of the study area.	With the use of equipment in wet environments in several locations within the M2 corridor, there is a risk that juvenile Plague Minnow could be spread in wet mud. With the implementation of the proposed mitigation measures, the spread of this species is however unlikely. The proposed works are not considered likely to modify the waterways of the study area in such a way as to encourage the proliferation of the Plague Minnow.

5.2 Impacts on Fauna

Measures would be implemented to minimise the risk of harm to native fauna during construction activities. Detailed consideration of the impacts of the project on threatened species is provided in the Assessments of Significance in **Appendix F**. Species assessed include:

- Green and Golden Bell Frog
- Red-crowned Toadlet
- Swift Parrot
- Regent Honeyeater
- Gang-gang Cockatoo
- Glossy Black Cockatoo
- Powerful Owl
- Grey-headed Flying-Fox
- Eastern Freetail-bat
- Yellow-bellied Sheathtail-bat
- Greater Broad-nosed Bat
- Eastern Bentwing-bat
- Large-footed Myotis
- Large-eared Pied Bat.

Migratory species assessed include:

- Black-faced Monarch *Monarcha melanopsis*
- Rainbow Bee-eater *Merops ornatus*

- Rufous Fantail *Rhipidura rufifrons*
- Satin Flycatcher *Myiagra cyanoleuca*
- White-throated Needletail *Hirundapus caudacutus*

The conclusions of the assessments are that a significant adverse impact on the above species is unlikely.

Green and Golden Bell Frog

While some of this area is considered to be potential foraging habitat for this species, most of this area is considered to be marginal or unsuitable as habitat due to a lack of suitable vegetation cover, dry surface conditions and distance from potential breeding habitat. Modification to these areas as a result of clearing may result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term.

Assessments of significance concluded that a significant impact on the Green and Golden Bell Frog is unlikely.

Red-crowned Toadlet

Although the Red-crowned Toadlet was not recorded during current surveys within the M2 corridor, this species has been recorded between Wicks Road and Epping Road, North Ryde, adjacent to the M2 corridor (Eco Logical Australia, 2009 and Biosphere, 2007), and also at Nile Close, Marsfield. The North Ryde area is occupied by Transport Infrastructure Development Corporation (TIDC) and is currently proposed as a compound site for the M2 Upgrade project.

Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat. Much of the widening works are not are not in close proximity to breeding areas of the Red-crowned Toadlet and are considered to be at best, marginal as habitat for the species.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on this species is unlikely.

Swift Parrot

Favoured feed trees of the Swift Parrot are wintering flowering eucalypts. Little of this vegetation remains however revegetation along the edges of the M2 Motorway has involved in the planting of some individuals of these species. This revegetation consists of narrow bands of immature trees between the edge of the M2 Motorway and adjacent residential lands.

Given the lack of breeding habitat and the relatively small amount of marginal potential foraging habitat that would be affected, the M2 Upgrade project is not considered likely to significantly disrupt the breeding cycle of any subset of the population of the Swift Parrot.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Swift Parrot is unlikely.

Regent Honeyeater

The Regent Honeyeater generally inhabits dry, temperate woodlands and open forests of the inland slopes of south-eastern Australia (DECCW, 2009). There are only three known major breeding locations and two of these occur in NSW.

Breeding of the species has not been recorded in the Sydney area and breeding of the species in the vicinity of the M2 corridor is considered highly unlikely. A reduction in available foraging habitat in the short-term would occur but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation would be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Regent Honeyeater is unlikely.

Gang-Gang Cockatoo

The Gang-gang Cockatoo was recorded during the current study flying overhead in the vicinity of the Terry Creek overpass near Crimea Road on the border of Epping and Marsfield.

A population of Gang-gang Cockatoos persists in the Hornsby and Kur-ing-gai Local Government Areas and is largely believed to be confined to an area bounded by Thornleigh and Wahroonga in the north, Epping and North

Epping in the south, Beecroft and Cheltenham in the west and Turramurra/South Turramurra to the east (DECCW, 2009). The population encompasses, but is not restricted to, Pennant Hills Park and parts of Lane Cove National Park.

Given the proximity of the existing M2 Motorway to the vegetation that would be affected, it is considered unlikely that sites used for breeding by this species would be affected. Potential nesting hollows for the species are not known or considered likely to be abundant in the area affected by the proposed M2 Upgrade. No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed.

Assessments of significance (provided in **Appendix F**) concluded the proposed M2 Upgrade is unlikely to have a significant adverse impact on the Gang-gang Cockatoo.

Glossy Black Cockatoo

This species depends on large hollow-bearing eucalypts for nest sites and feeds exclusively on the seeds of several species of She-oak (Casuarina and Allocasuarina species). No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed as a result of the M2 Upgrade project.

These birds are all highly mobile species with large home ranges and the small linear patch of vegetation removal that is proposed would not significantly increase habitat fragmentation for these species.

Due to their ability to fly, the bird species may forage within the vegetation along the M2 corridor but most are likely only as occasional visitors to these areas with their core habitat being within larger more intact areas of vegetation in the locality.

Assessments of significance (provided in **Appendix F**) concluded a significant impact on a local population of the Glossy Black Cockatoo is unlikely.

Powerful Owl

The Powerful Owl requires large tracts of forest or woodland habitat but can also occur in fragmented landscapes (DEC, 2006). This species is known to nest in large tree hollows (at least 0.5 m deep), in large eucalypts that are at least 150 years old (DECCW, 2009) and some of their prey also rely on tree hollows for refuge.

No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed. The majority of the trees to be removed are relatively small due to low nutrient and moisture levels, previous clearing for the existing M2 Motorway and the logging history of the area.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on this species is unlikely.

Grey-headed Flying Fox

The Grey-headed Flying-fox was recorded flying overhead in several locations during field surveys. Individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon.

Foraging habitat for this species is considered to be present throughout the study area wherever fleshy-fruited and nectar-producing trees are present and forages throughout the Sydney Metropolitan area. No camp sites are present within or in the bushland adjacent to the M2 corridor.

Modification and vegetation clearing as a result of the M2 Upgrade project would result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation would be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Grey-headed Flying-fox is unlikely.

Insectivorous (microchiropteran) bats

The study area does not contain any caves, or mines near or above water and is consequently unlikely to provide preferred roosting or maternity sites for many of the threatened microbat species listed above. Preferred habitat for threatened microbat species is likely to be found lower within moister valleys of the locality rather than the upper slope areas in which the M2 Motorway is chiefly located. Species such as the Eastern False Pipistrelle are not considered to occur within the study area as they prefer moist habitats in vegetation characterised with tree species over 20 metres (DECCW, 2009).

The core likely foraging habitat for threatened microbats in the locality is concentrated in the larger areas of more mature vegetation that would not be substantially affected by the proposed works. The habitat affected by the proposed works is of marginal quality due to previous clearing, weed invasion and traffic noise. Due to the lack of suitable roosting habitat, and disturbance, this area is considered to be of relatively low value as potential habitat for the threatened microbat species listed above when compared to larger areas of vegetation at greater distance from the M2 Motorway.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on insectivorous (microchiropteran) bats is unlikely.

Migratory Species

Migratory species are considered unlikely to rely on the affected areas as breeding, foraging or roosting habitat due to the level of disturbance adjacent to the M2 Motorway. Breeding habitat is more likely to be located in core bushland areas beyond the study area. Suitable foraging habitat is only considered to be marginal at best with preferred habitat more likely to be located in areas of less-disturbed habitat in the locality. Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on migratory species is unlikely.

5.2.1 Fauna habitat loss

The main direct impact on fauna is habitat removal. The works would cause a reduction in habitat available for native fauna species through the removal of native vegetation and habitat features such as rock outcrops and organic debris. The extent of habitat removal is likely to total approximately 21 hectares, of which approximately 10 ha is considered to be in relatively good condition (predominantly native). Of this total, 3 ha would be subsequently rehabilitated.

Vegetation removal (particularly native vegetation) has the potential to impact on fauna species through a reduction in the availability of feeding resources, shelter from environmental extremes, refuge from predators and breeding sites. Whilst removal of vegetation within the development footprint would be permanent, clearing for access and compound areas would be temporary as these areas would be rehabilitated post-construction.

No tree hollows of sufficient size to provide nesting opportunities for larger hollow-dependant species were observed within the areas potentially affected by clearing activities. Most of the trees removed are immature or semi-mature, but have the potential to develop hollows as they mature, providing opportunities for populations of hollow-dependent fauna to recover. The mitigation measures proposed include the installation of nest boxes to compensate for the loss of potential hollow-bearing trees.

5.2.2 Lighting

Following the upgrade, there will be additional lighting requirements at the new interchanges at Windsor Road, Christie Road and Herring Road only. Given that there is existing lighting along the Motorway and at these interchanges, the increase in lighting to fauna species will be negligible as a result of the M2 Upgrade.

Lighting during the construction period will be required for works carried out at night-time (ie pre-sunset and post-sunset), especially during the winter months. Lighting will be required at all compound sites however eight proposed compound sites may be operational 24 hours a day. These compounds are discussed in detail in the *M2 Motorway Upgrade Environmental Assessment Specialist Report Lighting Impact Assessment* (Heggies, 2009). It is assumed that the remaining compounds would be lit with localised security lighting during night time periods.

Light spill will occur at locations of the proposed compound sites. Potential impacts to fauna resulting from obtrusive light spill will be greatest adjacent to larger areas of bushland reserves, such as the proposed Terrys Creek Compound and the Darling Mills Creek Compound.

Nocturnal species are adapted to low light conditions to forage for food and could therefore be deterred from foraging areas as a result of excessive light spill. Nocturnal mammals and birds are also likely to be disturbed by artificial light at night-time as they are at an increased risk from predators.

The regular route of threatened bat species may also be affected as a result of light spill. The Grey-headed Flying-fox was recorded flying overhead in several locations and individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon. The study area does not contain any camp sites for the Grey-headed Flying-fox and although vegetation in parts of the M2 corridor may be suitable for roosting, the presence of the M2 Motorway and walking trails with existing noise and light disturbances is considered likely to dissuade the species from roosting in these areas.

Potential impacts may occur to threatened insectivorous bat species, however species such as the Large-footed Myotis (*Myotis adversus*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) are more likely to be found lower within the moister valleys of the locality rather than the upper slope areas in which the Motorway and compound areas are chiefly located. Therefore, roosting and breeding habit for these species is considered unlikely to be affected by the increase in lighting as a result of the proposed project. The potential impacts to threatened bat species as a result of obtrusive light spill are considered to be less likely during the winter months when foraging activities decline.

The increase in some species of insects attracted to light sources (e.g. moths) may be beneficial to some threatened insectivorous bat species that are high speed aerial foragers such as the Eastern Bentwing-Bat and Yellow-bellied Sheathtail-Bat.

Light mitigation will be addressed during the detail design stage to develop appropriate light spill management strategies, including measures such as correctly positioned and aimed floodlights and screening of compound areas for the control of construction vehicle headlamp impacts. Careful design and selection of luminaries is considered likely to minimise the impacts on fauna.

5.2.3 Habitat Fragmentation

Alteration to fauna movement (wildlife) corridors through the permanent removal of approximately 21 ha of eucalypt forest and woodland may occur as a result of the works, of which 10 ha is considered to be in relatively good condition . Of this 10 ha, 3 ha is required to be removed for access and compound sites. This 3 ha area would be rehabilitated post-construction and mature trees would be avoided where practicable. The vegetation types that occur in the 3 ha area comprise Hinterland Sandstone Gully Forest and Sandstone Riparian Scrub. These communities are not listed as an EEC under the EPBC Act or TSC Act. The main wildlife corridors within the M2 Corridor include the bushland and disturbed vegetation surrounding Blue Gum Creek, Devlins Creek, Darling Mills Creek and Terrys Creek.

Where bridge structures span Darling Mills Creek, Devlins Creek and Terrys Creek, the vegetation underneath forms the only habitat connection between bushland areas on opposite sides of the Motorway. These areas are considered to be of particular importance to fauna movement. The vegetation underneath these structures is somewhat degraded due to previous earthworks and the impacts of shading and interception of rainfall by the roadway overhead.

Closing the existing gap between the two bridge structures across Devlins Creek and widening to the south is the preferred option to minimise the potential impacts on the surrounding environment and avoid the need to construct two new culverts which would impact on the water quality of the Creek during construction.

Bridges and arch structures generally have the least impact on fish passage as they normally involve limited disturbance to the flow or the aquatic habitat of a waterway (Fairfull and Witheridge, 2003).

Possible impacts to fish passage movement include (Fairfull and Witheridge, 2003):

- large scale turbulence resulting from bridge piers
- changes to in-stream and bank vegetation affecting water shading
- habitat values
- water velocities and increased flood flow velocities
- limited light penetration under the bridge deck can create a non-physical barrier for some fish species that may avoid dark areas during daylight hours

The potential impact of the bridge piers may also result in localised changes to flow patterns and localised scour. Due to the sandy nature of soil under bridges, the construction of piers may result in increased erosion and sedimentation during the construction phase however erosion control plans will be implemented and these areas will be remediated (revegetated) or stabilised post-construction.

The proposed widening of the bridge structures over each of these creeks has the potential to result in further degradation of the riparian vegetation of these areas and hence limits their ability to act as movement corridors for terrestrial species due to shading and the reduction in soil moisture.

The extension of culverts may also affect the passage of fish and other aquatic fauna. The most common fish passage problems associated with culverts include: excessive flow velocities within the culvert, inadequate flow depth within the culvert and debris blockage of the culvert (Fairfull and Witheridge, 2003). As these culverts currently present a substantial constraint to fish movement, the extension of these barriers is unlikely to substantially alter the current situation. Design and construction considerations for bridges and arches have been included in the mitigation measures to avoid potential disturbance to fish passage during the construction phase.

With the implementation of the proposed habitat enhancement measures, such as the placement of woody debris, soil coverings and revegetation, the utility of these areas as wildlife corridors for land-based species is likely to be improved or maintained.

Degradation of fauna habitat as a result of weed invasion and proliferation is a potential impact of the works. Weed dominance may result in a reduction in plant species which are important as habitat for native wildlife. Weed thickets may harbour feral animals such as foxes and rabbits. With the implementation of the proposed weed management and vegetation rehabilitation measures the current weed situation is unlikely to be significantly exacerbated.

Impacts on water quality may occur as a result of the exposure of soils to erosion during construction and the flow of turbid water into local creeks.

5.2.4 Other Operational Impacts

Once constructed, there may be additional run-off from the upgraded motorway. As described in the Technical Paper 6, M2 Upgrade Environmental Assessment – Surface Water Assessment (AECOM, 2010), the existing water quality basins would be modified as required to account for any significant changes in contributing catchment area or to meet the target pollutant reduction criteria. Due to the constrained project corridor, and in an effort to minimise further disturbance of the established vegetation, wherever practical it is proposed to modify the inlet/outlet details of the existing basins to better utilise the storage volume already available by increasing the ponded (extended) depth.

There are not expected to be other significant additional impacts above and beyond the current motorway use.

6.0 Environmental Management

An Environmental Management Plan (EMP) will be developed which describes in detail the minimisation, mitigation and management measures which would be conducted during construction (CEMP) and operation (OEMP) of the works. The EMP would be developed in consultation with DECCW, I&INSW and other relevant stakeholders. Options for offsetting residual impacts on flora and fauna habitat are also proposed (Section 6.1).

The CEMP would include measures to **minimise removal of vegetation** in areas of construction throughout the extent and duration of the project, such as:

- Clearly marking and delineating the extents of required vegetation clearance in order to minimise the risk of over-clearing.
- Minimising clearing for construction compounds by retaining mature trees and other vegetation of conservation significance where feasible within compound sites.
- The demarcation of Blue Gum High Forest boundary to avoid potential indirect impacts to this CEEC.
- Prior to the commencement of construction, all specimens of *Epacris purpurascens* var. *purpurascens* within areas identified for temporary clearing would be marked by an ecologist. Wherever feasible, the temporary clearing extents would be slightly modified to avoid the need to remove individuals of this species. Pre-clearance surveys prior to construction will also be conducted by a suitably qualified ecologist to avoid the need to remove threatened flora species potentially occurring within the M2 corridor, as listed in Table 9.
- Potential hollow-bearing trees will be identified and marked, and targeted measures to minimise potential harm to fauna during clearing will be implemented.
- Stabilisation of the riparian zone against flow changes would be implemented as described in the Technical Paper 6, M2 Upgrade Environmental Assessment – Surface Water Assessment (AECOM, 2010). Riparian areas disturbed during the works would be reinstated and replanted as quickly as possible.

The CEMP would include measures to **minimise the indirect impacts on flora and fauna** as a result of vegetation removal in areas of construction throughout the extent and duration of the project, such as:

- All earth-working machinery will be received on-site free from excessive soil and vegetative matter to minimise the likelihood of introducing weed seeds and plant pathogens (e.g. Phytophthora root rot fungus) to project areas.
- Cleaning of equipment used for works within detention basins to minimise the likelihood of the transmission of any frog pathogens (e.g. Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)) will involve the use of a high pressure hose (or a suitable alternative method) to remove mud after use in a water body and allowing equipment to dry fully prior to use in the next water body.

Measures to **minimise the direct impacts on flora and fauna** would include:

- Prior to works which involve the clearing of vegetation and debris within detention basins or drainage lines, a suitable and targeted survey will be undertaken by an ecologist in order to allow for the detection of any Green and Golden Bell Frogs or Red-crowned Toadlets. If Green and Golden Bell Frogs or Red-crowned Toadlets are detected, no clearing works within these areas would commence until the threatened frog species response provisions in the EMP have been implemented.
- Weed control measures in known Red-crowned Toadlet occupation sites (TIDC site) should be avoided.
- Construction compound lighting will be directed towards the ground so that the angle between the beam and the vertical is kept as small as possible. Glare will be kept to a minimum by keeping the main beam angle less than 70^{o} wherever practicable.
- Non-translucent barriers should be positioned to shield sensitive locations located directly opposite access points to minimise disturbances to native fauna from vehicle headlights entering and exiting the site.
- Where feasible, site lighting should be directed away from sensitive locations such as potential foraging areas and movement corridors within the larger more intact areas of bushland such as Bidjigal Reserve, Lane Cove National Park and Pennant Hills Park. Wherever possible, trees will not be directly illuminated.
- Accessories such as light shields mounted at the front or back of the light source should be used to direct light to the intended area only and minimise excessive light spill.
- Where feasible, the mounting height of the lighting column will be lowered to reduce horizontal light spill.

- The use of high power lamps used for security at compound sites should be avoided. Accessories such as glass protectors (glass glazing) are preferred due to their UV filtration characteristics will be considered during the design of light installations.

Measures to **mitigate the loss of vegetation** as a result of the project would include:

- Revegetation of disturbed areas as a result of construction activities, adjacent to the construction areas and bordering natural bushland will be conducted by suitably qualified and experienced persons using local provenance plant species representative of the relevant vegetation communities. This strategy would be documented in a Landscape Plan or bushland rehabilitation section of the CEMP.
- In areas bordering adjacent urban development, revegetation works would be undertaken in accordance with a Landscape Plan.
- Where available, seeds will be collected from local understorey and ground layer vegetation prior to clearing and from felled trees and branches following clearing where feasible for use in revegetation.
- A revegetation strategy would be developed that takes into account the availability of light, moisture and the most suitable plant species.
- Re-use of felled native trees in habitat augmentation within revegetated areas and mulching of other native vegetation cleared for use in soil stabilisation and vegetation rehabilitation.
- Weed management as required in areas affected by construction throughout the extent and duration of the project (in a staged manner and for a minimum period of two years following construction works).
- Re-use of the soil seedbank where practicable during revegetation works either within or outside the M2 corridor.

The CEMP would include measures to **minimise the impacts on aquatic environments** such as:

- All potential chemical pollutants (e.g. fuels, oils, lubricants, paints, etc.) will be stored in appropriate containers within bunded areas within construction compounds to minimise the risk of pollution of aquatic environments.
- Works around waterways will be managed to retain bank stability and prevent erosion.
- Water quality would be protected through the implementation of suitable sediment control measures in relevant work areas.
- Where practicable and feasible, bridge piers or foundations located within the main waterway channel would be avoided.
- Where practical, culverts would be aligned with the downstream channel to minimise bank erosion.
- Works would be sited and carried out to avoid the clearing of riparian vegetation where practicable.
- Riparian areas disturbed during the works would be reinstated and replanted as quickly as possible with the aim of providing a net long term biodiversity benefit.

6.1 Biodiversity Offset Strategy

Although the ecological assessment concludes that the project would not have a significant impact on threatened flora and fauna species or ecological communities, there would be some residual impacts after mitigation measures have been applied. In order to offset the residual impacts to native fauna habitat and the residual impacts to *Epacris purpurascens var. purpurascens,* a biodiversity offset strategy would be developed in consultation with DECCW.

The residual impacts to 7ha of native forest and woodland habitat that is proposed to be cleared permanently would be offset. The area of habitat to be offset includes the following vegetation types:

1) Coastal Sandstone Ridgetop Woodland;
2) Hinterland Sandstone Gully Forest;
3) Sydney Hinterland Transition Woodland; and
4) Sandstone Riparian Scrub.

The management measures that will be compiled for offsetting impacts to these communities will focus on conservation and enhancement of habitat in the M2 Motorway corridor that will not be impacted by the project.

The biodiversity offset strategy would outline the process for identifying priority areas for habitat enhancement within the M2 Motorway corridor and management measures that would be undertaken to enhance the value of habitat. The areas to be included in the biodiversity offset strategy and the management measures would be determined in consultation with DECCW.

In terms of identifying priority areas for habitat enhancement, it is anticipated that priority would be given to habitat within the M2 Motorway corridor that adjoins major waterway crossings, is along the edges of high quality native vegetation in which weed invasion is apparent and the edges of waterways. In addition, factors such as the condition of habitat, its connectivity and proximity to remnant native vegetation would also be considered when identifying areas for enhancement.

Management measures to enhance native fauna habitat within the M2 Motorway corridor would include bush regeneration throughout the M2 Motorway corridor, installation of nest boxes for birds and bats, and the use of boulders and felled timber to enhance the structural complexity of fauna habitat. The following management actions could also be considered:

- Control of weeds
- Management of fire for conservation
- Management of human disturbance
- Retention of regrowth and remnant native vegetation
- Replanting or supplementary planting where natural regeneration will not be sufficient
- Retention of dead timber
- Control of erosion
- Retention of rocks

The following measures warrant further consideration for enhancement of habitat areas and rehabilitation of the degraded nature of existing vegetation communities:

- A system of gravity fed perforated stormwater pipes to be installed underneath bridges that will result in rainfall being distributed across all areas underneath bridges structures, thereby providing adequate moisture for plant growth; and
- The underside and inner surface of bridge structures over Terrys Creek and Darling Mills Creek will be constructed with a rough finish that would enable the bird species, Fairy Martins (*Hirundo ariel*), to create their bottle-shaped mud nests. A wide variety of native fauna species (including the threatened Large-eared Pied Bat (*Chalinolobus picatus*) have been recorded using the abandoned nests of Fairy Martins attached to artificial structures such as bridges and culverts.
- There is an opportunity to improve habitat connectivity between neighbouring areas through intensive treatment of environmental weeds within and immediately adjacent to the Blue Gum High Forest adjacent to Pennant Hills Golf Course.
- The Landscape Plan should seek opportunities to implement additional habitat creation (such as breeding areas) for threatened species within open space areas adjacent to the M2 Motorway.

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Appendix A

Director-General's Requirements

NSW GOVERNMENT
Department of Planning

COPY

Office of the Director General

Y09/988

Mr Michael Bushby
A/Chief Executive
Roads and Traffic Authority
Locked Bag 928
NORTH SYDNEY NSW 2059

Dear Mr Bushby

Director General's Requirements for the Environmental Assessment of Proposed M2 Upgrade

The Department has received your application for the proposed M2 Upgrade project (Application Number: 09-0049).

I have attached a copy of the Director-General's requirements (DGRs) for the environmental assessment of the Project. These requirements have been prepared based on consultation with the relevant government agencies.

It should be noted that the Director-General's requirements have been prepared based on the information provided to date. Under section 75F(3) of the Act, the Director-General may alter or supplement these requirements if necessary and in light of any additional information that may be provided prior to the proponent seeking approval for the Project.

I would appreciate it if you could contact the Department at least two weeks before you propose to submit the Environmental Assessment for the Project to determine:

- the fees applicable to the application;
- relevant land owner notification requirements;
- consultation and public exhibition arrangements that will apply;
- options available in publishing the Environmental Assessment via the Internet; and
- number and format (hard-copy or CD-ROM) of the Environmental Assessment that will be required.

Prior to exhibiting the Environmental Assessment, the Department will review the document to determine if it adequately addresses the DGRs. The Department may consult with other relevant government agencies in making this decision. If the Director-General considers that the Environmental Assessment does not adequately address the DGRs, the Director-General may require the proponent to revise the Environmental Assessment to address the matters notified to the proponent. Following this review period the Environmental Assessment will be made publicly available for a minimum period of 30 days.

Bridge St Office 23-33 Bridge St Sydney NSW 2000 GPO Box 39 Sydney NSW 2001 DX 22 Sydney
Telephone: (02) 9228 6111 Facsimile: (02) 9228 6191 Website planning.nsw.gov.au

If your proposal includes any actions that could have a significant impact on matters of National Environmental Significance, it will require an additional approval under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). This approval would be in addition to any approvals required under NSW legislation and it is your responsibility to contact the Department of Environment, Heritage, Water and the Arts to determine if an approval under the EPBC Act is required for your proposal (6274 1111 or http://www.environment.gov.au).

Please note that the Commonwealth Government has accredited the NSW environmental assessment process for assessing impacts on matters of National Environmental Significance. As a result, if it is determined that an approval is required under the EPBC Act, please contact the Department immediately as supplementary Director-General's requirements will need to be issued.

If you have any enquiries about these requirements, please contact Diane Fajmon, Senior Environmental Planning Officer, Major Infrastructure Assessments on 02 9228 6370 or via email (diane.fajmon@planning.nsw.gov.au).

Yours sincerely

SHaddad

Sam Haddad
Director General
6/4/2009.

Bridge St Office 23-33 Bridge St Sydney NSW 2000 GPO Box 39 Sydney NSW 2001 DX 22 Sydney
Telephone: (02) 9228 6111 Facsimile: (02) 9228 6191 Website planning.nsw.gov.au

Director-General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number	09_0049
Project	Upgrade of the M2 Motorway between Windsor Road, Baulkham Hills, and Dehli Road, North Ryde
Location	In and around the existing M2 Motorway corridor, in the Ryde, Hornsby and Baulkham Hills local government areas
Proponent	NSW Roads and Traffic Authority
Date issued	6 April 2009
Expiry date	6 April 2011
General requirements	The Environmental Assessment must include the following: 1. an **executive summary**. 2. a **description** of the project including: ▪ route alignment of the project, including an indication of areas for widened or new carriageways, on/ off ramps, breakdown lanes and associated and ancillary facilities; ▪ key design elements of the project, including carriageway, tunnel and bridging works; ▪ ancillary operational components, including upgrades to the Motorway's Intelligent Transport Systems, upgrades to toll facilities, park and ride facilities, cycle facilities, signals and connections with the surrounding road network; and ▪ construction facilities, including construction compounds, lay-down areas and spoil stockpiling/ management areas. 3. an **assessment of the key issues**, with the following aspects addressed for each key issue (where relevant): ▪ description of the existing environment; ▪ assessment of the potential impacts (direct and indirect) of the project for both construction and operation stages, in accordance with relevant policies and guidelines; ▪ identification of how relevant planning, land use and development matters, (including relevant strategic and statutory matters), have been considered in the impact assessment and/ or in developing management/ mitigation measures; and ▪ description of measures to be implemented to avoid, minimise, manage, mitigate, offset and/or monitor the impacts of the project; and ▪ any residual impacts. 4. a **draft Statement of Commitments** incorporating or otherwise capturing measures to avoid, minimise, manage, mitigate, offset and/or monitor impacts identified in the impact assessment sections of the Environmental Assessment. The Statement of Commitments must clearly articulate the desired environmental outcome of the commitment. The Statement of Commitments must be achievable, measurable (with respect to compliance), and time-specific, where relevant. 5. **certification** by the author of the Environmental Assessment that the information contained in the Assessment is neither false nor misleading.
Key issues	▪ **Strategic Justification –** the Environmental Assessment must outline the strategic need and justification for the project, taking into account existing and proposed transport infrastructure and services within the adjoining subregions, and as relevant the outcomes and objectives of the *State Plan* (2006), *City of Cities: A Plan for Sydney's Future* (2005) (the "Metropolitan Strategy") and the accompanying draft subregional strategies, and the NSW Government's *Urban Transport Statement* (November, 2006). ▪ **Project Justification** – the Environmental Assessment must justify the project and its components taking into consideration the objects of the *Environmental Planning and Assessment Act 1979.* This justification must include an assessment of alternatives considered, demonstrate that the project will enhance the use of public transport and that the project will not unduly induce traffic and exacerbate congestion

	in the medium to longer term within the adjoining subregions. The assessment must specifically address how the proposed park and ride facility will enhance public transport patronage, including a cost benefit analysis.
	▪ **Operational Traffic and Transport Implications** – 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).
	▪ **Operational Noise Impacts** – the Environmental Assessment must include an assessment of the noise impacts of the project during operation, consistent with the *Environmental Criteria for Road Traffic Noise* (EPA, 1999). The assessment must include specific consideration of impacts to sensitive receivers (schools, hospitals, aged care facilities), as relevant.
	▪ **Impacts on Ecology** – the Environmental Assessment must include an assessment of the potential ecological impacts of the project, with specific reference to the need for vegetation clearing, habitat and connectivity implications, edge effects, and stormwater and watercourse implications. The Environmental Assessment must make specific reference to impacts on threatened species, populations and communities, including the Sydney Turpentine-Ironbark Forest and Blue Gum High Forest Endangered Ecological Communities, and the native fauna that may utilise those communities. The Environmental Assessment shall demonstrate that the extent of vegetation clearing has been minimised through the design of the project, and shall include details of any off-set measures that may be proposed.
	▪ **Urban Design and Landscaping Issues –** the Environmental Assessment must include consideration of the urban design and landscape implications of the project, including identification of urban design and landscaping objectives to enhance the current road corridor and to demonstrate how the proposed urban design elements of the project would be consistent with the existing (and desired) character of the area.
	▪ **Aboriginal Cultural Heritage** – the Environmental Assessment must include an assessment of the potential Aboriginal cultural heritage impacts of the project, including an assessment of objects, places of significance, natural and landscape values of the corridor and surrounding area, taking into account the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, July 2005).
	▪ **General Construction Impacts** – the Environmental Assessment must consider the potential impacts associated with the construction of the project, and present a management framework for construction works to ensure that impacts are mitigated, monitored and managed. The Environmental Assessment must include consideration of, and a management framework for:
	  ▪ construction noise and vibration, including a considered approach to scheduling construction works having regard to the nature of construction activities (including transport, blasting and tonal or impulsive noise-generating works, as relevant), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially-affected human receivers and structures, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management). The Environmental Assessment must also present a strategy for monitoring and mitigating construction noise and vibration, with a particular focus placed on those activities identified as having the greatest potential for adverse noise or vibration impacts, and a broader, more generic approach developed for lower-risk activities;
	  ▪ 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; and ▪ erosion, sedimentation, water quality and riparian management issues for works in and around watercourse crossings. The Environmental Assessment must specifically consider how construction of the project will be undertaken and managed to minimise the potential for impacts on riparian vegetation, fish passage and water quality in watercourses for the duration of construction works. ▪ **Environmental Risk Analysis –** notwithstanding the above key assessment requirements, the Environmental Assessment must include an environmental risk analysis to identify potential environmental impacts associated with the project (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the Environmental Assessment.
Consultation	The Environmental Assessment must reflect an appropriate and justified level of consultation with relevant stakeholders during the preparation of the Environmental Assessment, including: ▪ the Department of Environment and Climate Change; ▪ the Department of Water and Energy; ▪ the Department of Primary Industries; ▪ Ryde City Council, Hornsby Shire Council and Baulkham Hills Shire Council; and ▪ relevant public stakeholders, including special interest groups and affected landowners. The Environmental Assessment must outline the consultation process, document all community consultation undertaken to date and identify the issues raised (including where these have been addressed in the Environmental Assessment).

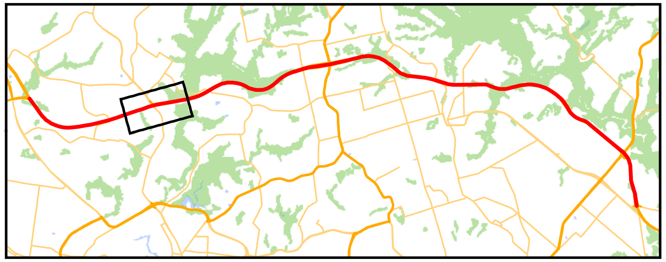
Appendix B

Vegetation Mapping

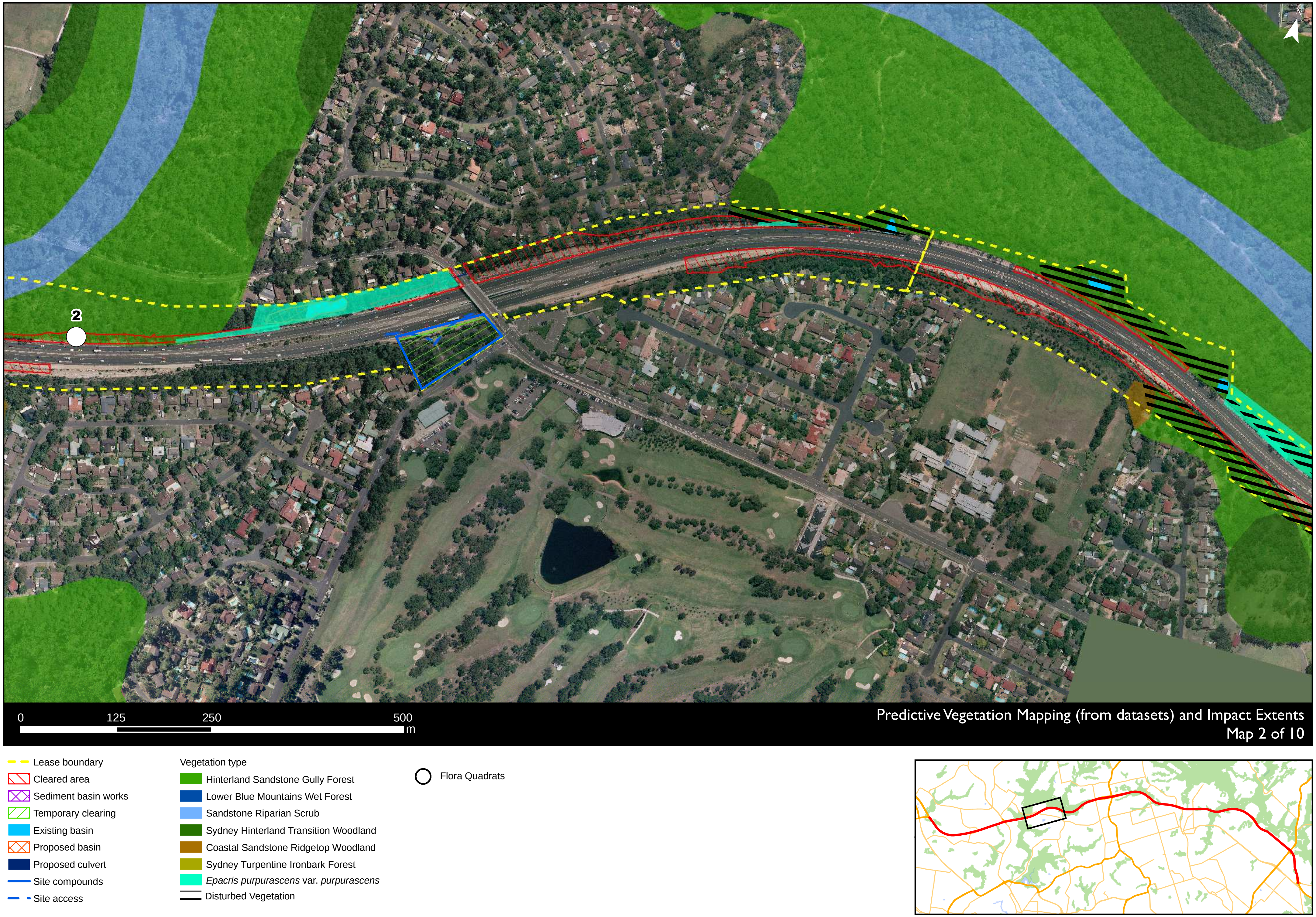
Lease boundary
Cleared area
Sediment basin works
Temporary clearing
Existing basin
Proposed basin
Proposed culvert
Site compounds
Site access

Vegetation type
Hinterland Sandstone Gully Forest
Lower Blue Mountains Wet Forest
Sandstone Riparian Scrub
Sydney Hinterland Transition Woodland
Coastal Sandstone Ridgetop Woodland
Sydney Turpentine Ironbark Forest
Epacris purpurascens var. *purpurascens*
Disturbed Vegetation

Flora Quadrats



Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.



Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

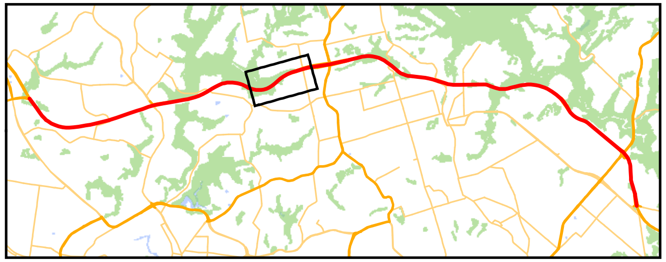
Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 3 of 10

- Lease boundary
- Cleared area
- Sediment basin works
- Temporary clearing
- Existing basin
- Proposed basin
- Proposed culvert
- Site compounds
- Site access

Vegetation type

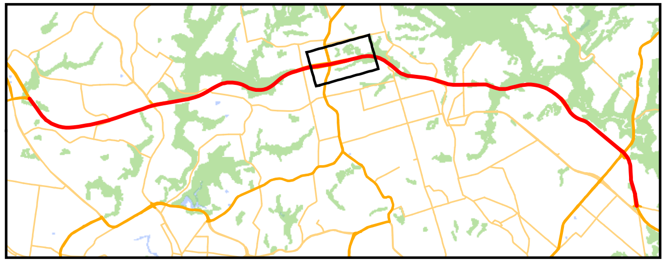
- Hinterland Sandstone Gully Forest
- Lower Blue Mountains Wet Forest
- Sandstone Riparian Scrub
- Sydney Hinterland Transition Woodland
- Coastal Sandstone Ridgetop Woodland
- Sydney Turpentine Ironbark Forest
- *Epacris purpurascens* var. *purpurascens*
- Disturbed Vegetation

- Flora Quadrats



Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 4 of 10



Lease boundary
Cleared area
Sediment basin works
Temporary clearing
Existing basin
Proposed basin
Proposed culvert
Site compounds
Site access

Vegetation type
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Epacris purpurascens var. *purpurascens*
Disturbed Vegetation

Flora Quadrats

Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 5 of 10

- Lease boundary
- Cleared area
- Sediment basin works
- Temporary clearing
- Existing basin
- Proposed basin
- Proposed culvert
- Site compounds
- Site access

Vegetation type
- Hinterland Sandstone Gully Forest
- Lower Blue Mountains Wet Forest
- Sandstone Riparian Scrub
- Sydney Hinterland Transition Woodland
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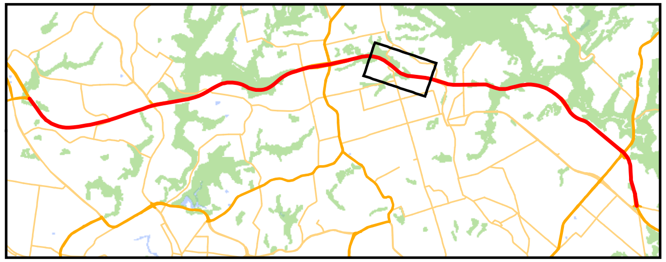
- Sydney Turpentine Ironbark Forest
- *Epacris purpurascens* var. *purpurascens*
- Disturbed Vegetation

- Flora Quadrats



Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 6 of 10

Lease boundary
Cleared area
Sediment basin works
Temporary clearing
Existing basin
Proposed basin
Proposed culvert
Site compounds
Site access

Vegetation type
Hinterland Sandstone Gully Forest
Lower Blue Mountains Wet Forest
Sandstone Riparian Scrub
Sydney Hinterland Transition Woodland
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Epacris purpurascens var. *purpurascens*
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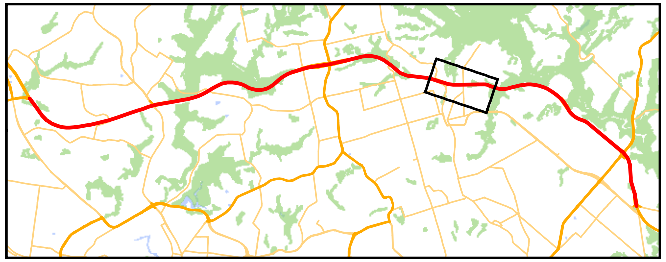
Flora Quadrats



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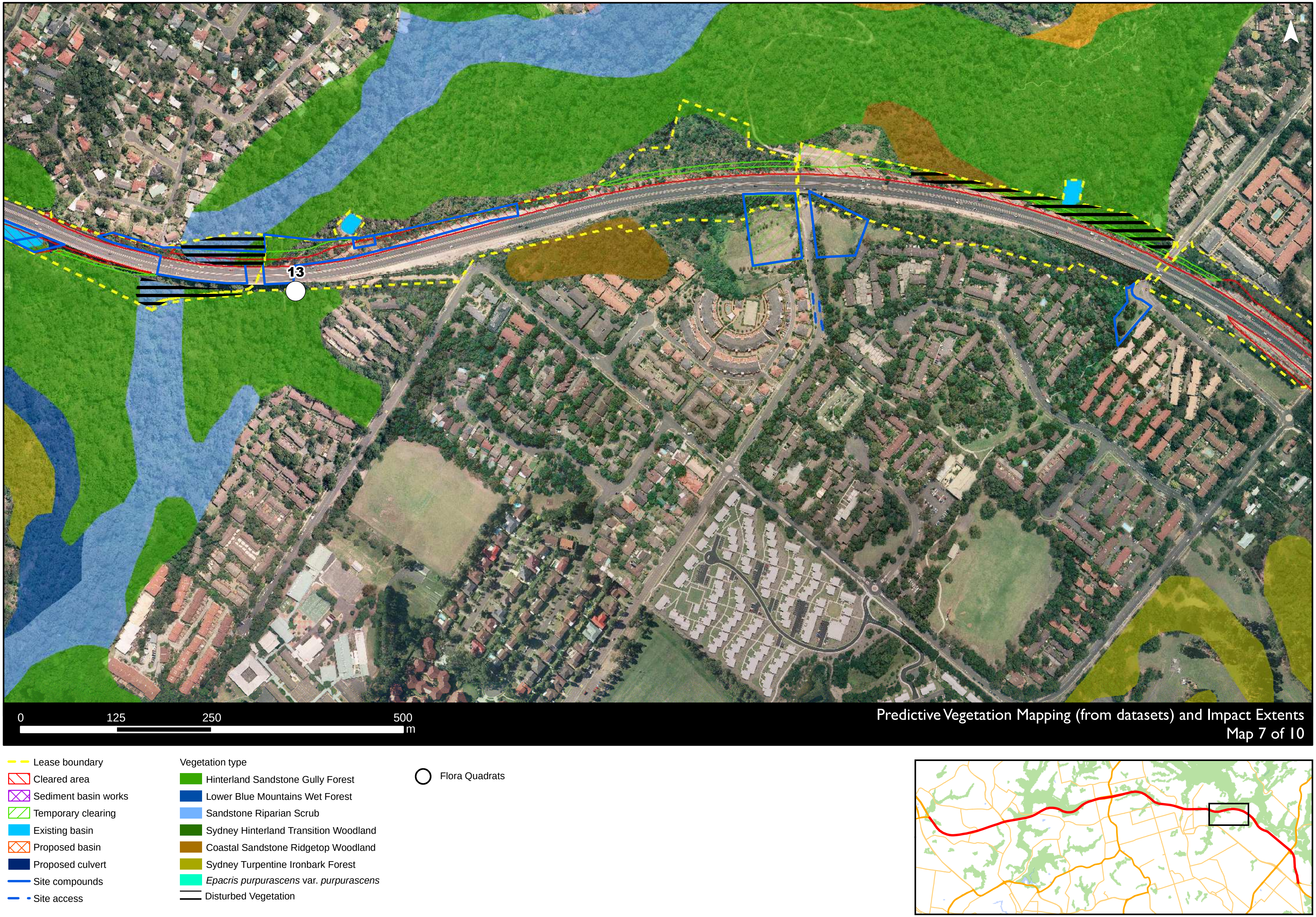

Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 8 of 10

- Lease boundary
- Cleared area
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- Temporary clearing
- Existing basin
- Proposed basin
- Proposed culvert
- Site compounds
- Site access

Vegetation type

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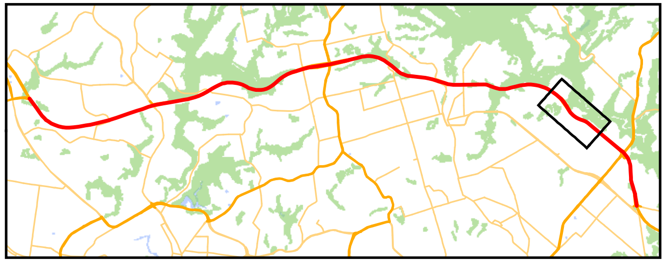

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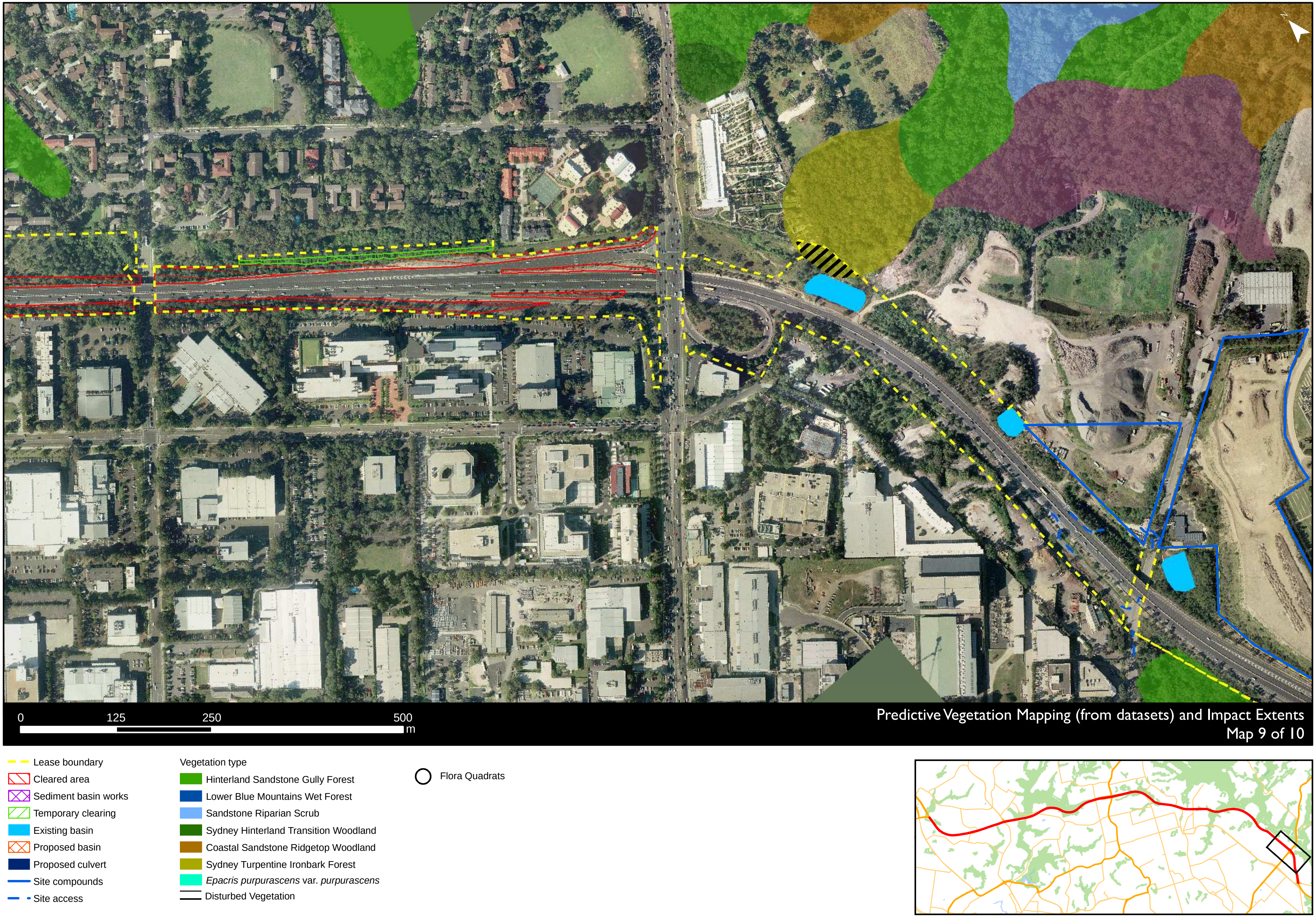

Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

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Predictive Vegetation Mapping (from datasets) and Impact Extents
Map 10 of 10

- Lease boundary
- Cleared area
- Sediment basin works
- Temporary clearing
- Existing basin
- Proposed basin
- Proposed culvert
- Site compounds
- Site access

Vegetation type

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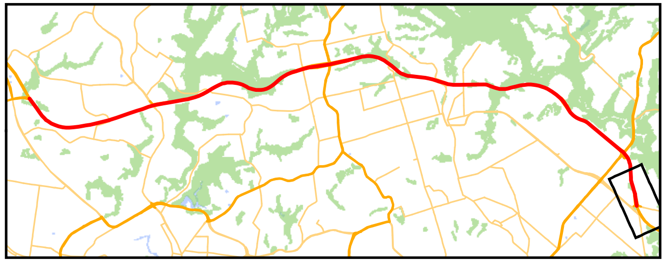

Source: RTA (2009). Based on raw data from Tozer et al (2006). Boundaries may differ slightly from original data.

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Appendix C

Results of Threatened Species Searches

Table 1 Threatened Fauna Species

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Birds			
(Australian) Painted Snipe *Rostratula (benghalensis) australis*	Vulnerable (EPBC Act) Endangered (TSC Act)	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (DEC, 2005).	Low – inappropriate habitat
Australian Bittern *Botaurus poiciloptilus*	Vulnerable (TSC Act)	Widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (Typha spp.) and spikerushes (Eleoacharis spp.). Hides during the day amongst dense reeds or rushes. Feeding platforms may be constructed over deeper water from reeds trampled by the bird; platforms are often littered with prey remains (DEC, 2005).	Low to moderate
Barking Owl *Ninox connivens*	Vulnerable (TSC Act)	Inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting (DEC, 2005).	Low to moderate
Black Bittern *Ixobrychus flavicollis*	Vulnerable (TSC Act)	Wide distribution, from southern NSW north to Cape York and along the north coast to the Kimberley region. In NSW, records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland. Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves (DEC, 2005).	Low
Black-necked Stork *Ephippiorhynchus asiaticus*	Endangered (TSC Act)	Lakes, swamps, freshwater pools and mangroves. Nests in trees or large bushes, often over swamps (DEC, 2005).	Low – occasional vagrant
Black-tailed Godwit *Limosa limosa*	Vulnerable (TSC Act)	Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps. Individuals have been recorded in wet fields and sewerage treatment works (DEC, 2005).	Low to moderate – seasonal migrant.

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Cotton Pygmy-Goose *Nettapus coromandelianus*	Endangered (TSC Act)	Occurs in freshwater lakes, lagoons, swamps and dams, particularly those vegetated with waterlilies and other floating and submerged aquatic vegetation. The Cotton Pygmy-Goose uses standing dead trees with hollows close to water for roosting and breeding (DEC, 2005).	Low – occassional vagrant
Gang-gang Cockatoo *Callocephalon fimbriatum*	Vulnerable (TSC Act)	In summer, the species is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas (DEC, 2005).	High – recorded in the M2 corridor
Glossy Black-cockatoo *Calyptorhynchus lathami*	Vulnerable (TSC Act)	Coastal forest and open inland woodland. Feeds primarily on *littoralis* or *Allocasuarina torulosa* (DEC, 2005).	Moderate
Little Lorikeet *Glossopsitta pusilla*	Vulnerable (TSC Act)	Found in open forests and woodlands, particularly where there are large flowering eucalypts. This species is also a mallee specialist (DEC, 2005).	Low
Osprey *Pandion haliaetus*	Vulnerable (TSC Act) Migratory (EPBC Act)	Found around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia (DEH 2005). Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water. Nests are made high up in dead trees or in dead crowns of live trees, usually within 1 km of the ocean (DEC, 2005).	Low – inappropriate habitat
Pink Robin *Petroica rodinogaster*	Vulnerable (TSC Act)	Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies.	Low to moderate
Powerful Owl *Ninox strenua*	Vulnerable (TSC Act)	Eucalypt forests along the Great Dividing Range, preferring tall wet sclerophyll forests, where 800-1000 ha territories centre on densely vegetated gullies (DEC, 2005).	Moderate to high
Regent Honeyeater *Anthochaera phrygia (syn. Xanthomyza phrygia)*	Endangered (EPBC Act) Endangered (TSC Act)	The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes (DEC, 2005, DEH, 2005).	Moderate – marginal habitat possible occasional visitor.

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Superb Fruit-dove *Ptilinopus superbus*	Vulnerable (TSC Act)	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms. It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees (DEC, 2005).	Low to moderate
Superb parrot *Polytelis swainsonii*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Found throughout eastern inland NSW. Inhabit Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest (DEC, 2005).	Low – records of likely aviary escapees outside species natural range. Breeding unlikely.
Swift Parrot *Lathamus discolor*	Endangered (TSC Act) Endangered (EPBC Act) Migratory (EPBC Act)	Migrates to the Australian south-east mainland between March and October. On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany, Spotted Gum, Red Bloodwood, Mugga Ironbark, and White Box. Commonly used lerp infested trees include Grey Box, Grey Box and Blackbutt (DEC, 2005).	Moderate – marginal habitat possible, seasonal visitor.
Frogs			
Giant Barred Frog *Mixophyes iteratus*	Endangered (TSC Act) Endangered (EPBC Act)	Forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest. They breed around shallow, flowing rocky streams from late spring to summer (DEC, 2005).	Low – habitat marginal and species not recorded in the CMA sub-regions in which the study area is located. Streams of the study area likely to be too polluted for species to persist.
Giant Burrowing Frog *Heleioporus australiacus*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	The Giant Burrowing Frog occurs from the NSW Central Coast to eastern Victoria, but is most common on the Sydney sandstone. It has been found from the coast to the Great Dividing Range. Found in heath, woodland and open forest with sandy soils (DEC, 2005). Usually live along clear, small slowly flowing water courses which traverse plateaus and broad upland gullies. Giant Burrowing Frogs have not been recorded breeding in waters that are even mildly polluted and are adversely affected by small pH changes (NPWS 2001).	Low – no waterways on upland gullies or plateaus within study area. Waterways of the study area modertaely to heavily polluted.
Green and Golden Bell Frog *Litoria aurea*	Vulnerable (EPBC Act) Endangered (TSC Act)	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (Typha spp.) or spikerushes (Eleocharis spp.). Some sites, particularly in the Greater Sydney region occur in highly disturbed areas. Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as *Gambusia holbrooki*, have a grassy area nearby and diurnal sheltering sites available (DEC, 2005).	Moderate – previously recorded in study area (most recently in 1995) however may be locally extinct.
Red-crowned Toadlet *Pseudophryne australis*	Vulnerable (TSC Act)	The species occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones. Shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter (DEC, 2005).	Moderate to high

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Stuttering Barred Frog *Mixophyes balbus*	Endangered (TSC Act) Vulnerable (EPBC Act)	Occur along the east coast of Australia from southern Queensland to the north-eastern Victoria. In recent surveys it has only been recorded at three locations south of Sydney. Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. Outside the breeding season (when occupy streams), adults live in deep leaf litter and thick understorey vegetation on the forest floor. The species depends on freshwater streams and riparian vegetation for breeding and habitation. No records are known from riparian habitat that has been disturbed (DEC, 2005).	Low – species not recorded in the CMA sub-regions in which the study area is located. Streams of the study area likely to be too polluted for species to persist.
Reptiles			
Broad-headed Snake *Hoplocephalus bungaroides*	Endangered (TSC Act) Vulnerable (EPBC Act)	Largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer. Within the Pittwater (Part B) sub-catchment area, the species restricted to the most northern areas (DEC, 2005).	Low – species restricted known distribution does not reach the study area.
Rosenberg's Goanna *Varanus rosenbergi*	Vulnerable (TSC Act)	Found in heath, open forest and woodland. Associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component (DEC, 2005).	Low to moderate
Molluscs			
Cumberland Land Snail *Meridolum corneovirens*	Endangered (TSC Act)	Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish (DECCW, 2009).	Low
Mammals			
Brush-tailed Rock-wallaby *Petrogale penicillata*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north (DEC, 2005).	Low – inappropriate habitat and not recorded in the CMA sub-regions odf study area.

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	Vulnerable (TSC Act)	Occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. Maternity caves have very specific temperature and humidity regimes. At other times of the year, populations disperse within about 300 km range of maternity caves. Cold caves are used for hibernation in southern Australia (DEC, 2005).	Moderate to high
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	Vulnerable (TSC Act)	Occurs in moist habitats, with trees taller than 20 m. Roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings (DEC, 2005).	Low to moderate
Eastern Freetail-bat *Mormopterus norfolkensis*	Vulnerable (TSC Act)	Occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosting occurs mainly in tree hollows but will also roost under bark or in man-made structures (DEC, 2005).	Moderate to high
Greater Broad-nosed Bat *Scoteanax rueppellii*	Vulnerable (TSC Act)	Occurs in woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Usually roosts in tree hollows; however, it has also been found in buildings (DEC, 2005).	Moderate to high
Grey-headed Flying-fox *Pteropus poliocephalus*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy (DEC, 2005).	High – recorded
Large-eared Pied Bat, Large Pied Bat *Chalinolobus dwyeri*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Found in well-timbered areas containing gullies mainly in areas with extensive cliffs and caves. Frequents low to mid-elevation dry open forest and woodland close to these features. Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (Hirundo ariel) (DEC, 2005).	Moderate to high – occasional visitor.
Large-footed Myotis *Myotis adversus*	Vulnerable (TSC Act)	Generally roost in groups of 10-15 close to water in caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface (DEC, 2005).	Moderate to high

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Long-nosed Potoroo *Potorous tridactylus tridactylus*	Vulnerable (EPBC Act – SE mainland)	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (DEC, 2005).	Low – inappropriate habitat and not recorded in the CMA sub-regions odf study area.
Southern Brown Bandicoot (eastern) *Isoodon obesulus obesulus*	Endangered (TSC Act) Endangered (EPBC Act)	It is found in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River. They are generally only found in heath or open forest with a healthy understorey on sandy or friable soils (DEC, 2005).	Low – small areas of potential habitat exists for this species in the locality however there are no records from the study area, Lane Cove NP, Bidjigal Reserve or other contiguous areas.
Spot-tailed Quoll *Dasyurus maculatus*	Vulnerable (TSC Act) Endangered (EPBC Act)	Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites. Females occupy home ranges up to about 750 hectares and males up to 3500 hectares; usually traverse their ranges along densely vegetated creeklines (DEC, 2005; DEH, 2005).	Low – not recorded in the bushland surrounding the study area which is fragmented and unlikely to be of sufficient size to support a resident population.
Yellow-bellied Glider *Petaurus australis*	Vulnerable (TSC Act)	The species occurs in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Denning occurs in hollows of large trees (DEC, 2005).	Low to moderate
Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*	Vulnerable (TSC Act)	Roosts in tree hollows and buildings; and in treeless areas they are known to utilise mammal burrows. Forages in most habitats across its very wide range, with and without trees (DEC, 2005).	Moderate
Fish			
Australian Grayling *Prototroctes maraena*	Vulnerable (EPBC Act) Protected (FM Act)	Australian grayling occur in freshwater streams and rivers (NSW DPI 2006). Chiefly occurs in clear gravelly streams with a moderate flow, as well as estuarine areas (DEC, 2005).	Low – habitat inappropriate.
Macquarie Perch *Macquaria australasica*	Endangered (EPBC Act) Endangered (FM Act)	Found in the Murray-Darling Basin (particularly upstream reaches) of the Lachlan, Murrumbidgee and Murray rivers, and parts of south-eastern coastal NSW, including the Hawkesbury/Nepean and Shoalhaven catchments (NSW DPI, 2005).	Low – streams of the study area not appropriate as species habitat.

Species Name	Status	General Habitat Requirements/Comment	Potential to Occur in M2 corridor
Migratory Species			
Black-faced Monarch *Monarcha melanopsis*	Migratory	Found along the coast of eastern Australia. Found in rainforests, eucalypt woodlands, coastal scrub and damp gullies and in more open woodland when migrating. Resident in the north of its range, but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March (Australian Musuem, 2005).	Moderate – potential breeding habitat for this species is considered to be found throughout the core bushland areas in the locality of the project. This species is considered unlikely to rely on the affected areas as breeding or foraging or roosting habitat.
Rainbow Bee-eater *Merops ornatus*	Migratory	Widely distributed throughout Australia (SPRAT, 2005). Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (SPRAT, 1999). The Rainbow Bee-eater has not been formally identified to occur in any threatened ecological communities (DEWHA, 2010).	Moderate – marginal habitat possible occasional visitor.
Rufous Fantail *Rhipidura rufifrons*	Migratory	The Rufous Fantail is found in northern and eastern coastal Australia, being more common in the north. During migration, it may be found in more open habitats or urban areas. Strongly migratory in the south of its range, it moves northwards in winter (Australian Musuem, 2008).	Moderate – potential breeding habitat for this species is considered to be found throughout the core bushland areas in the locality of the project. This species is considered unlikely to rely on the affected areas as breeding or foraging or roosting habitat.
Satin Flycatcher *Myiagra cyanoleuca*	Migratory	Breeds in south eastern Australia. The species occurs at numerous and widespread sites in eastern Australia (DEWHA, 2010).	Moderate – potential breeding habitat for these species is considered to be found throughout the core bushland areas in the locality of the project. This species is considered unlikely to rely on the affected areas as breeding or foraging or roosting habitat.
White-throated Needletail *Hirundapus caudacutus*	Migratory	In eastern Australia, it is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains.	Moderate –Habitat present for this aerial species but not affected by the proposed project.

Table 2 Threatened Flora Species

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Acacia bynoeana Bynoe's Wattle	Endangered (TSC Act) Vulnerable (EPBC Act)	Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leafed Apple (DEC, 2005).	Moderate – a small amount of potential habitat for this species occurs within the M2 corridor.
Acacia pubescens Downy Wattle	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone. Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland (DEC, 2005).	Low – all areas that may previously have supported potential habitat for the species are highly modified through earthworks and weed invasion.
Caladenia tessellata Tessellated Spider Orchid	Endangered (TSC Act) Vulnerable (EPBC Act)	Known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil (DEC, 2005).	Low – species not recently recorded in region and habitat of study area is marginal at best.
Callistemon linearifolius	Vulnerable (TSC Act)	Grows in dry sclerophyll forest on the coast and adjacent ranges, chiefly from Georges River to the Hawkesbury River. This shrub occurs most commonly within ecological communities associated with eucalypts, wattles and banksias and in areas of low soil fertility (DEC, 2005).	Moderate
Camarophyllopsis kearneyi	Endangered (TSC Act)	Known only from its type locality in Lane Cove Bushland Park in the Lane Cove local government area in the Sydney metropolitan region. Known only from its type locality in Lane Cove Bushland Park in the Lane Cove local government area in the Sydney metropolitan region.	Low
Cryptostylis hunteriana Leafless Tongue Orchid	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum, Silvertop Ash, Red Bloodwood and Black Sheoak (DEC, 2005).	Low – species recorded only once from the region habitat of study area is marginal.
Darwinia biflora	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Associated overstorey species include *Eucalyptus haemastoma, Corymbia gummifera* and/or *E. squamosa*. The vegetation structure is usually woodland, open forest or scrub-heath (DEC, 2005).	Moderate to high – Possible in eastern half of M2 Corridor though not recorded during field surveys.

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Darwinia peduncularis	Vulnerable (TSC Act)	Often grows on or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone. Resprouts on disturbed sites bush margins (DEC, 2005).	Low
Deyeuxia appressa	Endangered (TSC Act) Endangered (EPBC Act)	Was first collected in 1930 at Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown. Was then collected in 1941 from Killara, near Hornsby. Has not been collected since and may now be extinct. Given that *D. appressa* hasn't been seen in over 60 years, almost nothing is known of the species' habitat and ecology. Flowers spring to summer and is mesophytic (grows in moist conditions) (DEC, 2005).	Low – not recorded for many years. Moist habitats within study area are chiefly highly disturbed.
Epacris purpurascens var. *purpurascens*	Vulnerable (TSC Act)	The species is commonly found associated with open eucalypt forest to 20 m tall, with an open subcanopy of sheoaks and wattles. The understorey includes a usually sparse mixed layer of sclerophyllous and mesophyllous shrubs stratum and continuous grassy groundcover (DEC, 2005).	High – recorded.
Eucalyptus camfieldii Camfield's Stringybark	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall. Localised and scattered distribution includes sites at Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai, Wattamolla and a few other sites in Royal National Park. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas. Associated species frequently include stunted species of *E. oblonga* Narrow-leaved Stringybark, *E. capitellata* Brown Stringybark and *E. haemastoma* Scribbly Gum (DEC, 2005).	Low to moderate – few records and little, if any suitable habitat present.
Eucalyptus nicholii	Vulnerable (TSC Act) Vulnerable (EPBC Act)	This species is rare and grows in dry grassy woodland, on shallow and infertile soils, mainly on granite (DEC, 2005).	Low – non-local species, specimens planted.
Eucalyptus scoparia	Endangered (TSC Act) Vulnerable (EPBC Act)	This species grows in open eucalypt forests and woodland on well-drained granite hilltops, slopes and rocky outcrops (DEC, 2005).	Low – non-local species, specimens planted.

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Gallium australe Tangled Bedstraw	Endangered (TSC Act)	Once regarded as presumed extinct in NSW, this species is now known from the Towamba Valley near Bega, Lake Yarrunga near Kangaroo Valley, Cullendulla Creek Nature Reserve near Batemans Bay, Conjola National Park, Swan Lake near Swanhaven, and the Big Hole in Deua National Park. It was recorded historically from the Clyde River near Batemans Bay and the Mongarlowe area near Braidwood. The species also occurs beside Lake Windemere in the Australian Capital Territory at Jervis Bay. There is also an outlying record to the north from near Byabarra on the north coast. In NSW Tangled Bedstraw has been found in moist gullies of tall forest, *Eucalyptus tereticornis* forest, coastal Banksia shrubland, and *Allocasuarina nana* heathland (DEC, 2005).	Low to moderate
Genoplesium baueri Bauer's Midge Orchid	Vulnerable (TSC Act)	The species has been recorded from locations between Ulladulla and Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga. No collections have been made from those sites in recent years. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded at locations now likely to be within the following conservation reserves: Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. May occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments Grows in sparse sclerophyll forest and moss gardens over sandstone (DEC, 2005).	Low to moderate
Grammitis stenophylla Narrow-leaf Finger Fern	Endangered (TSC Act)	Occurs in eastern Queensland and eastern NSW. In NSW it has been found on the south, central and north coasts and as far west as Mount Kaputar National Park near Narrabrai. Moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest (DEC, 2005).	Low to moderate
Grevillea caleyi Caley's Grevillea	Endangered (TSC Act) Endangered (EPBC Act)	Restricted to an 8 km square area around Terrey Hills, approximately 20 km north of Sydney. Occurs in three major areas of suitable habitat, namely Belrose, Ingleside and Terrey Hills/Duffys Forest within the Ku-ring-gai, Pittwater and Warringah Local Government Areas. All sites occur on the ridgetop between elevations of 170 to 240 m and, in association with laterite soils and a vegetation community of open forest, generally dominated by *Eucalyptus sieberi* and *E. gummifera*. Commonly found in the endangered Duffys Forest ecological community (DEC, 2005).	Low – not recorded in locality and little, if any suitable habitat present.

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Grevillea parviflora subsp. Parviflora Small-flower Grevillea	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks (DEC, 2005).	Low – not recorded in locality and minimal if any habitat present.
Haloragodendron lucasii	Endangered (TSC Act) Endangered (EPBC Act)	Associated with dry sclerophyll forest. Reported to grow in moist sandy loam soils in sheltered aspects, and on gentle slopes below cliff-lines near creeks in low open woodland. Associated with high soil moisture and relatively high soil-phosphorus levels (DEC, 2005).	Low to moderate – minimal, if any potential habitat within M2 corridor.
Hibbertia superans	Endangered (TSC Act)	The species occurs on sandstone ridgetops often near the shale/sandstone boundary. Occurs in both open woodland and heathland, and appears to prefer open disturbed areas, such as tracksides. Highly sensitive to both frequent and infrequent fire and other disturbance regimes (DEC, 2005).	Low
Hygrocybe anomala var. ianhinomarginata	Vulnerable (TSC Act)	The species occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. They are associated with alluvial sandy soils of the Hawkesbury Soil Landscapes which are naturally low fertility and erodible. This species can also occur on rotten tree substrates include soil, humus, or moss (DEC, 2005).	Low
Hygrocybe aurantipes	Vulnerable (TSC Act)	The species occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. They are associated with alluvial sandy soils of the Hawkesbury Soil Landscapes which are naturally low fertility and erodible. This species can also occur on rotten tree substrates include soil, humus, or moss (DEC, 2005).	Low
Hygrocybe austropratensis	Endangered (TSC Act)	Only know from type locality at Lane Cove Bushland Park, Lane Cove Local Government Area. Occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss (DEC, 2005).	Low

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Hygrocybe lanecovensis	Endangered (TSC Act)	The species occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. They are associated with alluvial sandy soils of the Hawkesbury Soil Landscapes which are naturally low fertility and erodible. This species can also occur on rotten tree substrates include soil, humus, or moss (DEC, 2005).	Low
Hygrocybe reesiae	Vulnerable (TSC Act)	The species occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. They are associated with alluvial sandy soils of the Hawkesbury Soil Landscapes which are naturally low fertility and erodible. This species can also occur on rotten tree substrates include soil, humus, or moss (DEC, 2005).	Low
Hygrocybe rubronivea	Vulnerable (TSC Act)	The species occurs in gallery warm temperate forests dominated by Lilly Pilly, Grey Myrtle, Cheese Tree and Sweet Pittosporum. They are associated with alluvial sandy soils of the Hawkesbury Soil Landscapes which are naturally low fertility and erodible. This species can also occur on rotten tree substrates include soil, humus, or moss (DEC, 2005).	Low
Lasiopetalum joyceae	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Grows in heath on lateritic to shaley ridgetops of sandstone areas (DEC, 2005).	Low – minimal, if any, potential habitat within M2 corridor. Study area outside of species known range.
Leptospermum deanei	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Woodland on lower hill slopes or near creeks. Sandy alluvial soil or sand over sandstone Occurs in Riparian Scrub – e.g. *Tristaniopsis laurina*, *Baechea myrtifolia*; Woodland – e.g. *Eucalyptus haemstoma*; and Open Forest – e.g. *Angophora costata, Leptospermum trinervium, Banksia ericifolia* (DEC, 2005).	Low – some potential habitat may exist along Devlins Creek though vegetation here is moderately to highly degraded and unlikely to support the species.
Melaleuca deanei Deane's Paperbark	Vulnerable (TSC Act) Vulnerable (EPBC Act)	The species grows in wet heath on sandstone (DEC, 2005).	Low to moderate – minimal, if any, potential wet heath habitat occurs within the M2 corridor.
Persoonia hirsuta Hairy Geebung	Endangered (TSC Act) Endangered (EPBC Act)	Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. It is usually present as isolated individuals or very small populations (DEC, 2005).	Moderate – potential habitat present though species not recorded in adjacent bushland valleys.

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Persoonia mollis subsp. *maxima*	Endangered (TSC Act) Endangered (EPBC Act)	Occurs in sheltered aspects of deep gullies or on the steep upper hillsides of narrow gullies on Hawkesbury Sandstone. These habitats support relatively moist, tall forest vegetation communities, often with warm temperate rainforest influences (DEC, 2005).	Low-moderate – not recorded in adjacent bushland valleys. Preferred habitat not found within M2 corridor.
Persoonia nutans	Endangered (TSC Act) Endangered (EPBC Act)	Inhabits aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland (DEC, 2005).	Low
Pimelea curviflora var. *curviflora*	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands (DEC, 2005).	Moderate – species recorded at unspecified location near the M2 in 1992 EIS however not located in M2 corridor during recent studies.
Pomaderris prunifolia	Endangered population in the Paramatta, Auburn, Strathfield and Bankstown LGAs	Identified from only three sites within the listed local government areas, at Rydalmere, within Rookwood Cemetery and at The Crest of Bankstown. At Rydalmere it occurs along a road reserve near a creek, among grass species on sandstone. At Rookwood Cemetery it occurs in a small gully of degraded Cooks River/Castlereagh Ironbark Forest on shale soils (DEC, 2005).	Low – known from only three sites that are not within the study area
Prostanthera marifolia	Critically Endangered (TSC Act) Extinct (EPBC Act)	Previously recorded from the Sydney harbour region and was presumed extinct. All attempts to recollect this species were unsuccessful until 2001. Found in woodland dominated by *Eucalyptus sieberi* and *Corymbia gumnifera*. In deeply weathered clay soil with ironstone nodules (DEC, 2005).	Low – areas near M2 where species previously recorded are now developed. Preferred habitat not found within M2 corridor.
Syzygium paniculatum Magenta Lilly Pilly	Vulnerable (TSC Act) Vulnerable (EPBC Act)	The species occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities (DEC, 2005).	Low to moderate – species is widely cultivated

Species Name	Status	Habitat Requirements / Comment	Potential to Occur in M2 Corridor
Tetratheca glandulosa	Vulnerable (TSC Act) Vulnerable (EPBC Act)	Associated with shale-sandstone transition habitat where shale-cappings occur over sandstone, with associated soil landscapes such as Lucas Heights, Gymea, Lambert and Faulconbridge. Topographically, the plant occupies ridgetops, upper-slopes and to a lesser extent mid-slope sandstone benches. Soils are generally shallow, consisting of a yellow, clayey/sandy loam. Stony lateritic fragments are also common in the soil profile on many of these ridgetops. Vegetation structure varies from heaths and scrub to woodlands/open woodlands, and open forest. Vegetation communities correspond broadly to Benson & Howell's Sydney Sandstone Ridgetop Woodland (Map Unit 10ar). Common woodland tree species include: *Corymbia gummifera*, *C. eximia*, *Eucalyptus haemastoma*, *E. punctata*, *E. racemosa,* and/or *E. sparsifolia*, with an understorey dominated by species from the families Proteaceae, Fabaceae, and Epacridaceae (DEC, 2005).	Moderate – a small amount of potential habitat for this species is present within the M2 corridor. Species not recorded within M2 corridor during recent surveys.
Triplarina imbricata Creeping Triplarina	Endangered (TSC Act) Endangered (EPBC Act)	Found only in a few locations in the ranges south-west of Glenreagh and near Tabulam in north-east NSW. Along watercourses in low open forest with Water Gum (DEC, 2005).	Low
Wilsonia backhousei Narrow-leafed Wilsonia	Vulnerable (TSC Act)	This species occurs on the margins of salt marshes and lakes, both coastal and inland (DEC, 2005).	Low

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Appendix D

Flora and Fauna Species List

Flora Inventory

Flora plot survey locations as listed below and presented in Appendix B – Vegetation Mapping.

1) Excelsior Reserve
2) Excelsior Reserve
3) Bidjigal Reserve
4) Bidjigal Reserve
5) Bidjigal Reserve
6) Beecroft (opposite Pennant Hills Golf Course)
7) Pennant Hills Golf Course
8) Beecroft Recreation Reserve
9) Beecroft Recreation Reserve
10) Beecroft Recreation Reserve
11) Cheltenham
12) North Epping
13) Crimea Road Bridge

Table 1 Flora Inventory

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Fabaceae (Mimosoideae)	*Acacia baileyana*	Cootamundra Wattle		P	Y	Y		
Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall		P	Y			
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle, Green Wattle		U	Y	Y	Y	7, 11, 12
Fabaceae (Mimosoideae)	*Acacia echinula*	Hedgehog Wattle		U	Y	Y		
Fabaceae (Mimosoideae)	*Acacia elata*	Mountain Cedar Wattle		U	Y			
Fabaceae	*Acacia falcata*				Y	Y	Y	7

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Fabaceae	*Acacia filicifolia*	Fern-leaved Wattle				Y		
Fabaceae – Mimosoideae	*Acacia fimbriata*	Fringed Wattle					Y	7
Fabaceae (Mimosoideae)	*Acacia floribunda*	White Sally		U	Y	Y	Y	2, 3, 13
Fabaceae - Mimosoideae	*Acacia implexa*	Hickory Wattle					Y	7
Fabaceae - Mimosoideae	*Acacia linearifolia*	Narrow-leaved Wattle					Y	2, 6, 9
Fabaceae (Mimosoideae)	*Acacia linifolia*	Flax-leaved Wattle		U	Y	Y		5, 10
Fabaceae (Mimosoideae)	*Acacia longifolia*			U	Y	Y		
Fabaceae (Mimosoideae)	*Acacia myrtifolia*	Red-stemmed Wattle		U	Y			
Fabaceae	*Acacia obtusifolia*					Y		
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle		U	Y	Y		
Fabaceae	*Acacia podalyriifolia*	Queensland Silver Wattle				Y		
Fabaceae	*Acacia saligna*	Golden Wreath Wattle			Y			
Fabaceae (Mimosoideae)	*Acacia stricta*	Straight Wattle		U	Y	Y		
Fabaceae (Mimosoideae)	*Acacia suaveolens*	Sweet Wattle		U	Y	Y	Y	6, 13
Fabaceae (Mimosoideae)	*Acacia terminalis*	Sunshine Wattle		U	Y		Y	13
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses		U	Y	Y	Y	3,5,6, 7, 10

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Aceraceae	*Acer negundo*	Box-elder Maple, Box Elder, Ash-leaved Maple			Y	Y		
Polygonaceae	*Acetosa sagittata*	Rambling Dock, Turkey Rhubarb			Y	Y		
Myrtaceae	*Acmena smithii*	Lilly Pilly		U		Y		
Apiaceae	*Actinotus helianthi*	Flannel Flower		P	Y	Y		
Apiaceae	*Actinotus minor*	Lesser Flannel Flower		U	Y			
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair			Y		Y	7
Adiantaceae	*Adiantum formosum*	Giant Maidenhair			Y			
Adiantaceae	*Adiantum hispidulum*	Rough Maidenhair Fern			Y			
Asteraceae	*Ageratina adenophora**	Crofton Weed		U	Y	Y		11
Asteraceae	*Ageratina riparia**	Mistflower		U	Y			
Simaroubaceae	*Ailanthus altissima*	Tree of Heaven			Y			
Lamiaceae	*Ajuga australis*	Austral Bugle			Y			
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak		U	Y	Y	Y	9
Casuarinaceae	*Allocasuarina torulosa*	Forest Oak		U	Y	Y	Y	3, 5, 7, 10
Rhamnaceae	*Alphitonia excelsa*	Red Ash					Y	6, 7
Alstroemeriaceae	*Alstroemeria psittacina*				Y			
Alstroemeriaceae	*Alstroemeria pulchella**	Parrot Alstroemeria		U	Y			
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed		U	Y			
Apiaceae	*Ammi majus*	Bishop's-weed, Bullwort				Y		

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Euphorbiaceae	*Amperea xiphoclada*			U	Y	Y		4, 13
Euphorbiaceae	*Amperea xiphoclada var. papillata*			U			Y	2
Euphorbiaceae	*Amperea xiphoclada var. xiphoclada*			U			Y	
Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel, Blue Pimpernel			Y			
Poaceae	*Andropogon virginicus**	Whisky Grass		U	Y	Y	Y	4
Myrtaceae	*Angophora bakeri*	Narrow-leaved Apple		U	Y	Y	Y	1, 2, 4
Myrtaceae	*Angophora costata*	Sydney Red/Rusty Gum		U	Y	Y	Y	3, 4, 5, 6, 7, 10, 12, 13
Myrtaceae	*Angophora floribunda*	Apple, Rough-barked Apple				Y	Y	7
Myrtaceae	*Angophora hispida*	Dwarf Apple		P	Y			
Poaceae	*Anisopogon avenaceus*	Oat Speargrass		U	Y	Y		
Basellaceae	*Anredera cordifolia*	Madeira Vine, Lamb's Tail, Jalap, Potato Vine			Y	Y		
Apocynaceae	*Araujia sericifera**	Moth Vine		U	Y	Y		
Poaceae	*Aristida sp.*						Y	5, 9
Poaceae	*Arundo donax*	Spanish Reed, Giant Reed			Y			
Asparagaceae	*Asparagus aethiopicus**	Asparagus Fern		U	Y	Y		
Liliaceae	*Asparagus asparagoides*	Bridal Creeper, Florist's Smilax			Y		Y	3,4, 5, 9,11, 13
Liliaceae	*Asparagus scandens*	Asparagus Fern			Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Liliaceae	*Asparagus setaceus*				Y			
Aspleniaceae	*Asplenium australasicum*	Bird's Nest Fern			Y			
Aspleniaceae	*Asplenium flabellifolium*	Necklace Fern		U	Y	Y	Y	2, 3
Asteraceae	*Aster subulatus*	Wild Aster, Bushy Starwort			Y			
Epacridaceae	*Astroloma humifusum*	Native Cranberry				Y		
Araliaceae	*Astrotricha latifolia*			U		Y		
Araliaceae	*Astrotricha longifolia*			U	Y		Y	13
Poaceae	*Austrodanthonia sp.*						Y	2, 4, 7
Poaceae	*Austrodanthonia tenuior*			U		Y		
Myrtaceae	*Austromyrtus tenuifolia*			U	Y	Y		
Poaceae	*Austrostipa pubescens*			U	Y		Y	2, 5, 6
Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle		U		Y	Y	3
Myrtaceae	*Baeckea densifolia*				Y			
Proteaceae	*Banksia ericifolia*	Heath-leaved Banksia		P	Y			
Proteaceae	*Banksia marginata*	Silver Banksia			Y			
Proteaceae	*Banksia oblongifolia*	Fern-leaved Banksia		P	Y	Y		
Proteaceae	*Banksia serrata*	Old-man Banksia		U	Y	Y	Y	4, 13
Proteaceae	*Banksia spinulosa*	Hairpin Banksia		P	Y	Y		
Proteaceae	*Banksia spinulosa var. Spinulosa*			P			Y	1,2, 4, 5

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Cunoniaceae	*Bauera rubioides*	River Rose		U	Y		Y	
Asteraceae	*Bidens pilosa**	Cobblers Pegs			Y	Y		11
Pittosporaceae	*Billardiera scandens*	Appleberry		U		Y	Y	1, 2, 3, 4, 5, 6, 10
Blechnaceae	*Blechnum cartilagineum*	Gristle Fern		U	Y	Y	Y	1, 3
Rutaceae	*Boronia ledifolia*	Sydney Boronia		P	Y			
Rutaceae	*Boronia pinnata*			P	Y		Y	13
Fabaceae	*Bossiaea ensata*	Sword Bossiaea			Y			
Fabaceae (Faboideae)	*Bossiaea heterophylla*	Variable Bossiaea		U	Y		Y	13
Fabaceae (Faboideae)	*Bossiaea obcordata*	Spiny Bossiaea		U	Y	Y	Y	1, 2, 4, 5, 6, 10
Fabaceae	*Bossiaea prostrata*					Y		
Fabaceae - Faboideae	*Bossiaea rhombifolia*						Y	13
Fabaceae (Faboideae)	*Bossiaea scolopendria*			U	Y			
Sterculiaceae	*Brachychiton acerifolius*	Flame Tree, Illawarra Flame Tree			Y		Y	
Sterculiaceae	*Brachychiton populneus*	Kurrajong				Y		7
Asteraceae	*Brachyscome angustifolia var. angustifolia*						Y	7, 9
Euphorbiaceae	*Breynia oblongifolia*	Coffee Bush		U	Y	Y	Y	1, 6, 7, 8, 9, 10
Poaceae	*Briza maxima**	Quaking Grass		U	Y	Y		
Poaceae	*Bromus unioloides*				Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Acanthaceae	*Brunoniella pumilio*	Dwarf Blue Trumpet		U	Y			
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn		U	Y	Y		7
Pittosporaceae	*Bursaria spinosa subsp. spinosa*						Y	1, 2
Liliaceae	*Caesia parviflora*	Pale Grass-lily				Y		
Anthericaceae	*Caesia parviflora var. parviflora*			U			Y	1
Liliaceae	*Caesia vittata*				Y			
Orchidaceae	*Caladenia carnea*	Pink Fairy, Pink Fingers			Y			
Orchidaceae	*Caladenia catenata*	White Caladenia, White Fingers			Y			
Portulacaceae	*Calandrinia sp.*					Y		
Cunoniaceae	*Callicoma serratifolia*	Black Wattle		U	Y	Y	Y	4
Myrtaceae	*Callistemon citrinus*	Crimson Bottlebrush		P	Y			
Myrtaceae	*Callistemon linearis*	Narrow-leaved Bottlebrush		P	Y			
Myrtaceae	*Callistemon salignus*	Willow Bottlebrush					Y	7
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern		P	Y	Y		
Cannaceae	*Canna indica*	Tous-les-mois Arrowroot			Y			
Sapindaceae	*Cardiospermum grandiflorum*	Cardiospermum grandiflorum			Y			11, 12
Caesalpiniaceae	*Cassia coluteoides*				Y			
Caesalpiniaceae	*Cassia floribunda*				Y	Y		
Asteraceae	*Cassinia aculeata*	Dolly Bush		U	Y	Y		
Asteraceae	*Cassinia aureonitens*	Yellow Cassinia				Y		
Asteraceae	*Cassinia denticulata*			U	Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Lauraceae	*Cassytha glabella*			U	Y	Y		
Lauraceae	*Cassytha pubescens*			U	Y	Y	Y	1, 2, 3, 4, 5, 13
Casuarinaceae	*Casuarina glauca*	Swamp Oak, Guman (Cadigal)					Y	13
Casuarinaceae	*Casuarina torulosa*	Forest Oak					Y	1
Cyperaceae	*Caustis flexuosa*	Curly Wig		P	Y	Y	Y	13
Vitaceae	*Cayratia clematidea*	Native Grape			Y	Y		
Apiaceae	*Centella asiatica*	Indian Pennywort		U		Y		
Cunoniaceae	*Ceratopetalum apetalum*	Coachwood		U	Y	Y	Y	3, 13
Cunoniaceae	*Ceratopetalum gummiferum*	Christmas Bush		P	Y	Y	Y	1, 3, 4
Solanaceae	*Cestrum parqui*	Green Cestrum, Green Poisonberry, Willow Leaved Jessamine			Y			
Adiantaceae	*Cheilanthes sieberi*			U	Y	Y		
Adiantaceae	*Cheilanthes sieberi subsp. sieberi*	Poison Rock Fern, Mulga Fern					Y	4, 9
Poaceae	*Chloris gayana*	Rhodes Grass			Y			
Thelypteridaceae	*Christella dentata*			U		Y		
Asteraceae	*Chrysanthmoides monilifera*				Y			
Lauraceae	*Cinnamomum camphora**	Camphor Laurel		U	Y	Y	Y	4, 13
Asteraceae	*Cirsium vulgare*	Spear Thistle			Y	Y		
Vitaceae	*Cissus antarctica*	Water Vine		U	Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Vitaceae	*Cissus hypoglauca*	Giant Water Vine		U	Y	Y	Y	1
Rutaceae	*Citrus limonia*				Y			
Ranunculaceae	*Clematis aristata*	Old Man's Beard		U	Y	Y		7, 8, 9
Ranunculaceae	*Clematis aristida*						Y	1
Ranunculaceae	*Clematis glycinoides*	Headache Vine		U	Y	Y	Y	6
Lamiaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum		U	Y	Y		
Polygalaceae	*Comesperma ericinum*			U	Y			
Polygalaceae	*Comesperma volubile*			U	Y			
Commelinaceae	*Commelina cyanea*	Native Wandering Jew		U	Y	Y	Y	7
Convolvulaceae	*Convolvulus erubescens*	Blushing Bindweed				Y		
Asteraceae	*Conyza albida*				Y			
Asteraceae	*Conyza bonariensis**	Flaxleaf Fleabane		U	Y	Y	Y	3, 6, 13
Agavaceae	*Cordyline stricta*	Narrow-leaved Palm Lily			Y			
Asteraceae	*Coreopsis lanceolata*	Coreopsis			Y			
Rutaceae	*Correa reflexa*	Native Fuschia		U			Y	1
Poaceae	*Cortaderia selloana*	Pampas Grass			Y	Y	Y	4, 13
Orchidaceae	*Corybas aconitiflorus*	Spurred Helmet Orchid			Y			
Myrtaceae	*Corymbia gummifera*	Red Bloodwood		U	Y	Y	Y	2, 5
Malaceae	*Cotoneaster glaucophyllus**			U	Y	Y		
Malaceae	*Cotoneaster microphyllus*						Y	13
Orchidaceae	*Cryptostylis erecta*	Tartan Tongue Orchid		P	Y		Y	4, 6, 10

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Cyatheaceae	*Cyathea australis*	Rough Treefern		P	Y	Y		
Cyatheaceae	*Cyathea cooperi*	Straw Treefern		P	Y	Y	Y	13
Cyperaceae	*Cyathochaeta diandra*			U			Y	2
Apiaceae	*Cyclospermum leptophyllum**	Slender Celery		U	Y			
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass		U	Y			
Poaceae	*Cynodon dactylon*	Common Couch		U		Y		
Cyperaceae	*Cyperus eragrostis**	Umbrella Sedge		U	Y	Y		
Cyperaceae	*Cyperus sp.Y*					Y		
Goodeniaceae	*Dampiera purpurea*				Y			
Goodeniaceae	*Dampiera stricta*			U	Y		Y	13
Poaceae	*Danthonia caespitosa*					Y		
Poaceae	*Danthonia longifolia*				Y			
Poaceae	*Danthonia pallida*				Y			
Fabaceae	*Daviesia corymbosa*					Y		
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea		U	Y	Y		
Loranthaceae	*Dendrophthoe vitellina*			U		Y		
Liliaceae	*Dianella caerulea*	Blue Flax-lily			Y	Y		
Phormiaceae	*Dianella caerulea var. producta*			P			Y	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13
Liliaceae	*Dianella laevis*				Y	Y		
Phormiaceae	*Dianella revoluta*	Blueberry Lily, Blue Flax-Lily		U	Y	Y		

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Phormiaceae	*Dianella revoluta var. revoluta*						Y	1
Poaceae	*Dichelachne crinita*	Longhair Plumegrass		U			Y	4, 7
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass		U	Y	Y		
Poaceae	*Dichelachne rara*			U	Y	Y		
Convolvulaceae	*Dichondra repens*	Kidney Weed		U	Y	Y	Y	7, 8, 9
Fabaceae	*Dillwynia retorta*				Y	Y	Y	1, 4, 13
Fabaceae	*Dillwynia tenuifolia*				Y			
Orchidaceae	*Dipodium punctatum*				Y	Y		
Fabaceae	*Dipogon lignosus*	Dolichos Pea			Y			
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush		U	Y	Y	Y	1, 2, 4
Blechnaceae	*Doodia aspera*	Prickly Rasp Fern		U	Y	Y		
Blechnaceae	*Doodia caudata*	Small Rasp Fern		U	Y	Y		
Blechnaceae	*Doodia media*				Y			
Epacridaceae	*Dracophyllum secundum*				Y			
Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass		U	Y	Y	Y	4, 5, 6
Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass		U	Y	Y		
Poaceae	*Ehrharta erecta**	Panic Veldtgrass		U	Y			
Chenopodiaceae	*Einadia hastata*	Berry Saltbush					Y	7
Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash		U	Y	Y	Y	3, 4, 6, 7,8, 9, 10,13
Poaceae	*Entolasia marginata*	Bordered Panic		U	Y	Y	Y	3, 5, 6, 7, 8
Poaceae	*Entolasia stricta*	Wiry Panic		U	Y	Y	Y	1, 2, 4, 5, 8, 9, 10,

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
								13
Ericaceae	*Epacris microphylla*			U	Y			
Ericaceae	*Epacris pulchella*			U	Y	Y	Y	1, 2, 4
Ericaceae	*Epacris purpurascens var. purpurascens*			V			Y	2
Onagraceae	*Epilobium billardierianum*				Y			
Poaceae	*Eragrosits brownii*						Y	5
Poaceae	*Eragrostis philippica*					Y		
Poaceae	*Eragrostis pilosa*	Soft Lovegrass				Y		
Rutaceae	*Eriostemon australasius*						Y	4
Fabaceae	*Erythrina sykesii*	Coral Tree			Y	Y		
Myrtaceae	*Eucalyptus acmenoides*	White Mahogany				Y		
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark				Y		
Myrtaceae	*Eucalyptus eugenioides*	Thin-leaved Stringybark				Y		
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark		U		Y		
Myrtaceae	*Eucalyptus globoidea*	White Stringybark		U	Y	Y		
Myrtaceae	*Eucalyptus haemastoma*	Broad-leaved Scribbly Gum		U	Y	Y		
Myrtaceae	*Eucalyptus moluccana*	Grey Box				Y		
Myrtaceae	*Eucalyptus oblonga*	Stringybark			Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Myrtaceae	*Eucalyptus paniculata*	Grey Ironbark		U	Y	Y		7
Myrtaceae	*Eucalyptus paniculata subsp. paniculata*			U			Y	
Myrtaceae	*Eucalyptus pilularis*	Blackbutt		U	Y	Y	Y	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12
Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint		U	Y	Y	Y	13
Myrtaceae	*Eucalyptus punctata*	Grey Gum				Y		
Myrtaceae	*Eucalyptus resinifera*	Red Mahogany		U	Y			
Myrtaceae	*Eucalyptus resinifera*	Red Mahogany				Y		
Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum		U	Y	Y	Y	7
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum				Y		
Euphorbiaceae	*Euphorbia peplus*	Petty Spurge, Radium Plant			Y	Y		
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry		U	Y	Y	Y	1, 5, 6, 7, 8, 9
Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart, Native Cherry			Y	Y	Y	7
Moraceae	*Ficus coronata*	Creek Sandpaper Fig		U	Y			
Malvaceae	*Ficus rubiginosa*	Port Jackson Fig, Rusty Fig			Y			
Moraceae	*Ficus rubiginosa*	Port Jackson Fig, Rusty Fig		U		Y		
Malvaceae	*Ficus superba*	Deciduous Fig			Y			
Cyperaceae	*Fimbristylis dichotoma*	Common Fringe-sedge				Y		
Apiaceae	*Foeniculum vulgare*	Fennel			Y	Y		

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Fumariaceae	*Fumaria capreolata*	Climbing Fumitory			Y			
Cyperaceae	*Gahnia sieberiana*	Red-fruit Saw-sedge		P		Y	Y	13
Rubiaceae	*Galium binifolium*			U			Y	
Philesiaceae	*Geitonoplesium cymosum*	Scrambling Lily			Y			
Fabaceae	*Genista linifolia*	Flaxleaf Broom			Y			
Fabaceae	*Genista monspessulana*	Montpellier Broom			Y	Y		
Geraniaceae	*Geranium homeanum*			U			Y	
Iridaceae	*Gladiolus undulatus*	Wild Gladiolus			Y			
Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern, Tangle Fern		P	Y		Y	13
Gleicheniaceae	*Gleichenia microphylla*	Scrambling Coral Fern, Umbrella Fern, Parasol Fern				Y		
Euphorbiaceae	*Glochidion ferdinandi*	Cheese Tree			Y	Y	Y	1
Fabaceae (Faboideae)	*Glycine clandestina*			U	Y	Y	Y	6, 7, 8, 9
Fabaceae (Faboideae)	*Glycine tabacina*	Glycine		U	Y	Y		
Asteraceae	*Gnaphalium sp.*					Y		
Asteraceae	*Gnaphalium spicatum*				Y			
Asclepiadaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush			Y			
Fabaceae (Faboideae)	*Gompholobium latifolium*	Golden Glory Pea		U	Y			

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Fabaceae	*Gompholobium minus*	Dwarf Wedge Pea			Y	Y		
Haloragaceae	*Gonocarpus tetragynus*				Y	Y	Y	2, 3
Haloragaceae	*Gonocarpus teucrioides*	Raspwort		U	Y			
Goodeniaceae	*Goodenia bellidifolia*			U		Y		
Goodeniaceae	*Goodenia decurrens*				Y			
Goodeniaceae	*Goodenia dimorpha*				Y			
Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia		U	Y	Y		
Goodeniaceae	*Goodenia hederacea subsp. hederacea*						Y	1, 2, 4
Goodeniaceae	*Goodenia heterophylla*			U	Y	Y		3
Goodeniaceae	*Goodenia heterophylla subsp. Heterophylla*						Y	
Goodeniaceae	*Goodenia ovata*	Hop Goodenia			Y			
Proteaceae	*Grevillea buxifolia*	Grey Spider Flower		U	Y		Y	13
Proteaceae	*Grevillea linearifolia*			U	Y	Y	Y	1
Proteaceae	*Grevillea robusta*	Silky Oak			Y			
Proteaceae	*Grevillea sericea*			U	Y			
Proteaceae	*Grevillea speciosa*	Red Spider Flower		U	Y			
Proteaceae	*Hakea dactyloides*	Finger Hakea, Broad-leaved Hakea		P	Y	Y		
Proteaceae	*Hakea salicifolia*	Willow-leaved Hakea		U	Y	Y		

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Proteaceae	*Hakea salicifolia subsp. salicifolia*			U			Y	7
Proteaceae	*Hakea sericea*	Needlebush		U	Y	Y	Y	1,2
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla		U	Y	Y		
Araliaceae	*Hedera helix*	English Ivy			Y			
Zingiberaceae	*Hedychium gardneranum*				Y			
Asteraceae	*Helichrysum scorpioides*				Y			
Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower		U		Y	Y	1,2
Dilleniaceae	*Hibbertia dentata*	Twining Guinea Flower		U	Y	Y	Y	8
Dilleniaceae	*Hibbertia empetrifolia*				Y			3,4
Dilleniaceae	*Hibbertia linearis*			U	Y	Y		
Dilleniaceae	*Hibbertia scandens*	Climbing Guinea Flower			Y	Y		
Poaceae	*Holcus lanatus*	Yorkshire Fog			Y			
Euphorbiaceae	*Homalanthus populifolius*			U	Y	Y		8
Iridaceae	*Homeria flaccida*				Y			
Fabaceae (Faboideae)	*Hovea linearis*			U	Y	Y	Y	4
Apiaceae	*Hydrocotyle bonariensis*				Y			
Apiaceae	*Hydrocotyle laxiflora*	Stinking pennywort, Stinking Pennywort			Y			
Apiaceae	*Hydrocotyle peduncularis*			U			Y	7

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Hymenophyllaceae	*Hymenophyllum cupressiforme*	Common Filmy Fern		U	Y			
Hypericaceae	*Hypericum gramineum*	Small St. John's Wort				Y		
Clusiaceae	*Hypericum japonicum*			U	Y			
Hypericaceae	*Hypericum perforatum*	St. Johns Wort				Y		
Asteraceae	*Hypochaeris radicata**	Catsear		U	Y	Y		
Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern		U	Y		Y	4
Poaceae	*Imperata cylindrica*	Blady Grass			Y	Y	Y	4,6,, 8, 13
Fabaceae	*Indigofera australis*	Australian Indigo			Y			
Convolvulaceae	*Ipomoea indica*	Morning Glory			Y	Y		
Proteaceae	*Isopogon anemonifolius*	Broad-leaf Drumsticks			Y			
Proteaceae	*Isopogon anemonifolius*	Broad-leaf Drumsticks		P		Y	Y	2, 5
Proteaceae	*Isopogon anethifolius*			P	Y	Y		
Asteraceae	*Jacaranda mimosifolia*	Jacaranda			Y			
Fabaceae	*Jacksonia scoparia*	Winged Broom-pea, Dogwood				Y		
Juncaceae	*Juncus usitatus*			U	Y	Y		
Fabaceae (Faboideae)	*Kennedia rubicunda*	Red Kennedy Pea		U	Y	Y	Y	6, 10
Myrtaceae	*Kunzea ambigua*	Tick Bush		P	Y	Y	Y	1,13
Asteraceae	*Lactuca serriola*	Prickly Lettuce				Y		1, 2, 4
Proteaceae	*Lambertia formosa*	Mountain Devil		U	Y	Y	Y	

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Verbenaceae	*Lantana camara**	Lantana		U	Y	Y	Y	4, 11, 12
Sterculiaceae	*Lasiopetalum ferrugineum*			U	Y	Y		
Sterculiaceae	*Lasiopetalum ferrugineum var. cordatum*						Y	1, 2
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily		U	Y	Y	Y	4
Cyperaceae	*Lepidosperma concavum*			U	Y			
Cyperaceae	*Lepidosperma filiforme*					Y	Y	1
Cyperaceae	*Lepidosperma laterale*			U	Y	Y	Y	2, 4, 5, 6, 8
Cyperaceae	*Lepidosperma urophorum*				Y	Y		
Santalaceae	*Leptomeria acida*	Native Currant, Sour Currant Bush			Y		Y	6
Myrtaceae	*Leptospermum arachnoides*			U	Y			
Myrtaceae	*Leptospermum flavescens*				Y	Y		
Myrtaceae	*Leptospermum lanigerum*	Wooly Teatree			Y			
Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree		U	Y	Y	Y	1,2, 4, 5, 13
Restionaceae	*Lepyrodia scariosa*			U	Y			
Amaryllidaceae	*Leucojum aestivum*	Snowflake, Loddon Lily			Y			
Ericaceae	*Leucopogon ericoides*			U	Y			

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Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath		U	Y	Y	Y	4, 5, 6, 7, 9
Ericaceae	*Leucopogon lanceolatus*			U	Y	Y		
Ericaceae - Styphelioideae	*Leucopogon lanceolatus subsp. group b*						Y	3, 9, 10
Ericaceae	*Leucopogon microphyllus*			U	Y			
Epacridaceae	*Leucopogon muticus*	Blunt Beard-heath				Y		
Oleaceae	*Ligustrum lucidum**	Large-leaved Privet		U	Y	Y		11
Oleaceae	*Ligustrum sinense**	Small-leaved Privet		U	Y	Y	Y	4, 13, 8, 11
Lindsaeaceae	*Lindsaea linearis*	Screw Fern		U	Y			5, 6
Lindsaeaceae	*Lindsaea microphylla*	Lacy Wedge Fern		U	Y	Y		
Hamamelidaceae	*Liquidambar styraciflua**	Sweetgum		U	Y	Y		
Lobeliaceae	*Lobelia alata*					Y		
Lobeliaceae	*Lobelia gracilis*	Trailing Lobelia		U	Y			
Loganiaceae	*Logania albiflora*			U	Y		Y	1, 7
Loganiaceae	*Logania pusilla*			U			Y	2
Poaceae	*Lolium perenne*	Perennial Ryegrass			Y			
Lomandraceae	*Lomandra brevis*						Y	2
Lomandraceae	*Lomandra cylindrica*						Y	2
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush		U	Y			
Lomandraceae	*Lomandra filiformis subsp. flavior*						Y	3, 10

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Lomandraceae	*Lomandra glauca*	Pale Mat-rush		U			Y	3, 4
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush		U	Y	Y	Y	1, 2, 4, 5, 6, 7, 9, 13
Lomandraceae	*Lomandra multiflora*				Y			
Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush		U			Y	1, 2, 8, 10
Lomandraceae	*Lomandra obliqua*			U	Y	Y	Y	1, 2, 5, 6, 8, 10, 13
Proteaceae	*Lomatia ilicifolia*	Holly Lomatia, Native Holly			Y			
Proteaceae	*Lomatia myricoides*	River Lomatia		U	Y	Y		1, 2, 3, 6, 13
Proteaceae	*Lomatia silaifolia*	Crinkle Bush		P	Y	Y	Y	5, 10
Caprifoliaceae	*Lonicera japonica**	Japanese Honeysuckle		U	Y	Y		
Apocynaceae	*Marsdenia suaveolens*	Scented Marsdenia		U	Y	Y	Y	2. 3
Celastraceae	*Maytenus silvestris*	Narrow-leaved Orangebark		U	Y	Y	Y	6, 7
Myrtaceae	*Melaleuca decora*					Y		
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark, Budjur (Gadigal)			Y			
Myrtaceae	*Melaleuca nodosa*					Y		
Meliaceae	*Melia azedarach*	White Cedar, Chinaberry Tree			Y	Y		
Ericaceae	*Melichrus procumbens*	Jam Tarts		U	Y			
Euphorbiaceae	*Micrantheum ericoides*			U	Y	Y		
Euphorbiaceae	*Micrantheum hexandrum*				Y			

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Poaceae	*Microlaena stipoides*			U	Y			
Poaceae	*Microlaena stipoides*	Weeping Grass				Y		
Poaceae	*Microlaena stipoides var. stipoides*			U			Y	2, 3, 4, 5, 6, 7, 8, 9, 13
Myrtaceae	*Micromyrtus ciliata*	Fringed Heath-myrtle			Y			
Orchidaceae	*Microtis unifolia*	Common Onion Orchid		P	Y			
Loganiaceae	*Mitrasacme polymorpha*				Y	Y		
Epacridaceae	*Monotoca elliptica*	Tree Broom-heath			Y			
Ericaceae	*Monotoca scoparia*			U	Y	Y		
Rubiaceae	*Morinda jasminoides*	Sweet Morinda		U	Y	Y	Y	6, 8, 9, 10
Moraceae	*Morus alba**	White Mulberry		U	Y	Y		
Loranthaceae	*Muellerina eucalyptoides*				Y			
Myrsinaceae	*Myrsine variabilis*			U	Y	Y	Y	
Lauraceae	*Neolitsea dealbata*	Hairy-leaved Bolly Gum				Y		
Davalliaceae	*Nephrolepis cordifolia*	Fishbone Fern		U	Y			
Oleaceae	*Notelaea longifolia*	Large Mock-olive		U	Y			
Oleaceae	*Notelaea longifolia f. longifolia*						Y	1, 3, 5, 6, 9, 10
Alliaceae	*Nothoscordum inodorum*				Y			
Oleaceae	*Notolaea venosa*					Y		
Ochnaceae	*Ochna serrulata**	Mickey Mouse Plant		U	Y		Y	1, 5, 6, 8, 9, 10

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Oleaceae	*Olea africana*	Olea europaea subsp. cuspidata			Y			
Asteraceae	*Olearia microphylla*			U	Y	Y		5
Rubiaceae	*Opercularia aspera*	Coarse Stinkweed		U	Y	Y	Y	3, 9
Rubiaceae	*Opercularia varia*	Variable Stinkweed			Y			
Poaceae	*Oplismenus aemulus*			U	Y	Y	Y	1, 7
Poaceae	*Oplismenus imbecillis*			U	Y	Y		8, 9, 12
Oxalidaceae	*Oxalis articulata*				Y			
Oxalidaceae	*Oxalis corniculata*				Y	Y		
Fabaceae	*Oxylobium ilicifolium*					Y		
Asteraceae	*Ozothamnus diosmifolius*	White Dogwood		P	Y	Y	Y	1, 2, 4, 6, 7, 9
Bignoniaceae	*Pandorea pandorana subsp. pandorana*						Y	3, 6, 9, 10
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine		U	Y	Y		7, 8
Poaceae	*Panicum simile*	Two-colour Panic		U	Y	Y		
Apocynaceae	*Parsonsia straminea*	Common Silkpod		U	Y	Y		5, 10
Poaceae	*Paspalum dilatatum*	Paspalum			Y	Y		
Poaceae	*Paspalum distichum*	Water Couch		U	Y			
Poaceae	*Paspalum urvillei*	Vasey Grass			Y	Y		
Passifloraceae	*Passiflora edulis*	Common Passionfruit			Y	Y		
Iridaceae	*Patersonia sericea*	Silky Purple-Flag		U	Y	Y	Y	1, 4, 5, 10
Malvaceae	*Pavonia hastata*				Y			
Sinopteridaceae	*Pellaea falcata*	Sickle Fern			Y	Y		

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Poaceae	*Pennisetum clandestinum**	Kikuyu Grass		U	Y	Y		
Polygonaceae	*Persicaria capitata**			U	Y			
Polygonaceae	*Persicaria lapathifolium*				Y	Y		
Polygonaceae	*Persicaria sp. A*					Y		
Polygonaceae	*Persicaria strigosa*				Y			
Proteaceae	*Persoonia lanceolata*	Lance Leaf Geebung		P	Y		Y	13
Proteaceae	*Persoonia laurina*			P	Y	Y		
Proteaceae	*Persoonia laurina subsp. laurina*						Y	1
Proteaceae	*Persoonia levis*	Broad-leaved Geebung		P	Y	Y	Y	2, 4, 10, 13
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung		P	Y	Y	Y	1, 5, 6, 10
Proteaceae	*Persoonia pinifolia*	Pine-leaved Geebung		P	Y	Y		5
Proteaceae	*Petrophile pedunculata*	Conesticks				Y		
Proteaceae	*Petrophile pulchella*	Conesticks		P	Y		Y	2
Caryophyllaceae	*Petrorhagia nanteuilii*				Y	Y		
Poaceae	*Phalaris aquatica*	Phalaris				Y		
Euphorbiaceae	*Phyllanthus gasstroemii*				Y	Y		
Phyllanthaceae	*Phyllanthus hirtellus*			U	Y	Y	Y	2, 4, 5, 6, 10
Poaceae	*Phyllostachys aurea*	Golden Bamboo*						12
Fabaceae (Faboideae)	*Phyllota phylicoides*	Heath Phyllota		U	Y	Y		
Phytolaccaceae	*Phytolacca octandra**	Inkweed		U		Y		

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Thymelaeaceae	*Pimelea curviflora*					Y		
Thymelaeaceae	*Pimelea latifolia subsp. hirsuta*						Y	4
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower		U	Y	Y		
Pinaceae	*Pinus radiata*	Radiata Pine, Monterey Pine			Y			
Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum		U	Y	Y		
Pittosporaceae	*Pittosporum revolutum*	Wild Yellow Jasmine, Rough fruit Pittosporum					Y	
Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum		U	Y	Y	Y	1, 3, 4, 5, 7, 8, 9, 10, 13
Plantaginaceae	**Plantago lanceolata*	Lamb's Tongues, Plantain			Y	Y		
Plantaginaceae	*Plantago major*	Large Plantain				Y		
Polypodiaceae	*Platycerium bifurcatum*	Elkhorn		P		Y		
Fabaceae (Faboideae)	*Platylobium formosum*			U	Y	Y	Y	3, 6
Apiaceae	*Platysace ericoides*				Y		Y	1
Apiaceae	*Platysace lanceolata*	Shrubby Platysace		U	Y	Y	Y	1, 2, 3, 5
Apiaceae	*Platysace linearifolia*			U	Y	Y	Y	1, 4
Lamiaceae	*Plectranthus parviflorus*			U	Y	Y		9
Poaceae	*Poa affinis*			U	Y	Y	Y	
Podocarpaceae	*Podocarpus spinulosus*	Spiny-leaf Podocarp			Y	Y	Y	1
Araliaceae	*Polycias sambucifolia*						Y	3, 4, 6, 10

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Polygonaceae	*Polygonum aviculare*	Wireweed			Y			
Araliaceae	*Polyscias sambucifolia*	Elderberry Panax		U	Y	Y		
Aspidiaceae	*Polystichum formosum*	Broad Shield Fern			Y			
Rhamnaceae	*Pomaderris discolor*					Y	Y	1
Rhamnaceae	*Pomaderris ferruginea*				Y			
Rhamnaceae	*Pomaderris sp.*						Y	1, 2
Rubiaceae	*Pomax umbellata*			U	Y	Y	Y	4, 6, 10
Rutaceae	*Populus alba*	White Poplar			Y			,
Euphorbiaceae	*Poranthera corymbosa*			U	Y			
Euphorbiaceae	*Poranthera ericifolia*			U	Y	Y		
Euphorbiaceae	*Poranthera microphylla*			U	Y	Y		
Lobeliaceae	*Pratia purpurascens*	Whiteroot		U	Y	Y	Y	2, 7, 9
Lamiaceae	*Prunella vulgaris**	Self-heal		U	Y	Y		
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower		U	Y	Y	Y	3, 5, 6, 8, 9, 10
Psilotaceae	*Psilotum nudum*	Skeleton Forked Fern		U		Y		
Dennstaedtiaceae	*Pteridium esculentum*	Bracken		P	Y	Y	Y	1, 3, 6, 10
Cyperaceae	*Ptilothrix deusta*			U	Y			
Fabaceae (Faboideae)	*Pultenaea daphnoides*	Large-leaf Bush-pea		U	Y		Y	4
Fabaceae (Faboideae)	*Pultenaea flexilis*			U	Y	Y		

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Fabaceae	*Pultenaea scabra*					Y	Y	3
Fabaceae (Faboideae)	*Pultenaea stipularis*			U	Y			
Fabaceae (Faboideae)	*Pultenaea tuberculata*			U	Y			
Fabaceae	*Pultenaea villosa*					Y		
Rosaceae	*Pyracantha angustifolia*	Orange Firethorn			Y	Y		
Polypodiaceae	*Pyrrosia rupestris*	Rock Felt Fern			Y			
Ranunculaceae	*Ranunculus inundatus*	River Buttercup				Y		
Ranunculaceae	*Ranunculus repens*	Creeping Buttercup			Y			
Chenopodiaceae	*Rhagodia hastata*					Y		
Anacardiaceae	*Rhus succedanea*	Rhus Tree			Y	Y		
Euphorbiaceae	*Ricinocarpos pinifolius*	Wedding Bush		U	Y			13
Euphorbiaceae	*Ricinocarpus pinifolius*						Y	
Euphorbiaceae	*Ricinus communis**	Castor Oil Plant			Y	Y		11
Brassicaceae	*Rorippa nasturtium-aquaticum**	Watercress		U	Y	Y		
Rosaceae	*Rubus fruticosus sp. agg.**	Blackberry complex		U			Y	4
Rosaceae	*Rubus rosifolius*	Rose-leaf Bramble, Native Raspberry				Y		
Rosaceae	*Rubus ulmifolius*	Blackberry			Y	Y		
Polygonaceae	*Rumex brownii*	Swamp Dock			Y	Y		

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Polygonaceae	*Rumex crispus**	Curled Dock		U	Y			
Salicaceae	*Salix babylonica*	Weeping Willow			Y	Y		
Menispermaceae	*Sarcopetalum harveyanum*	Pearl Vine		U	Y			
Goodeniaceae	*Scaevola albida*	Pale Fan-flower			Y			
Goodeniaceae	*Scaevola ramosissima*	Purple Fan-flower		U	Y		Y	1
Schizaeaceae	*Schizaea bifida*	Forked Comb Fern			Y			
Schizaeaceae	*Schizaea dichotoma*	Branched Comb Fern		U	Y			
Cunoniaceae	*Schizomeria ovata*	Crabapple		U	Y	Y		
Cyperaceae	*Schoenoplectus mucronatus*					Y		
Cyperaceae	*Schoenus imberbis*			U		Y		
Asteraceae	*Senecio hispidulus*	Hill Fireweed		U		Y	Y	7
Asteraceae	*Senecio lautus*	Variable Groundsel			Y	Y		
Asteraceae	*Senecio linearifolius*				Y			
Asteraceae	*Senecio mikanioides*				Y	Y		
Asteraceae	*Senecio vulgaris*				Y			
Poaceae	*Setaria geniculata*				Y	Y		
Poaceae	*Setaria palmifolia*	Palm Grass			Y			
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne		U	Y	Y		
Asteraceae	*Sigesbeckia orientalis*				Y			
Caryophyllaceae	*Silene gallica*				Y			
Smilacaceae	*Smilax australis*	Lawyer Vine, Wait-a-while, Barbwire Vine			Y	Y		

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Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla		U	Y	Y	Y	1, 3, 4, 9, 13
Solanaceae	*Solanum americanum*	Glossy Nightshade					Y	
Solanaceae	*Solanum cinereum*	Narrawa Burr				Y		
Solanaceae	*Solanum mauritianum**	Wild Tobacco Bush		U	Y	Y		
Solanaceae	*Solanum nigrum*	Black-berry Nightshade			Y	Y		
Solanaceae	*Solanum pseudocapsicum*	Madeira Winter or Jerusalem Cherry			Y			
Asteraceae	*Sonchus oleraceus**	Common Sowthistle		U	Y	Y		
Poaceae	*Sorghum halepense**	Johnson Grass		U	Y			
Poaceae	*Sporobolus africanus*	Parramatta Grass			Y	Y		
Poaceae	*Sporobolus elongatus*	Slender Rat's Tail Grass				Y		
Caryophyllaceae	*Stellaria media*	Common Chickweed			Y	Y		
Proteaceae	*Stenocarpus salignus*	Scrub Beefwood		U		Y		
Poaceae	*Stenotaphrum secundatum*	Buffalo Grass, Soft Buffalo				Y		
Gleicheniaceae	*Sticherus flabellatus*	Shiny Fan Fern, Umbrella Fern			Y	Y		
Poaceae	*Stipa rudis*				Y			
Poaceae	*Stipa verticillata*				Y			
Stylidiaceae	*Stylidium graminifolium*	Grass Triggerplant		U	Y	Y		
Stylidiaceae	*Stylidium lineare*	Narrow-leaved Triggerplant					Y	3
Liliaceae	*Stypandra caespitosa*				Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Ericaceae	*Styphelia tubiflora*			U	Y	Y		
Myrtaceae	*Syncarpia glomulifera*	Turpentine		U	Y	Y		
Myrtaceae	*Syncarpia glomulifera subsp. glomulifera*						Y	2, 3, 4, 5, 6, 7, 9, 11
Myrtaceae	*Syzygium paniculatum*	Syzygium paniculatum			Y			
Asteraceae	*Taraxacum officinale*	Dandelion, Pissabed			Y			
Winteraceae	*Tasmannia insipida*	Brush Pepperwood		U		Y		
Orchidaceae	*Thelymitra pauciflora subsp. pauciflora*						Y	1
Poaceae	*Themeda australis*	Kangaroo Grass		U	Y	Y	Y	6
Acanthaceae	*Thunbergia alata**	Black-eyed Susan		U		Y		
Liliaceae	*Thysanotus juncifolius*				Y			
Liliaceae	*Thysanotus tuberosus*	Common Fringe-lily			Y			
Osmundaceae	*Todea barbara*	King Fern				Y		
Apiaceae	*Trachymene incisa*				Y	Y		
Commelinaceae	*Tradescantia albiflora**	Wandering Jew		U	Y	Y		11, 12
Ulmaceae	*Trema tomentosa*	Native Peach, Poison Peach					Y	
Ulmaceae	*Trema tomentosa var. viridis*	Native Peach		U	Y			
Liliaceae	*Tricoryne elatior*	Yellow Autumn-lily, Yellow Rush-lily				Y		
Fabaceae	*Trifolium dubium*	Yellow Suckling Clover				Y		
Fabaceae	*Trifolium glomeratum*	Clustered Clover			Y			

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Fabaceae (Faboideae)	*Trifolium repens**	White Clover		U		Y		
Myrtaceae	*Tristaniopsis collina*	Mountain Water Gum, Hill Kanuka			Y	Y		
Myrtaceae	*Tristaniopsis laurina*	Water Gum, Kanooka, Kanuka			Y			3
Myrtaceae	*Tristaniopsis laurina*	Kanooka		U		Y	Y	
Ericaceae	*Trochocarpa laurina*	Tree Heath		U		Y		
Tropaeolaceae	*Tropaeolum majus*	Nasturtium			Y			
Asclepiadaceae	*Tylophora barbata*	Bearded Tylophora			Y	Y	Y	
Typhaceae	*Typha orientalis*	Broadleaf Cumbungi				Y		
Verbenaceae	*Verbena bonariensis**	Purpletop		U	Y	Y		
Verbenaceae	*Verbena officinalis*	Common Verbena, Vervain			Y	Y		
Scrophulariaceae	*Veronica calycina*	Hairy Speedwell			Y			
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell, Creeping Speedwell					Y	
Scrophulariaceae	*Veronica sp.*					Y		
Fabaceae (Faboideae)	*Viminaria juncea*	Native Broom		U	Y			
Violaceae	*Viola hederacea*	Ivy-leaved Violet		U	Y	Y		
Violaceae	*Viola odorata*	Sweet Violet			Y			
Campanulaceae	*Wahlenbergia communis*						Y	
Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell		U	Y	Y	Y	3
Iridaceae	*Watsonia angusta*					Y		

Family	Scientific Name	Common Name	EPBC Legal Status	NSW Legal Status	Mount King 1992a	Mount King 1992b	Current (random meander/flora surveys)	Flora quadrat (refer to vegetation mapping in Appendix B)
Ericaceae	*Woollsia pungens*			U	Y	Y	Y	13
Asteraceae	*Xanthium occidentale*	Noogoora Burr, Cockle Burr				Y		
Xanthorrhoeaceae	*Xanthorrhoea arborea*			P	Y	Y		
Xanthorrhoeaceae	*Xanthorrhoea media*			P		Y		
Xanthorrhoeaceae	*Xanthorrhoea resinosa*			P	Y			
Xanthorrhoeaceae	*Xanthorrhoea sp.*						Y	13
Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia		U	Y	Y	Y	1, 2, 3, 4, 13
Apiaceae	*Xanthosia tridentata*	Rock Xanthosia		U	Y		Y	2
Proteaceae	*Xylomelum pyriforme*	Woody Pear		P	Y	Y	Y	1
Araceae	*Zantedeschia aethiopica*	Arum Lily, Pig Lily, Calla Lily, White Arum Lily, Lily of the Nile, Egyptian Lily			Y			
Rutaceae	*Zieria smithii*	Sandfly Zieria		U	Y	Y	Y	3, 4, 5, 6, 7

Fauna Inventory

Table 2 Fauna Inventory

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Bird	*Acanthiza chyrsorrhoa*	Yellow-rumped Thornbill	-	P	Y			
Bird	*Acanthiza lineata*	Striated Thornbill	-	P	Y	Y	Y	
Bird	*Acanthiza nana*	Yellow Thornbill	-	P	Y	Y	Y	
Bird	*Acanthiza pusilla*	Brown Thornbill	-	P	Y		Y	Y
Bird	*Acanthiza pusilla*	Brown Thornbill	-	P		Y		
Bird	*Gerygone mouki*	Brown Gerygone	-	P	Y		Y	
Bird	*Sericornis frontalis*	White-browed Scrubwren	-	P	Y	Y	Y	Y
Bird	*Sericornis magnirostris*	Large-billed Scrubwren	-	P			Y	
Bird	*Smicrornis brevirostris*	Weebill	-	P	Y			
Bird	*Accipiter fasciatus*	Brown Goshawk	-	P			Y	
Bird	*Aviceda subcristata*	Pacific Baza	-	P	Y		Y	
Bird	*Hieraaetus morphnoides*	Little Eagle	-	P		Y		
Bird	*Ceyx azureus*	Azure Kingfisher	-	P				Y
Bird	*Dacelo novaeguineae*	Laughing Kookaburra	-	P	Y	Y	Y	Y
Bird	*Todiramphus sanctus*	Sacred Kingfisher	-	P	Y	Y	Y	Y
Bird	*Anas superciliosa*	Pacific Black Duck	-	P	Y	Y	Y	Y
Bird	*Chenonetta jubata*	Australian Wood Duck	-	P	Y			Y
Bird	*Hirundapus caudacutus*	White-throated Needletail	-	P	Y	Y		
Bird	*Cracticus torquatus*	Grey Butcherbird	-	P	Y	Y	Y	Y
Bird	*Gymnorhina tibicen*	Australian Magpie	-	P	Y	Y	Y	Y
Bird	*Strepera graculina*	Pied Currawong	-	P	Y	Y	Y	Y
Bird	*Cacatua galerita*	Sulphur-crested Cockatoo	-	P		Y	Y	Y

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Bird	*Cacatua sanguinea*	Little Corella	-	P		Y	Y	Y
Bird	*Callocephalon fimbriatum*	Gang-gang Cockatoo	-	V	Y			Y
Bird	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo	-	P			Y	Y
Bird	*Eolophus roseicapillus*	Galah	-	P	Y	Y	Y	Y
Bird	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	-	P	Y	Y	Y	Y
Bird	*Vanellus miles*	Masked Lapwing	-	P	Y	Y		
Bird	*Cormobates leucophaea*	White-throated Treecreeper	-	P	Y	Y	Y	Y
Bird	*Columba leucomela*	White-headed Pigeon	-	P			Y	
Bird	*Columba livia**	Rock Dove	-	U	Y	Y		Y
Bird	*Macropygia amboinensis*	Brown Cuckoo-Dove	-	P	Y			
Bird	*Ocyphaps lophotes*	Crested Pigeon	-	P	Y	Y		Y
Bird	*Streptopelia chinensis**	Spotted Turtle-Dove	-	U	Y	Y	Y	Y
Bird	*Eurystomus orientalis*	Dollarbird	-	P	Y		Y	
Bird	*Corvus coronoides*	Australian Raven	-	P	Y	Y	Y	Y
Bird	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	-	P	Y	Y	Y	
Bird	*Chrysococcyx basalis*	Horsfield's Bronze-Cuckoo	-	P			Y	
Bird	*Eudynamys scolopacea*	Common Koel	-	P	Y		Y	
Bird	*Scythrops novaehollandiae*	Channel-billed Cuckoo	-	P	Y		Y	
Bird	*Neochmia temporalis*	Red-browed Firetail	-	P		Y	Y	Y
Bird	*Falco longipennis*	Australian Hobby	-	P		Y		
Bird	*Falco peregrinus*	Peregrine Falcon	-	P	Y			
Bird	*Carduelis carduelis*	European Goldfinch	-	U	Y			

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Bird	*Hirundo neoxena*	Welcome Swallow	-	P	Y	Y		Y
Bird	*Petrochelidon ariel*	Fairy Martin	-	P	Y	Y		
Bird	*Malurus cyaneus*	Superb Fairy-wren	-	P	Y	Y	Y	Y
Bird	*Malurus lamberti*	Variegated Fairy-wren	-	P	Y	Y	Y	
Bird	*Acanthorhynchus tenuirostris*	Eastern Spinebill	-	P	Y	Y	Y	Y
Bird	*Anthochaera carunculata*	Red Wattlebird	-	P	Y	Y	Y	Y
Bird	*Anthochaera chrysoptera*	Little Wattlebird	-	P	Y		Y	
Bird	*Lichenostomus chrysops*	Yellow-faced Honeyeater	-	P	Y	Y	Y	Y
Bird	*Lichenostomus penicillatus*	White-plumed Honeyeater	-	P	Y			
Bird	*Manorina melanocephala*	Noisy Miner	-	P	Y	Y		Y
Bird	*Meliphaga lewinii*	Lewin's Honeyeater	-	P			Y	
Bird	*Melithreptus lunatus*	White-naped Honeyeater	-	P				Y
Bird	*Philemon corniculatus*	Noisy Friarbird	-	P	Y		Y	
Bird	*Phylidonyris nigra*	White-cheeked Honeyeater	-	P		Y		
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	-	P	Y			Y
Bird	*Grallina cyanoleuca*	Magpie-lark	-	P	Y	Y		
Bird	*Monarcha melanopsis*	Black-faced Monarch	-	P	Y	Y	Y	
Bird	*Myiagra cyanoleuca*	Satin Flycatcher	-	P		Y	Y	
Bird	*Myiagra rubecula*	Leaden Flycatcher	-	P		Y	Y	
Bird	*Turdus merula**	Eurasian Blackbird	-	U		Y		
Bird	*Daphoenositta chrysoptera*	Varied Sitella	-	P		Y		
Bird	*Oriolus sagittatus*	Olive-backed Oriole	-	P	Y			
Bird	*Colluricincla harmonica*	Grey Shrike-thrush	-	P		Y	Y	
Bird	*Falcunculus frontatus*	Crested Shrike-tit	-	P			Y	

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Bird	*Pachycephala pectoralis*	Golden Whistler	-	P	Y	Y	Y	Y
Bird	*Pachycephala rufiventris*	Rufous Whistler	-	P	Y	Y	Y	
Bird	*Pardalotus punctatus*	Spotted Pardalote	-	P	Y		Y	Y
Bird	*Pardalotus striatus*	Striated Pardalote	-	P		Y	Y	
Bird	*Lonchura punctulata*	Nutmeg Mannikin	-	U		Y		
Bird	*Passer domesticus**	House Sparrow	-	U	Y	Y	Y	
Bird	*Eopsaltria australis*	Eastern Yellow Robin	-	P	Y	Y	Y	Y
Bird	*Microeca leucophaea*	Jacky Winter	-	P	Y			
Bird	*Petroica rosea*	Rose Robin	-	P			Y	
Bird	*Podargus strigoides*	Tawny Frogmouth	-	P	Y	Y	Y	Y
Bird	*Tachybaptus novaehollandiae*	Australasian Grebe	-	P		Y		
Bird	*Alisterus scapularis*	Australian King-Parrot	-	P	Y	Y	Y	Y
Bird	*Platycercus elegans*	Crimson Rosella	-	P	Y	Y	Y	Y
Bird	*Platycercus eximius*	Eastern Rosella	-	P	Y	Y	Y	Y
Bird	*Trichoglossus chlorolepidotus*	Scaly-breasted Lorikeet	-	P	Y			
Bird	*Trichoglossus concinna*	Musk Lorikeet	-	P	Y			
Bird	*Trichoglossus haematodus*	Rainbow Lorikeet	-	P	Y	Y	Y	
Bird	*Psophodes olivaceus*	Eastern Whipbird	-	P	Y	Y	Y	Y
Bird	*Ptilinorhynchus violaceus*	Satin Bowerbird	-	P	Y		Y	
Bird	*Pycnonotus jocosus**	Red-whiskered Bulbul	-	U	Y	Y	Y	Y
Bird	*Gallinula tenebrosa*	Dusky Moorhen	-	P		Y		
Bird	*Rhipidura fuliginosa*	Grey Fantail	-	P	Y	Y	Y	Y
Bird	*Rhipidura leucophrys*	Willie Wagtail	-	P	Y	Y	Y	
Bird	*Rhipidura rufifrons*	Rufous Fantail	-	P	Y	Y	Y	
Bird	*Ninox boobook*	Southern Boobook	-	P	Y		Y	

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Bird	*Acridotheres tristis*	Common Myna	-	U	Y	Y	Y	Y
Bird	*Sturnus vulgaris*	Common Starling	-	U	Y	Y		
Bird	*Cisticola exilis*	Golden-headed Cisticola	-	P		Y		
Bird	*Zosterops lateralis*	Silvereye	-	P	Y	Y	Y	
Fish	*Anguilla australis*	Short-finned Eel	-		Y	Y		Y
Fish	*Anguilla reinhardtii*	Long-finned Eel	-		Y	Y		
Fish	*Carassius auratus*	Goldfish	-	U	Y	Y		
Fish	*Cyprinus carpio*	Common carp	-	U	Y	Y		
Fish	*Gobiomorphus australis*	Striped Gudgeon	-		Y	Y		
Fish	*Gobiomorphus coxii*	Cox Gudgeon	-		Y	Y		
Fish	*Hypseleotris compressus*	Empire Gudgeon	-		Y	Y		
Fish	*Hypseleotris galii*	Firetail Gudgeon	-		Y	Y		
Fish	*Philypnodon grandiceps*	Falthead Gudgeon	-		Y	Y		
Fish	*Galaxias maculatus*	Common Jollytail	-		Y	Y		
Fish	*Gambusia affinis*	Mosquito fish	-	U	Y	Y		Y
Fish	*Retropinna semoni*	Australian Smelt	-		Y	Y		
Frog	*Litoria aurea*	Green and Golden Bell Frog	V	E	Y	Y		
Frog	*Litoria caerulea*	Green Tree Frog	-	P	Y	Y		
Frog	*Litoria citropa*	Blue Mountain's Tree Frog	-	P	Y	Y	Y	
Frog	*Litoria dentata*	Bleating Tree Frog	-	P	Y	Y		
Frog	*Litoria fallax*	Dwarf Tree Frog	-	P	Y	Y		Y
Frog	*Litoria freycineti*	Freycinets Frog	-	P	Y	Y		
Frog	*Litoria peronii*	Peron's Tree Frog	-	P	Y	Y	Y	Y
Frog	*Litoria phyllochroa*	Leaf-green Tree Frog	-	P	Y	Y		Y

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Frog	*Litoria verreauxii*	Verreaux Tree Frog	-	P	Y	Y		
Frog	*Crinia signifera*	Common Eastern Froglet	-	P	Y	Y	Y	Y
Frog	*Limnodynastes dumerilii*	Eastern Banjo Frog	-	P	Y	Y		
Frog	*Limnodynastes peronii*	Striped Marsh Frog	-	P	Y	Y	Y	Y
Frog	*Limnodynastes tasmaniensis*	Spotted Grass Frog	-	P	Y	Y		
Frog	*Pseudophryne australis*	Red-crowned Toadlet	-	V	Y	Y	Y	
Frog	*Pseudophryne bibronii*	Brown Toadlet	-	P	Y	Y		
Mammal	*Vulpes vulpes**	Fox	-	U	Y	Y	Y	Y
Mammal	*Equus caballus*	Horse	-	U	Y	Y		
Mammal	*Felis catus**	Cat	-	U	Y	Y		
Mammal	*Oryctolagus cuniculus**	Rabbit	-	U	Y	Y	Y	
Mammal	*Tadarida australis*	White-striped Freetail-bat	-	P				Y
Mammal	*Mus musculus*	House Mouse	-	U	Y	Y		
Mammal	*Rattus fuscipes*	Bush Rat	-	P	Y	Y		
Mammal	*Rattus rattus**	Black Rat	-	U	Y	Y		
Mammal	*Perameles nasuta*	Long-nosed Bandicoot	-	P	Y	Y		Y
Mammal	*Petaurus breviceps*	Sugar Glider	-	P		Y		Y
Mammal	*Trichosurus vulpecula*	Common Brushtail Possum	-	P	Y	Y	Y	Y
Mammal	*Pseudocheirus peregrinus*	Common Ringtail Possum	-	P	Y	Y	Y	Y
Mammal	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	V	Y	Y	Y	Y
Mammal	*Tachyglossus aculeatus*	Short-beaked Echidna	-	P	Y	Y		Y
Mammal	*Chalinolobus gouldii*	Gould's Wattled Bat	-	P				Y
Mammal	*Chalinolobus morio*	Chocolate Wattled Bat	-	P				Y

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Mammal	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	-	V				
Mammal	*Vespadelus vulturnus*	Little Forest Bat	-	P				
Reptile	*Amphibolurus muricatus*	Jacky Lizard	-	P	Y	Y		
Reptile	*Physignathus lesueurii*	Eastern Water Dragon	-	P	Y	Y	Y	Y
Reptile	*Pogona barbata*	Bearded Dragon	-	P	Y	Y		
Reptile	*Morelia spilota*	Diamond Python	-	P	Y	Y		
Reptile	*Chelodina longicollis*	Long-necked Tortoise	-	P	Y	Y		
Reptile	*Boiga irregularis*	Brown Tree Snake	-	P	Y	Y		
Reptile	*Dendrelaphis puntulatus*	Green Tree Snake	-	P	Y	Y		
Reptile	*Acanthophis antarcticus*	Death Adder	-	P	Y	Y		
Reptile	*Cacophis squamulosus*	Golden-crowned Snake	-	P	Y	Y		Y
Reptile	*Furina diadema*	Red-naped Snake	-	P	Y	Y		
Reptile	*Hemiaspis signata*	Black-bellied Swamp Snake	-	P	Y	Y		
Reptile	*Notechis scutatus*	Tiger Snake	-	P	Y	Y		
Reptile	*Pseudechis porphyriacus*	Red-bellied Black Snake	-	P	Y	Y	Y	
Reptile	*Pseudonaja textilis*	Eastern Brown Snake	-	P	Y	Y		
Reptile	*Vermicella annulata*	Bandy Bandy	-	P	Y	Y		
Reptile	*Diplodactylus vittatus*	Wood Gecko	-	P	Y	Y		
Reptile	*Oedura lesueurii*	Lesueur's Velvet Gecko	-	P	Y	Y	Y	
Reptile	*Phyllurus platurus*	Broad-tailed Gecko	-	P	Y	Y	Y	Y
Reptile	*Underwoodisaurus millii*	Thick-tailed Gecko	-	P	Y	Y		
Reptile	*Lialis burtonis*	Burton's Snake-lizard	-	P	Y	Y		
Reptile	*Pygopus lepidopodus*	Common Scaly-foot	-	P	Y	Y		
Reptile	*Acritoscincus platynotum*	Red-throated Skink	-	P	Y	Y		

Type of animal	Scientific Name	Common Name	EPBC Act Status	Legal Status (NSW)	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current
Reptile	*Cryptoblepharus virgatus*	Fence Skink	-	P	Y	Y	Y	Y
Reptile	*Ctenotus robustus*	Eastern Striped Skink	-	P	Y	Y		
Reptile	*Ctenotus taeniolatus*	Copper-tailed Skink	-	P	Y	Y		Y
Reptile	*Egernia cunninghami*	Cunningham's Skink	-	P	Y	Y		
Reptile	*Egernia whitii*	White's Skink	-	P	Y	Y		
Reptile	*Eulamprus quoyii*	Eastern Water-skink	-	P	Y	Y	Y	Y
Reptile	*Lampropholis delicata*	Dark-flecked Garden Sunskink	-	P	Y	Y	Y	Y
Reptile	*Lampropholis guichenoti*	Pale-flecked Garden Sunskink	-	P			Y	Y
Reptile	*Lampropholis quichnoti*	Eastern Grass Skink	-	P	Y	Y	Y	Y
Reptile	*Saiphos equalis*	Three-toed Skink	-	P	Y	Y		Y
Reptile	*Saproscincus mustelina*	Weasel Skink	-	P	Y	Y		Y
Reptile	*Tiliqua scincoides*	Eastern Blue-tongued Lizard	-	P	Y	Y		
Reptile	*Ramphotyphlops nigrescens*	Blind Snake	-	P	Y	Y		
Reptile	*Varanus varius*	Lace Monitor	-	P	Y	Y		

Key to Symbols
P = Protected, E= Endangered, V= Vulnerable, Y = recorded during study

Appendix E

Site Photos

Photo 1 Concrete drainage channel and vegetation at Junction Road

Photo 2   Rock armoured batter slopes

Photo 3 ***Epacris purpurascens* beside the existing M2 Motorway within Bidjigal reserve**

Photo 4   Detention basin at Craig Avenue

Photo 5   Waterway crossing at Bidjigal Reserve

Photo 6 Vegetation near Livingstone Avenue

Photo 7 Stevenson Creek Bridge Vegetation Survey Site

Photo 8 Native vegetation within Bidjigal Reserve, beside the M2 Motorway

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Appendix F

Assessments of Significance

F.1 Threatened Species Conservation Act 1995 Assessments of Significance

The following species and communities are assessed below:

- Green and Golden Bell Frog *Litoria aurea*
- Red-crowned Toadlet *Pseudophryne australis*
- Regent Honeyeater *Anthochaera phrygia*
- Gang-gang Cockatoo *Callocephalon fimbriatum*
- Glossy Black-cockatoo *Calyptorhynchus lathami*
- Powerful Owl *Ninox strenua*
- Grey-headed Flying-fox *Pteropus poliocephalus*
- Insectivorous (microchiropteran) bats: Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*, Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*, Greater Broad-nosed Bat *Scoteanax rueppellii*, Large Footed Myotis *Myotis adversus*, Eastern Freetail Bat *Mormopterus norfolkensis* and Large-eared Pied Bat *Chalinolobus dwyeri*
- *Acacia bynoeana*
- Netted Bottle Brush *Callistemon linearifolius*
- *Darwinia biflora*
- *Epacris purpurascens ssp purpurascens*
- Hairy Geebung *Persoonia hirsuta*
- *Pimelea curviflora var. curviflora*
- Glandular Pink-bell *Tetratheca glandulosa*
- Blue Gum High Forest in the Sydney Basin Bioregion

F.1.1 FAUNA

F.1.2 Green and Golden Bell Frog *Litoria aurea*

The Green and Golden Bell Frog (GGBF) was once distributed along the coastal lowlands in NSW from approximately 50 kilometres south of the Queensland border to north-east Victoria. Since the 1970's the species has undergone a decline in its population and distribution.

This species was not recorded during targeted surveys within the M2 corridor.

The Green GGBF is listed as Endangered under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of the Green and Golden Bell Frog?

The proposed works would result in the removal of approximately 3 ha of vegetation for detention basin works and access roads. The detention basins within the M2 corridor contain an artificial assemblage of emergent native aquatic plants which were planted when the detention basins were constructed. Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface. It is unknown whether or not the Amphibian Chytrid Fungus is found in any of these basins but it is possible that it may have been introduced there by colonising frogs and therefore on tnis basis are unlikely to provide suitable breeding habitat for the GGBF. Detention basin works are being designed to favour the GGBF through revegetation works with emergent aquatic plant species. Due to the very small area of impact and the absence of important populations of GGBF in the study area, the M2 Upgrade is not likely to affect the lifecycle of the GGBF.

How is the proposal likely to affect the habitat of the Green and Golden Bell Frog?

Whilst the removal of approximately 3 ha of vegetation would occur for permanent access roads to new and existing detention basins, much of this is currently weedy regrowth from the original construction of the basins. Due to the propensity of the species to utilise recently disturbed habitat and its probable competitive interaction with other frog species, it is unclear whether such disturbance is likely to increase or decrease the area potentially occupied by the species.

Vegetation clearance around detention basins is likely to improve the potential of these areas as GGBF foraging habitat as the initially low, dense regrowth that is likely to result is likely to be more suitable for the species than much of the existing vegetation. Vegetation clearance here is also likely to increase light levels.

These works may alter the area of occupancy of potential breeding, foraging and shelter habitat of the GGBF temporarily due to an alteration to the environmental conditions such as water depth and light levels.

Detention basins would be planted with emergent native aquatic plant species.

The proposed works may result in the removal of vegetation from an area of up to approximately 20 ha of which approximately 3 ha would be subsequently rehabilitated post construction. While some of this area may be potential foraging habitat for this species, most of this area is marginal or unsuitable as habitat due to a lack of suitable vegetation cover, dry surface conditions and distance from potential breeding habitat.

Only the permanent clearing for widening works will permanently modify the potential area of occupancy of the species, but the areas affected are chiefly considered to be marginal as habitat for the species. Modification to other areas as a result of clearing for access may result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating and replanted vegetation begins to mature.

Due to the very small area of impact and the absence of important populations of GGBF in the study area, the extent of habitat to be removed or modified by the proposed M2 Upgrade is not likely to have a significant negative impact on the GGBF.

How is the proposal likely to affect habitat connectivity?

The GGBF is a relatively mobile frog species that forages and seeks shelter at distances of up to 1 km or more from breeding sites during favourable weather conditions. In doing so, individuals may move through and forage within highly cleared and fragmented landscapes. Major roads may act as barriers to the movement of the species particularly if walls and culverts limit access to ground-dwelling fauna. The existing M2 Motorway is currently a barrier to wildlife movement and the widening works will not increase the barrier significantly.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for the GGBF.

The following Key Threatening Processes (KTPs) are considered to contribute to the decline of the GGBF (DEC 2005):

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands,
- Clearing of native vegetation,
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis
- Predation by the European Red Fox, and
- Predation by the Plague Minnow (*Gambusia holbrooki*) (DEC 2005).

The increased road surface as a result of the works could further alter the natural flow regime of the waterways of the study area. The detention basin works proposed are being designed with capacity for the additional stormwater from the motorway.

The proposal would result in vegetation removal however this vegetation is considered to be largely unsuitable or marginal as habitat for the species. The regeneration and revegetation of disturbed areas post-construction are consistent with the aims of the recovery plan for the species.

With the use of equipment in wet environments in several locations within the M2 corridor, there is a risk that Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis* could be spread in wet mud. Chytridiomycosis caused by Amphibian Chytrid Fungus has been implicated in severe population declines and species extinctions of frogs in the past 20 years (DEH 2006). With the implementation of the proposed mitigation measures, this risk of spreading this disease to uninfected water bodies will be low.

The proposal is unlikely to affect the vegetation or otherwise affect habitat such that the European Red Fox would increase in abundance or in its impact on native species.

With the use of equipment in wet environments in several locations within the M2 corridor, there is a risk that juvenile Plague Minnow could be spread in wet mud. With the implementation of the proposed mitigation measures, the spread of this species is however unlikely.

The proposed works are not likely to modify the waterways of the study area in such a way as to encourage the proliferation of the Plague Minnow.

A draft recovery plan for the GGBF has been prepared (DEC 2005) and considers the conservation requirements of the species across its known range. Based on the above, the M2 Upgrade will be consistent with the Recovery Plan for the GGBF (DECC 2005).

Conclusion

Based on this assessment, a significant impact on a local population of the Green and Golden Bell Frog is unlikely.

F.1.3 Red-crowned Toadlet *Pseudophryne australis*

Red-crowned Toadlets are small frogs with a bright reddish-orange ‘triangular pattern on top of the head’. Mature specimens are usually around 20-25 mm in length. When mature, female are slightly larger than males (NPWS, 2001).

The Red-crowned Toadlet has a restricted distribution. It is confined to the Sydney Basin, from Pokolbin in the north, the Nowra area to the south, and west to Mt Victoria in the Blue Mountains (DEC, 2005).

The species occurs close to ridge-tops in open forests and inhabits periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings. Principle vegetation community occupied by this species is Sydney Sandstone Ridgetop Woodland (mainly dominated by *Corymbia gummifera* and *Eucalyptus haemostoma*) (NPWS, 2001).

Red-crowned Toadlets usually live in the vicinity of permanently moist soaks or areas of dense ground vegetation or leaf litter along or near head-water stream beds (NPWS, 2001). They prefer the first or second order ephemeral drainage lines and do not usually live along permanent flowing water courses occurring in gullies, instead preferring moist soaks or areas of dense ground vegetation or litter along headwater stream beds (NPWS, 2001).

Outside the breeding period, the frog shelters under sandstone ‘bush-rock’ and logs and amongst masses of dense vegetation or thick piles of leaf litter (NPWS, 2001). The Red-crowned Toadlet’s diet is believed to consist mainly of ants and termites, although they are likely to eat most small invertebrates when encountered.

The Red-crowned Toadlet is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of the Red-crowned Toadlet?

The Red-crowned Toadlet is confined to Hawkesbury Sandstone country of around Sydney and the NSW Central Coast. It has an unusual terrestrial reproductive strategy. Rather than spawn in water, the toadlet mates and spawns on moist leaf litter (NPWS, 2001). Small nests are found within decomposing, accumulated leaf matter and clutch sizes are small, consisting of around 20-24 large eggs (NPWS, 2001).

When not in breeding, Red-crowned Toadlets are thought to disperse over wider areas of its sandstone habitat, (i.e. into non-breeding areas) and many individuals have been observed sheltering under cover that would be unsuitable for egg-laying (NPWS, 2001). However, it is likely that such ‘dispersion’ is only in the order of tens of metres from suitable breeding areas (NPWS, 2001). Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat (NPWS, 2001).

Much of the area surrounding the M2 is highly urbanised consisting chiefly of residential properties, parkland, weed-infested areas and disturbed riparian vegetation. Although the Red-crowned Toadlet (*Pseudophryne australis*) was not recorded during current surveys within the M2 corridor, this species has been recorded between Wicks Road and Epping Road, North Ryde, adjacent to the M2 corridor (Eco Logical Australia, 2009 and Biosphere, 2007), and also at Nile Close, Marsfield. The North Ryde area is occupied by Transport Infrastructure Development Corporation (TIDC) and is currently proposed as a compound site for the M2 Upgrade. Monitoring of the population of Red-crowned Toadlets at the TIDC site has been recommended to assess the potential changes to persistence of the species during works carried out for the M2 site and was undertaken by Eco Logical Australia in 2009. The mitigation measures proposed for the M2 Upgrade project include targeted searches for this species during pre-clearance surveys for the construction phase to mimise impacts to any Red-crowned Toadlets occurring at this location.

The Red-crowned Toadlet's specialised terrestrial reproductive strategy and reliance on ephemeral water flows mean that the species may be particularly vulnerable to a range of activities that impact on hydrology or water quality. The increased road surface as a result of the works could further alter the natural flow regime of the creeks of the study area however the detention basin works are being designed with capacity for the additional stormwater from the Motorway.

As Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat, impacts to populations of Red-crowned Toadlets would occur if the proposed works are within favoured breeding or refuge sites. Much of the widening works are not are not in close proximity to breeding areas of the Red-crowned Toadlet and are considered to be at best, marginal as habitat for the species. As Red-crowned Toadlets are well represented in National Parks within Sydney it is not considered likely that a significant impact on the lifecycle such that a viable population of the species is likely to be placed at risk of extinction.

How is the proposal likely to affect the habitat of the Red-crowned Toadlet?

Permanent removal of vegetation would occur in areas occupied by the widened motorway.

The proposed works may result in the permanent removal of less than one hectare of marginal potential habitat for this species. This habitat consists of Coastal Sandstone Ridgetop Woodland and Coastal Sandstone Gully Forest located within a few hundred metres of ephemeral drainage lines on gully slopes. Additional areas of marginal potential foraging habitat (approximately 1 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

The proposed works may involve disturbance to such Red-crowned Toadlet habitat as a result of water quality effects and vegetation clearance and bush rock removal during the M2 upgrade works.

The M2 compound site occupied by TIDC has become weed infested (Eco Logical 2009). With the implementation of the mitigation measures proposed for the M2 Upgrade, such as exclusion of weed control measures at known Red-crowned Toadlet occupation sites, impacts to potential habitat for this species is unlikely.

Only the permanent clearing for the widening works is considered to permanently modify the potential area of occupancy of the species however these rocky outcrop areas are not within areas of permanent soaks or drainage lines. Preferred breeding habitat is not considered to be affected by the proposed M2 Upgrade works.

How is the proposal likely to affect habitat connectivity?

Although vegetation and some areas of bush rock would be removed during construction, abundant rock outcrops closer to potential breeding habitat is not considered likely to be affected. As the widening is alongside the existing motorway, vegetation fragmentation is not likely to be significantly increased.

How is the proposal likely to affect critical habitat?

No Critical habitat has been declared for the Red-crowned Toadlet.

The following Key Threatening Processes are considered to contribute to the decline of the Red-crowned Toadlet:

- Alteration to the natural flow regimes of watercourses
- Bush rock removal
- Clearing of habitat
- Increase of fires

The increased road surface as a result of the works could further alter the natural flow regime of the waterways of the study area however the proposed works proposed are being designed with capacity for the additional stormwater from the motorway.

Some areas of bushrock would be removed during construction however these areas are not likely to contain suitable breeding for the Red-crowned Toadlet due to their distance from permanent moist soaks and drainage lines.

The proposal would result in vegetation removal however this vegetation is considered to be largely unsuitable or marginal as habitat for the species. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating species and replanted vegetation begins to mature. With the implementation of the mitigation measures proposed for the M2 Upgrade such as establishment of habitat boundaries and erosion and sedimentation control works, impacts to Red-crowned Toadlet habitat at the TIDC compound site is unlikely.

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.

With the use of equipment in wet environments in several locations within the M2 Corridor, there is a risk that Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis* could be spread in wet mud. Chytridiomycosis caused by Amphibian Chytrid Fungus has been implicated in severe population declines and species extinctions of frogs in the past 20 years (DEH 2006). With the implementation of the proposed mitigation measures, this risk of spreading this disease to uninfected water bodies is considered to be low.

A recovery plan has not been prepared for the Red-crowned Toadlet.

Conclusion

Based on the above investigation, it is considered a significant impact on the Red-crowned Toadlet is unlikely.

F.1.4 Swift Parrot *Lathamus discolor*

The Swift Parrot breeds in Tasmania during spring and summer and migrates to eastern Australia in autumn and winter. The breeding population has declined from in excess of 10,000 pairs to less than 1,000 with only a fraction of this number occurring in NSW (DECC 2009).

On the mainland, Swift Parrots occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations (DECC 2009). Favoured feed trees include Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens* (DECC 2009). Commonly used lerp trees are Grey Box *E. microcarpa*, Grey Box *E. moluccana* and blackbutt *E. pilularis* (DECC 2009). Swift Parrots show little site fidelity between years (Mac Nally & Horrocks, 2000) and this is probably due to the random variation in lerp infestation and flowering of their feed trees.

How is the proposal likely to affect the lifecycle of the Swift Parrot?

As a wide-ranging, nomadic and migratory species that breeds in a localized area in Tasmania, all Swift Parrots are likely to comprise a single population with high levels of genetic mixing.

The Swift Parrot does not breed on mainland Australia. Therefore, the M2 Upgrade will not disrupt the breeding cycle of the Swift Parrot.

Given its wide range and lack of site fidelity, the localised works will not disrupt the migration patterns of the Swift Parrot.

How is the proposal likely to affect the habitat of the Swift Parrot?

Potential winter foraging habitat for the Swift Parrot consists of stands of trees containing winter-flowering eucalypt species and lerp-infested trees.

Eucalypt species usually have regular flowering seasons, though many also show a degree of variability in flowering patterns as a result of the age of plants, local environmental conditions and variation in rainfall and other environmental conditions between years (DEC 2004).

None of the dominant tree species within the bushland areas of the M2 corridor are primarily winter-flowering. One of the dominant or sub-dominant species throughout much of the bushland is Red Bloodwood *Corymbia gummifera* which chiefly flowers in February and March but also sporadically in late autumn and winter.

The original native vegetation at the western end of the M2 corridor may have contained winter-flowering eucalypts. None of this original vegetation remains here however revegetation along the edges of the M2 has involved the planting of some individuals of these species.

How is the proposal likely to affect habitat connectivity?

The Swift Parrot is a highly mobile, wide-ranging migratory species that forages within coastal and inland areas of eastern Australia. In doing so, individuals move through and forage within highly cleared and fragmented landscapes.

The relatively small amount of clearing proposed is not considered likely to significantly affect the species in the study area. As the widening is alongside the existing motorway, vegetation fragmentation and barrier effects are not likely to be significantly increased.

How is the proposal likely to affect critical habitat?

No Critical habitat has been declared for the Swift Parrot.

Threats to the Swift Parrot include:

- Clearing of habitat/habitat modification
- Collision with wire netting fences and cars during the breeding season

The proposal would result in vegetation removal however this vegetation is considered to be largely unsuitable or marginal as habitat for the species. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating species and replanted vegetation begins to mature. The extent of habitat to be removed or modified by the proposed M2 Upgrade is not considered significant in relation to areas of less-disturbed habitat in the locality. The proposed installation of nest boxes of a variety of designs would also provide habitat for hollow-dependant fauna such as the Swift Parrot.

A number of invasive fauna species exist within the study area. Of these, only the Noisy Miner *Manorina melanocephala* is considered to potentially affect the Swift Parrot. The Noisy Miner is an aggressive colonial native honeyeater that has increased in urban areas most likely as a result of alteration to vegetation structure and excludes many other bird species from potential foraging resources. The proposed works are not likely to modify habitats in the of the study area in a way that would lead to an increase in the Noisy Miner.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any additional invasive fauna species that may compete with, parasitise or prey upon the Swift Parrot.

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may be detrimental to potential habitat for the Swift Parrot. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is considered to be low.

The proposed works are not likely to further increase the risk of collision with cars as the existing M2 Motorway is not considered to be adjacent to suitable foraging habitat.

A recovery plan has been prepared for the Swift Parrot (DPI, 2001). The mitigation measures proposed are consistent with the actions in the recovery plan.

Conclusion

Based on the above investigation, it is unlikely to have a significant impact on the Swift Parrot.

F.1.5 Regent Honeyeater *Anthochaera phrygia*

The Regent Honeyeater is a generalist forager on the nectar of eucalypts and mistletoes (DECCW, 2009). Key eucalypt species include Mugga Ironbark (*Eucalyptus sideroxylon*), Yellow Box (*E. melliodora*), Blakely's Red Gum (*E. blakelyi*), White Box (*E. albens*) and Swamp Mahogany (*E. robusta*) but the Regent Honeyeater also utilises *E. microcarpa, E. punctata, E. polyanthemos, E. moluccana, Corymbia robusta, E. crebra, E. caleyi, Corymbia maculata, E.mckieana, E. macrorhyncha, E. laevopinea*, and *Angophora floribunda* (DECCW, 2009). Nectar and fruit from the Mistletoes (*Amyema miquelii, A. pendula and A. cambagei*) are also eaten during the breeding season (DECCW, 2009). When nectar is scarce, lerp and honeydew comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings. A shrubby understorey is an important source of insects and nesting material (DECCW, 2009).

The Regent Honeyeater generally inhabits dry, temperate woodlands and open forests of the inland slopes of south-eastern Australia (DECCW, 2009). There are only three known major breeding locations and two of these occur in NSW. In NSW the distribution is very patchy and largely confined to Capertee Valley and in the Bundarro-Barraba region and surrounding fragmented woodlands (DECCW, 2009).

Regent Honeyeaters sometimes occur in coastal forest, especially in stands dominated by Swamp Mahogany and Spotted Gum, but also on sandstone ranges with banksias (*Banksia* spp.) in the understorey (DEWHA 2009a). The species is occasionally observed in a variety of other vegetation types including low open forest on coastal scrub or heathland dominated by Banksia and Leptospermum species. It is possible that these habitats are used predominantly as a refuge when the preferred box-ironbark habitats are affected by drought (Menkhorst et al. 1999).

The Regent Honeyeater is listed as Endangered under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of the Regent Honeyeater?

Breeding of the species has not been recorded in the Sydney area and breeding of the species in the vicinity of the M2 Corridor is considered highly unlikely. The population of Regent Honeyeater in Victoria and NSW is patchy, with little information available on the movement patterns of this highly mobile species (DEWHA, 2009). Given the low likelihood of the species breeding in the locality and the small extent of impact on potential foraging habitat (such as specimens of *E.gummifera*), the M2 Upgrade is not considered likely to significantly disrupt the breeding cycle of the population of the Regent Honeyeater.

How is the proposal likely to affect the habitat of the Regent Honeyeater?

The proposed works may result in the permanent removal of up to approximately 7 ha of native vegetation considered to be marginal potential foraging habitat for this species.

Areas of marginal potential foraging habitat (approximately 3 ha) would be modified through temporary clearing for access areas and compound sites. This may result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

How is the proposal likely to affect habitat connectivity?

The Regent Honeyeater is a highly mobile, wide-ranging species that moves considerable distances between breeding areas and temporarily variable food resources. In doing so, individuals move through and forage within highly cleared and fragmented landscapes. The relatively small amount of clearing proposed is not considered likely to significantly affect this species.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for the Regent Honeyeater.

The following Key Threatening Processes are considered to contribute to the decline of the Regent Honeyeater and are relevant to the M2 Upgrade:

- Fragmentation and degradation of habitat
- Loss of key habitat trees and remnant woodlands
- Suppression of natural regeneration of overstorey tree species and shrub species
- As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased.

A reduction in available foraging habitat in the short-term will occur but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Conclusion

Based on the above investigation, a significant impact on the Regent Honeyeater is unlikely.

F.1.6 Gang-gang Cockatoo *Callocephalon fimbriatum* and Gang-gang Cockatoo *Callocephalon fimbriatum* population in the Hornsby and Kur-ing-gai Local Government Areas

In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes (DECCW, 2009).

In summer, Gang-gangs are generally found in tall mountain forests and woodlands, particularly heavily timbered and mature wet sclerophyll areas (DECCW, 2009). They move to lower altitudes in winter to drier, more open eucalypt forests and woodlands, including urban areas. Gang-gangs favour old growth, hollow-bearing trees for nesting and roosting (DECCW, 2006). Preferred breeding habitat is in hollows >10 cm in diameter and > 9m above the ground in eucalypts.

A population of Gang-gang Cockatoos persists in the Hornsby and Kur-ing-gai Local Government Areas and is listed as an endangered population under the TSC Act.

This endangered population is believed to be largely confined to an area bounded by Thornleigh and Wahroonga in the north, Epping and North Epping in the south, Beecroft and Cheltenham in the west and Turramurra/South Turramurra to the east (DECCW, 2009). The population encompasses, but is not restricted to, Pennant Hills Park and parts of Lane Cove National Park. Individual birds are likely on occasion to move across the population boundary and should still be considered as part of this population (Scientific Committee, 2008).

The Hornsby and Kuring-gai population is significant as it is the last known breeding population in the Sydney Metropolitan area. Current estimates of the population size are to be between 18 - 40 pairs (DECCW, 2009). The species shows strong nest site fidelity (NSW Scientific Committee, 2008).

The Gang-gang is listed as vulnerable in NSW under the TSC Act. The Gang-gang Cockatoo *Callocephalon fimbriatum* population in the Hornsby and Kur-ing-gai Local Government Areas is listed as an endangered population under the TSC Act.

How is the proposal likely to affect the lifecycle of the Gang-gang Cockatoo?

The Gang-gang Cockatoo was recorded during the current study flying overhead in the vicinity of the Terry Creek overpass near Crimea Road on the border of Epping and Marsfield.

Given the proximity of the existing motorway to the vegetation that would be affected, it is unlikely that sites used for breeding by this species would be affected.

Based on the above, the proposed M2 Upgrade works is not considered likely to have a significant adverse effect on lifecycle of the species and a viable local population is unlikely to be placed at risk of extinction.

How is the proposal likely to affect the habitat of the Gang-gang Cockatoo?

Loss of habitat, particularly core food and breeding trees, continues to be a major threat to the population (NSW Scientific Committee, 2008).

Although potential foraging habitat for the Hornsby and Kuring-gai population may be removed, it is not considered likely that breeding habitat will be significantly affected

Habitat for the species exists within the older, more intact stands of vegetation occurring within the study area.

Approximately 7 ha (predominantly native vegetation) of potential habitat for this species may be permanently lost. Much of this area is marginal as habitat for the species due to a lack of mature trees which provide abundant food and dominance of the understorey by introduced species. A significant reduction in the area of occupancy of this population is considered unlikely. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Potential nesting hollows for the species are not known or considered likely to be abundant in the area affected by the proposed M2 Upgrade.

The density of mature, potentially hollow-bearing, trees within the M2 corridor is lower than would be expected to occur in undisturbed forest. Previous land use activities such as timber-getting and forestry (e.g. in the former Darling Mills State Forest) and clearing for infrastructure and residential development are likely to have reduced the local abundance of tree hollows.

No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed. The majority of the trees to be removed are relatively small due to low nutrient and low moisture soils, previous clearing for the existing motorway and the logging history of the area.

Large and medium-sized tree hollows are likely to exist within the larger, more mature trees particularly in mature *Eucalyptus pilularis* (Blackbutt). These larger trees are chiefly found on lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material that are not considered likely to be affected by the proposed works.

While it is considered that potential foraging habitat for the Gang-gang Cockatoo will be removed by the proposed M2 upgrade, greater areas of suitable foraging habitat exist in the surrounding bushland areas. The more intact bushland areas of the sandstone valleys are likely to have the greatest importance as foraging habitat for this species. These are located beyond the study area particularly within Bidjigal Reserve and Lane Cove National Park. Therefore, habitat for the Hornsby and Kur-ing-gai Local Government Areas population is considered unlikely to be significantly affected by the proposed works.

The minimisation of vegetation clearing and post-construction vegetation rehabilitation targeted at creating appropriate foraging and sheltering habitat would minimise the extent of negative impact on potential habitat for the species.

The proposed installation of nest boxes of a variety of designs would also provide habitat for hollow-dependant fauna such as the Gang-gang Cockatoo.

How is the proposal likely to affect habitat connectivity?

Foraging habitat for the Gang-gang Cockatoo occurs throughout the study area. Much of the original vegetation of the study area has been cleared for residential development and road construction. This has resulted in fragmentation of the remaining vegetation. As the widening is alongside the existing Motorway, vegetation fragmentation is not likely to be significantly increased.

Much of the potential habitat to be removed is only likely to be used by this species as foraging habitat. Due to its mobility, the Gang-gang Cockatoo is not likely to be significantly affected as large areas of similar habitat exist in the local area. These areas are likely to contain the core foraging and breeding habitat for the species in the locality.

How is the proposal likely to affect critical habitat?

No Critical habitat has been declared for the Gang-gang Cockatoo.

The following Key Threatening Processes are considered to contribute to the decline of the Gang-gang Cockatoo:

- Urban development resulting in clearing of forest and woodland habitat
- Loss of nesting trees from clearing and frequent fire
- Ongoing disturbance to nesting and roosting sites
- Predation be cats

While it is considered that potential foraging habitat for the Gang-gang Cockatoo will be removed by the proposed M2 upgrade, greater areas of suitable foraging habitat exist in the surrounding bushland areas.

No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed.

The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral cats would be likely to increase in abundance or in their impact on native species.

Conclusion

Native vegetation would be cleared for the project however the impact of this clearing on the Gang Gang Cockatoo is not likely to have a significant impact on the local occurrence of the species. It is considered a significant impact on the Gang-gang Cockatoo is unlikely.

F.1.7 Glossy Black-cockatoo *Calyptorhynchus lathami*

The Glossy Black-cockatoo inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 m in which stands of She-oak species, particularly Black She-oak (*Allocasuarina littoralis),* Forest She-oak (*A. torulosa*) or Drooping She-oak (*A. verticillata*) occur. For breeding, this species is dependent on large hollow-bearing eucalypts as nest sites (DEC 2005). Adults only breed during the autumn and winter (NPWS, 1999). The species is usually recorded in family parties of seldom more than 10 (DEC, 1999). The species is locally nomadic and small flocks roam in search of feeding areas and roost communally (DEC, 1999). The Glossy Black-cockatoo is probably the most specialised member of its family feeding exclusively on seeds extracted from the wooden cones of casuarinas (she-oaks).

The Glossy Black-cockatoo is listed as vulnerable under the TSC Act.

How is the proposal likely to affect the lifecycle of the Glossy Black-cockatoo?

The Glossy Black Cockatoo was not recorded within the study area during current surveys within the M2 corridor although this species has been previously recorded within the locality (DECCW, 2009).

Casuarina and Allocasuarina species within the M2 corridor are not mature enough to provide suitable feeding habitat for the Glossy Black-cockatoo. These species chiefly occur as stands of regrowth amongst disturbed riparian areas or are not considered to be present in enough numbers to support small flocks.

No large tree hollows or trees of sufficient size to support large hollows were observed within the M2 corridor. Whilst the Glossy Black-cockatoo may use the study area on a sporadic basis it is not considered likely that suitable breeding habitat exists within the M2 corridor.

The proposed activity is not likely to significantly affect the life cycle of the Glossy Black-cockatoo.

How is the proposal likely to affect the habitat of the Glossy Black-cockatoo?

Permanent removal of vegetation would occur in areas occupied by the widened Motorway.

The proposed works may result in the permanent removal of up to 7 ha of potential foraging habitat for this species. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

The habitat affected by the proposed works is of marginal quality due to previous clearing, weed invasion and other forms of disturbance. Most of the trees removed are immature or semi-mature and are likely to contain chiefly small to medium-sized hollows that are potential habitat for smaller species of birds and mammals.

Large and medium-sized tree hollows that are likely to provide suitable nesting sites are more likely to occur within the larger, more mature trees, particularly in mature *Eucalyptus pilularis* (Blackbutt) beyond the study area. These larger trees are chiefly found on lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material that are not considered likely to be affected by the proposed works.

Due to the lack of suitable roosting and foraging habitat within the M2 corridor, this area is considered to be of relatively low value as potential habitat for this species when compared to larger areas of vegetation at greater distance from the M2 Motorway.

The small increase in the distance between vegetated areas on either side of the Motorway created through the widening works is considered unlikely to have a significant impact on the ability of the species to move between potential habitats in the locality and further afield.

How is the proposal likely to affect habitat connectivity?

These birds are all highly mobile species and as the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased.

Modification to areas as a result of vegetation clearance will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although vegetation removal will occur, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for the Glossy Black-cockatoo.

The following key threatening processes are known or considered likely to be affecting the habitat of these species in the study area.

- Clearing of native vegetation
- Removal of hollow-bearing trees
- Competition from feral honeybees

Due to the vegetation clearing involved the proposed works would contribute to the clearing of native vegetation. Given the small extent of clearing and the proposed weed control and revegetation measures, the contribution of the proposed works to the operation of these processes is considered to be minor and is not considered likely to significantly affect populations of this species.

No large tree hollows or trees of sufficient size to support large hollows were observed within the M2 corridor. Post-construction vegetation rehabilitation targeted at creating appropriate foraging and sheltering habitat would minimise the extent of negative impact on potential habitat for the species.

The proposed works are not considered likely to result to increase the effects of competition from feral honeybees.

Conclusion

Based on the above assessment, it is not considered likely that the proposed works will have a significant impact on the Glossy Black-cockatoo.

F.1.8 Powerful Owl *Ninox strenua*

The Powerful Owl is the largest owl in Australasia, reaching 60 cm in length and with a wingspan of 140 cm required to lift its 1.45 kg bulk (DEC, 2006). It is a typical hawk-owl, in that it lacks the facial-disc of the *Tyto* owls. The deep, resonant double hoot of the Powerful Owl can be heard throughout the year, however calling peaks in the winter breeding season (DEC, 2006).

The Powerful Owl is endemic to eastern Australia, mainly on the coastal side of the Great Dividing Range (DEC, 2006). In NSW, it is widely distributed throughout the eastern forests from the coast to the tablelands (DEC, 2006). Records on the western slopes and plains are mostly historical suggesting populations in that region are on the verge of extinction.

The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well (DECCW, 2009). The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation.

Pairs of Powerful Owls are believed to have high fidelity to a small number of hollow-bearing nest trees and will defend a large home range of 400-1450 ha. Powerful Owls nest in large tree hollows (at least 0.5 m deep), in large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old (DECCW, 2009) and some of their prey species also rely on tree hollows for refuge.

Powerful Owls perch in the top one-third of roost trees but decrease their perch height with increasing temperature (and *vice versa*) suggesting that structurally heterogeneous habitat is fundamental for the species persistence in an area (Cooke *et al.* 2002).

The main prey items are medium-sized arboreal marsupials, particularly the Greater Glider, Common Ringtail Possum and Sugar Glider. There may be marked regional differences in the prey taken by Powerful Owls. For example in southern NSW, Ringtail Possum make up the bulk of prey in the lowland or coastal habitat.

The Powerful Owl is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of the Powerful Owl?

The proposed activity is not considered likely to adversely affect potential breeding habitat for this species as the vegetation clearance is of a small extent when compared to the relatively large home range of these species. No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed. The majority of the trees to be removed are relatively small due to low nutrient and low moisture soils, previous clearing for the existing motorway and the logging history of the area.

Given the large home range of individuals and breeding pairs of this species, it is likely that the entire bushland area surrounding the motorway is within the home range of one or two breeding pairs. Given the proximity of the existing motorway to the vegetation that would be affected, it is considered unlikely that sites used for breeding by this species would be affected.

The likely ability of the owls to disperse over tens of kilometres through a mosaic of forested and cleared land suggests that there are unlikely to be any barriers to gene flow within NSW (DEC, 2006). Given the relatively small amount of potential habitat that would be affected, and the lack of mature size hollow bearing trees, the M2 Upgrade is not likely to significantly disrupt the breeding cycle of the Powerful Owl.

No other element of relevance to the lifecycle of this species is likely to be affected such that a viable local population of these species is likely to be placed at risk of extinction.

How is the proposal likely to affect the habitat of the Powerful Owl?

Permanent removal of vegetation would occur in areas occupied by the widened motorway.

The proposed works may result in the permanent removal of up to 7 ha of potential roosting and foraging habitat for this species. Additional areas of potential roosting and foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Permanent occupation of currently vegetated areas by the widened motorway would result in a reduction in available foraging and roosting habitat. Although vegetation will be removed, the Powerful Owl is also likely to hunt and roost throughout the bushland of the study area and contiguous areas of bushland in the locality.

Large and medium-sized tree hollows are likely to exist within the larger, more mature trees, particularly in mature *Eucalyptus pilularis* (Blackbutt). These larger trees are chiefly found on lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material that are not considered likely to be affected by the proposed works.

Optimal habitat for the Powerful Owl which includes a tall shrub layer and abundant hollows supporting high densities of arboreal marsupials was not found to be within the areas of permanent vegetation removal. The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

How is the proposal likely to affect habitat connectivity?

The small increase in the distance between vegetated areas on either side of the motorway created through the widening works is considered unlikely to have a significant impact on the ability of the species to move between potential habitats in the locality and further afield.

Proposed environmental management measures including the minimisation of the clearing of mature vegetation and the regeneration and revegetation of disturbed areas post-construction are considered to be consistent with the aims of the recovery plan for the species.

How is the proposal likely to affect critical habitat?

The habitat found in the study area or subject site is not listed as critical habitat.

Key threatening processes considered to contribute to the decline of the Powerful Owl include:

- Fragmentation of suitable forest and woodland habitat from land clearing
- Disturbance during breeding period
- High frequency hazard reduction burning
- Predation by foxes, dogs and cats

No tree hollows of sufficient size to provide nesting opportunities for larger species, such as the Powerful Owl, were observed within the areas potentially affected by clearing activities.

Most of the trees removed are immature or semi-mature and are likely to contain chiefly small to medium-sized hollows that are potential habitat for smaller species of birds and mammals. These trees also have the potential to develop hollows as they mature, providing opportunities for populations of hollow-dependent fauna to recover.

Disturbances such as noise during the breeding period (late summer to mid-autumn) have the potential to affect breeding success however these are considered to be temporary during the construction phase only.

The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral animals would be likely to increase in abundance or in their impact on native species.

Conclusion

Based on the above investigation, a significant impact on the Powerful Owl is unlikely.

F. 1.9 Grey-headed Flying-fox *Pteropus poliocephalus*

The Grey-headed Flying-fox is distributed in a coastal belt from south-eastern Queensland to Melbourne, Victoria and is infrequently found west of the Great Dividing Range (Tidemann 1998). The species is highly mobile and the distribution of the national population varies within the species range with groups of bats moving up and down the east coast in response to seasonal food availability (Menkhorst 1995; Tidemann 1998).

Studies have indicated that there appears to be a single interbreeding population, with constant genetic exchange and movement between camps throughout the entire geographic range of the species. Bats commute daily between roosting sites (camps) and feeding areas which are usually located within 15 kilometres of camp sites (Tidemann 1998).

Roost sites are typically located near water, such as lakes, rivers or the coast and vegetation often consists of rainforest patches, paperbark forest, mangroves and riparian vegetation though colonies also use highly modified vegetation in urban and suburban areas (DEWHA 2009a).

The closest known camp site to the study area is in the Ku-ring-gai Flying-fox Reserve in Gordon which is located approximately 4 to 15 kilometres from the M2 Corridor. The population size of the Ku-ring-gai Flying-fox Reserve camp varies with an average of approximately 30,000 individuals. Two other flying-fox camps are known in the Sydney region, at Cabramatta Creek and in the Sydney Royal Botanic Gardens.

The Grey-headed Flying-fox was recorded flying overhead in several locations during field surveys and was recorded feeding in mature flowering Blackbutt *Eucalyptus pilularis* within the M2 Corridor near Bidjigal Reserve. Individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon.

The Grey-headed Flying-fox is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of the Grey-headed Flying-fox?

Critical phases of the life-cycle, including court-ship, mating, and raising of young all occur in the colonies or camps. The study area does not contain any camp sites for the Grey-headed Flying-fox. Therefore, the M2 Upgrade will not impact on the life cycle of the species.

How is the proposal likely to affect the habitat of the Grey-headed Flying-fox?

The proposed works may result in the permanent removal of up to approximately 7 ha of known and potential foraging habitat for this species. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

The Grey-headed Flying Fox forages in larger areas of similar habitat throughout the Sydney Metropolitan area therefore the extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

How is the proposal likely to affect habitat connectivity?

The Grey-headed Flying-fox is a highly mobile, wide-ranging species that forages at distances of up to 15 km or more from roost sites during a single evening. In doing so, individuals move through and forage within highly cleared and fragmented landscapes. The existing M2 Motorway is currently a barrier to wildlife movement therefore the widening works will not significantly increase the barrier to any significant degree. It is not likely to significantly affect the subset of the population of the species that utilises the study area.

How is the proposal likely to affect critical habitat?

No Critical habitat has been declared for the Grey-headed Flying-fox as it is not listed on Schedule 1 of the TSC Act.

The following Key Threatening Processes are considered contribute to the decline of the Grey-headed Flying-Fox and are relevant to the M2 Upgrade:

- Loss of foraging habitat
- Disturbance of roosting sites

The Grey-headed Flying-Fox is a highly mobile species that forages throughout the Sydney Metropolitan area. As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased.

The M2 Upgrade will not impact upon known roost camps for this species.

Conclusion

Based on the above investigation, a significant impact on a local population of the Grey-headed Flying-fox is unlikely.

F.1.10 Insectivorous (microchiropteran) bats

- Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*
- Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*
- Greater Broad-nosed Bat *Scoteanax rueppellii*
- Large Footed Myotis *Myotis adversus*
- Eastern Freetail Bat *Mormopterus norfolkensis*
- Large-eared Pied Bat *Chalinolobus dwyeri*

Eastern Bentwing-bat

Eastern Bent-wing Bats occur along the east and north-west coasts of Australia. Caves provide their primary roosting habitat, but the species also inhabits derelict mines, storm-water tunnels, buildings and other man-made structures. They form discrete populations centred on maternity caves which have very specific temperature and humidity regimes. During the remaining part of the year, populations disperse within a 300 kilometre range of maternity caves. Breeding or roosting colonies can number from 100-50,000 individuals. This bat hunts in forested areas, above the tree tops (DEC, 2005).

Yellow-bellied Sheathtail

The Yellow-Bellied Sheathtail Bat occurs throughout tropical Australia with many records extending into south-eastern Australia (Churchill, 1998). In the most southerly part of its range - most of Victoria, south-western New South Wales (NSW) and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes (DEC, 2005). Most records reported between January and June (Churchill, 1998). The Yellow-Bellied Sheathtail Bat is found in a variety of habitats from wet and dry sclerophyll forests to open woodland, *Acacia* scrubland, mallee, grasslands and deserts. It forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. This species roosts singly or in groups of up to six in tree-hollows, and abandoned nests of Sugar Gliders and occasionally hanging from the outside walls of buildings in broad daylight (Churchill, 1998). In treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country (DEC, 2005).

Greater Broad-nosed Bat

The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In New South Wales (NSW) the bat is widespread on the New England Tablelands, however does not occur at altitudes above 500 metres (except in the very north of its range, where it has been recorded at 780 metres (Churchill, 1998). This species utilises a variety of habitats from dry woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although usually roosting in tree hollows and branches, it has also been found in buildings. (DEC, 2005).

The Greater Broad-nosed Bat consumes beetles and other large, slow-flying insects after sunset. It has also been known to eat small bat species, including the threatened Little Bent-wing Bat *Miniopterus australis*. (DEC, 2005). It will also feed on ground beetles that are 'hawked' within 20 metres of the ground along rows of trees which line creeks and small rivers and the edges of patches of woodland in otherwise cleared paddocks (Churchill, 1998).

Large footed Myotis

This species has been recorded in mangroves, paperbark swamps and in a range of forest and woodland habitats (Churchill 1998). Large-footed Myotis are cave dwellers but are also known to roost in tree hollows, under bridges, in clumps of vegetation and in mine tunnels and stormwater drains (Menkhorst & Knight 2001; Churchill 1998). Roosts are usually in close proximity to water over which the bats forage. The large feet and hind claws are used to rake the water surface for insects and small fish, and Large-footed Myotis are known to forage in small groups of three or four (Churchill 1998). This species is also capable of foraging aerially (Menkhorst & Knight 2001).

Eastern Freetail Bat

The East Coast Freetail-bat occurs from southeast Queensland to Bateman's Bay on the south coast of NSW and east of the Great Dividing Range (NPWS Wildlife Atlas; NPWS 2000a). There is a paucity of information concerning the species' general biology and ecological requirements and there has been limited research regarding the species dietary requirements and reproductive biology (Churchill 1998; Duncan *et al* 1999). Its preferred habitat is dry sclerophyll forest and woodlands (Alison & Hoye 1995; NPWS 1994) where it utilises the forest canopy and edges for foraging and roosts in tree-hollows (Churchill 1998; Duncan *et al* 1999).

Large-eared Pied Bat

The Large-eared Pied Bat is found from south-eastern Queensland (Rockhampton) to New South Wales (NSW) (south to Bungonia), from the coast to the western slopes of the Divide. There are scattered records from the New England Tablelands and North West Slopes. The NSW distribution is generally rare and very patchy, with the species found predominantly in areas with extensive cliffs and caves.

The Large-eared Pied Bat remains loyal to the same maternity cave over many years. (Churchill1998). It is not known whether this species ever utilises tree hollows as roosting habitat (Environment Australia, 1999). It has been speculated (Churchill, 1998) that this species may also utilise tree hollows for roosting though the use of tree hollows by the species has not been reported. Although few details are currently known, it probably forages for small, flying insects, below the forest canopy (Churchill, 1998).

It roosts in caves and mines, crevices in cliffs, and in the disused, bottle-shaped mud nests of the Fairy Martin (*Hirundo ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. It roosts in colonies of 3-37, clustered in indentations in the ceiling, most commonly in the twilight areas of the caves, close to the entrance. Maternity caves are found in well-timbered areas containing gullies.

There are three records of this species on the Atlas of NSW Wildlife database within 10 km of the Motorway.

How is the proposal likely to affect the lifecycle of the threatened species?

The proposed activity is not likely to have a significant adverse effect potential breeding habitat of these species as:

- The vegetation clearance is of a small extent when compared to the relatively large home ranges of several of these species,
- Several of these species also use other types of habitat as sheltering sites such as bark, rock crevices and fallen timber in addition to tree hollows,
- Most of the semi-mature trees that would be removed are not considered likely to provide an abundant source of tree hollows.
- The small water bodies (detention basins) and streams within the study area are not considered to constitute high quality foraging habitat for the Large-footed Myotis due to the scarcity of pools of open water over which the species can readily forage.
- No cave habitat that may be suitable as breeding habitat would be affected by the project.
- Whilst it is unknown if the subject site is occupied by the Large-eared Pied Bat, the paucity of records in the sandstone valleys of the area and the marginal quality of the potential roosting habitat present indicates that the study area is unlikely to support an important population of the species.

No other element of relevance the lifecycles of these species is likely to be affected such that a viable local population of any of these species is likely to be placed at risk of extinction.

How is the proposal likely to affect the habitat of the threatened species?

Permanent removal of vegetation would occur in areas occupied by the widened motorway.

The proposed works may result in the permanent removal of up to 7 ha of potential roosting and foraging habitat for these species.

Additional areas of potential roosting and foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites. Although vegetation would be removed in these temporary clearing areas, upon completion of works, vegetation will be re-established. Although this vegetation may be of different structure and composition to that currently present, is likely to provide similar potential as foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat as these species are high speed aerial foragers that feed in open air spaces.

The study area does not contain any caves, or mines near or above water and is consequently unlikely to provide preferred roosting or maternity sites for the Large-footed Myotis. Preferred habitat for the Greater Broad-nosed Bat is likely to be found lower within moister valleys of the locality rater than the upper slope areas in which motorway is chiefly located.

The extent of already disturbed habitat to be removed or modified by the proposed M2 upgrade is not considered significant in relation to areas of less-disturbed habitat in the locality.

The core likely foraging habitat for threatened microbats in the locality is concentrated in the larger areas of more mature vegetation that would not be substantially affected by the proposed works. The habitat affected by the proposed works is of marginal quality due to previous clearing, weed invasion and other forms of disturbance such as artificial lighting and traffic noise. Due to the lack of suitable roosting habitat, and disturbance, this area is considered to be of relatively low value as potential habitat for this species when compared to larger areas of vegetation at greater distance from the motorway.

Potential roosting habitat for the Large-eared Pied Bat is considered to be present in steep areas containing rock outcrops within the bushland valleys of the region, chiefly in the vicinity of the Darling Mills Creek crossing adjacent to Bidjigal Reserve, North Rocks. Potential foraging habitat is considered to exist within larger areas of native vegetation within a few kilometres of these areas. One large rock does contain a relatively deep, darkened cavity, but this area is near ground level and would likely provide easy access to potential predators. These overhangs are thus considered to be marginal as roosting habitat for cave-dwelling bats.

How is the proposal likely to affect habitat connectivity?

The microbat species listed are highly mobile species that are able to forage in fragmented landscapes including urban areas where these contain patches of native vegetation. The proposed works would not fragment forested areas or significantly increase their isolation from one another or other patches of potential habitat in the local area for mobile species such as microbats.

Microbats in general are highly mobile species that are capable of utilising modified landscapes including artificial breaks in woodland and forest for foraging activities (Churchill, 1998). Whilst it is unknown to what extent the Large-eared Pied Bat is capable of tolerating habitat fragmentation, the relatively small amount of clearing proposed and the barrier created by the existing M2 Motorway is unlikely to increase habitat fragmentation.

How is the proposal likely to affect critical habitat?

The habitat found in the study area or subject site is not listed as critical habitat (DECCW, 2008) for any threatened species.

Key threatening process considered to contribute to a decline in microbat species include:

- Clearing and isolation of forest and woodland habitats near cliffs and caves
- Loss of foraging habitat
- Damage to roosting and nesting sites
- Application of pesticides in or adjacent to foraging areas

Permanent removal of vegetation would occur in areas occupied by the widened motorway.

The proposed works may result in the permanent removal of up to 7 ha of potential roosting and foraging habitat for these species. Although vegetation would be removed, upon completion of works, vegetation will be re-established. The proposed works would not fragment forested areas or significantly increase their isolation from one another or other patches of potential habitat in the local area for mobile species such as microbats.

The core likely foraging habitat for threatened microbats in the locality is concentrated in the larger areas of more mature vegetation that would not be substantially affected by the proposed works.

Conclusion

Based on the above investigation, significant impacts on threatened microbat species are unlikely to occur as a result of the project.

F.1.11 FLORA

F.1.12 *Acacia bynoeana*

Acacia bynoeana occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leafed Apple.

Found in central eastern NSW, from the Hunter District (Morisset), south to the Southern Highlands and west to the Blue Mountains.

It is known from 30 locations and typically only 1-5 individuals occur at each site. A few sites contain 30-50 individuals. The total population is estimated to be only a few hundred plants (DEWHA 2009a).

Records of this species in the vicinity of the M2 corridor are chiefly to the north in the Baulkham Hills and Ku-ring-gai LGAs (NPWS 2009). The closest records are within 2 km of the M2 corridor in the east in Gordon and in the west near the northern boundary of Bidjigal Reserve (NPWS 2009).

Acacia bynoeana is listed as Endangered under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of *Acacia bynoeana*?

At most recorded sites, this species occurs in low numbers. It is not known how many individuals of this species (if any) occur within the M2 corridor though it is considered unlikely that a large population would exist here as the species has not been located here. It is considered unlikely that any population here would be considered a key source population either for breeding or dispersal as the potential habitat here is isolated from habitat containing known populations in the region as a result of urban development.

It is also considered unlikely that any population here is likely to be genetically distinct from other populations in the region or to be necessary for maintaining genetic diversity of the species as a whole.

The potential habitat for this species within the M2 corridor is not at the limit of the species known distribution as the species is distributed to the north, west and south of the locality on the outskirts of the Sydney metropolitan area and beyond. The species was not recorded during flora surveys within the M2 Corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor.

The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.

How is the proposal likely to affect the habitat of *Acacia bynoeana*?

Whilst the proposed works may modify, destroy, remove or isolate or decrease the availability or quality of habitat for this species, the extent of such impact on the species (should it occur) is likely to be minor as any population present here is likely to be small and isolated from known important populations. This level of potential impact is considered unlikely to cause the species to decline.

How is the proposal likely to affect habitat connectivity?

The proposed works would result in additional vegetation removal and disturbance however as the widening is alongside the existing motorway vegetation fragmentation is not likely to be significantly increased. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature.

How is the proposal likely to affect critical habitat?

No critical habitat has been listed for this species..

Key threatening process considered to contribute to a decline in *Acacia bynoeana* include:

- Habitat disturbance during road, trail and powerline maintenance
- Invasion by exotic species
- High frequency fires

The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential habitat for the species.

The mitigation measures proposed are considered to be consistent with the priority actions identified as being required for the recovery of the species. Therefore, the project is considered unlikely to interfere substantially with the recovery of the species.

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 Corridor.

Conclusion

Based on the above investigation, it is considered a significant impact on *Acacia bynoeana* is unlikely.

F.1.13 Netted Bottle Brush *Callistemon linearifolius*

This shrub is up to 3-4 m tall, with linear (long and narrow) to linear-lanceolate (lance shaped) leaves 8-10 cm long, and 5-7 mm wide with a sharp tip, thickened margins, and distinct lateral veins (DECCW, 2010). Flowers are clustered into the typical "bottlebrushes" of Callistemons.

Capsules are 7 mm diameter. The species flowers in spring – summer and grows in dry sclerophyll forest on the coast and adjacent ranges (DECCW, 2010).

Callistemon linearifolius has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River.

Callistemon linearifolius is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of *Callistemon linearifolius*?

Callistemon linearifolius was not recorded during surveys however records indicate the species has recently been located within 50 m of the proposed works at Marsfield (DECCW, 2010), towards the southern extent of the study area. It is considered unlikely that this forms part of a viable population that exists within the M2 Corridor.

Callistemon linearifolius was more widespread across its distribution in the past. There are currently only 5-6 populations in the Sydney area, of the 22 populations recorded in the past. Three of these are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve, and Spectacle Island Nature Reserve.

It is not considered likely that the proposed works will impact upon this local occurrence of *Callistemon linearifolius* or affect the lifecycle of *C.linearifolius* that may be located in the vicinity. Species located in the area are not likely to be genetically distinct from other populations in the Sydney region or to be necessary for maintaining genetic diversity of the species as a whole.

No certainty can be concluded that the proposed works will not impact upon the pollinator species for *C.linearifolius* however it is not considered likely that the proposed works will impact on areas of potential habitat for the species in adjacent areas of bushland and cross-pollination and seed dispersal is thus unlikely to be significantly affected.

How is the proposal likely to affect the habitat of *Callistemon linearifolius*?

Much of the habitat to be removed has been modified by previous road construction and is in poor to moderate condition, with a high degree of weed invasion and a high degree of fragmentation. Although vegetation will be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by bushland regeneration works and revegetation.

How is the proposal likely to affect habitat connectivity?

The proposed works would result in additional vegetation removal and disturbance however as the widening is alongside the existing motorway vegetation fragmentation is not likely to be significantly increased. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature.

How is the proposal likely to affect critical habitat?

No critical habitat has been listed for *Callistemon linearifolius* under the TSC Act.

Key threatening process considered to contribute to a decline in *Acacia bynoeana* include:

- Habitat disturbance during road, trail and powerline maintenance
- Invasion by exotic species
- High frequency fires

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.

The proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of weed invasion is not considered likely to be increased significantly.

It is possible that *Phytopthora cinnamomi* could be introduced by the proposed action but this outcome is unlikely as mitigation measures would be implemented to prevent the introduction of this soil-borne pathogen during earthworks. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.

Conclusion

Based on the above investigation, a significant impact on a local population of this species is unlikely.

F.1.14 *Darwinia biflora*

Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Associated overstorey species include *Eucalyptus haemastoma*, *Corymbia gummifera* and/or *E. squamosa*. The vegetation structure is usually woodland, open forest or scrub-heath. This species occurs at 129 sites in the northern and north-western suburbs of Sydney and within the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai local government areas (DEWHA 2009a).

There are 20 populations of *Darwinia biflora* within the Sydney Region that are not currently covered by the reserve system and have been identified as important and suitable to be targeted for conservation. The bushland of the M2 corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove National Park) are not included in these lists of important populations.

The species was not recorded during flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a large population exists here.

Darwinia biflora is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of *Darwinia biflora*?

The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species as: a potentially important population is not likely to exist within the M2 corridor.

How is the proposal likely to affect the habitat of *Darwinia biflora*?

The proposed works may result in the permanent removal or modification of approximately 10 ha of native vegetation however most of this area is considered to be unsuitable as habitat for the species due to minimal shale soil influence. Approximately 0.2 hectares of vegetation that may be affected has a shale influence and is potential habitat for the species.

Potential reduction in the area of occupancy as a result of the proposed works is expected to have minimal impact on an important population of the species as: a potentially important population is not considered likely to exist within the M2 corridor, and larger areas of similar potential habitat for this species also occur nearby within and beyond the M2 corridor.

How is the proposal likely to affect habitat connectivity?

As the widening is alongside the existing motorway vegetation fragmentation is not likely to be significantly increased. Although vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature. This would restore continuity between an already fragmented landscape.

How is the proposal likely to affect critical habitat?

No critical habitat has been declared for *Darwinia biflora* under the TSC Act.

Darwinia biflora is threatened by continuing loss of habitat due to primary urban development.

The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Darwinia biflora* becoming established in the species' potential habitat.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible. The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.

Conclusion

Based on the above investigation, a significant impact on a local population of *Darwinia biflora* is unlikely.

F.1.15 *Epacris purpurascens ssp. purpurascens*

Epacris pururascens ssp. *purpurascens* is an erect shrub, 50-180 cm high that is found in a range of habitat types, most of which have a strong shale soil influence and habitats which remain, particularly on ridgetops, are under increasing threat of clearance or habitat modification (DECCW, 2009).This species is listed as Vulnerable under the TSC Act.

During opportunistic observations while gaining access to the field survey locations, *E. p. purpurascens* was found to be locally abundant within several areas of Bidjigal Reserve outside of the M2 corridor, both within a few hundred metres of the corridor and at greater distances. These occurrences of the species and those within the M2 corridor are considered to form part of a single, apparently viable and moderately large, local population.

How is the proposal likely to affect the lifecycle of *E. p. purpurascens*?

Dispersal of the species is likely to be localised except during times of high winds or heavy rainfall when dispersal over a longer distance is probable however pollinators of the species are unknown (NPWS, 2002). *E. p. purpurascens*is killed by fire and re-establishes from soil-stored seed (NPWS, 2002). Information on seed germination is limited, but it is thought that a dormancy mechanism and minimum of 2-4 years is required before seed is produced in the wild (NPWS, 2002).

Based on the above considerations, no certainty can be concluded that the proposed works will not impact upon the pollinator species for *E. p. purpurascens.*However, mitigation measures have been designed to minimise the likelihood of disturbance regimes that may affect pollination of the species.

A conservative estimate of potential habitat for *E. p. purpurascens* within the M2 corridor is approximately 30 ha. Approximately 20 individuals of this species are likely to be removed. Within the M2 corridor, this species is restricted to translocated soils including earth mounds and rock armoured batter slopes.

It appears that these individuals have regenerated from soil removed from the location of the existing motorway. In light of this, regeneration of the species from soils translocated during the proposed project is considered likely.

The potential loss of approximately 20 individuals of this species is unlikely to significantly affect the viability of a local population of this species.

How is the proposal likely to affect the habitat of *E. p. purpurascens*?

Much of the habitat to be removed has been modified by previous road construction. The less-disturbed vegetation further from the edge of the M2 Motorway does not appear to contain any unique or rare features.

Although vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works. As the current populations observed appear to be growing in translocated soil amongst patches of moderately disturbed vegetation it is not considered likely that the proposed works would modify the extent of the local community.

How is the proposal likely to affect habitat connectivity?

The proposed works would result in vegetation removal and disturbance however as the widening is alongside the existing motorway vegetation fragmentation is not likely to be significantly increased. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature.

How is the proposal likely to affect critical habitat?

No critical habitat has been declared for *E. p. purpurascens* under the *Threatened Species Conservation Act 1995*. As the individuals located appear to have regenerated from soil removed from the location of the existing motorway, the study area is not considered to be critical to the survival of this species.

Key threatening processes that are considered to contribute to the decline of *E. p. Purpurascens* include:

- Habitat clearance
- Infection of native plants by *Phytophthora cinnamomi*
- Invasion and establishment of exotic vines and scramblers

- Invasion and establishment and spread of *Lantana camara*

Whilst the proposed M2 Upgrade would result in removal of approximately 20 individuals of *E. p. Purpurascens*, rehabilitation and revegetation works will be conducted post-construction and regeneration of this species from soils translocated during the proposed works is likely.

It is possible that *Phytopthora cinnamomi* could be introduced by the proposed action but this outcome is unlikely as mitigation measures would be implemented to prevent the introduction of this soil-borne pathogen during earthworks. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of weed invasion is not likely to be increased significantly.

Conclusion

Based on the consideration of potential impacts, a significant impact on a local population of *E.p.purpurascens*is is unlikely.

F.1.16 *Persoonia hirsuta*

This species occurs in dry sclerophyll eucalypt woodland or forest and in shrub-woodland. It grows in sandy to stony soils derived from sandstone or very rarely on shale, from near sea level to 600 m altitude.

The species has been recorded from a number of National Parks (Blue Mountains, Wollemi, Dharug, Ku-ring-gai Chase, Marramarra, Royal and Sydney Harbour).

Most locations consist of one to three plants, with the exception of two currently known locations with between 10 and 20 plants. There is evidence of continued decline in the number of locations and the number of individuals. The species is particularly prone to local population extinction because of the small number of plants found at all locations.

Persoonia hirsuta is listed as Endangered under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of *Persoonia hirsuta*?

The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, the closest recent (post 1980) record of the species is approximately 5 km from the M2 corridor and the species has not been detected within the adjacent bushland reserves.

The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species asa potentially important population is not likely to exist within the M2 corridor.

How is the proposal likely to affect the habitat of *Persoonia hirsutat*?

The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation.

How is the proposal likely to affect disturbance regimes?

The M2 Upgrade is thus unlikely to result in additional invasive species that are likely harmful to *P. hirsuta* becoming established in the species' potential habitat. Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

How is the proposal likely to affect habitat connectivity?

Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on the species as continuity would be enhanced between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 corridor.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for *P.hirsuta*.

Key threatening processes that are considered to contribute to the decline of *P.hirsuta* include:

- Loss of habitat
- Burning for hazard reduction
- Competition of feral honeybees

The proposed M2 Upgrade would result in additional vegetation removal however the potential habitat for this species on the site is presently subject to light to heavy weed invasion. Rehabilitation and revegetation works would restore habitat as regenerating species and replanted vegetation begins to mature.

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.

The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral honeybees would be likely to increase in abundance or in their impact on native species.

Conclusion

Based on the above investigation, a significant impact on a local population of *P. hirsuta* is unlikely.

F.1.17 *Pimelea curviflora var. curviflora*

Pimelea curviflora var*. curviflora o*ccurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands.

This species is confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west.

It is usually recorded as rare with only 2 sites with estimates of 300 plants, and most sites with only a few plants or estimates of <100 plants. The taxon has an inconspicuous cryptic habitat as it is fine and scraggly and often grows amongst dense grasses and sedges. It may not always be visible at a site as it appears to survive for some time without any foliage after fire or grazing, relying on energy reserves in its tuberous roots (DECCW 2009).

The species has been recorded in Lane Cove National Park and in Epping near the M2 Corridor (NPWS 2009). Species recorded during EIS for the western section though the specific location and numbers were not recorded (Mt King 1992b).

P. c. curviflora is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

At most recorded sites, this species occurs in low numbers. *P. c. curviflora* is found in two fairly small populations in Lane Cove National Park, North Ryde and a few plants were recorded in the Pages Creek area. The Field of Mars Reserve, Ryde has a population estimated to be greater than 300 plants (Kubiak 1995).

It is not known how many individuals of this species (if any) occur within the M2 Corridor. It is considered unlikely that any population here would be considered key source populations, either for breeding or dispersal, as the potential habitat here is isolated from other areas of habitat in the region as a result of urban development.

It is also considered unlikely that any population here is likely to be genetically distinct from other populations in the region or to be necessary for maintaining genetic diversity of the species as a whole.

P. c. curviflora was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the study area, it is not considered likely that a potentially important population exists within the M2 corridor or that pollination and seed-dispersal vectors are unlikely to be affected. Therefore, the M2 Upgrade is unlikely to disrupt the breeding cycle of *P. c. curviflora.*

How is the proposal likely to affect the habitat of *P. c. curviflora*?

The proposed works may result in the permanent removal of up to approximately 7 ha of potential habitat for this species. Additional areas of potential habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites. The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation.

Potential reduction in the area of occupancy as a result of the proposed works is expected to have a minimal impact on an important population of the species as it is not likely that a potentially important population exists within the M2 corridor.

How is the proposal likely to affect habitat connectivity?

Whilst the proposed M2 Upgrade would result in vegetation removal it is not likely to be significantly increased as the widening is alongside the existing motorway vegetation. It is considered likely that continuity would be enhanced between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 corridor through rehabilitation and revegetation works post-construction.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for *P. c. Curviflora.*

Key threatening processes that are considered to contribute to the decline of *P. c. Curviflora* include:

- Loss of habitat
- Invasion and establishment of exotic vines and scramblers (TSC)
- Invasion, establishment and spread of *Lantana camara*

Whilst the proposed M2 Upgrade would result in vegetation removal upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature.

The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *P. c. curviflora* becoming established in the species' potential habitat.

Conclusion

Based on the above investigation, it is considered a significant impact on a local population of the *P. c. curviflora* is unlikely.

F.1.18 Glandular Pink-bell *Tetratheca glandulosa*

Tetratheca glandulosa is associated with areas of shale-sandstone transition habitat. The vegetation varies from heaths and scrub to woodlands/open woodlands, and open forest. The larger populations of *Tetratheca glandulosa* occur in woodland/open woodland vegetation communities that provide semi-shade (NSW NPWS 2000).

Tetratheca glandulosa is considered to be part of the Endangered Shale/Sandstone Transition Forest and Cumberland Plain Woodland; the Critically Endangered Turpentine Ironbark Forest, White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland; and the Blue Gum High Forest (DEWHA 2009a).

Tetratheca glandulosa is found in the following Local Government Areas: Baulkham Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah and Wyong (NSW NPWS 2000).

Tetratheca glandulosa occurs in 150–200 populations. Strongholds for the species south of the Hawkesbury River include the Berowra Valley, Maroota-South Maroota area, and Marramarra National Park. Strongholds to the north of the Hawkesbury River are in Dharug National Park, the Mangrove Mountain-Central Mangrove area, and Ourimbah State Forest (NSW NPWS 2000).

Tetratheca glandulosa is listed as Vulnerable under the TSC Act 1995.

How is the proposal likely to affect the lifecycle of *Tetratheca glandulosa*?

The NSW NPWS (2000) considers that areas of habitat containing populations of *Tetratheca glandulosa* greater than 100 plants should be considered significant. However populations with less than 100 plants may also be significant depending on the subregional distribution of other populations in the locality.

The exact number of mature reproducing *Tetratheca glandulosa* plants is uncertain, but is estimated at about 11,100 plants (DEWHA). Population sizes at the species distributional limits are often low, at less than 20 plants.

The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor.

The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.

How is the proposal likely to affect the habitat of *Tetratheca glandulosa*?

The extent of occurrence is estimated at 6174 km², based on herbarium data from the Australian Virtual Herbarium (AVH) project. The area of occupancy is estimated at 105 km², based on the number of 1 km² grid squares in which the species is thought to occur. The estimate is considered to be of low reliability, as recent ground-truthing at all populations has not occurred.

Potential reduction in the area of occupancy as a result of the proposed works is expected to have minimal impact on an important population of the species as a potentially important population is not considered likely to exist within the M2 corridor, and larger areas of similar potential habitat for this species also occur nearby within and beyond the M2 corridor.

The M2 Upgrade is unlikely to disrupt the breeding cycle of this species as potential pollination and seed-dispersal vectors are unlikely to be affected.

How is the proposal likely to affect habitat connectivity?

Tetratheca glandulosa populations have been fragmented by urban and rural development. They occur as scattered, discontinuous populations on ridge tops, upper slopes and associated sandstone benches (NSW NPWS 2000).

Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on the species as connectivity to larger areas of similar potential habitat beyond the M2 corridor is expected to be enhanced through revegetation works and rehabilitation of disturbed areas.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for *Tetratheca glandulosa*.

Key threatening processes considered to contribute to the decline in *Tetratheca glandulosa:*

- Clearing of native vegetation and habitat fragmentation
- Invasion of exotic species
- High frequency fires

As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased. Whilst the proposed M2 Upgrade would result in vegetation removal upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring habitat as regenerating species and replanted vegetation begins to mature.

The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Tetratheca glandulosa* becoming established in the species' potential habitat.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.

The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species.

Conclusion

Based on the above investigation, a significant impact on a local population of the *Tetratheca glandulosa* is unlikely.

F.1.19 ECOLOGICAL COMMUNITIES

Blue Gum High Forest in the Sydney Basin Bioregion

Within the study area Blue Gum High Forest, conforming to the national listing, is restricted to a single patch that is partially within the M2 corridor and partially within the adjacent Pennant Hills Golf Course.

This patch is approximately 1.36 hectares in area and varies considerably in condition. Some areas within this patch contain native species, consistent with the description of this community, in all vegetation layers. Other areas however lack one or more layers. The areas in poorest condition have a native canopy with very little native under-storey or ground layer vegetation. Weed invasion is moderate to high throughout this patch.

Several other areas within the M2 corridor would have once supported Blue Gum High Forest. Due to previous clearing and other forms of disturbance the original forest in these locations has been eliminated or reduced to isolated trees. These disturbed areas, including those containing isolated trees, are not within the context of other native vegetation and do not conform to the national listing of Blue Gum High Forest.

Several other native vegetation communities in the study area share a number of species with Blue Gum High Forest. This vegetation are likely to contribute to the viability of the patch near Pennant Hills Golf Course through interaction in the form of seed dispersal and cross-pollination and through providing habitat for the animals that pollinate and disperse the seeds of many plant species.

The Blue Gum High Forest is listed as a Critically Endangered Ecological Community under the TSC Act 1995.

How is the proposal likely to affect the habitat of the ecological community?

No reduction in the extent of the patch of Blue Gum High Forest occurring adjacent to the M2 corridor would occur as a result of the M2 Upgrade. The design option for the proposed M2 Motorway was specifically chosen to avoid vegetation clearing or modification to this ecological community.

The M2 Upgrade would have little detrimental impact on the ecological processes occurring within the Blue Gum High Forest of the study area. Vegetation removal in bushland areas in the vicinity of the Blue Gum High Forest is unlikely to significantly affect population of fauna (birds, flying foxes, insects) that are potential pollinators and dispersers of seed. Genetic interaction between the Blue Gum High Forest and adjacent areas of bushland through cross-pollination and seed dispersal is thus unlikely to be significantly affected.

The proposed works do have some potential to result in the introduction of species that may be detrimental to the ecological community as earthworks would be conducted in nearby areas. The weed management and restoration measures are however likely to prevent any additional weed species becoming established.

The proposed measures for the prevention of the spread of weeds and plant pathogens during construction and site rehabilitation would minimise the likelihood of diseases being introduced to the area containing the ecological community.

Proposed rehabilitation works within the Blue Gum High Forest are likely to improve the functioning of natural ecological processes such as nutrient cycling, and vegetative succession as a result of the removal of the dominant invasive weeds and the creation of conditions conducive to the recruitment of native plants.

How is the proposal likely to affect habitat connectivity?

No fragmentation of any patches of Blue Gum High Forest would occur as a result of the M2 Upgrade.

How is the proposal likely to affect critical habitat?

No habitat critical to the survival of Blue Gum High Forest would be affected by the proposed works.

The priority recovery and threat abatement actions required for this ecological community are:

- prevent further clearing or fragmentation of the ecological community through the protection of protected remnants and/or local council zoning;
- restore and enhance remaining areas of Blue Gum High Forest of the Sydney Basin Bioregion to create buffer zones and to link fragments with remnants of other native vegetation;
- manage weed infestation through weeding and bush regeneration activities; and
- develop and implement appropriate management regimes to prevent further loss or decline of functionally important species and reduction in community integrity (DEWHA 2009a).

The minimisation of vegetation clearing and post-construction vegetation rehabilitation and weed control would minimise the extent of potential indirect impacts such as weed invasion on the community.

Management measures, where possible, will be implemented that are consistent with the actions and best practice guidelines identified for the recovery of this ecological community.

Conclusion

Based on the above investigation, a significant impact on the Blue Gum High Forest is unlikely.

F.2 Commonwealth Assessments of Impact Significance

F.2.1 Assessments of Significance

Vulnerable Species

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- *lead to a long-term decrease in the size of an important population of a species;*
- reduce the area of occupancy of an important population;
- fragment an existing important population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- introduce disease that may cause the species to decline; or
- interfere substantially with the recovery of the species.

These factors are addressed under separate headings for each vulnerable species.

F.2.2 FAUNA

F.2.3 Green and Golden Bell Frog *Litoria aurea*

Size of an important population

- *lead to a long-term decrease in the size of an important population of a species;*

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- *key source populations either for breeding or dispersal;*
- *populations that are necessary for maintaining genetic diversity; and/or*
- *populations that are near the limit of the species range.*

The Green and Golden Bell Frog (GGBF) was once distributed along the coastal lowlands in NSW from approximately 50 kilometres south of the Queensland border to north-east Victoria. Since the 1970's the species has undergone a decline in its population and distribution, particularly in inland areas.

Extant key populations in the Sydney region include populations in the following locations (DEC 2005):

- Kurnell,
- Homebush Bay,
- Clyde/Rosehill,
- Merrylands,
- Arncliffe,
- St Marys,
- Hammonville

Occasional records have been reported from North Ryde near Macquarie University and tributaries of the Lane Cove River and other locations in the Sydney Region. Some of these scattered Sydney records could indicate the continued persistence of unknown populations with conservation significance (DEC 2005).

The three GGBF records in the NPWS Atlas of NSW Wildlife in the vicinity of the M2 Corridor are all from 1995 to 1999 in the vicinity of North Ryde, Macquarie Park and Epping.

The GGBF has not been recorded recently in the vicinity of the M2 Corridor and it is possible that the species is now locally extinct. It is also possible however that one or more populations may persist and hence consideration of potential impacts on this species is required.

The GGBF is often considered to be a colonising species that is tolerant of a wide range of environmental conditions but does not compete favourably with other frog species. The GGBF tends to be displaced from newly created or disturbed habitats in a form or ecological succession as environmental conditions change and additional frog species establish in such areas (DEC 2005).

GGBF habitat typically consists of four functional types:

- Breeding habitat: shallow, sunlit water bodies, permanent or temporary, natural or artificial, particularly those with emergent vegetation (typically *Typha* and *Eleocharis* spp.), which lack predatory fish such as the Plague Minnow *Gambusia holbrooki*.
- Foraging habitat: areas of low vegetation, typically dominated by grasses and other grass-like plants usually within one kilometre of breeding habitat,
- Overwintering habitat: features such as rocks, logs and other debris, including non-natural materials that provide moist conditions and a relatively stable temperature range during winter when the frogs are inactive,
- Corridor habitat: areas with appropriate environmental conditions (e.g. moisture, temperature) that act as movement corridors between breeding, foraging and overwintering habitat where these are not adjacent to one another – typically streams, ditches and drainage depressions (DEC 2005).

When constructed, the detention basins of the M2 corridor were planted with emergent aquatic native plants with the intention of providing wildlife habitat in addition to the primary purpose of slowing stormwater flows to minimise water pollution and impacts to the hydrology of adjacent waterways.

Emergent aquatic plants currently found growing in the detention basins include *Eleocharis sphacelata, Bolboschoenus fluviatilis,* and *Typha orientalis*. Frog surveys conducted in several of these detention basins in the vicinity of North Ryde did not detect the presence of GGBF however four other frog species were recorded there. The frog species recorded were *Litoria peronii, L. fallax, Limnodynastes peronii* and *Crinia signifera*.

The detention basins vary somewhat in the characteristics of the aquatic vegetation found within them, some having an almost complete cover of emergent vegetation whilst others have larger areas of open water. The height and structure of the vegetation surrounding the basins also varies with some overshadowed by tree regrowth and others in relatively open sunlit conditions. Water levels within these basins are likely to increase after rainfall and decrease during extended dry periods though it is likely that water is continually present in most if not all of these basins. Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface. As most of the basins are isolated from other water bodies, they are unlikely to be inhabited by fish though other potential GGBF predators such as tortoises, eels, snakes and wading birds may be found in these locations. It is unknown whether or not the Amphibian Chytrid Fungus is found in any of these basins but it is possible that it may have been introduced there by colonising frogs.

In general the basins appear to provide conditions that may be suitable for GGBF breeding however the abundance of other frog species present within the basins may have resulted in competitive exclusion of the species. Changing environmental conditions such as increased shading, greater height and density of adjacent vegetation and the possibility of Amphibian Chytrid Fungus may have favoured other frog species to the detriment of the GGBF.

The bushland in the vicinity of many of the detention basins is not considered to be favourable GGBF foraging habitat as it lacks the open grassy structure preferred by the species. Several of the detention basins in more disturbed locations do have some open grassy areas nearby with the most extensive of these being located in the North Ryde area.

Some potential sheltering (overwintering) habitat is likely to be found in the vicinity of all of the detention basins in the form of rocks, fallen logs, rubbish and clump-forming plants though, in general, the abundance and variety of this type of habitat appears to be relatively low within the M2 corridor.

The characteristics of any population that may persist here are unknown and hence the potential importance of any such population is also uncertain.

Key threatening processes affecting GGBF in the region include the following:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands,
- Clearing of native vegetation,
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis
- Predation by the European Red Fox, and
- Predation by the Plague Minnow (*Gambusia holbrooki*) (DEC 2005).

This species was not recorded during targeted surveys within the M2 corridor.

Area of occupancy

- *reduce the area of occupancy of an important population;*

The proposed works would result in the removal of approximately 3 ha of vegetation clearance for detention basin works and access roads. The detention basins within the M2 corridor contain an artificial assemblage of emergent native aquatic plants which were planted when the detention basins were constructed.

Detention basin works may alter the area of occupancy of potential foraging and shelter habitat of the GGBF temporarily due to an alteration to the environmental conditions such as water depth and light levels.

Vegetation clearance around detention basins is considered likely to improve the potential of these areas as GGBF foraging habitat as the initially low, dense regrowth that is likely to result is likely to be more suitable for the species than much of the existing vegetation. Vegetation clearance here is also likely to increase light levels.

Modification to other areas as a result of clearing for access may result in a reduction in available foraging habitat in the short-term but is not likely to prevent the species from using these areas as foraging sites in the medium to long term. The extent of habitat to be removed or modified by the proposed M2 Upgrade is not considered likely to have a significant negative impact on the GGBF. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating and replanted vegetation begins to mature.

Fragmentation

- *fragment an existing important population into two or more populations;*

The GGBF is a relatively mobile frog species that forages and seeks shelter at distances of up to 1 km or more from breeding sites during favourable weather conditions. In doing so, individuals may move through and forage within highly cleared and fragmented landscapes. Major roads may act as barriers to the movement of the species particularly if walls and culverts limit access to ground-dwelling fauna. The existing M2 Motorway is currently a barrier to wildlife movement therefore the widening works will not significantly increase the barrier to any significant degree.

The relatively small amount of clearing proposed and the resultant minor increase in habitat fragmentation is however not likely to significantly affect any population of the species that may utilise the study area.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

No critical habitat has been listed for the GGBF. The M2 corridor and surrounding bushland is not likely to contain habitat critical to the survival of the species.

Breeding cycle

- *disrupt the breeding cycle of an important population;*

The detention basins within the M2 corridor contain an artificial assemblage of emergent native aquatic plants which were planted when the detention basins were constructed. This species was not recorded during targeted surveys within the M2 corridor. Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface. It is unknown whether or not the Amphibian Chytrid Fungus is found in any of these basins but it is possible that it may have been introduced there by colonising frogs and therefore on this basis, is unlikely to provide suitable breeding habitat for the GGBF. Detention basin works are being designed to favour the GGBF through revegetation works with emergent aquatic plant species. Due to the very small area of impact and the absence of important populations of GGBF in the study area, the M2 Upgrade is not likely to affect the breeding cycle of the GGBF.

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

Vegetation clearance around detention basins is considered likely to improve the potential for GGBF foraging habitat as the initially low, dense regrowth is likely to be more suitable for the species than much of the existing vegetation. Vegetation clearance here is also likely to increase light levels.

The proposed works may result in the permanent removal of vegetation from an area of up to approximately 20 ha of which approximately 7 ha is dominated by native vegetation. While some of this area is considered to be potential foraging habitat for this species, most of this area is considered to be marginal or unsuitable as habitat due to a lack of suitable vegetation cover, dry surface conditions and distance from potential breeding habitat. Additional areas of marginal potential foraging habitat would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Only the permanent clearing for widening works is considered to permanently reduce the area of habitat (foraging and sheltering habitat only) for the species. Modification to other areas as a result of clearing for access may result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally. The area would also be supplemented by bushland regeneration works thereby restoring foraging habitat as regenerating and replanted vegetation begins to mature.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not likely to have a significant negative impact on the GGBF.

Invasive species

- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;*

A number of invasive fauna species exist within the study area. Of these species, only the Plague Minnow *Gambusia holbrooki* and the European Red Fox *Vulpes vulpes* are considered to likely affect the GGBF.

With the use of equipment in wet environments in several locations within the M2 Corridor, there is a risk that juvenile Plague Minnow could be spread in wet mud. With the implementation of the proposed mitigation measures, the spread of this species is however unlikely.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any additional invasive fauna species. These include any fauna species that may compete with, parasitise or prey upon the GGBF or increase the impact of existing species (such as the European Red Fox).

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may be detrimental to the habitat of the GGBF. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is low.

Disease

- *introduce disease that may cause the species to decline; or*

With the use of equipment in wet environments in several locations within the M2 Corridor, there is a risk that Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis* could be spread in wet mud. Chytridiomycosis caused by Amphibian Chytrid Fungus has been implicated in severe population declines and species extinctions of frogs in the past 20 years (DEH 2006). With the implementation of the proposed mitigation measures, this risk of spreading this disease to uninfected water bodies is considered to be low.

Recovery

- *interfere substantially with the recovery of the species.*

The following measures have been identified as being required for the recovery of the species:

- Maintain captive bred populations for future possible re-introduction programs.
- Initiate community awareness programs that highlight the presence of populations and catchment management approaches to improving stormwater quality, habitat retention and management.
- Develop measures to control or eradicate the introduced Plague Minnow.
- Establish protocols for handling of frogs and educational strategies to minimise the inadvertent spread of fungal pathogens from site to site.
- Develop strategies to provide for the development or enhancement of frog habitat to improve reproductive success and recruitment at known sites.
- Develop site specific plans of management to improve conservation outcomes for targeted populations.
- Develop strategies to provide disease-free and fish-free breeding habitat (DEC 2005).

No recovery plans have been finalised for this species. A draft recovery plan for the GGBF has been prepared (DEC 2005) and considers the conservation requirements of the species across its known range.

Most of these recovery objectives relate to research and management activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.

The minimisation of vegetation clearing and post-construction vegetation rehabilitation targeted at creating appropriate foraging and sheltering habitat would minimise the extent of negative impact on potential foraging and sheltering habitat for the species.

Measures to minimise the likelihood of introducing Plague Minnow and Amphibian Chytrid Fungus would minimise the chance of habitat degradation as result of the introduction of these species.

The placement of large woody debris around detention basins would enhance the availability of sheltering habitat in these locations.

The proposed works are considered unlikely to interfere substantially with the recovery of the species. The proposed mitigation measures are consistent with the actions in the draft recovery plan (DEC 2005).

F.2.4 Grey-headed Flying-fox *Pteropus poliocephalus*

Size of an important population

- *lead to a long-term decrease in the size of an important population of a species;*

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal;
- populations that are necessary for maintaining genetic diversity; and/or
- populations that are near the limit of the species range.

The Grey-headed Flying-fox is distributed in a coastal belt from south-eastern Queensland to Melbourne, Victoria and is infrequently found west of the Great Dividing Range (Tidemann 1998). The species is highly mobile and the distribution of the national population varies within the species range with groups of bats moving up and down the east coast in response to seasonal food availability (Menkhorst 1995; Tidemann 1998).
Studies have indicated that there appears to be a single interbreeding population, with constant genetic exchange and movement between camps throughout the entire geographic range of the species. Bats commute daily between roosting sites (camps) and feeding areas which are usually located within 15 kilometres of camp sites (Tidemann 1998).

Roost sites are typically located near water, such as lakes, rivers or the coast and vegetation often consists of rainforest patches, paperbark forest, mangroves and riparian vegetation though colonies also use highly modified vegetation in urban and suburban areas (DEWHA 2009a).

The closest known camp site to the study area is in the Ku-ring-gai Flying-fox Reserve in Gordon which is located approximately 4 to 15 kilometres from the M2 corridor. The population size of the Ku-ring-gai Flying-fox Reserve camp varies with an average of approximately 30,000 individuals. Two other flying-fox camps are known in the Sydney region, at Cabramatta Creek and in the Sydney Royal Botanic Gardens.

The Grey-headed Flying-fox was recorded flying overhead in several locations during field surveys and was recorded feeding in mature flowering Blackbutt *Eucalyptus pilularis* within the M2 corridor near Bidjigal Reserve. Individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon.

Foraging habitat for this species is considered to be present throughout the study area wherever fleshy-fruited and nectar-producing trees are present. This includes all bushland areas dominated by eucalypts and a variety of native and introduced trees within the urban landscape. Areas containing tall eucalypt forest are considered to be particularly important to this species as foraging habitat.

The study area does not contain any known camp sites for the Grey-headed Flying-fox and although the vegetation and topography in parts of the M2 Corridor (e.g. along Devlins Creek) may be suitable for roosting, the presence of the M2 and walking trails with associated noise disturbance in these locations is likely to dissuade the species from roosting here.

Area of occupancy

- *reduce the area of occupancy of an important population;*

The proposed works may result in the permanent removal of up to approximately 0.2 ha of marginal potential roosting habitat and up to approximately 7 ha of known and potential foraging habitat for this species. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Only the permanent clearing for widening works is considered to permanently reduce the area of occupancy of the species. Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally. The area would also be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating and replanted trees begin to mature.

The Grey-headed Flying Fox forages in larger areas of similar habitat throughout the Sydney Metropolitan area therefore the extent of habitat to be removed or modified by the proposed M2 Upgrade is not considered significant in relation to areas of less-disturbed habitat in the locality.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Fragmentation

- *fragment an existing important population into two or more populations;*

The Grey-headed Flying-fox is a highly mobile, wide-ranging species that forages at distances of up to 15 km or more from roost sites during a single evening. In doing so, individuals move through and forage within highly cleared and fragmented landscapes.

The relatively small amount of clearing proposed and the resultant minor increase in habitat fragmentation is not considered likely to significantly affect the subset of the population of the species that utilises the study area.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

No critical habitat has been listed for the Grey-headed Flying-fox. The M2 corridor and surrounding bushland is not considered likely to contain habitat critical to the survival of the species.

Breeding cycle

- *disrupt the breeding cycle of an important population;*

Grey-headed Flying-foxes mate and give birth within maternity camps and initially carry their young while foraging. As they begin to mature, juvenile bats are left at the camp while their mothers forage.

No camp sites are present within or in the bushland adjacent to the M2 corridor. Whilst it is considered possible that the vegetation of the M2 corridor could be utilised as a camp site in future, it is not considered likely.

Given the relatively small amount of potential habitat that would be affected, the M2 Upgrade is not considered likely to significantly disrupt the breeding cycle of any subset of the population of the Grey-headed Flying-fox.

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

The proposed works may result in the permanent removal of up to approximately 0.2 ha of marginal potential roosting habitat and up to approximately 7 ha of known and potential foraging habitat for this species. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

The Grey-headed Flying Fox forages in larger areas of similar habitat throughout the Sydney Metropolitan area and larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Invasive species

- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;*

A number of invasive fauna species exist within the study area. None of these species are considered to be likely to affect the Grey-headed Flying-fox.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any additional invasive fauna species that may compete with, parasitise or prey upon the Grey-headed Flying-fox.

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may detrimental to habitat of the Grey-headed Flying-fox. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is however considered to be low.

Disease

- *introduce disease that may cause the species to decline; or*

The M2 Upgrade is unlikely to introduce any disease that may infect bat species as no animals or material used in animal husbandry is proposed to be brought into the study area.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*) that may degrade fauna habitat. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The proposed upgrade works are unlikely to result in the introduction of diseases that may cause the Grey-headed Flying-fox to decline.

Recovery

- *interfere substantially with the recovery of the species.*

No recovery plans have been completed for this species. A recovery plan is in preparation.

The Action Plan for Australian Bats (Environment Australia, 1999) lists the following recovery objectives for the species:

- Stabilise the population at its current level.
- Define patterns of landscape use, and identify and protect essential habitat.
- Develop non-destructive methods for crop protection.
- Develop non-destructive methods for management of camps in problem areas.
- Ensure consistent management of the species across all range states (Queensland, New South Wales and Victoria).

Most of these recovery objectives relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.

The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential foraging habitat for the species.

The project is not likely to interfere substantially with the recovery of the species.

F.2.5 Large-eared Pied Bat *Chalinolobus dwyeri*

Size of an important population

- *lead to a long-term decrease in the size of an important population of a species;*

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- *key source populations either for breeding or dispersal;*
- *populations that are necessary for maintaining genetic diversity; and/or*
- *populations that are near the limit of the species range.*

The Large-eared Pied Bat is found from south-eastern Queensland (Rockhampton) to New South Wales (NSW) (south to Bungonia), from the coast to the western slopes of the Divide. There are scattered records from the New England Tablelands and North West Slopes. The NSW distribution is generally rare and very patchy, with the species found predominantly in areas with extensive cliffs and caves.

The bat is most commonly found in dry sclerophyll forest and woodland, however also in sub-alpine woodland, and on the edge of rainforests and wet sclerophyll rainforest. It roosts in caves and mines, crevices in cliffs, and in the disused, bottle-shaped mud nests of the Fairy Martin (*Hirundo ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. It roosts in colonies of 3-37, clustered in indentations in the ceiling, most commonly in the twilight areas of the caves, close to the entrance. Maternity caves are found in well-timbered areas containing gullies.

The bats remain loyal to the same maternity cave over many years. (Churchill,1998). It is not known whether this species ever utilises tree hollows as roosting habitat (Environment Australia, 1999). It has been speculated (Churchill, 1998) that this species may also utilise tree hollows for roosting though the use of tree hollows by the species has not been reported. Although few details are currently known, it probably forages for small, flying insects, below the forest canopy (Churchill, 1998).

This distribution and habitat requirements of this species are poorly understood however in NSW the species is known from the following the areas shown in the table below (Environment Australia, 1999).

There are three records of this species on the Atlas of NSW Wildlife database within ten kilometres of the motorway.

It is likely that the density of threatened species records is somewhat biased by the extent of survey effort in the region with areas subject to greater development pressure receiving greater survey effort during environmental impact assessment.

This may account for the records of the species in the locality being within heavily cleared areas as opposed to the nearby bushland reserves.

The Large-eared Pied Bat was not recorded during the targeted bat surveys undertaken as part of this assessment. The Large-eared Pied Bat is readily identifiable from Anabat call recordings. Despite the collection of a large number of calls from other bat species, no calls attributable to this species were recorded.

Potential roosting habitat for this species is considered to be present chiefly in steep areas containing rock outcrops within the bushland valleys of the region. Potential foraging habitat is considered to exist within larger areas of native vegetation within a few kilometres of these areas.

There are some steep areas containing rock outcrops in close proximity to the motorway, chiefly in the vicinity of the Darling Mills Creek crossing adjacent to Bidjigal Reserve, North Rocks.

There are several rock overhangs in this locality. Most of these overhangs are relatively open and contain few fissures or cracks. One large rock does contain a relatively deep, darkened cavity however this area is near ground level and would likely provide easy access to potential predators. These overhangs are thus considered to be marginal as roosting habitat for cave-dwelling bats.

The proposed works may result in the removal of up to approximately less than one hectare of marginal potential roosting habitat and up to approximately 7 ha of potential foraging habitat. Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Whilst it is unknown if the subject site is occupied by this species, the paucity of records in the sandstone valleys of the area and the marginal quality of the potential roosting habitat present indicates that the study area is unlikely to support an important population of the species.

Area of occupancy

- *reduce the area of occupancy of an important population;*

The proposed works may result in the permanent removal of less than one hectare of marginal potential sandstone cave roosting habitat and up to approximately 7 ha of potential foraging habitat (includes roosting habitat). Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Only the permanent clearing for widening works are considered to reduce the potential area of occupancy of the species. Modification to other areas as a result of clearing for access is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Fragmentation

- *fragment an existing important population into two or more populations;*

Law and Chidel (1999) found that 30 percent of microbat taxa were sensitive to the effects of forest fragmentation while 60 percent appeared tolerant of fragmentation. Although total activity in small remnants and corridors was as great as that in large forests continuous within a 690,000 ha national park, feeding activity was greatest in continuous forests, suggesting that larger forests with high habitat diversity offered more foraging opportunities. Despite providing fewer feeding opportunities, remnants represent an important conservation resource for bats because activity is concentrated here and they provide potential roost sites. Law and Chidel (1999) also found that bats were generally insensitive to the effects of patch size and shape as well as the amount of remnant vegetation in the landscape.

Microbats in general are highly mobile species that are capable of utilising modified landscapes including artificial breaks in woodland and forest for foraging activities (Churchill, 1998).

Whilst it is unknown to what extent the Large-eared Pied Bat is capable of tolerating habitat fragmentation, the relatively small amount of clearing proposed and the barrier created by the existing M2 Motorway is unlikely to increase habitat fragmentation.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

No critical habitat has been listed for the Large-eared Pied Bat. The study area is not considered likely to support an important population of the species or to contain habitat critical to the survival of the species.

Breeding cycle

- *disrupt the breeding cycle of an important population;*

Some potential foraging habitat for the Large-eared Pied Bat may be affected however this habitat is considered to be marginal and unlikely to be used by the species as breeding habitat.

Given the relatively small amount of this potential habitat that would be affected, the M2 Upgrade is not likely to significantly disrupt the breeding cycle of any population of the Large-eared Pied Bat.

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

The proposed works may result in the permanent removal of less than one hectare of marginal potential sandstone cave roosting habitat and up to approximately 7 ha of potential foraging habitat (includes roosting habitat). Additional areas of potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Modification to other areas as a result of clearing for access is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Invasive species

- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;*

A number of invasive fauna species exist within the study area. Of these, cats and foxes may prey upon the Large-eared Pied Bat occasionally if roost entrances are close to ground level. The Pied Currawong, a possibly over-abundant native bird species, may also prey on the species. This impact is expected to be minimal as the Pied Currawong is a day-active species and predation of bats is only likely to occur occasionally during twilight hours.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any invasive fauna species that may compete with, parasitise or prey upon the Large-eared Pied Bat.

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may be detrimental to the habitat of the Large-eared Pied Bat. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is low.

Disease

- *introduce disease that may cause the species to decline; or*

The M2 Upgrade is unlikely to introduce any disease that may infect bat species as no animals or material used in animal husbandry is proposed to be brought into the study area.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*) that may degrade fauna habitat. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The proposed upgrade works are unlikely to result in the introduction of diseases that may cause the Large-eared Pied Bat to decline.

Recovery

- *interfere substantially with the recovery of the species.*

No recovery plans have been completed for this species. A recovery plan is in preparation.

The Action Plan for Australian Bats (Environment Australia, 1999) lists the following recovery actions for the species:

- Protection of known roosts and associated foraging habitats.
- Undertake targeted surveys for the species to clarify distribution and status.
- Carry out ecological research to determine habitat requirements, roost and maternity site selection; foraging strategy, population dynamics and threatening processes.
- Encourage active management actions such as installation of 'Fairy Martin (bird species) friendly structures' in road culverts and bridges (as a means to promote bat roost sites, see Schulz 1998); and inspection of bridges/culverts prior to demolition or major capital works to reduce impact on colonies already utilising these structures by State and local government authorities with responsibility for construction and maintenance of roads.

Most of these recovery actions relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.

The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential habitat for the species.

The project is considered unlikely to interfere substantially with the recovery of the species.

F.2.6 FLORA

F.2.7 *Acacia bynoeana*

- Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leafed Apple.
- Found in central eastern NSW, from the Hunter District (Morisset), south to the Southern Highlands and west to the Blue Mountains.
- It is known from 30 locations, typically only 1-5 individuals occur at each site. A few sites contain 30-50 individuals. The total population is estimated to be only a few hundred plants (DEWHA 2009a).

Records of this species in the vicinity of the M2 corridor are chiefly to the north in the Baulkham Hills and Ku-ring-gai LGAs (NPWS 2009).

The closest records are within 2 km of the M2 corridor in the east in Gordon and in the west near the northern boundary of Bidjigal Reserve (NPWS 2009).

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • key source populations either for breeding or dispersal; • *populations* that are necessary for maintaining genetic diversity; and/or • *populations* that are near the limit of the species range.
lead to a long-term decrease in the size of an important population of a species;	No recovery plan has been prepared for this species and no important populations have been specifically identified. At most recorded sites, this species occurs in low numbers. It is not known how many individuals of this species (if any) occur within the M2 corridor though it is considered unlikely that a large population would exist here as the species has not been located here. It is considered unlikely that any population here would be considered a key source population either for breeding or dispersal as the potential habitat here is isolated from habitat containing known populations in the region as a result of urban development. It is also considered unlikely that any population here is likely to be genetically distinct from other populations in the region or to be necessary for maintaining genetic diversity of the species as a whole. The potential habitat for this species within the M2 corridor is not at the limit of the species known distribution as the species is distributed to the north, west and south of the locality on the outskirts of the Sydney metropolitan area and beyond. The species was not recorded during flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor. The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.

Impact Criteria	Assessment of Impact
reduce the area of occupancy of an important population;	As a potentially important population is not considered likely to exist within the M2 corridor, no reduction in the area of occupancy of an important population is considered likely.
fragment an existing important population into two or more populations;	As a potentially important population is not considered likely to exist within the M2 corridor, no fragmentation of an important population is considered likely.
adversely affect habitat critical to the survival of a species;	A potentially important population is not considered likely to exist within the M2 corridor and no critical habitat has been listed for this species. The M2 Upgrade would not adversely affect habitat critical to the survival of this species.
disrupt the breeding cycle of an important population;	A potentially important population is not considered likely to exist within the M2 corridor and hence the M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species.
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	A potentially important population is not considered likely to exist within the M2 corridor. Whilst the proposed works may modify, destroy, remove or isolate or decrease the availability or quality of habitat for this species, the extent of such impact on the species (should it occur) is likely to be minor as any population present here is likely to be small and isolated from known important populations. This level of potential impact is unlikely to cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;	The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Acacia bynoeana* becoming established in the species' potential habitat.
introduce disease that may cause the species to decline; or	Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible. The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.
interfere substantially with the recovery of the species.	No recovery plan has been completed for this species. Thirteen priority actions have been identified as being required for the recovery of the species (DECCW 2009). Most of these recovery objectives relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation. The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential habitat for the species. The mitigation measures proposed are considered to be consistent with the priority actions identified as being required for the recovery of the species. Therefore, the project is unlikely to interfere substantially with the recovery of the species.

F.2.8 *Darwinia biflora*

- Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Associated overstorey species include *Eucalyptus haemastoma*, *Corymbia gummifera* and/or *E. squamosa*. The vegetation structure is usually woodland, open forest or scrub-heath.
- Occurs at 129 sites in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai local government areas (DEWHA 2009a).

The nearest populations to the M2 Corridor occur in Lane Cove NP and Pennant Hills Park. This species has been recorded within 1 km of the M2 Corridor (NPWS 2009).

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • key source populations either for breeding or dispersal; • *populations* that are necessary for maintaining genetic diversity; and/or • *populations* that are near the limit of the species range.
lead to a long-term decrease in the size of an important population of a species;	The following sites that have been recorded as containing > 5000 individuals (DEWHA 2009a). **Site** — **Tenure** Bobbin Head track — DEC (National Park) Murrua track — DEC (National Park) Gibberagong track — DEC (National Park) Berowra Valley Regional Park, Dural — Berowra Valley Regional Park Beaumont track — DEC (National Park) Berowra Valley Regional Park, — Galston Berowra Valley Regional Park Mt Colah — DEC (National Park) There are 20 populations within the Sydney Region that are not currently covered by the reserve system and have been identified as important and suitable to be targeted for conservation. The bushland of the M2 Corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove National Park) are not included in these lists of important populations. The species was not recorded during flora surveys within the M2 Corridor. Whilst it is considered possible that this species may exist within the M2 Corridor, it is considered unlikely that a large population exists here. A potentially important population is not considered likely to exist within the M2 Corridor. The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.
reduce the area of occupancy of an	The proposed works may result in the permanent removal or modification of approximately 10 ha of native vegetation

Impact Criteria	Assessment of Impact
important population;	however most of this area is considered to be unsuitable as habitat for the species due to minimal shale soil influence. Approximately 0.2 hectares of vegetation that may be affected has a shale influence and is potential habitat for the species. Potential reduction in the area of occupancy as a result of the proposed works is expected to have minimal impact on an important population of the species as: • a potentially important population is not considered likely to exist within the M2 Corridor, and • larger areas of similar potential habitat for this species also occur nearby within and beyond the M2 Corridor.
fragment an existing important population into two or more populations;	Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on an important population of the species as: a potentially important population is not considered likely to exist within the M2 Corridor, and continuity would be maintained between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 Corridor.
adversely affect habitat critical to the survival of a species;	A potentially important population is not considered likely to exist within the M2 Corridor and no critical habitat has been listed for this species. The M2 Upgrade would not adversely affect habitat critical to the survival of this species.
disrupt the breeding cycle of an important population;	The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species as: a potentially important population is not considered likely to exist within the M2 Corridor, proposed mitigation measures would minimise the likelihood of spreading weeds which could suppress seedling recruitment, and potential pollination and seed-dispersal vectors are unlikely to be affected
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	A potentially important population is not considered likely to exist within the M2 Corridor. The proposed works may modify, destroy, remove, isolate or decrease the availability or quality of habitat for this species. However, the extent of such impact on the species (should it occur) is likely to be minor as any population present here is likely to be small and isolated from known important populations. This level of potential impact is unlikely to cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;	The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Darwinia biflora* becoming established in the species' potential habitat.
introduce disease that may cause the species to decline; or	Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible. The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.
interfere substantially with the	The overall objective of the Darwinia biflora recovery plan is to prevent the status of D. biflora from becoming

Impact Criteria	Assessment of Impact
recovery of the species.	endangered, by reducing the continual loss of populations and by implementing management regimes aimed at maintaining representative populations across the species' range. Actions identified as being required for the recovery of the species are: • Identify sites that are a high priority to protect • Carry out negotiations with public authorities to protect sites • Liaise with private landholders to protect sites • Threat and habitat management programs will be implemented by public authorities on public lands • Easement maintenance activities will not affect the long term survival of populations of D. biflora • Informed environmental assessment and planning decisions will be made • Investigate aspects of the ecology of the species • Identify and survey potential habitat • Encourage community involvement • Provide advice and assistance to private landholders • DEC to be advised of any consents or approvals that affect D. biflora • Re-assess conservation status of species (DEC 2004). Most of these recovery objectives relate to research and education activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation. The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species and is considered to be consistent with the primary objective of the recovery plan. The proposed mitigation measures will be included in the EMP and are consistent with the actions of the recovery plan for the species.

F.2.9 *Pimelea curviflora var. curviflora*

- Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands.
- Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west.
- It is usually recorded as rare with only 2 sites with estimates of 300 plants, and most sites with only a few plants or estimates of <100 plants. The taxon has an inconspicuous cryptic habitat as it is fine and scraggly and often grows amongst dense grasses and sedges. It may not always be visible at a site as it appears to survive for some time without any foliage after fire or grazing, relying on energy reserves in its tuberous roots (DECCW 2009).

Species recorded in Lane Cove NP and in Epping near the M2 Corridor (NPWS 2009).

Species recorded during EIS for the western section though the specific location and numbers were not recorded (Mt King 1992b).

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • key source populations either for breeding or dispersal; • *populations* that are necessary for maintaining genetic diversity; and/or • *populations* that are near the limit of the species range.
lead to a long-term decrease in the size of an important population of a species;	No recovery plan has been prepared for this species and no important populations have been specifically identified. At most recorded sites, this species occurs in low numbers. *Pimelea curviflora var. curviflora* is found in two fairly small populations in Lane Cove National Park, North Ryde and a few plants were recorded in the Pages Creek area. The Field of Mars Reserve, Ryde has a population was estimated to be greater than 300 plants (Kubiak 1995). It is not known how many individuals of this species (if any) occur within the M2 corridor. It is considered unlikely that any population here would be considered key source populations, either for breeding or dispersal, as the potential habitat here is isolated from other areas of habitat in the region as a result of urban development. It is also considered unlikely that any population here is likely to be genetically distinct from other populations in the region or to be necessary for maintaining genetic diversity of the species as a whole. The potential habitat for this species within the M2 corridor is not at the limit of the species known distribution as the species is distributed within Hornby and Baulkham Hills (Hills Shire) LGA to the north and an important population is found within Ryde area to the south (Kubiak 1995). The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor. The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.
reduce the area of occupancy of an important population;	The proposed works may result in the permanent removal of up to approximately 7 ha of potential habitat for this species. Additional areas of potential habitat (approximately 3 ha) would be modified through temporary clearing and

Impact Criteria	Assessment of Impact
	subsequent rehabilitation of access areas and compound sites. Potential reduction in the area of occupancy as a result of the proposed works is expected to have minimal impact on an important population of the species as: • a potentially important population is not considered likely to exist within the M2 corridor, and • larger areas of similar potential habitat for this species also occur nearby within and beyond the M2 corridor.
fragment an existing important population into two or more populations;	Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on an important population of the species as: • a potentially important population is not considered likely to exist within the M2 corridor, and • continuity would be maintained between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 corridor.
adversely affect habitat critical to the survival of a species;	A potentially important population is not considered likely to exist within the M2 corridor and no critical habitat has been listed for this species. The M2 Upgrade would not adversely affect habitat critical to the survival of this species.
disrupt the breeding cycle of an important population;	The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species as: • a potentially important population is not considered likely to exist within the M2 corridor, • proposed mitigation measures would minimise the likelihood of spreading weeds which could suppress seedling recruitment, and • potential pollination and seed-dispersal vectors are unlikely to be affected
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	Whilst the proposed works may modify, destroy, remove or isolate or decrease the availability or quality of habitat for this species, the extent of such impact on the species (should it occur) is likely to be minor as any population present here is likely to be small and isolated from known important populations and proposed mitigation measures would minimise impacts on potential habitat. This level of potential impact is unlikely to cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;	The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Pimelea curviflora var curviflora* becoming established in the species' potential habitat.
introduce disease that may cause the species to decline; or	Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible. The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.
interfere substantially with the recovery of the species.	No recovery plan has been prepared for this species. Seven priority actions identified as being required for the recovery of the species (DECC 2009). Most of these recovery objectives relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.

Impact Criteria	Assessment of Impact
	The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species and is considered to be consistent with the primary objective of the recovery plan. The project is considered unlikely to interfere substantially with the recovery of the species and the EMP will seek to include the priority actions identified as being required for the recovery of the species.

F.2.10 *Tetratheca glandulosa*

- *Tetratheca glandulosa* (Glandular Pink-bell) is associated with areas of shale-sandstone transition habitat. The vegetation varies from heaths and scrub to woodlands/open woodlands, and open forest. The larger populations of Glandular Pink-bell occur in woodland/open woodland vegetation communities that provide semi-shade (NSW NPWS 2000).
- Glandular Pink-bell is considered to be part of the Endangered Shale/Sandstone Transition Forest and Cumberland Plain Woodland; the Critically Endangered Turpentine Ironbark Forest, White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland; and the Blue Gum High Forest (DEWHA 2009a).
- Glandular Pink-bell is found in the following Local Government Areas: Baulkham Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah and Wyong (NSW NPWS 2000).

Glandular Pink-bell occurs in 150–200 populations. Strongholds for the species south of the Hawkesbury River include the Berowra Valley, Maroota-South Maroota area, and Marramarra National Park. Strongholds to the north of the Hawkesbury River are in Dharug National Park, the Mangrove Mountain-Central Mangrove area, and Ourimbah State Forest (NSW NPWS 2000).

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • key source populations either for breeding or dispersal; • *populations* that are necessary for maintaining genetic diversity; and/or • *populations* that are near the limit of the species range.
lead to a long-term decrease in the size of an important population of a species;	The NSW NPWS (2000) considers that areas of habitat containing populations of Glandular Pink-bell greater than 100 plants should be considered significant. However populations with less than 100 plants may also be significant depending on the subregional distribution of other populations in the locality. The exact number of mature reproducing Glandular Pink-bell plants is uncertain, but is estimated at about 11 100 plants (DEWHA). Population sizes at the species distributional limits are often low, at less than 20 plants. Populations recorded with more than 200 plants exist in the Berowra Valley, Maroota-South Maroota area, Marramarra National Park, Dharug National Park, Mangrove Mountain-Central Mangrove area and the Ourimbah State Forest (NSW NPWS 2000). The species was not recorded during recent flora surveys within the M2 Corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is d unlikely that a potentially important population exists within the M2 corridor. The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.

Impact Criteria	Assessment of Impact
reduce the area of occupancy of an important population;	The extent of occurrence is estimated at 6174 km², based on herbarium data from the Australian Virtual Herbarium (AVH) project. The area of occupancy is estimated at 105 km², based on the number of 1 km² grid squares in which the species is thought to occur. The estimate is considered to be of low reliability, as recent ground-truthing at all populations has not occurred. Potential reduction in the area of occupancy as a result of the proposed works is expected to have minimal impact on an important population of the species as: • a potentially important population is not considered likely to exist within the M2 corridor, and • larger areas of similar potential habitat for this species also occur nearby within and beyond the M2 corridor.
fragment an existing important population into two or more populations;	Glandular Pink-bell populations have been fragmented by urban and rural development. They occur as scattered, discontinuous populations on ridge tops, upper slopes and associated sandstone benches (NSW NPWS 2000). Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on an important population of the species as: • a potentially important population is not considered likely to exist within the M2 corridor, and • continuity would be maintained between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 corridor.
adversely affect habitat critical to the survival of a species;	A potentially important population is not considered likely to exist within the M2 corridor and no critical habitat has been listed for this species. The M2 Upgrade would not adversely affect habitat critical to the survival of this species.
disrupt the breeding cycle of an important population;	The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species as: • a potentially important population is not considered likely to exist within the M2 corridor, • proposed mitigation measures would minimise the likelihood of spreading weeds which could suppress seedling recruitment, and • potential pollination and seed-dispersal vectors are unlikely to be affected.
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;	Whilst the proposed works may modify, destroy, remove or isolate or decrease the availability or quality of habitat for this species, the extent of such impact on the species (should it occur) is likely to be minor as any population present here is likely to be small and isolated from known important populations and proposed mitigation measures would minimise impacts on potential habitat. This level of potential impact is unlikely to cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;	The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. The M2 Upgrade is thus unlikely to result in additional invasive species that are harmful to *Tetratheca glandulosa* becoming established in the species' potential habitat.

Impact Criteria	Assessment of Impact
introduce disease that may cause the species to decline; or	Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible. The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.
interfere substantially with the recovery of the species.	No recovery plan has been prepared for this species. The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species. The EMP will seek to include the priority actions identified as being required for the recovery of the species therefore the project is unlikely to interfere substantially with the recovery of the species.

F.2.11 Endangered Species

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

These factors are addressed under separate headings for each endangered species.

F.2.12 Regent Honeyeater *Anthochaera (Xanthomyza) phrygia*

The Regent Honeyeater is a generalist forager on the nectar of eucalypts and mistletoes (DECCW, 2009). Key eucalypt species include Mugga Ironbark *Eucalyptus sideroxylon*, Yellow Box *E. melliodora*, Blakely's Red Gum *E. blakelyi*, White Box *E. albens* and Swamp Mahogany *E. robusta* but the Regent Honeyeater also utilises *E. microcarpa*, *E. punctata*, *E. polyanthemos*, *E. moluccana*, *Corymbia robusta*, *E. crebra*, *E. caleyi*, *Corymbia maculata*, *E.mckieana*, *E. macrorhyncha*, *E. laevopinea*, and *Angophora floribunda* (DECC, 2009). Nectar and fruit from the Mistletoes *Amyema miquelii*, *A. pendula* and *A. cambagei* are also eaten during the breeding season (DECCW, 2009). When nectar is scarce, lerp and honeydew comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings. A shrubby understorey is an important source of insects and nesting material (DECCW, 2009).

The Regent Honeyeater generally inhabits dry, temperate woodlands and open forests of the inland slopes of south-eastern Australia (DECCW, 2009). There are only three known major breeding locations and two of these occur in NSW. In NSW the distribution is very patchy and largely confined to Capertee Valley and in the Bundarro-Barraba region and surrounding fragmented woodlands (DECCW, 2009).

Regent Honeyeaters sometimes occur in coastal forest, especially in stands dominated by Swamp Mahogany and Spotted Gum, but also on sandstone ranges with banksias *Banksia spp.* in the understorey (DEWHA 2009a). The species is occasionally observed in a variety of other vegetation types including low open forest with dry heathy understorey on and coastal scrub or heathland dominated by *Banksia* and *Leptospermum* species. It is possible that these habitats are used predominantly as a refuge when the preferred box-ironbark habitats are affected by drought (Menkhorst et al. 1999).

Size of population

- *lead to a long-term decrease in the size of a population;*

The Regent Honeyeater has three main population centres; the Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria. Evidence of movement of birds between these areas and little discernable difference in their genetics indicates that the species exists as a single population (DEWHA 2009a).

The limited removal of marginal potential drought period foraging habitat for this species as described in the following sections is considered unlikely to lead to a short-term or long-term decrease in the size of this population.

Area of occupancy

- *reduce the area of occupancy of the species;*

Potential drought period foraging habitat for the Regent Honeyeater in the vicinity of the M2 corridor consists of stands of open forest, particularly areas winter-flowering eucalypt species, lerp-infested trees and areas with a heath understorey.

Eucalypt species usually have regular flowering seasons, though many also show a degree of variability in flowering patterns as a result of the age of plants, local environmental conditions and variation in rainfall and other environmental conditions between years (DEC 2004).

None of the dominant tree species within the bushland areas of the M2 corridor are primarily winter-flowering. One of the dominant or sub-dominant species throughout much of the bushland is Red Bloodwood *Corymbia gummifera* which chiefly flowers in February and March however it is also known to flower sporadically during late autumn and winter.

The original native vegetation at the western end of the M2 corridor may have contained grassy woodland with winter-flowering eucalypts that may have been potential foraging habitat for the Regent Honeyeater. None of this original vegetation remains here, however revegetation along the edges of the M2 has involved the planting of some individuals of such species. This revegetation consists of narrow bands of immature trees between the edge of the M2 Motorway and adjacent residential lands and includes the following winter flowering species:

- *Grey Box Eucalyptus molucanna*
- *Grey Ironbark Eucalyptus paniculata*
- *Forest Red Gum Eucalyptus tereticornis*
- *Spotted Gum Corymbia maculata*

Of these species only Spotted Gum flowers chiefly during autumn and winter. The remaining species chiefly flower during summer but have variable flowering patterns that include occasional winter flowering.

Commonly used lerp infested trees include found in the M2 corridor include *E. moluccana* (in revegetated areas) and *E. pilularis* in bushland areas.

The proposed works may result in the permanent removal of up to approximately 7 ha of marginal potential foraging habitat for this species. Additional areas of marginal potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Only the permanent clearing for widening works is considered to permanently reduce the potential area of occupancy of the species. Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating and replanted trees begin to mature.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve, Lane Cove National Park and Pennant Hills Park.

The extent of marginal potential habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Fragmentation

- *fragment an existing population into two or more populations;*

The Regent Honeyeater is a highly mobile, wide-ranging species that moves considerable distances between breeding areas and temporally variable food recourses. In doing so, individuals move through and forage within highly cleared and fragmented landscapes.

The relatively small amount of clearing proposed and the resultant minor increase in habitat fragmentation is not considered likely to significantly affect the subset of the population of the species that may utilise vegetation within the M2 Corridor.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

No critical habitat has been listed for the Regent Honeyeater. The M2 corridor and surrounding bushland is not considered likely to contain habitat critical to the survival of the species.

Breeding cycle

- *disrupt the breeding cycle of a population;*

There are only two known major breeding locations for the Regent Honeyeater in NSW. Occasional small breeding events have also been recorded in several locations in NSW and the ACT. Breeding of the species has not been recorded in the Sydney area and breeding of the species in the vicinity of the M2 Corridor is considered highly unlikely.

Given the low likelihood of the species breeding in the locality and the small extent of impact on potential foraging habitat, the M2 Upgrade is not considered likely to significantly disrupt the breeding cycle of any subset of the population of the Regent Honeyeater.

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

The proposed works may result in the permanent removal of up to approximately 7 ha of marginal potential foraging habitat for this species. Additional areas of marginal potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Invasive species

- *result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;*

A number of invasive fauna species exist within the study area. Of these, only the Noisy Miner *Manorina melanocephala* is considered to potentially affect the Regent Honeyeater. The Noisy Miner is an aggressive colonial native honeyeater that has increased in urban areas most likely as a result of alteration to vegetation structure and excludes many other bird species from potential foraging resources.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any additional invasive fauna species that may compete with, parasitise or prey upon the Regent Honeyeater.

There may be some temporary increase competitive advantage of the Noisy Miner over other native birds due to a reduced density of native vegetation in areas of temporary clearing. This effect is however expected to be short-term as revegetation would re-establish the prior structure in the medium to long term.

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may be detrimental to potential habitat for the Regent Honeyeater. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is considered to be low.

Disease

- *introduce disease that may cause the species to decline; or*

The M2 Upgrade is unlikely to introduce any disease that may infect bird species as no animals or material used in animal husbandry is proposed to be brought into the study area.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*) that may degrade fauna habitat. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The proposed upgrade works are unlikely to result in the introduction of diseases that may cause the Regent Honeyeater to decline.

Recovery

- *interfere substantially with the recovery of the species.*

A recovery plan (Menkhorst et al 1999) has been completed for this species which lists the following recovery objectives for the species:

- Effectively organise and administer the recovery effort to ensure that recovery plan objectives are met.
- Maintain and enhance the value of Regent Honeyeater habitat at the key sites and throughout the former range, by active participation in land-use planning processes and by active vegetation rehabilitation at strategic sites
- Monitor trends in the Regent Honeyeater population size and dispersion across its range to allow assessment of the efficacy of management actions.
- Facilitate research on strategic questions which will enhance the capacity to achieve the long-term objectives. In particular, determine the whereabouts of Regent Honeyeaters during the non-breeding season and during breeding season absences from known sites. Identify important sites and habitat requirements at these times.
- Maintain and increase community awareness, understanding and involvement in the recovery effort.
- Maintain the captive population of Regent Honeyeaters at a size which will provide adequate stock to: provide insurance against the demise of the wild population; continuously improve captive-breeding and husbandry techniques; provide adequate stock for trials of release strategies; and maintain 90% of the wild heterozygosity in the captive population.

Most of these recovery objectives relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.
The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential foraging habitat for the species.

Where possible, the EMP will incorporate management measures consistent with the Regent Honeyeater Recovery Plan. The project is therefore not considered likely to interfere substantially with the recovery of the species.

F.2.13 Swift Parrot *Lathamus discolor*

The Swift Parrot breeds in Tasmania during spring and summer and migrates to eastern Australia in autumn and winter. The breeding population has declined from in excess of 10,000 pairs to less than 1,000 with only a fraction of this number occurring in NSW (DECC 2009).

On the mainland, Swift Parrots occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations (DECC 2009). Favoured feed trees include Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens* (DECC 2009). Commonly used lerp trees are Grey Box *E. microcarpa*, Grey Box *E. moluccana* and blackbutt *E. pilularis* (DECC 2009). Swift Parrots show little site fidelity between years (Mac Nally & Horrocks, 2000) and this is probably due to the random variation in lerp infestation and flowering of their feed trees.

Size of population

- *lead to a long-term decrease in the size of a population;*

As a wide-ranging, nomadic and migratory species that breeds in a localized area in Tasmania, all Swift Parrots are likely to comprise a single population with high levels of genetic mixing.

The limited removal of marginal potential winter foraging habitat for this species as described in the following sections is unlikely to lead to a short-term or long-term decrease in the size of this population.

Area of occupancy

- *reduce the area of occupancy of the species;*

Potential winter foraging habitat for the Swift Parrot consists of stands of trees containing winter-flowering eucalypt species and lerp-infested trees.

Eucalypt species usually have regular flowering seasons, though many also show a degree of variability in flowering patterns as a result of the age of plants, local environmental conditions and variation in rainfall and other environmental conditions between years (DEC 2004).

None of the dominant tree species within the bushland areas of the M2 corridor are primarily winter-flowering. One of the dominant or sub-dominant species throughout much of the bushland is Red Bloodwood *Corymbia gummifera* which chiefly flowers in February and March however it is also known to flower sporadically during late autumn and winter.

The original native vegetation at the western end of the M2 corridor may have contained winter-flowering eucalypts. None of this original vegetation remains here however revegetation along the edges of the M2 has involved the planting of some individuals of these species. This revegetation consists of narrow bands of immature trees between the edge of the M2 Motorway and adjacent residential lands and includes the following winter flowering species:

- Grey Box Eucalyptus *molucanna*
- Grey Ironbark Eucalyptus *paniculata*
- Forest Red Gum Eucalyptus *tereticornis*
- Spotted Gum *Corymbia maculata*

Of these species only Spotted Gum flowers chiefly during autumn and winter. The remaining species chiefly flower during summer but have variable flowering patterns that include occasional winter flowering. Commonly used lerp infested trees include found in the M2 corridor include *E. moluccana* (in revegetated areas) and *E. pilularis* in bushland areas.

The proposed works may result in the permanent removal of up to approximately 7 ha of marginal potential foraging habitat for this species. Additional areas of marginal potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Only the permanent clearing for widening works is considered to permanently reduce the area of occupancy of the species. Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works thereby restoring foraging habitat as regenerating and replanted trees begin to mature.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve, Lane Cove National Park and Pennant Hills Park.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not considered significant in relation to areas of less-disturbed habitat in the locality.

Fragmentation

- *fragment an existing population into two or more populations;*

The Swift Parrot is a highly mobile, wide-ranging migratory species that forages within coastal and inland areas of eastern Australia. In doing so, individuals move through and forage within highly cleared and fragmented landscapes.

The relatively small amount of clearing proposed and the resultant minor increase in habitat fragmentation is not considered likely to significantly affect the subset of the subset of the national population of the species that may utilise the study area.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

No critical habitat has been listed for the Swift Parrot. The M2 corridor and surrounding bushland is not considered likely to contain habitat critical to the survival of the species.

Breeding cycle

- *disrupt the breeding cycle of a population;*

The Swift Parrot does not breed on mainland Australia.

Given the lack of breeding habitat and the relatively small amount of marginal potential foraging habitat that would be affected, the M2 Upgrade is not likely to significantly disrupt the breeding cycle of the Swift Parrot.

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

The proposed works may result in the permanent removal of up to approximately 7 ha of marginal potential foraging habitat for this species. Additional areas of marginal potential foraging habitat (approximately 3 ha) would be modified through temporary clearing and subsequent rehabilitation of access areas and compound sites.

Modification to other areas as a result of clearing for access will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve.

The extent of habitat to be removed or modified by the proposed M2 Upgrade is not significant in relation to areas of less-disturbed habitat in the locality.

Invasive species

- *result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;*

A number of invasive fauna species exist within the study area. Of these, only the Noisy Miner *Manorina melanocephala* is considered to potentially affect the Swift Parrot. The Noisy Miner is an aggressive colonial native honeyeater that has increased in urban areas most likely as a result of alteration to vegetation structure and excludes many other bird species from potential foraging resources.

The proposed works are not considered likely to modify the habitats of the study area in such a way as to encourage the establishment of any additional invasive fauna species that may compete with, parasitise or prey upon the Swift Parrot.

There may be some temporary increase competitive advantage of the Noisy Miner over other native birds due to a reduced density of native vegetation in areas of temporary clearing. This effect is however expected to be short-term as revegetation would re-establish the prior structure in the medium to long term.

The proposed works do have some potential to result in the introduction to the locality of invasive exotic plant species and plant diseases that may be detrimental to potential habitat for the Swift Parrot. With the implementation of the proposed measures to minimise the likelihood of spreading weeds and plant diseases the likelihood of introducing these species is considered to be low.

Disease

- *introduce disease that may cause the species to decline; or*

The M2 Upgrade is unlikely to introduce any disease that may infect bird species as no animals or material used in animal husbandry is proposed to be brought into the study area.

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*) that may degrade fauna habitat. The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The proposed upgrade works are unlikely to result in the introduction of diseases that may cause the Swift Parrot to decline.

Recovery

- *interfere substantially with the recovery of the species.*

A recovery plan (Swift Parrot Recovery Team, 2001) has been completed for this species which lists the following recovery objectives for the species:

- To identify priority habitats and sites across the range of the swift parrot.
- To implement management strategies to protect and improve priority habitats and sites resulting in a sustained improvement in carrying capacity.
- To reduce the incidence of collisions with man-made structures.
- To determine population trends within the breeding range.
- To quantify improvements in carrying capacity by monitoring changes in extent and quality of habitat.
- To increase public awareness about the recovery program and to involve the community in the recovery

Most of these recovery objectives relate to activities carried out by universities and government agencies and the proposed works would neither contribute to nor detract from their implementation.

The minimisation of vegetation clearing and post-construction vegetation rehabilitation would minimise the extent of impact on potential foraging habitat for the species.

Where possible, the EMP will incorporate management measures consistent with the Swift Parrot Recovery Plan.

F.2.14 Hairy Geebung Persoonia hirsuta

This species occurs in dry sclerophyll eucalypt woodland or forest and in shrub-woodland. It grows in sandy to stony soils derived from sandstone or very rarely on shale, from near sea level to 600 m altitude.

The species has been recorded from a number of National Parks (Blue Mountains, Wollemi, Dharug, Ku-ring-gai Chase, Marramarra, Royal and Sydney Harbour).

Most locations consist of one to three plants, with the exception of two currently known locations with between 10 and 20 plants. There is evidence of continued decline in the number of locations and the number of individuals. The species is particularly prone to local population extinction because of the small number of plants found at all locations.

Size of population

- *lead to a long-term decrease in the size of a population*;

The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, the closest recent (post 1980) record of the species is approximately 5 km from the M2 corridor and the species has not been detected within the adjacent bushland reserves.

The proposed works are thus unlikely to lead to a long-term decrease in the size of an important population of this species.

Area of occupancy

- *reduce the area of occupancy of the species;*

An important population of this species is not known within the M2 Corridor.

Fragmentation

- *fragment an existing population into two or more populations;*

Fragmentation of habitat as a result of the proposed works is expected to have minimal impact on an important population of the species as a potentially important population is not considered likely to exist within the M2 corridor and continuity would be maintained between potential habitat for the species adjacent to work areas and larger areas of similar potential habitat for this species within and beyond the M2 corridor.

Critical habitat

- *adversely affect habitat critical to the survival of a species;*

Critical habitat has not been declared for *P.hirsuta*.

Breeding cycle

- *disrupt the breeding cycle of a population;*

The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of this species as a potentially important population is not considered likely to exist within the M2 corridor. The proposed mitigation measures would minimise the likelihood of spreading weeds which could suppress seedling recruitment and potential pollination and seed-dispersal vectors are unlikely to be affected

Habitat removal and modification

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;*

It is considered unlikely that a population of this species occurs within the M2 corridor and therefore it is unlikely that the proposed project will modify, destroy, remove or isolate or decrease the availability or quality of habitat for thisspecies.

Invasive species

- *result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat;*

The potential habitat for this species on the site is presently subject to light to heavy weed invasion. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation.

The M2 Upgrade is thus unlikely to result in additional invasive species that are likely harmful to *Persoonia hirsuta* becoming established in the species' potential habitat.

Disease

- *introduce disease that may cause the species to decline; or*

Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens (e.g. Phytophthora Root Rot Fungus *Phytophthora cinnamoni*). The importation of soil and mulch into bushland areas would be minimised through the use of in situ materials wherever feasible.

The M2 Upgrade is thus unlikely to introduce disease that may cause this species to decline.

Recovery

- *interfere substantially with the recovery of the species.*

No recovery plan has been prepared for this species. The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species. Rehabilitation and revegetation works would restore habitat as regenerating species and replanted vegetation begins to mature.

The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.

The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral honeybees would be likely to increase in abundance or in their impact on native species.

F.2.15 Critically endangered and endangered ecological communities

Blue Gum High Forest in the Sydney Basin Bioregion

Within the study area Blue Gum High Forest, conforming to the national listing, is restricted to a single patch that is partially within the M2 corridor and partially within the adjacent Pennant Hills Golf Course.

This patch is approximately 1.36 hectares in area and varies considerably in condition. Some areas within this patch contain native species, consistent with the description of this community, in all vegetation layers. Other areas however lack one or more layers. The areas in poorest condition have a native canopy with very little native under-storey or ground layer vegetation. Weed invasion is moderate to high throughout this patch.

Several other areas within the M2 corridor would have once supported Blue Gum High Forest. Due to previous clearing and other forms of disturbance the original forest in these locations has been eliminated or reduced to isolated trees. These disturbed areas, including those containing isolated trees, are not within the context of other native vegetation and do not conform the national listing of Blue Gum High Forest.

Several other native vegetation communities in the study area share a number of species with Blue Gum High Forest. This vegetation are likely to contribute to the viability of the patch near Pennant Hills Golf Course through interaction in the form of seed dispersal and cross-pollination and through providing habitat for the animals that pollinate and disperse the seeds of many plant species.

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will: *reduce the extent of an ecological community;*	No reduction in the extent of any Blue Gum High Forest patches that meet the EPBC Act listing criteria would occur as a result of the M2 Upgrade.
fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines;	No fragmentation of any patches of Blue Gum High Forest that meet the EPBC Act listing criteria would occur as a result of the M2 Upgrade.
adversely affect habitat critical to the survival of an ecological community;	No habitat critical to the survival of Blue Gum High Forest would be affected by the proposed works.
modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns;	The M2 Upgrade would have little detrimental impact on the ecological processes occurring within the Blue Gum High Forest of the study area. Vegetation removal in bushland areas in the vicinity of the Blue Gum High Forest is unlikely to significantly affect population of fauna (birds, flying foxes, and insects) that are potential pollinators and dispersers of seed. Genetic interaction between the Blue Gum High Forest and adjacent areas of bushland through cross-pollination and seed dispersal is thus unlikely to be significantly affected. Proposed rehabilitation works within the Blue Gum High Forest are likely to improve the functioning of natural ecological processes such as nutrient cycling, and vegetative succession as a result of the removal of the dominant invasive weeds and the creation of conditions conducive to the recruitment of native plants.
cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting;	No removal of habitat for Blue Gum High Forest that meets the EPBC Act listing criteria would occur as a result of the M2 Upgrade. Proposed rehabilitation works within the Blue Gum High Forest are likely to improve the condition of this patch.
cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: *assisting invasive species, that are harmful to the listed ecological community, to become established; or* *causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community*	The proposed works do have some potential to result in the introduction of species that may be detrimental to the ecological community as earthworks would be conducted in nearby areas. The weed management and restoration measures are however likely to prevent any additional weed species becoming established. The proposed measures for the prevention of the spread of weeds and plant pathogens during construction and site rehabilitation would minimise the likelihood of diseases being introduced to the area containing the ecological community.
interfere substantially with the recovery of the	The priority recovery and threat abatement actions required for this ecological community are:

Impact Criteria	Assessment of Impact
species.	• prevent further clearing or fragmentation of the ecological community through the protection of protected remnants and/or local council zoning; • restore and enhance remaining areas of Blue Gum High Forest of the Sydney Basin Bioregion to create buffer zones and to link fragments with remnants of other native vegetation; • manage weed infestation through weeding and bush regeneration activities; and • develop and implement appropriate management regimes to prevent further loss or decline of functionally important species and reduction in community integrity (DEWHA 2009a). The minimisation of vegetation clearing and post-construction vegetation rehabilitation and weed control would minimise the extent of potential indirect impacts such as weed invasion on the community. The EMP will incorporate management measures, where possible, that are consistent with the actions identified in the recovery plan for this ecological community.

F.2.16 Migratory Species

- Black-faced Monarch *Monarcha melanopsis*
- Rainbow Bee-eater *Merops ornatus*
- Rufous Fantail *Rhipidura rufifrons*
- Satin Flycatcher *Myiagra cyanoleuca*
- White-throated Needletail *Hirundapus caudacutus*

Black-faced Monarch *Monarcha melanopsis*

The Black-faced Monarch is found along the coast of eastern Australia, becoming less common further south. This species is found in rainforests, eucalypt woodlands, coastal scrub and damp gullies and in more open woodland when migrating. The Black-faced Monarch is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March (Australian Musuem, 2005).

This species forages for insects among foliage and builds nests from Casuarina needles, bark, roots, moss and spider webs (Birds Australia, 2010).

Rainbow Bee-eater *Merops ornatus*

Widely distributed throughout Australia (DEWHA, 2009) the species occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (SPRAT, 1999). In Australia it is widespread, except in desert areas, usually near water (Birds of Australia, 2006). The Rainbow Bee-eater has not been formally identified to occur in any threatened ecological communities (DEWHA, 2010).

Southern populations move north, often in huge flocks during winter before returning to summer breeding areas Birds of Australia, 2010). Rainbow bee-eaters eat insects, and forages around beehives preferring honey bees and wasps. This species is usually seen in pairs or small flocks, although when migrating it may occur in groups of up to 500 birds or more (Higgins, 1999). The loss of eggs has been attributed to predation by dingoes, feral dogs and flooding.y

Rufous Fantail *Rhipidura rufifrons*

The Rufous Fantail is found in northern and eastern coastal Australia, being more common in the north. During migration, it may be found in more open habitats or urban areas. Strongly migratory in the south of its range, it moves northwards in winter (DEWHA, 2009).

Satin Flycatcher *Myiagra cyanoleuca*

The Satin Flycatcher is an active, mobile species that is found along the east coast of Australia from far northern Queensland to Tasmania (Birds of Australia, 2010). This species breeds in southern Australia and occurs at numerous and widespread sites in eastern Australia (DEWHA, 2010). The species is found in tall forests, preferring wetter habitats such as heavily forested gullies (Birds of Australia, 2010). The Satin Flycatcher is a migratory species, moving northwards in winter to northern Queensland and Papua New Guinea, returning south to breed in spring (Birds of Austalia, 2010).

The Satin Flycatcher breeds from October to February and nests in loose colonies of two to five pairs nesting at intervals of about 20 m-50 m apart (Birds of Australia, 2010).

White-throated Needletail *Hirundapus caudacutus*

In eastern Australia, White-throated Needletails are widespread in eastern and south-eastern Australia and has been recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains (DECCW, 2010). White-throated Needletails are non-breeding migrants in Australia with breeding taking place in northern Asia (DEWHA, 2009). This species almost always foarges aerially on flying insects although, they sometimes forage closer to the gorund in open habitats. The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests.

Impact Criteria	Assessment of Impact
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:	
substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;	Modification to areas as a result of clearing will result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent any migratory species with a moderate likelihood of occurrence from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation will be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works. As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased. The extent of habitat to be removed or modified by the proposed M2 Upgrade is not considered significant in relation to areas of less-disturbed habitat in the locality. Larger areas of similar potential habitat for this species also occur nearby but beyond the study area, particularly within Bidjigal Reserve. The increased road surface as a result of the works could further alter the natural flow regime of the waterways of the study area however the detention basin works proposed are being designed with capacity for the additional stormwater from the motorway. Proposed rehabilitation works within the aras proposed to be cleared are likely to improve the functioning of natural ecological processes such as nutrient cycling, and vegetative succession as a result of the removal of the dominant invasive weeds and the creation of conditions conducive to the recruitment of native plants. The proposed works are not likely to exacerbate the frequency of fires within bushland areas adjacent to the M2 corridor.
result in an invasive speciesthat is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	The proposed works are not considered likely to result in an invasive speciesthat is harmful to migratory species becoming established in an area of important habitat for the migratory species as: • The proposal is unlikely to affect the vegetation or otherwise affect habitat such that rabbits would be likely to increase in abundance or in their impact on native species • The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral cats would be likely to increase in abundance or in their impact on native species • The proposal is unlikely to affect the vegetation or otherwise affect habitat such that the European

Impact Criteria	Assessment of Impact
	Red Fox would be likely to increase in abundance or in its impact on native species • The minimisation of vegetation clearing, post-construction vegetation rehabilitation and measures to prevent the spread of weeds and plant pathogens would minimise the extent of impact on potential habitat for the species.
seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	The M2 Upgrade is unlikely to disrupt the breeding cycle of an important population of migratory species as: • potentially important populations are not considered likely to exist within the M2 corridor • potential breeding habitat is not considered likely to occur within the M2 corridor due to the level of disturbance and susception of predation as a result of the highly urbanised environment adjacent to the M2 Motorway. Breeding habitat is more likely to be located in core bushland areas beyond the study area. • Species such as the White-throated Needletails are non-breeding migrants in Australia with breeding taking place in northern Asia. • Suitable foraging habitat is only considered to be marginal at best with preferred habitat more likely to be located in areas of less-disturbed habitat in the locality. • The mobility of such species also suggests that it is unlikely that any local or regional populations would be genetically isolated from the remainder of the Australain population. Migratory species are unlikely to rely on the affected areas as breeding or foraging or roosting habitat.

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