7.1 Traffic

A technical working paper: traffic and transport (refer to **Appendix E**) has been prepared to assess the potential traffic and transport impacts of the project. This section provides a summary of the technical working paper.

Table 7-1 sets out the Director-General's Requirements as they relate to traffic and transport, and where in the environmental impact statement these have been addressed.

Table 7-1 Director-General's Requirements - traffic

Director-General's Requirement	Where addressed
A detailed description of the project and its relationship and/or interaction with the existing public transport service (rail and bus), bus stops, passenger facilities, location of routes, operator amenities, cyclist facilities, and the location and operational requirements of construction compounds.	Detailed description of the existing environment is provided in **Section 7.1.2** and **Appendix E**.
An assessment (including modelling) of the operational traffic impacts of the project, impacts (volumes, speeds, intersection performance, freight volumes, tolling etc.) on the M1 (M1 Pacific Motorway), M2 and M7 Motorways, Pennant Hills Road, Windsor Road and the surrounding local, regional and state road network.	Operational traffic impacts are addressed in **Section 7.1.4** and **Appendix E**.
An assessment of wider transport interactions (local and regional roads and public and freight transport).	Wider transport interactions are discussed in **Section 7.1.4** and **Appendix E**.
An assessment of the induced traffic and operational implications for public transport (particularly with respect to strategic bus corridors and bus routes) and consideration of opportunities to improve public transport. The assessment must address impacts on cyclists and pedestrian access and safety (for those ancillary works around the project corridor, as relevant) and consider opportunities to integrate cycleway and pedestrian elements with surrounding networks.	Operational implications for public transport are assessed in **Section 7.1.4** and **Appendix E**.
An assessment of construction traffic impacts, including a considered approach to route identification and scheduling of transport movements, the number, frequency and size of construction related vehicles (passenger, commercial and heavy vehicles, including spoil management movements), construction worker parking, the nature of existing traffic on construction access routes (including 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.	Construction traffic impacts including the identification of haulage routes and construction vehicle numbers are assessed in **Section 7.1.4** and **Appendix E**.
A strategy for managing construction 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.	Measures to manage and mitigate construction traffic impacts are provided in **Section 7.1.5** and **Appendix E**.

Director-General's Requirement	Where addressed
Consideration of the cumulative construction impacts on residents/businesses taking into account other infrastructure projects that have either commenced construction, are preparing for construction or have recently been completed.	Cumulative construction traffic impacts are considered in **Section 7.1.4** and **Appendix E**. The potential impacts of construction traffic on residents and businesses is discussed in **Section 7.2** (Social and economic).

7.1.1 Assessment methodology

An integrated traffic modelling and forecasting approach has been adopted for the traffic assessment for the project. This approach has involved:

- Use of existing traffic counts (2013) to characterise existing traffic conditions and road network performance.
- Application of a strategic Sydney traffic model (Cube traffic modelling package) to determine anticipated future growth in traffic on the major road network and the effects of tolling on road traffic demand.
- Use of strategic (Cube) and corridor (LinSig) traffic models to determine existing and future traffic conditions along the Pennant Hills Road corridor and key surrounding local roads. The outputs from these models have been used to assess the operational performance of the corridor and wider road network during construction and operation of the project.

The traffic environment has been assessed at the expected opening of the project (2019) and in the future (2029), including scenarios with and without the project. The changes in heavy vehicle volumes are generally an indicator of the anticipated changes in freight volumes on the road network.

Further information on the methodology, inputs and assumptions applied to the traffic assessment is provided in the technical working paper: traffic and transport in **Appendix E**.

Strategic Sydney traffic model

Transurban has developed, progressively updated and enhanced a strategic Sydney traffic model which provides the foundation for traffic predictions and acts as a tool for estimating the impact of significant network changes in terms of both traffic and revenue implications on Sydney toll roads. The strategic Sydney traffic model has been used to develop the traffic forecasts on which the traffic impact assessment for the project has been based.

The strategic Sydney traffic model includes:

- A strategic highway network model of the Sydney metropolitan area including Sydney's motorway network and all major state roads within the network.
- Anticipated changes and updates to the road network up until 2031.
- Anticipated future land uses as a basis for estimating future demand for travel for cars and trucks.
- Explicit modelling of the effect of tolls on the road network and traffic volumes, including a toll on the project at a level which is consistent with the Hills M2 Motorway.
- The presence of heavy vehicle regulation of Pennant Hills Road to ensure that eligible trucks utilise the main alignment tunnels. Further details regarding heavy vehicle regulation are provided in **Chapter 5**.
- Accommodation of different motorist behaviours including willingness to pay a toll to save travel time.
- Induced traffic which is attracted to Pennant Hills Road or the main alignment tunnels from competing routes as a result of improved travel times. Induced demand from other transport modes has not been considered in the model as there are no parallel or competing public transport routes which serve the same market along the proposed tunnel alignment.

The strategic Sydney traffic model has been used to determine anticipated future growth in traffic on the major road network and the effects of tolling changes. This information has been applied to existing traffic counts (2013) to estimate future traffic volumes as a basis for modelling and assessment of the traffic impacts of the project during construction and operation.

Further details regarding the inputs to the strategic traffic model and forecasting are provided in the technical working paper: traffic and transport in **Appendix E**.

Traffic network performance modelling

Traffic network performance modelling for the project has been based on:

- Derivation of existing 'base year' (2013) traffic patterns from network surveys conducted in December 2013.
- Development and calibration/ verification of a traffic model that reflects existing 'base year' (2013) traffic network performance as determined from network surveys conducted in December 2013.
- Extension of the calibrated / verified traffic model to assess traffic network performance in future years relevant to the project:
  - 2016 to reflect the anticipated construction of the project.
  - 2019 to reflect the anticipated opening of the project.
  - 2029 during operation of the project.

Derivation of base year (2013) traffic patterns

During early December 2013, automatic mid-block tube counts were carried out on a number of roads in the project area. While the perception may be that traffic volumes decrease in December, a review of Roads and Maritime count sites indicates that the first two weeks of December showed slightly higher average daily traffic compared to the average annual daily traffic. Therefore, no factoring of the traffic counts has been considered necessary. This data has been used to prepare average daily and weekly traffic profiles for the project area, which are presented in **Appendix E**. Demand on Pennant Hills Road has been assessed using typical AM and PM peak hours.

In addition to mid-block traffic counts, intersection counts were also obtained during early December 2013 to determine traffic behaviour at key intersections. Percentages of heavy vehicles were recorded for both mid-block and intersection counts.

Data collected from mid-block and intersection counts, including AM and PM peak volumes / flows, daily flows, and percentages of heavy vehicles, are presented in **Section 7.1.2**.

In order to gain an insight into historical traffic growth on the road network, annual growth rates have also been determined by comparing current traffic volumes with average annual daily traffic (AADT) figures ranging from 2005 to 2013. These historical annual growth rates are provided in **Section 7.1.2**.

Following the collection of network traffic data, operational performance of the existing Pennant Hills Road and surrounding network has been assessed by comparing peak period demand data with road and intersection design capacity. This assessment involved use of the following performance indicators:

- Road safety and incidence of traffic crashes (based on Roads and Maritime Crash Data for the 12 month period ending December 2013, and Transport for NSW Centre for Road Safety Data).
- Average travel speeds and travel times.
- Mid-block and intersection Level of Service (LoS).

To assess mid-block level of service for the existing Pennant Hills Road corridor and the Hills M2 Motorway, surveyed existing traffic volumes (2013) have been compared with the theoretical design capacity of these roads. This comparison has been used to derive AM and PM peak mid-block volume / capacity (V/C) ratios that indicate how much of the road is being taken up with vehicles during peak periods.

Existing intersection performance level of service and average intersection delays at key intersections have also been determined.

Development of base and future year traffic models

The corridor modelling software, LinSig, has been selected to model the road network and to assess existing and future traffic scenarios. LinSig, Roads and Maritime's preferred software package for this type of assessment, is a macro-simulation model capable of assessing the performance of isolated or co-ordinated networks of intersections.

Because cars and trucks of different sizes take up different amounts of road space, traffic in the LinSig model has been translated into an equivalent number of passenger car units (PCU) to provide a consistent basis for reference. For example, a passenger vehicle is one PCU, while an articulated truck is 2.9 PCUs. Further information on the use of PCUs is provided in **Appendix E**.

A base traffic model has been developed to replicate existing traffic conditions along the Pennant Hills Road corridor as experienced in 2013. Actual traffic data from surveys conducted in December 2013 have been used to calibrate and verify that the model accurately represents existing traffic conditions.

The calibrated / verified base traffic model has been used as the basis for developing future year models to assess the future operational performance of the Pennant Hills Road corridor. Following the standard assessment approach for this type of project, future years have been chosen to assess road network performance immediately after project opening (2019), and also once traffic patterns have become accustomed to changes brought about by the project (2029). These models cater for the assessment of the 'with project' and 'without project' scenarios.

In addition to operational traffic scenarios, 2016 'with construction' and 'without construction' scenarios have been developed to assess the effects of project construction traffic on the road network.

Measures of network performance

Levels of service have been used as a measure to assess the performance of intersections and mid-blocks (the section of road between intersections). Level of service is a qualitative measure used to describe the operational conditions and efficiency of a roadway or intersection. It is generally described in terms of service measures such as the following:

- Speed and travel time.
- Freedom to manoeuvre
- Traffic interruptions.
- Comfort and convenience.
- Road safety.

Average delay is commonly used to assess the operational performance of intersections, with level of service used as an index. A description of the level of service scale for intersection performance is provided in **Table 7-2**.

Table 7-2 Level of service criteria for intersections

Level of service	Average delay / vehicle (secs/veh)	Traffic signals / roundabouts	Give way and stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals incidents will cause excessive delays	At capacity; requires other control mode
F	>70	Roundabouts require other control mode	At capacity; requires other control mode

(Source: Guide to Traffic Generating Developments, RTA, 2002)

Mid-block volume / capacity ratios provide an indication of the saturation level of a segment of roadway, based on the theoretical design capacity of the road. These mid-block volume / capacity ratios can be used to provide a corresponding level of service for roadway operation, as detailed in Guide to Traffic Management – Part 3 Traffic Studies and Analysis (Austroads, 2007).

The range of mid-block volume / capacity ratios which correspond to each level of service vary with differing road conditions and road type classifications. Assessment of mid-block level of service for Pennant Hills Road has used the volume / capacity ratio ranges for multi-lane roads, and assessment of the Hills M2 Motorway and main alignment tunnels has used the volume / capacity ratio ranges for freeways (refer to **Table 7-3**).

Table 7-3 Mid-block level of service definitions and criteria

Level of service	Definition	V/C ratio criteria	
		Multi-lane Roads[1]	Freeways[2]
A	A condition of free flow in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high.	V/C <= 0.28	V/C <= 0.30
B	In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort is a little less than with level of service A.	0.28 < V/C <= 0.44	0.30 < V/C <= 0.48
C	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. The general level of comfort and convenience declines noticeably at this level.	0.44 < V/C <= 0.64	0.48 < V/C <= 0.70
D	Close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems.	0.64 < V/C <= 0.85	0.70 < V/C <= 0.90
E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown.	0.85 < V/C <= 1.00	0.90 < V/C <= 1.00
F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.	1.00 < V/C	1.00 < V/C

(Source: Guide to Traffic Management Part 3 Traffic Studies and Analysis, Austroads, 2007)

[1] Where free flow speed is taken as 80 kilometres per hour

[2] Where free flow speed is taken as 100 kilometres per hour

7.1.2 Existing environment

Regional and local road network

As discussed in **Section 3.3**, Pennant Hills Road between the M1 Pacific Motorway and the Hills M2 Motorway forms part of the AusLink National Land Transport Network (National Road Network). This is a network of roads that provides connections between all mainland states and territories of Australia. The National Road Network is based on national and inter-regional transport corridors including connections through urban areas, links to ports and airports, rail, road and intermodal connections that together are of critical importance to national and regional economic growth, development and connectivity. The primary objectives of the National Road Network are to facilitate overseas and interstate trade, to support regional development and to allow safe and reliable access to major population centres.

Following the completion of the Westlink M7 Motorway, the connection between the M1 Pacific Motorway and the Hills M2 Motorway represents an important 'missing link' in Sydney's motorway network. The section of Pennant Hills Road that currently links the two motorways is one of the two remaining sections of the National Road Network within Sydney that is not of motorway standard. The other is King Georges Road, located in southern Sydney.

Between the M1 Pacific Motorway and the Hills M2 Motorway, Pennant Hills Road operates as a major arterial route, providing access between the Hills M2 Motorway and Epping Road in the south to the M1 Pacific Motorway and Pacific Highway in the north, travelling through suburbs including West Pennant Hills, Thornleigh and Normanhurst (refer to **Figure 7-1**). Cars and cyclists using this section of Pennant Hills Road share the road with traffic travelling to or from major cities and regional centres, such as the Central Coast and Newcastle, Brisbane and Melbourne. This includes heavy vehicles transporting freight intrastate and interstate.

There are currently 21 signalised intersections along Pennant Hills Road between the M1 Pacific Motorway and the Hills M2 Motorway. Intersections with local roads provide access to residences, businesses and other facilities located within surrounding suburbs. Key intersections at the northern end of the project corridor include the M1 Pacific Motorway / Pennant Hills Road intersection, the M1 Pacific Motorway / Pacific Highway interchange and the Pennant Hills Road / Pacific Highway intersection. At the southern end of the project corridor is the existing Hills M2 Motorway / Pennant Hills Road interchange. Details of these key intersections are provided in **Table 7-4** and the existing layouts of the intersections shown in **Figure 7-2** to **Figure 7-5**.

The Hills M2 Motorway forms part of the Sydney Orbital Network, which provides a key arterial link between Sydney's north-west suburbs and a number of major employment, education and leisure centres, including the Sydney central business district, North Sydney and Macquarie Park. Along with the Westlink M7 Motorway, the Hills M2 Motorway provides access between the Hume Highway and the M1 Pacific Motorway, effectively linking southern NSW to Sydney and onward to the Central Coast, Newcastle and northern NSW.

The Hills M2 Motorway is a divided carriageway motorway consisting of either two or three lanes in each direction. Within the vicinity of the Hills M2 Motorway integration works there are currently three travel lanes for eastbound traffic and two for westbound traffic. Dedicated bus lanes operate in the centre of the roadway between Beecroft Road and Windsor Road, with median bus stops allowing passengers access via over or underpasses.

At the northern extent of the project corridor, Pennant Hills Road intersects with two major road corridors: the M1 Pacific Motorway and the Pacific Highway. The Pacific Highway is an urban corridor that provides access between the Sydney central business district and the M1 Pacific Motorway. The section of the Pacific Highway in the study area has two to three lanes in the northbound and southbound directions. Clearway conditions operate southbound from 6 am to 10 am and northbound from 3 pm to 7 pm, Monday to Friday. Most of this section of the Pacific Highway has a posted speed limit of 60 kilometres per hour. There are a number of school zones along this section of the Pacific Highway, between Lucinda Avenue and Finlay Road.

The M1 Pacific Motorway links Sydney to the Central Coast, Newcastle and Hunter regions. Commencing at its intersection with Pennant Hills Road, the motorway travels around 120 kilometres north before terminating at the junction of Weakleys Drive and John Renshaw Drive in Beresfield. Generally, the motorway has a posted speed limit of 110 kilometres per hour, however between the M1 Pacific Motorway / Pennant Hills Road intersection and the M1 Pacific Motorway / Pacific Highway interchange, a 70 kilometre per hour speed limit applies and between Junction Road and the Pacific Highway, an 80 kilometre per hour speed limit applies.

The section of the M1 Pacific Motorway that would be affected by tie-in works as part of the project is a divided carriageway consisting of three lanes in each direction.

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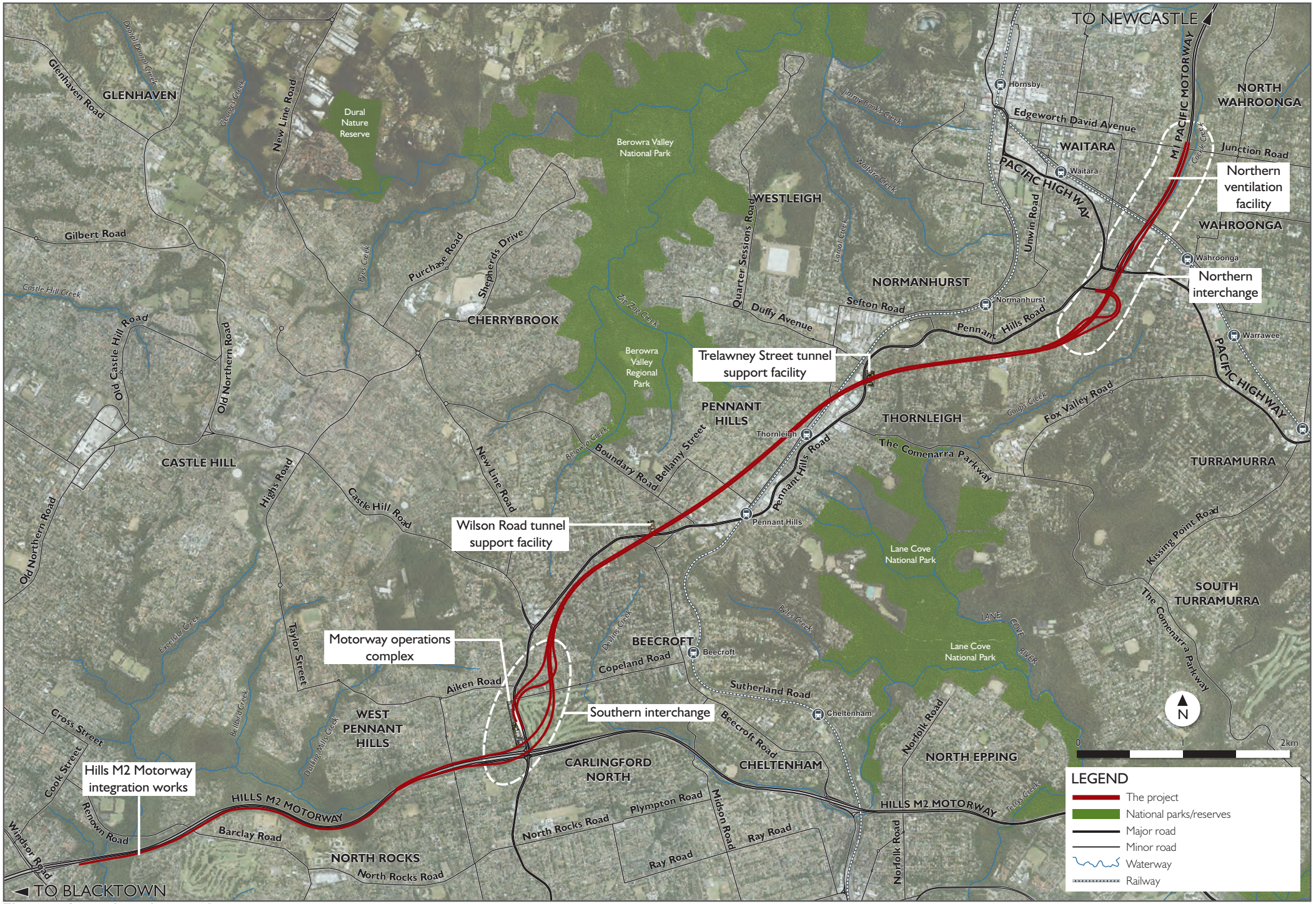

Figure 7-1 Local road network

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Table 7-4 Existing key intersection arrangements

Intersection / interchange	Type	Vehicle movements	Pedestrian and cyclist provisions
Hills M2 Motorway / Pennant Hills Road interchange	Grade separated four-way signalised interchange.	• An all movements interchange between the Hills M2 Motorway and Pennant Hills Road. • Dedicated east-facing bus ramps between Pennant Hills Road and the Hills M2 Motorway.	• North-south pedestrian movements on the eastern and western sides of the interchange. • East-west pedestrian movements on the northern side of the intersection only. • Provision for cyclists northbound and southbound on Pennant Hills Road across the interchange.
M1 Pacific Motorway / Pennant Hills Road intersection	At-grade signalised T-intersection.	• A left turn movement from the M1 Pacific Motorway southbound onto Pennant Hills Road southbound. • A right turn movement from Pennant Hills Road northbound onto the M1 Pacific Motorway northbound. • A left turn movement from Pennant Hills Road southbound onto the M1 Pacific Motorway northbound. • Straight through movements along Pennant Hills Road.	• North-south pedestrian movements on the eastern and western sides of the intersection. • East-west pedestrian movements on the northern side of the intersection only. • No dedicated cyclist facilities are provided.

Intersection / interchange	Type	Vehicle movements	Pedestrian and cyclist provisions
Pennant Hills Road / Pacific Highway intersection	At-grade signalised T-intersection.	• A right turn movement from the Pacific Highway westbound onto the Pacific Highway northbound. • A left turn movement from the Pacific Highway westbound onto Pennant Hills Road southbound. • A right turn movement from Pennant Hills Road northbound onto the Pacific Highway eastbound. • A straight movement from Pennant Hills Road northbound onto the Pacific Highway northbound. • A left turn movement from the Pacific Highway southbound onto the Pacific Highway eastbound. • A straight movement from the Pacific Highway southbound onto Pennant Hills Road southbound.	• North-south pedestrian movements on the eastern and western sides of the intersection. • East-west pedestrian movements on the northern side of the intersection only. • No dedicated cyclist facilities are provided.

Intersection / interchange	Type	Vehicle movements	Pedestrian and cyclist provisions
M1 Pacific Motorway / Pacific Highway interchange	Grade separated interchange for M1 Pacific Motorway through movements with signalised T-intersections on the ramps.	• A left turn movement from the M1 Pacific Motorway southbound onto the Pacific Highway eastbound. • A right turn movement from the M1 Pacific Motorway southbound onto the Pacific Highway westbound. • A left turn movement from the Pacific Highway eastbound onto the M1 Pacific Motorway northbound. • A right turn movement from the Pacific Highway westbound onto the M1 Pacific Motorway northbound. • Straight through movements along the Pacific Highway. • Straight through movements along the M1 Pacific Motorway.	• East-west pedestrian movements on the northern and southern sides of the intersection. • No dedicated cyclist facilities are provided.

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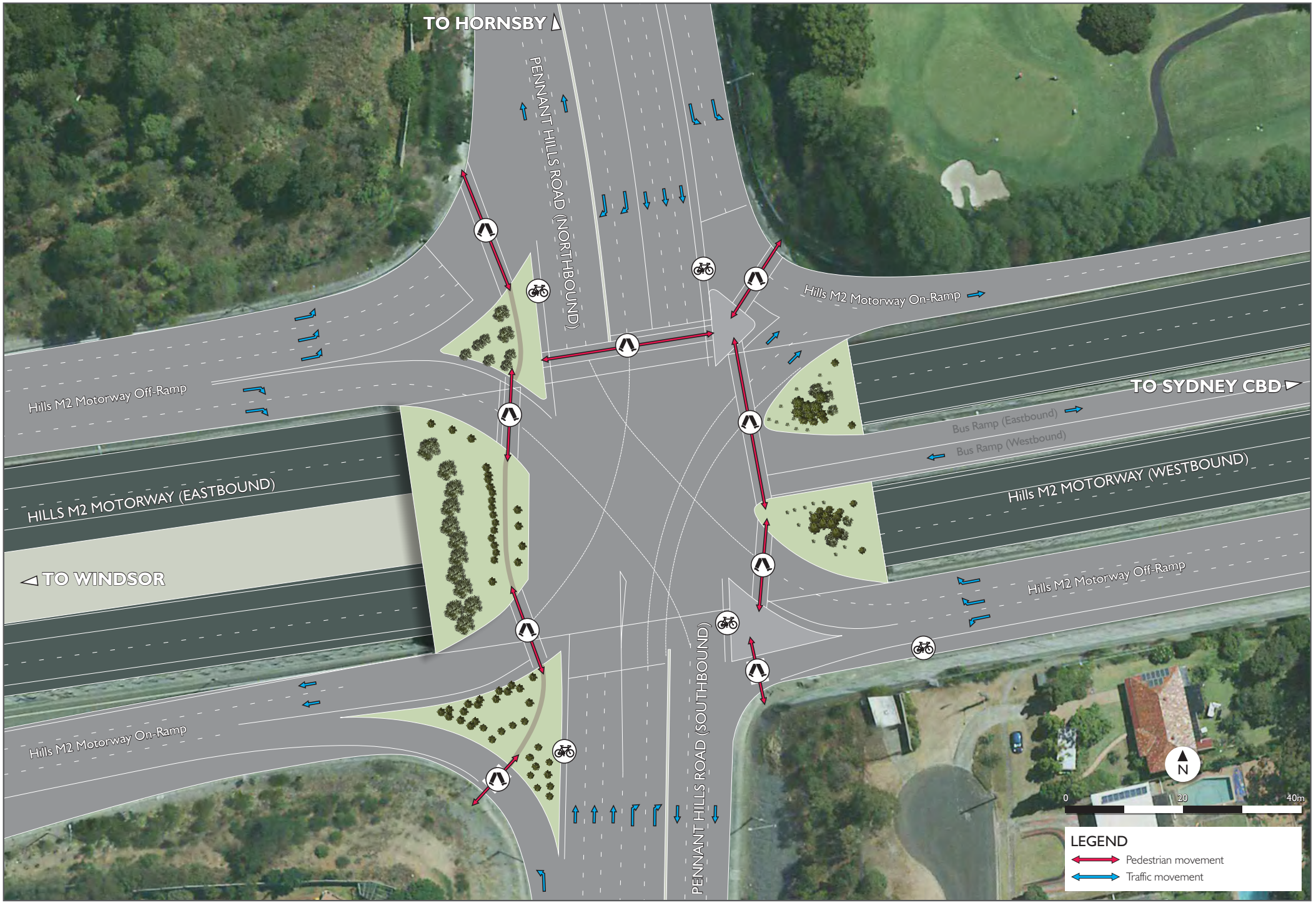

Figure 7-2 Existing Hills M2 Motorway - Pennant Hills Road Intersection

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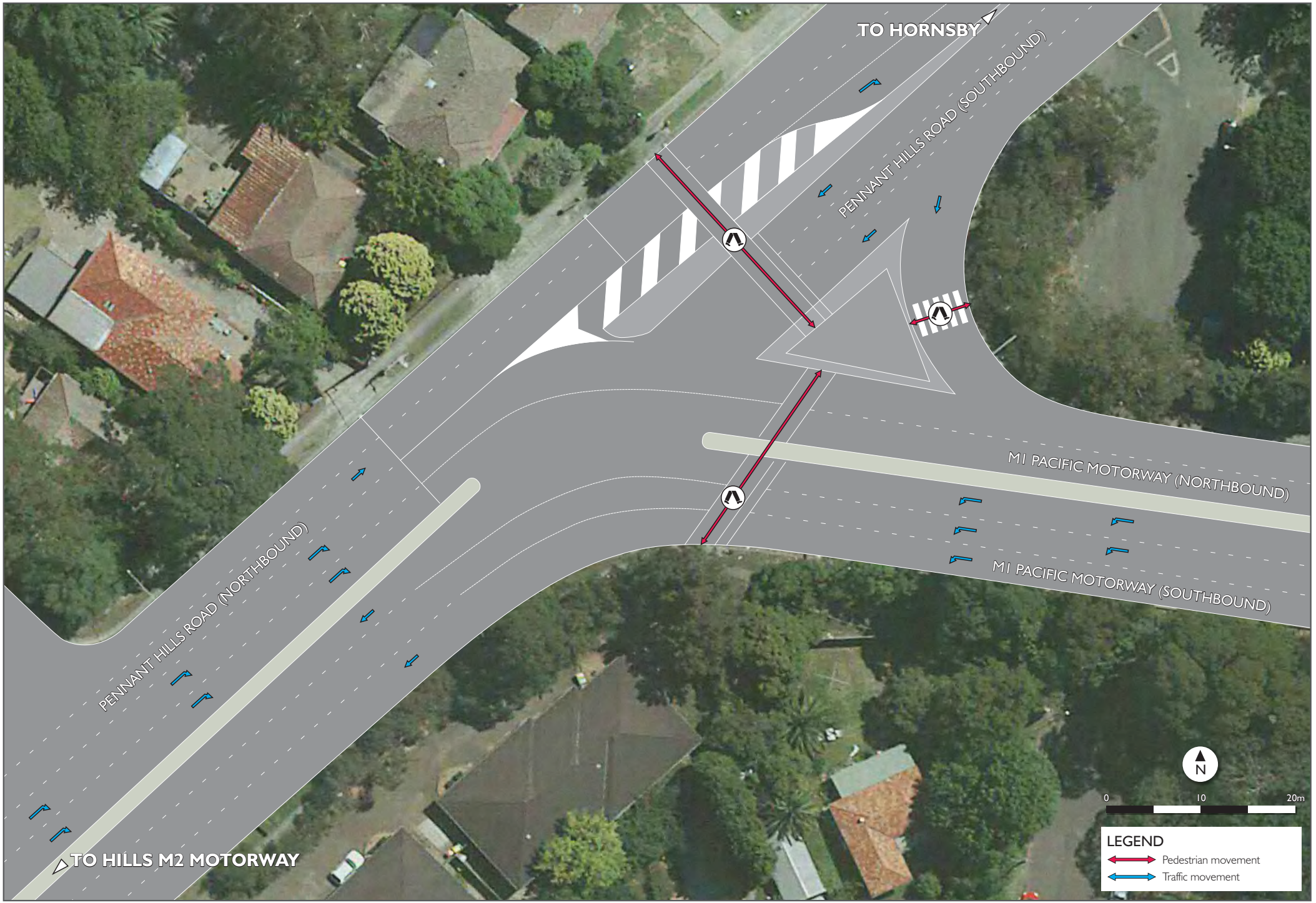

Figure 7-3 Existing M1 Pacific Motorway - Pennant Hills Road Intersection

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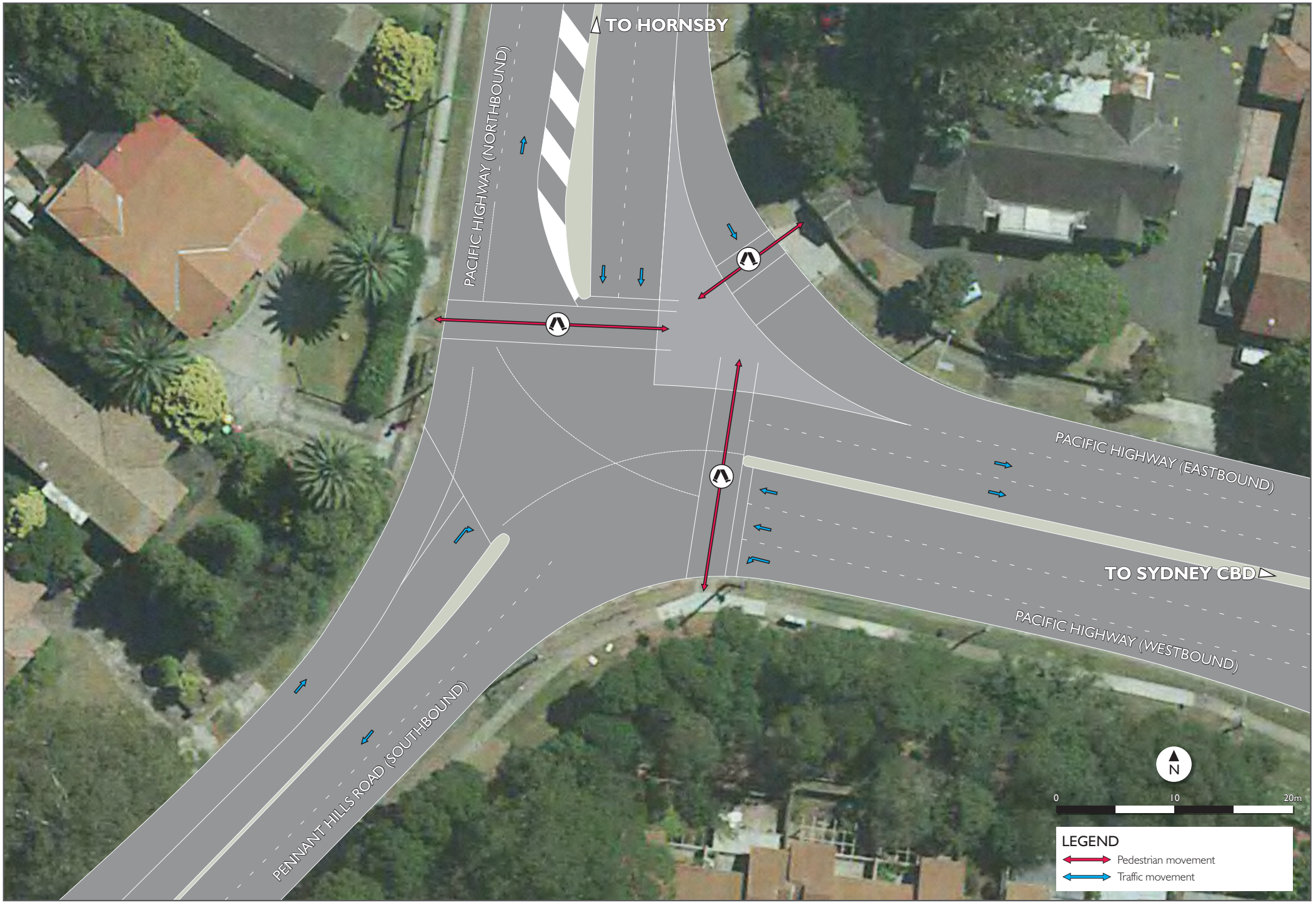

Figure 7-4 Existing Pennant Hills Road - Pacific Highway Intersection

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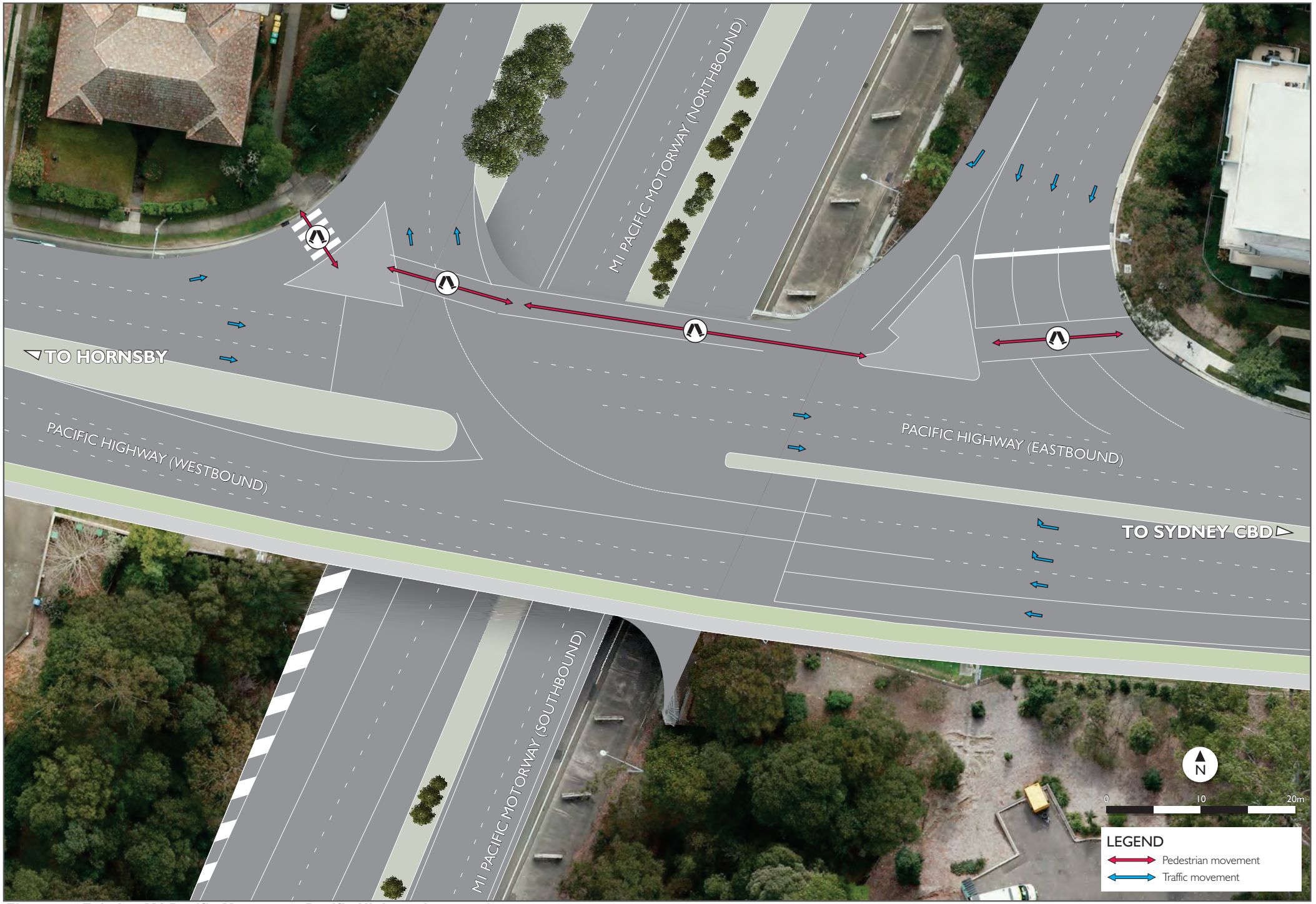

Figure 7-5 Existing M1 Pacific Motorway - Pacific Highway Intersection

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Future freight predictions

The NSW Freight and Port Strategy (TfNSW, 2013b) predicts that by 2031, the freight task in NSW is projected to nearly double to 794 million tonnes. The volumes of all commodities are expected to grow as population and economic activity increases. Capacity across the freight network varies, but key parts of the network are already constrained. Of the 409 million tonnes moved on the NSW transport network in 2011, the road network carried around 256 million tonnes (63 per cent), with the M1 Pacific Motorway and the M31 Hume Highway, the most frequently used road corridors, and rail carried about 33 per cent. The mode share for the total interstate freight task is 92 per cent by road and eight per cent by rail.

Freight modal data from 2001 (ABS, 2011) shows that rail mode share decreased from 37 per cent to 33 per cent in 2011. There is limited available freight capacity on the shared rail network in the metropolitan area, and priority for passenger trains in the rail timetables further constrains freight movements.

Completion of the North Sydney Freight Corridor project, which includes the Epping to Thornleigh Third Track (ETTT) Project, will expand the Main North Railway Line's freight capacity, mainly focused on freight movement between Sydney and Newcastle. However, it is likely that any future capacity increase as a result of the Epping to Thornleigh Third Track project will be taken up by the projected freight growth by 2031, and is unlikely to impact on the heavy vehicle movements on Pennant Hills Road.

As described in **Chapter 4**, the 2004 report investigated a rail and public transport only option, which included investment to increase market share in passenger and freight rail, as well as replacing the investment in the new link with a new passenger rail service. The rail and public transport only option was based on the implementation of all planned rail infrastructure improvements plus additional investment in lieu of expenditure on a road link. These improvements included the North West Rail Link (Epping to Rouse Hill), the full Chatswood to Parramatta rail link, the Epping to Thornleigh Third Track Project, the Main North Railway Line upgrade between Hornsby and Wyong, quadruplication of Strathfield to Hornsby line and two completely new train services linking the Central Coast with Parramatta and Western Sydney were included in the 2021 network, as well as the completion of the bus Transitways listed in *Action for Transport 2010*.

The 2004 report found that rail and public transport alone and in particular rail transport would be unlikely to satisfy future growth in transport demand. In relation to rail freight, the investigation found that the high rail freight growth scenario would only remove around ten per cent of trucks off Pennant Hills Road per day, resulting in a significant number of trucks still using Pennant Hills Road.

A number of projects identified above, such as North West Rail Link (NWRL) and the Epping to Thornleigh Third Track Project have either commenced construction or are in the final stages of planning. These projects would be undertaken concurrently with the project. However, they would be unlikely to satisfy future transport demand and would cater for different markets and objectives than the project. Both of these rail projects would enhance the existing rail infrastructure however they are unlikely to improve conditions on Pennant Hills Road.

Based on the above, no changes in future freight volumes (ie heavy vehicle movements) due to the North West Rail Link or Epping to Thornleigh Third Track projects have been assumed in the strategic model.

Pennant Hills Road annual traffic growth

Pennant Hills Road carries large volumes of traffic, with two-way AADT in 2011 of about 80,000 vehicles per day (Infrastructure NSW, 2011). AADT figures between 2005 and 2013, where available, have been examined to gain insight into traffic growth on Pennant Hills Road in previous years.

The figures show stagnant growth on the Pennant Hills Road corridor. This is attributable to the high levels of congestion during peak periods which limit the rate of potential traffic growth. These figures are presented in **Table 7-5**.

Table 7-5 Pennant Hills Road AADT traffic growth (2005-2013)

Location	2005	2009	2010	2011	2012	2013	Average growth per annum
Woodstock Road	-	-	47,500	47,900	46,300	-	-1%
Copeland Road	-	73,260	-	-	-	-	
Castle Hill Road	82,700	-	-	-	-	-	
Beecroft Road	-	59,500	62,600	62,100	62,200	62,000	1%

(Source: Roads and Maritime, 2013)

Traffic volumes and patterns

Mid-block

Table 7-6 presents results of traffic surveys that were carried out during December 2013 at various locations along Pennant Hills Road and the Pacific Highway. These results include percentages of average weekday daily traffic (AWDT) vehicles that were observed to be heavy vehicles. It is evident from these results that Pennant Hills Road between the Hills M2 Motorway and M1 Pacific Motorway is subject to high volumes of heavy vehicles, with up to 14.4 per cent of all traffic recorded as being heavy vehicles. The proportion of heavy vehicles on the Pacific Highway east of the M1 Pacific Motorway is lower than observed on Pennant Hills Road.

Table 7-6 Automatic tube counts, 2013 (weekday)

Location	Two-way traffic flows			
	AM peak (vehicles / hour)	PM peak (vehicles / hour)	AWDT flow (vehicles / day)	Percentage of heavy vehicles
Pennant Hills Road, north of the Pacific Highway intersection	2,290	2,620	37,180	6.4%
Pennant Hills Road, south of Pacific Highway intersection	1,750	1,840	26,880	8.0%
Pennant Hills Road, north of Hills M2 Motorway interchange	5,360	5,480	79,050	14.4%
Pennant Hills Road, south of Hills M2 Motorway interchange	3,620	3,250	47,630	10.4%
Pacific Highway east of the M1 Pacific Motorway	4.397	4,736	26,700	3.1%

(Source: Austraffic, 2013)

Intersection counts were also obtained during December 2013 at many of the key intersections along the project corridor (refer to **Table 7-7**). A number of intersections along the Pennant Hills Road corridor were found to be subject to both high traffic volumes and high proportions of heavy vehicles. At the intersection of Pennant Hills Road / Comenarra Parkway, 11.6 per cent of vehicles in the AM peak were recorded to be heavy vehicles. In terms of total vehicle volumes, the Pennant Hills Road / Boundary Road intersection was the highest surveyed, with 6,660 vehicles travelling through the intersection in the AM peak hour, and 6,840 in the PM peak.

Table 7-7 Intersection count summary, December 2013 (outside of school holidays)

Intersection	Light vehicles		Heavy vehicles		Total		Percentage of heavy vehicles	
	AM	PM	AM	PM	AM	PM	AM	PM
Pennant Hills Road / North Rocks Road	4,090	4,540	280	170	4,370	4,710	6.3%	3.8%
Hills M2 Motorway / Pennant Hills Road	5,410	5,780	600	480	6,010	6,260	10.0%	8.3%
Pennant Hills Road / Copeland Road	5,320	5,750	560	470	5,880	6,220	9.6%	8.2%
Pennant Hills Road / Castle Hill Road	4,720	5,790	550	440	5,270	6,230	10.5%	7.6%
Pennant Hills Road / Beecroft Road (S)	5,140	5,510	470	390	5,610	5,900	8.3%	7.1%
Pennant Hills Road / Beecroft Road (N)	6,150	5,890	490	410	6,640	6,300	7.3%	6.9%
Pennant Hills Road / Boundary Road	6,120	6,390	540	450	6,660	6,840	8.1%	7.1%
Pennant Hills Road / Comenarra Parkway	4,510	5,200	590	440	5,100	5,640	11.6%	8.4%
M1 Pacific Motorway / Pennant Hills Road	4,010	4,550	500	380	4,510	4,930	11.0%	8.3%
Pennant Hills Road / Pacific Highway	2,950	3,330	200	100	3,150	3,430	6.3%	3.2%
M1 Pacific Motorway / Pacific Highway	4,450	4,970	240	120	4,690	5,090	5.1%	2.4%

(Source: Austraffic, 2013)

The traffic survey data gathered during December 2013 have also been used to generate average daily and weekly traffic profiles for Pennant Hills Road between the Hills M2 Motorway and the M1 Pacific Highway (refer to **Appendix E**). Daily profiles at the southern end of Pennant Hills Road near the Hills M2 Motorway show high morning and afternoon peak period traffic volumes, with an inter-peak period characterised by much lower traffic volumes.

Weekly traffic profiles indicate that Pennant Hills Road is characterised by traffic volumes which are relatively constant over the week (refer to **Appendix E**). Many major roads accommodate high traffic volumes on weekdays, with a subsequent decline over the weekend. On Pennant Hills Road however, volumes on the weekend continue at similar levels to those experienced on weekdays. This is particularly the case for the section of Pennant Hills Road north of the Hills M2 Motorway.

Analysis of traffic survey data also indicates that the Hills M2 Motorway is heavily affected by peak traffic volumes. In the AM peak, the eastbound direction experiences high traffic volumes as people travel from the north-western suburbs to major centres such as the Central Business District, North Sydney and Macquarie Park. This is reversed during the PM peak, with the westbound direction experiencing high volumes of traffic as people leave these centres to return home.

Inter-peak traffic volumes on the Hills M2 Motorway are considerably lower than in peak hours, with traffic volumes at midday recorded to be about 50 per cent less than those surveyed during peak hours. The morning peak occurs between 7 am and 8 am, with traffic volumes increasing rapidly from 6 am. The afternoon peak occurs between 5 pm and 6 pm, with traffic decreasing after 7 pm.

Unlike Pennant Hills Road, traffic profiles generated for the Hills M2 Motorway indicate that the corridor experiences much higher peak traffic volumes on weekdays compared to the weekend. Peak traffic volumes on Saturday and Sunday are about 40 per cent lower than those recorded during the week, with weekend peak times also less pronounced than during the week. Weekly traffic profiles for the Hills M2 Motorway are presented in the technical working paper: traffic and transport (**Appendix E**).

Current network performance

Mid-block volume / capacity ratios along the Pennant Hills Road, Hills M2 Motorway, M1 Pacific Motorway and Westlink M7 Motorway corridors under existing (2013) conditions for the AM and PM peak are provided in **Table 7-8**.

The volume / capacity ratios show that during the AM peak hour, Pennant Hills Road between Beecroft Road and Comenarra Parkway is operating near capacity in the eastbound direction with a volume / capacity ratio of 0.95. In the PM peak hour, the sections of Pennant Hills Road from the Hills M2 Motorway to Castle Hill Road, and from Beecroft Road to Comenarra Parkway in the northbound direction both operate near capacity, with a volume / capacity ratio of 0.92. In most other cases, Pennant Hills Road currently operates in peak hours with a volume / capacity ratio of around 0.6 to 0.75. The mid-block level of service along Pennant Hills Road during peak hours is generally D to E.

The volume / capacity ratios for the Hills M2 Motorway west of Pennant Hills Road show that during the AM peak hour, the motorway operates well in both an eastbound and a westbound direction, with volume / capacity ratios of 0.71 and 0.68, respectively. The eastbound level of service is D and the westbound level of service is C. The motorway operates similarly in the PM peak in an eastbound direction, with a volume / capacity ratio of 0.5 and a level of service of C.

Table 7-8 Mid-block traffic volumes and LoS (existing 2013)

Road	Location	Direction	Mid-block capacity	Light vehicles	Heavy vehicles	V/C	LoS
AM peak							
Pennant Hills Road	North Rocks Road to Hills M2 Motorway	Northbound	2,800	1,270	150	0.61	D
		Southbound	2,800	1,830	100	0.76	D
Pennant Hills Road	Hills M2 Motorway to Castle Hill Road	Northbound	4,200	2,190	320	0.75	D
		Southbound	4,200	2,910	210	0.84	E
Pennant Hills Road	Castle Hill Road to Beecroft Road	Northbound	4,200	2,370	260	0.75	D
		Southbound	4,200	2,040	200	0.63	D
Pennant Hills Road	Beecroft Road to Comenarra Parkway	Northbound	4,200	3,170	280	0.95	E
		Southbound	4,200	2,980	210	0.85	E
Pennant Hills Road	Comenarra Parkway to Pacific Highway	Northbound	4,200	1,980	260	0.65	D
		Southbound	4,200	2,020	260	0.66	D
Pacific Highway	North of Pennant Hills Road	Northbound	2,800	1,310	70	0.53	C
		Southbound	4,200	1,050	80	0.30	B
Pacific Highway	East of M1 Pacific Motorway	Northbound	4,200	1,390	100	0.40	B
		Southbound	4,200	2,780	140	0.76	D
Hills M2 Motorway	West of the Pennant Hills Road interchange	Eastbound	6,900	3,700	490	0.71	D
		Westbound	4,600	2,620	240	0.68	C
M1 Pacific Motorway	North of the Pacific Highway interchange	Northbound	6,900	1,460	220	0.31	B
		Southbound	6,900	3,410	250	0.60	C
Westlink M7 Motorway	Between Old Windsor Road and Hills M2 Motorway	Eastbound	4,600	1,290	200	0.40	B
		Westbound	4,600	1,360	160	0.40	B
Westlink M7 Motorway	Between The Horsley Drive and Old Wallgrove Road	Northbound	4,600	2,190	470	0.77	D
		Southbound	4,600	2,210	470	0.78	D

Road	Location	Direction	Mid-block capacity	Light vehicles	Heavy vehicles	V/C	LoS
PM peak							
Pennant Hills Road	North Rocks Road to Hills M2 Motorway	Northbound	2,800	1,820	50	0.71	D
		Southbound	2,800	1,610	110	0.69	D
Pennant Hills Road	Hills M2 Motorway to Castle Hill Road	Northbound	4,200	3,320	180	0.92	E
		Southbound	4,200	2,620	280	0.82	E
Pennant Hills Road	Castle Hill Road to Beecroft Road	Northbound	4,200	2,350	160	0.67	D
		Southbound	4,200	2,110	250	0.68	D
Pennant Hills Road	Beecroft Road to Comenarra Parkway	Northbound	4,200	3,400	160	0.92	E
		Southbound	4,200	2,590	280	0.81	E
Pennant Hills Road	Comenarra Parkway to Pacific Highway	Northbound	4,200	2,630	180	0.75	D
		Southbound	4,200	1,980	230	0.63	D
Pacific Highway	North of Pennant Hills Road	Northbound	2,800	1,200	40	0.47	C
		Southbound	4,200	1490	50	0.39	B
Pacific Highway	East of M1 Pacific Motorway	Northbound	4,200	2,900	70	0.74	D
		Southbound	4,200	1,720	40	0.44	C
Hills M2 Motorway	West of the Pennant Hills Road interchange	Eastbound	6,900	2,990	230	0.50	C
		Westbound	4,600	3,750	430	1.00	F*
M1 Pacific Motorway	North of the Pacific Highway interchange	Northbound	6,900	3,590	230	0.62	C
		Southbound	6,900	1,900	180	0.35	B
Westlink M7 Motorway	Between Old Windsor Road and Hills M2 Motorway	Eastbound	4,600	1,590	130	0.43	B
		Westbound	4,600	2,130	220	0.60	C
Westlink M7 Motorway	Between The Horsley Drive and Old Wallgrove Road	Northbound	4,600	2,330	340	0.72	D
		Southbound	4,600	2,500	370	0.77	D

* At capacity

(Source: Austraffic, 2013)

Table 7-9 provides a summary of the intersection performance level of service at key locations along Pennant Hills Road under existing (2013) AM and PM peak hour traffic volumes. The analysis provides the average intersection delays and level of service for the worst performing movement at each intersection.

Table 7-9 Intersection performance (existing 2013)

Peak period	Light vehicles	Heavy vehicles	Average delay	Level of service
Pennant Hills Road / North Rocks Road				
AM peak	4,090	280	88.6	F
PM peak	4,540	170	91.0	F
Hills M2 Motorway / Pennant Hills Road				
AM peak	5,410	600	45.2	D
PM peak	5,780	480	86.0	F
Pennant Hills Road / Copeland Road / Eaton Road				
AM peak	5,320	560	61.4	E
PM peak	5,750	470	65.4	E
Pennant Hills Road / Aiken Road				
AM peak	5,070	561	19.8	B
PM peak	6,091	464	20.9	B
Pennant Hills Road / Castle Hill Road				
AM peak	4,720	550	13.6	A
PM peak	5,790	440	27.5	B
Pennant Hills Road / Beecroft Road (South)				
AM peak	5,140	470	35.8	C
PM peak	5,510	390	62.5	E
Pennant Hills Road / Beecroft Road (North)				
AM peak	6,150	490	54.4	D
PM peak	5,890	410	13.0	A
Pennant Hills Road / Boundary Road				
AM peak	6,120	540	51.9	D
PM peak	6,390	450	38.0	C
Pennant Hills Road / Yarrara Road				
AM peak	4,239	547	43.7	D
PM peak	5,840	451	39.6	C
Pennant Hills Road / Comenarra Parkway				
AM peak	4,510	590	67.2	E
PM peak	5,200	440	82.3	F
M1 Pacific Motorway / Pennant Hills Road				
AM peak	4,010	490	27.5	B
PM peak	4,550	380	40.4	C
Pennant Hills Road / Pacific Highway				
AM peak	2,950	200	58.1	E
PM peak	3,330	110	50.1	D
M1 Pacific Motorway / Pacific Highway				
AM peak	4,450	240	42.3	C
PM peak	4,970	120	55.3	D

The intersection performance results demonstrate that Pennant Hills Road currently experiences significant congestion during the AM and PM peak periods. As a result, motorists and other road users currently experience long delays.

Those intersections with a higher number of conflicting movements observe higher average intersection delays. Intersections currently operating at level of service F include:

- Pennant Hills Road / North Rocks Road intersection (AM and PM peak).
- Hills M2 Motorway / Pennant Hills Road interchange (PM peak).
- Pennant Hills Road / Comenarra Parkway intersection (PM peak).

Whilst the remainder of intersections operate at level of service E or better they would be susceptible to decreases in performance with an increase in demand, if improvements to intersection layout or further optimisation of signal timings is not undertaken. Intersections susceptible to decreases in performance following relatively small growth in traffic demand include:

- Pennant Hills Road / Copeland Road intersection (AM and PM peak).
- Pennant Hills Road / Beecroft Road (South) intersection (PM peak).
- Pennant Hills Road / Comenarra Parkway intersection (AM peak).
- Pennant Hills Road / Pacific Highway intersection (AM peak).

Travel speeds and travel times

Pennant Hills Road between the Hills M2 Motorway and the M1 Pacific Motorway currently has a posted speed limit of 70 kilometres per hour. Congestion is experienced during commuter peak periods and business hours, resulting in low average peak travel speeds, unreliable travel times and disruptions to inter-regional traffic movements.

Current travel time on Pennant Hills Road between the M1 Pacific Motorway intersection and Hills M2 Motorway interchange is reported to be about ten to 24 minutes for the southbound direction of travel in the AM peak, and about 12 to 17 minutes for the northbound direction in the PM peak (Roads and Maritime, 2013c). Average speeds are reported at around 28 kilometres per hour for the southbound direction of travel in the AM peak and 32 kilometres per hour for the northbound PM peak.

The Pacific Highway to the north and to the west of the M1 Pacific Motorway interchange also suffers high levels of congestion in the peak periods.

On the Pacific Highway between the M1 Pacific Motorway interchange and Mona Vale Road, the fastest average travel time was recorded for the northbound direction in the PM peak, and the slowest for the southbound AM peak. Average speed was the lowest in the southbound AM peak at a range of 21 to 41 kilometres per hour.

Delays on the Hills M2 Motorway between Pennant Hills Road and Windsor Road are acceptable for both the eastbound AM and PM peak period and westbound AM peak. This is likely to be attributable to the addition of eastbound lanes as part of the Hills M2 Motorway Upgrade project. However, delays are still experienced in the westbound direction during the PM peak.

Road safety

Both Pennant Hills Road and the Pacific Highway have a crash history that is broadly consistent with NSW averages. Historically, fatal crashes along these routes have occurred at a lower frequency than average, while injury crashes have occurred on a slightly higher than average frequency.

An analysis of crash statistics collected for Pennant Hills Roads between the Pacific Highway intersection and the Hills M2 Motorway interchange between 1 July 2008 and 30 June 2013 found that a total of 980 crashes occurred during this period, one of which was fatal and 342 of which were injury crashes.

The average crash severity index for Pennant Hills Road for this time period was 1.18, compared to an average of 1.24 for all crashes on public roads in NSW. This indicates that Pennant Hills Road has a lower than average proportion of fatal and injury crashes. This could be due to the frequent reduced speed environment of Pennant Hills Road, resulting from traffic congestion during peak hours. The high proportion (50 per cent) of crashes involving rear-end collisions also suggests that traffic congestion is a contributing factor.

The Hills M2 Motorway between Windsor Road and Pennant Hills Road has a crash history which is demonstrative of typical motorway conditions where grade separation, median barriers and other safety treatments are used to minimise conflicting or opposing traffic movements. Analysis of crash history data between 1 July 2008 and 30 June 2013 found that this section of the Hills M2 Motorway has a crash severity index of 1.21, which is broadly consistent with the NSW average (1.24).

The Hills M2 Motorway carries large volumes of traffic with relatively few incidents, recording substantially lower occurrences of both fatal and injury crashes per kilometre travelled than the NSW average. The latest Roads and Maritime data (for the 12 month period ending December 2013) indicates average fatality and injury rates across NSW of 0.5 and 28.0 per 100 million vehicle kilometres travelled (MVKM) respectively. By comparison, crash history data for the Hills M2 Motorway between Windsor Road and Pennant Hills Road reveals average fatality and injury rates of 0.0 and 8.3 per 100 MVKM respectively (refer to **Table 7-10**). The estimated cost of crashes per 100 MVKM travelled on the Hills M2 Motorway and Pennant Hills Roads is around $3.5 million and $14.7 million, respectively.

Table 7-10 Crash history data (1 July 2008 – 30 June 2013)

Route / location	Crash severity index	Crash rate per 100 MVKM			Cost per 100 MVKM
		Total	Fatal	Injury	
Hills M2 Motorway					
Windsor Road interchange to Pennant Hills Road interchange	1.21	19.9	0.0	8.3	$3,483,520
Pennant Hills Road					
Pennant Hills Road / Pacific Highway intersection to Pennant Hills Road / Hills M2 Motorway interchange	1.18	95.2	0.1	33.2	$14,670,060
New South Wales average					
Total – all public roads	1.24	-	0.5	28.0	-

(Source: Roads and Maritime Crash Data, TfNSW Centre for Road Safety Data, and Roads and Maritime Economic Analysis Manual (Economic parameters for 2009))

Modes of travel

Private vehicles

Private vehicles are the predominant mode of transport in the project area, which is reflected by higher than average vehicle ownership in The Hills and Hornsby local government areas. The average vehicle ownership per household in The Hills and Hornsby local government areas is 2.1 and 1.7 respectively, compared to an average of 1.6 in the Sydney Greater Metropolitan Area.

The NSW Bureau of Transport Statistics (2013) provides details of the mode share of average weekday travel demand made from each local government area in NSW. Data from the household travel survey shows that on average 77 per cent of trips on a typical weekday in the project area are car-based compared to an average of 68 per cent in the Sydney Greater Metropolitan Area. Travel mode shares for The Hills and Hornsby local government areas in comparison with the Sydney greater metropolitan area are shown in **Table 7-11**.

Table 7-11 Average weekday travel mode share for the Hills / Hornsby local government areas (2011 / 12)

Local Government Area	Private vehicle			Rail	Bus	Walk only	Other modes
	Driver	Passenger	Total				
The Hills	58%	24%	82%	2%	6%	9%	1%
Hornsby	50%	21%	71%	9%	4%	14%	2%
Sydney Greater Metropolitan Area	47%	21%	68%	5%	6%	18%	3%

(Source: NSW BTS, Household Travel Survey 2011/12 Summary Report, 2013 Release)

Public transport

Public transport services are a key method of transport for journeys to work in the project area, particularly for journeys to and from the central business district. **Table 7-11** shows that in The Hills and Hornsby local government areas, bus passengers represent six and four per cent of the mode share of average weekday travel demand respectively.

A number of HillsBus bus services currently operate along Pennant Hills Road with bus stops at regular intervals in both directions. These services provide connections between Pennant Hills, Beecroft, Castle Hill, Parramatta and the central business district via the Hills M2 Motorway.

The main bus services include Route 620 operating from Dural to the City via Cherrybrook, and Route 642 and 642X operating from Round Corner to the City. Each of these routes provides peak services at a frequency of less than 15 minutes in the AM peak, and less than 30 minutes in the PM peak. Service levels and reliability of bus operations are nonetheless dependent on traffic conditions on Pennant Hills Road, the Hills M2 Motorway and surrounding local road network.

A dedicated bus lane is provided in each direction along the Hills M2 Motorway between Windsor Road and Beecroft Road, allowing public transport priority during congested peak periods. Dedicated east facing on and off bus ramps are also provided at the Pennant Hills Road and Windsor Road interchanges.

The Oakes Road Hills M2 Motorway Bus stop is located in the median of the Hills M2 Motorway at the overpass of Oakes Road, to the west of the Pennant Hills Road / Hills M2 Motorway interchange. There are 15 services which stop at the interchange, with a further ten services joining and leaving the bus lanes at the Pennant Hills Road interchange.

Major bus services operating along the Hills M2 Motorway include Routes 610, 612, 616X and 620X. These services operate at high frequencies of between three and eight minutes in the AM peak and between six and nine minutes in the PM peak.

Table 7-11 shows that in The Hills and Hornsby local government areas, rail passengers represent two per cent and nine per cent of the mode share of average weekday travel respectively. Since the completion of the Epping to Chatswood Rail Link in 2009, services on the Northern Railway Line operate from Hornsby to Epping and onward to Macquarie Park, North Sydney and the central business district via stops at Normanhurst, Thornleigh, Pennant Hills, Beecroft and Cheltenham. Further along the Northern Railway Line, services to Strathfield can be accessed by transferring at Epping Railway Station. Towards the northern extent of the project, services are provided on the North Shore Railway Line from Hornsby to the central business district via Chatswood and North Sydney.

Rail services are not present on, or in the vicinity of, the component of the Hills M2 Motorway assessed as part of this project.

Public transport services are anticipated to change with the operation of the North West Rail Link in around 2020. Along with the addition of rail services, bus services are likely to be re-routed to feed passengers into the stations, providing efficient transport to Macquarie Park, Chatswood and the central business district.

Pedestrians and cyclists

Walk only trips in the area represent nine per cent of average weekday travel mode share in The Hills local government area and 14 per cent in Hornsby local government area (refer to **Table 7-11**). These figures do not include people walking to and from public transport stops, and as such may understate the importance of pedestrian infrastructure.

Pedestrian footpaths are provided along the length of Pennant Hills Road, with regular crossings via signalised intersections as well as four pedestrian overpasses. As it is a closed access road, pedestrians are not permitted to travel on the Hills M2 Motorway.

Cycle trips are not separately represented in the mode share data, although would account for a proportion of the ‘other’ category, representing one and two per cent in The Hills and Hornsby local government areas respectively (refer to **Table 7-11**).

With the exception of a short section near the Pennant Hills Road / Castle Hill Road intersection and the Hills M2 Motorway / Pennant Hills Road interchange, there are no dedicated cyclist facilities along this section of Pennant Hills Road. Further, there are no parallel routes for cyclists to access along the Pennant Hills Road corridor, leaving cyclists with currently limited dedicated options. Hornsby Council recognises the Pennant Hills Road corridor as a ‘high difficulty’ cycle route (Hornsby Shire Council, 2008).

Cyclists travel in each direction within the road shoulder of the Hills M2 Motorway, providing access along the length of the motorway to local cyclist network links, although cyclists are currently banned from the eastbound carriageway of the motorway between Pennant Hills Road and Delhi Road due to ongoing construction works.

7.1.3 Future conditions without the project

The future operational performance of the project area has been assessed under the 'without project' scenario, for 2019 (project opening) and 2029 (opening plus ten years).

Traffic volumes and patterns

Light and heavy vehicle AM and PM peak hour volumes at key intersections along Pennant Hills Road and mid-block AWDT volumes for key sections along Pennant Hills Road have been forecast for 2019 and 2029 under the 'without project' scenario. These volumes have been analysed and compared to existing (2013) volumes, in order to identify and assess relative changes in road network performance. Future year traffic volumes for Pennant Hills Road are provided in **Appendix E**.

The AWDT figures for 2019 range from 27,850 northbound in the south of the corridor between North Rocks Road and the Hills M2 Motorway, to 50,200 northbound between Beecroft Road and Comenarra Parkway. In the 2029 scenario without the project, volumes similarly range from 32,400 northbound in the south of the corridor to 56,000 northbound between Beecroft Road and Comenarra Parkway.

Traffic along the Hills M2 Motorway (west of Pennant Hills Road) from 2013 to 2019 and 2029 is general expected to increase steadily if the project does not proceed. The anticipated increase in light and heavy vehicles is shown in **Table 7-12**.

Table 7-12 Peak hour traffic volumes (2013, 2019 and 2029 without project) – Hills M2 Motorway

Direction	Light vehicles			Heavy vehicles		
	2013	2019	2029	2013	2019	2029
AM peak hour						
Eastbound	3,700	4,250	4,860	490	480	510
Westbound	2,640	2,730	3,030	240	260	350
PM peak hour						
Eastbound	2,990	3,140	3,520	240	290	360
Westbound	3,740	4,110	4,530	430	450	490

Surrounding road network

In addition to the above 'without project' traffic volume analysis for Pennant Hills Road, light and heavy vehicle volumes at key links within the wider road network have been forecast and compared to existing (2013) volumes.

The greatest increase in both light and heavy vehicle volumes on the surrounding road network between 2013 and 2019 is anticipated to occur on the Westlink M7 Motorway between Old Windsor Road and Hills M2 Motorway. By 2029, light vehicle flows on this section of the Westlink M7 Motorway are forecast to increase by 88 per cent northbound and 88 per cent southbound without the project, while heavy vehicle volumes would increase by 87 per cent northbound and 86 per cent southbound.

Large increases in heavy vehicle volumes between 2013 and 2029 are also anticipated on other roads such as Beecroft Road (south of the Hills M2 Motorway, and between the Hills M2 Motorway and Cheltenham Road), Castle Hill Road (between New Line Road and Edward Bennett Drive), and the Hume Highway (south of Elizabeth Drive).

Future year traffic volumes and growth rates for the surrounding road network are presented in **Appendix E**.

Network performance

A comparison of forecast mid-block traffic volumes, volume / capacity ratios and level of service for 2019 and 2029 under the 'without project' scenario is provided in **Table 7-13**.

Table 7-13 Mid-block traffic volumes and LoS (2019 and 2029) without project

Road	Location	Direction	Mid-block capacity	2019 Light vehicles	Heavy vehicles	V/C	LoS	2029 Light vehicles	Heavy vehicles	V/C	LoS
AM peak											
Pennant Hills Road	North Rocks Road to the Hills M2 Motorway interchange	Northbound	2,800	1,590	180	0.76	D	1,810	240	0.90	E
		Southbound	2,800	2,320	130	0.96	E	2,840	170	1.19	F
Pennant Hills Road	Hills M2 Motorway interchange to Castle Hill Road	Northbound	4,200	2,330	350	0.80	D	2,470	400	0.86	E
		Southbound	4,200	3,220	250	0.94	E	3,620	320	1.09	F
Pennant Hills Road	Castle Hill Road to Beecroft Road	Northbound	4,200	2,540	290	0.81	E	2,750	320	0.88	E
		Southbound	4,200	2,200	210	0.67	D	2,370	260	0.74	D
Pennant Hills Road	Beecroft Road to Comenarra Parkway	Northbound	4,200	3,430	340	1.05	F	3,750	430	1.19	F
		Southbound	4,200	3,380	210	0.95	E	3,930	280	1.13	F
Pennant Hills Road	Comenarra Parkway to Pacific Highway	Northbound	4,200	2,140	290	0.71	D	2,290	340	0.78	D
		Southbound	4,200	2,340	270	0.75	D	2,690	310	0.85	E
Pacific Highway	North of Pennant Hills Road	Northbound	2,800	1,470	100	0.63	D	1,570	80	0.64	D
		Southbound	4,200	1,150	80	0.33	B	1,200	90	0.35	B
Pacific Highway	East of the M1 Pacific Motorway	Northbound	4,200	1,600	120	0.46	C	1,800	160	0.54	C
		Southbound	4,200	3,000	170	0.83	E	3,240	130	0.86	E
Hills M2 Motorway	West of the Pennant Hills Road interchange	Eastbound	6,900	4,250	480	0.82	D	4,860	510	0.92	E
		Westbound	4,600	2,730	260	0.76	D	3,030	350	0.88	D
Hills M2 Motorway	East of the Pennant Hills Road interchange	Eastbound	6,900	4,190	340	0.75	D	4,490	360	0.80	D
		Westbound	6,900	2,020	180	0.37	B	2,140	180	0.39	B

Road	Location	Direction	Mid-block capacity	2019 Light vehicles	Heavy vehicles	V/C	LoS	2029 Light vehicles	Heavy vehicles	V/C	LoS
M1 Pacific Motorway	Between Ku-Ring-Gai Interchange and Windy Banks Interchange	Northbound	6,900	1,580	270	0.34	B	1,610	320	0.37	B
		Southbound	6,900	3,920	290	0.69	C	4,260	360	0.82	D
Westlink M7 Motorway	Old Windsor Road to Hills M2 Motorway	Eastbound	4,600	1,760	180	0.50	C	2,350	230	0.66	C
		Westbound	4,600	1,580	200	0.47	B	1,800	250	0.55	C
Westlink M7 Motorway	The Horsley Drive to Old Wallgrove Road	Northbound	4,600	3,260	730	1.17	F	3,560	720	1.23	F
		Southbound	4,600	2,680	460	0.88	D	3,270	510	1.04	F
PM peak											
Pennant Hills Road	North Rocks Road to the Hills M2 Motorway interchange	Northbound	2,800	2,080	50	0.80	D	2,420	60	0.93	E
		Southbound	2,800	1,980	140	0.86	E	2,280	220	1.04	F
Pennant Hills Road	Hills M2 Motorway interchange to Castle Hill Road	Northbound	4,200	3,640	190	1.00	E	4,050	240	1.13	F
		Southbound	4,200	2,970	310	0.92	E	2,620	370	1.05	F
Pennant Hills Road	Castle Hill Road to Beecroft Road	Northbound	4,200	2,450	160	0.69	D	2,560	170	0.73	D
		Southbound	4,200	2,250	290	0.73	D	2,400	340	0.80	D
Pennant Hills Road	Beecroft Road to Comenarra Parkway	Northbound	4,200	3,690	180	1.00	F	4,080	240	1.14	F
		Southbound	4,200	2,830	330	0.90	E	2,990	410	1.00	E
Pennant Hills Road	Comenarra Parkway to Pacific Highway	Northbound	4,200	2,890	170	0.81	D	3,140	230	0.90	E
		Southbound	4,200	2,970	310	0.92	E	3,300	380	1.05	F
Pacific Highway	North of Pennant Hills Road	Northbound	2,800	1,300	30	0.50	C	1,420	70	0.58	C
		Southbound	4,200	1,630	70	0.44	C	1,830	100	0.50	C

Road	Location	Direction	Mid-block capacity	2019 Light vehicles	Heavy vehicles	V/C	LoS	2029 Light vehicles	Heavy vehicles	V/C	LoS
Pacific Highway	East of the M1 Pacific Motorway	Northbound	4,200	3,030	80	0.78	D	3,270	100	0.85	E
		Southbound	4,200	1,790	60	0.47	C	1,900	110	0.53	C
Hills M2 Motorway	West of the Pennant Hills Road interchange	Eastbound	6,900	3,140	290	0.58	C	3,520	360	0.66	C
		Westbound	4,600	4,120	450	1.18	F	4,530	490	1.29	F
Hills M2 Motorway	East of the Pennant Hills Road interchange	Eastbound	6,900	2,590	200	0.46	C	2,840	200	0.50	C
		Westbound	6,900	4,290	330	0.76	D	4,700	330	0.82	D
M1 Pacific Motorway	Between Ku-Ring-Gai Interchange and Windy Banks Interchange	Northbound	6,900	4,060	270	0.70	D	4,580	340	0.81	D
		Southbound	6,900	2,000	230	0.38	B	2,030	310	0.42	B
Westlink M7 Motorway	Old Windsor Road to Hills M2 Motorway	Eastbound	4,600	1,910	200	0.55	C	2,090	260	0.62	C
		Westbound	4,600	2,890	270	0.80	D	3,440	300	0.94	E
Westlink M7 Motorway	The Horsley Drive to Old Wallgrove Road	Northbound	4,600	3,350	540	1.07	F	3,880	560	1.20	F
		Southbound	4,600	3,340	490	1.04	F	3,570	500	1.10	F

Results of mid-block performance analysis presented in **Table 7-13** demonstrate that under the 'without project' scenario, growth in background traffic would result in decreased levels of mid-block performance in 2019. This is particularly the case for sections of Pennant Hills Road between Beecroft Road and Comenarra Parkway, and between Castle Hill Road and North Rocks Road, which are expected to exceed theoretical design capacity of the road in 2019. Several other sections of Pennant Hills Road approach capacity under forecast 2019 traffic volumes, with volume / capacity ratios in excess of 0.90.

Under forecast 2029 traffic volumes, further sections of Pennant Hills Road are expected to exceed theoretical design capacity, including the southbound section from North Rocks Road to Castle Hill Road during the AM peak. In addition, the westbound section from Beecroft Road to Comenarra Parkway is expected to operate at a level of service F, while the eastbound section would remain beyond capacity as in 2019.

During the PM peak, westbound traffic on the Hills M2 Motorway west of Pennant Hills Road would be operating above theoretical design capacity in 2019, with further worsening of performance in 2029. AM peak eastbound traffic on this section of the Hills M2 Motorway is expected to approach capacity in 2029.

A comparison of forecast intersection performance (level of service) for 2019 and 2029 under the 'without project' scenario is provided in **Table 7-14**.

Table 7-14 Intersection performance (2019 and 2029) without project

Peak period	2019				2029			
	Light vehicles	Heavy vehicles	Average delay	LoS	Light vehicles	Heavy vehicles	Average delay	LoS
Pennant Hills Road / North Rocks Road								
AM peak	4,870	340	>100	F	5,650	440	>100	F
PM peak	5,190	210	>100	F	5,950	300	>100	F
Hills M2 Motorway / Pennant Hills Road								
AM peak	6,320	680	51.4	D	7,380	860	>100	F
PM peak	6,530	540	>100	F	7,280	660	>100	F
Pennant Hills Road / Copeland Road								
AM peak	6,100	640	>100	F	6,950	820	>100	F
PM peak	6,430	530	>100	F	7,180	650	>100	F
Pennant Hills Road / Aiken Road								
AM peak	5,570	620	63.9	E	6,190	750	>100	F
PM peak	6,810	520	27.8	B	7,560	640	61.9	E
Pennant Hills Road / Castle Hill Road								
AM peak	5,130	590	18.7	B	5,580	700	>100	F
PM peak	6,290	490	95.5	F	6,855	590	>100	F
Pennant Hills Road / Beecroft Road (South)								
AM peak	5,650	540	>100	F	6,320	670	>100	F
PM peak	5,910	450	>100	F	6,430	560	>100	F
Pennant Hills Road / Beecroft Road (North)								
AM peak	6,810	560	>100	F	7,680	710	>100	F
PM peak	6,330	470	16.3	B	6,810	590	51.0	D

Peak period	2019				2029			
	Light vehicles	Heavy vehicles	Average delay	LoS	Light vehicles	Heavy vehicles	Average delay	LoS
Pennant Hills Road / Boundary Road								
AM peak	6,860	630	63.2	E	7,640	760	>100	F
PM peak	6,980	560	41.1	C	7,610	720	72.7	F
Pennant Hills Road / Yarrara Road								
AM peak	6,070	620	>100	F	6,700	730	>100	F
PM peak	6,350	550	>100	F	6,890	710	>100	F
Pennant Hills Road / Comenarra Parkway								
AM peak	5,160	680	>100	F	5,880	780	>100	F
PM peak	5,810	530	>100	F	6,380	670	>100	F
M1 Pacific Motorway / Pennant Hills Road								
AM peak	4,500	540	45.5	D	5,020	620	>100	F
PM peak	4,870	430	79.5	F	5,290	560	>100	F
Pennant Hills Road / Pacific Highway								
AM peak	3,280	220	>100	F	3,680	250	>100	F
PM peak	3,560	130	53.2	D	3,970	170	>100	F
M1 Pacific Motorway / Pacific Highway								
AM peak	4,860	290	94.5	F	5,340	370	>100	F
PM peak	5,190	150	69.1	E	5,560	190	>100	F

The intersection performance results presented in **Table 7-14** demonstrate that under the 'without project' scenario, all key intersections along the Pennant Hills Road corridor would experience significant congestion during AM and PM peak hours in both 2019 and 2029. It is also evident that the performance of the intersections along Pennant Hills Road would deteriorate between 2019 and 2029.

Under forecast traffic volumes for 2019, intersections in the vicinity of the Hills M2 Motorway / Pennant Hills Road interchange would experience an increase in average intersection delay, particularly during the AM peak period. Further significant increases in average delays are predicted in 2029, with the majority of key intersections deteriorating to level of service F intersection performance.

As detailed in **Section 7.1.2**, analysis of existing (2013) network performance revealed a number of key intersections operating at or close to capacity. Once intersection demands exceed capacity, the values for average delay increase substantially.

Travel times

Analysis has been carried out to compare current average peak hour travel times against those predicted for 2019 and 2029 under the 'without project' scenario. This comparison has shown general deterioration of both peak hour travel time and speed across the extent of the project.

Compared to existing conditions, it is predicted that the northbound journey on Pennant Hills Road between the Hills M2 Motorway and the M1 Pacific Motorway would take around 12 minutes longer to complete during the PM peak in 2019, with travel time increasing from 19 minutes to 31 minutes. Average travel times for this movement would continue to deteriorate between 2019 and 2029, with an increase in travel time from 31 minutes to 46 minutes.

The Pacific Highway would also experience an increase in travel time and decrease in speed across each peak period in both directions. However, reductions in performance along the Pacific Highway are not predicted to be as significant as those on Pennant Hills Road.

For the Hills M2 Motorway between Pennant Hills Road and Windsor Road, results indicate that average speeds and travel times during the 2019 AM peak and the eastbound PM peak would remain largely unchanged without implementation of the project. However, during the 2019 PM peak, westbound average travel times are estimated to increase by nine minutes.

Further deterioration is predicted along the Hills M2 Motorway for 2029, with the average travel time for the westbound PM peak movement expected to increase by a further 11 minutes.

Road safety

Should traffic continue to grow with no modification to the road network, the frequency of crashes on Pennant Hills Road, the Pacific Highway and the Hills M2 Motorway would be expected to increase.

Traffic on the road network within the vicinity of the project is expected to grow at a rate of between around one and two per cent per annum under the 'without project' scenario. By 2029 this increase in traffic would be expected to result in an increase in crash frequencies, from an average of 196 to 245 per annum on Pennant Hills Road and 30 to 39 per annum on the Hills M2 Motorway.

The above analysis has assumed that the future frequency, type, and severity of crashes would be consistent with historic trends, despite a significant increase in traffic. However, it is likely that the frequency, type, and severity of crashes could change in the future, with forecast traffic growth causing:

- Increased frequency of conflicting at-grade turning movements along Pennant Hills Road, and consequently the potential for crashes between opposing traffic.
- Increased frequency of on-ramp and off-ramp merging and diverging movements on the Hills M2 Motorway, and consequently the potential for crashes between through traffic and traffic entering and exiting the motorway.
- Lower operating speeds and more time spent following other vehicles. This can result in vehicles travelling closer together, further increasing the likelihood of rear end crashes.

Public transport

Under the 'without project' scenario, the following impacts to bus services along Pennant Hills Road would be anticipated:

- An increase in bus service travel times due to slower travel speeds and increased intersection delays.
- More frequent delays to services caused by traffic incidents and congestion.
- The potential for crashes caused by buses stopping on Pennant Hills Road to pick-up and drop-off passengers would increase in proportion to the expected growth in traffic.
- Longer travel times to and from bus stops by supplementary travel modes (eg car passenger and walking to / from bus stop) due to an increase in traffic volumes, slower travel speeds and increased intersection delays.

Longer travel times for rail passengers travelling to and from Beecroft, Pennant Hills, Thornleigh and Normanhurst Railway Stations by car, bus, walking and cycling, would also be expected due to an increase in traffic volumes, slower travel speeds and increased intersection delays.

The dedicated bus lane along the Hills M2 Motorway is used solely for public transport. This would allow services to continue unaffected by increasing capacity constraints on lanes occupied by general traffic.

Pedestrians and cyclists

Under the 'without project' scenario, cyclists may experience the following impacts:

- Increased delays at intersections for on-road cyclists due to an increase in traffic volumes along the corridor.
- Reduced cyclist road safety. Increased potential for accidents with other road users throughout the project area caused by an increase in traffic on the existing road network.

7.1.4 Assessment of potential impacts with project

This section provides a summary of the assessment of construction and operational traffic and transport impacts of the project under the 'with project' traffic modelling scenarios.

Construction

During construction, there would be potential for changes and disruptions to the road network as a result of:

- The introduction of construction vehicles, especially heavy vehicles transporting spoil.
- Surface road works requiring temporary traffic cyclist and / or pedestrian diversions, road occupation, temporary road closures and
- Alterations to speed limits.

There would be 11 construction compounds used during construction. The locations of these compounds are shown in **Figure 5-25** to **Figure 5-32**. Establishment and ongoing use of construction ancillary facilities may result in impacts to local traffic as well as alterations to property access, pedestrian and cyclist movements and the location of existing bus stops.

A detailed description of key traffic activities at each construction compound is provided in the technical working paper: traffic and transport (**Appendix E**).

Background traffic growth rates

Light and heavy vehicle volumes at key intersections along Pennant Hills Road have been forecast for 2016 under the 'without construction' scenario. These volumes were compared to existing (2013) volumes, in order to demonstrate relative change. Future year volumes and growth rates are provided in **Appendix E**.

Under the 'without construction' scenario, light vehicle volumes on Pennant Hills Road would generally increase at modest rates of between one and three percent between 2013 and 2016, with a maximum growth rate of five per cent. Heavy vehicle volumes are forecast to increase at a higher rate of around six per cent, reflecting the status of Pennant Hills Road as a key link for heavy vehicles. The greatest growth in heavy vehicle volumes is predicted to occur along the Pacific Highway corridor during the PM peak, with increases ranging between six and 20 per cent.

Construction traffic and routes

Construction of the project would result in the generation of additional movements of both heavy and light vehicles, and project related buses on the road network. Heavy vehicles would be required to deliver plant, equipment and materials as well as to remove spoil and waste during construction of the project. Movement of the construction workforce to and from sites within the construction footprint would be primarily by buses from the Pioneer Avenue compound (C8). This would result in increased use of light vehicles for workers to access the Pioneer Avenue compound (C8) and for movement of staff such as Foremen and Engineers between the construction sites. Construction traffic has been divided into three categories:

- Removal of spoil generated by construction activities.
- Heavy vehicle deliveries and other heavy vehicles associated with construction activities.
- Light vehicles and buses associated with construction of the project.

The primary driver in identifying construction traffic routes was to utilise the motorway and arterial road network as much as possible, thereby reducing traffic related impacts on local roads. In order to achieve this, the proximity to the Hills M2 Motorway, the M1 Pacific Motorway or Pennant Hills Road was a significant factor in the construction site selection process.

Two potential heavy vehicle haulage routes have been identified for the transport of spoil and other heavy vehicle trips. Spoil would either be transported north via the M1 Pacific Motorway or south / west via the Hills M2 Motorway. Construction impacts have been assessed under northbound and southbound / westbound spoil haulage scenarios. In reality, there is reasonable potential that spoil would be disposed of at more than one site, with spoil transportation occurring in both a northbound and a southbound / westbound direction. By modelling and assessing both scenarios separately, and assuming all spoil transport in each direction, the assessment of potential spoil haulage impacts is a conservative, worst case approach.

It has been assumed that delivery of concrete would largely originate from batching plants in the Thornleigh region, although other sources may also be required. Other materials required for construction would generally utilise the arterial road network to access the various construction sites. Potential heavy vehicle haulage routes are illustrated in **Figure 7-6**. Details of haul routes and access / egress arrangements in the immediate vicinity of the four tunnelling support sites (the southern interchange compound (C5), the Wilson Road compound (C6), the Trelawney Street compound (C7) and the northern interchange compound (C9)) are shown in **Figure 7-7** to **Figure 7-10**. Haul routes would be re-examined during detailed design as part of the development of traffic management plans.

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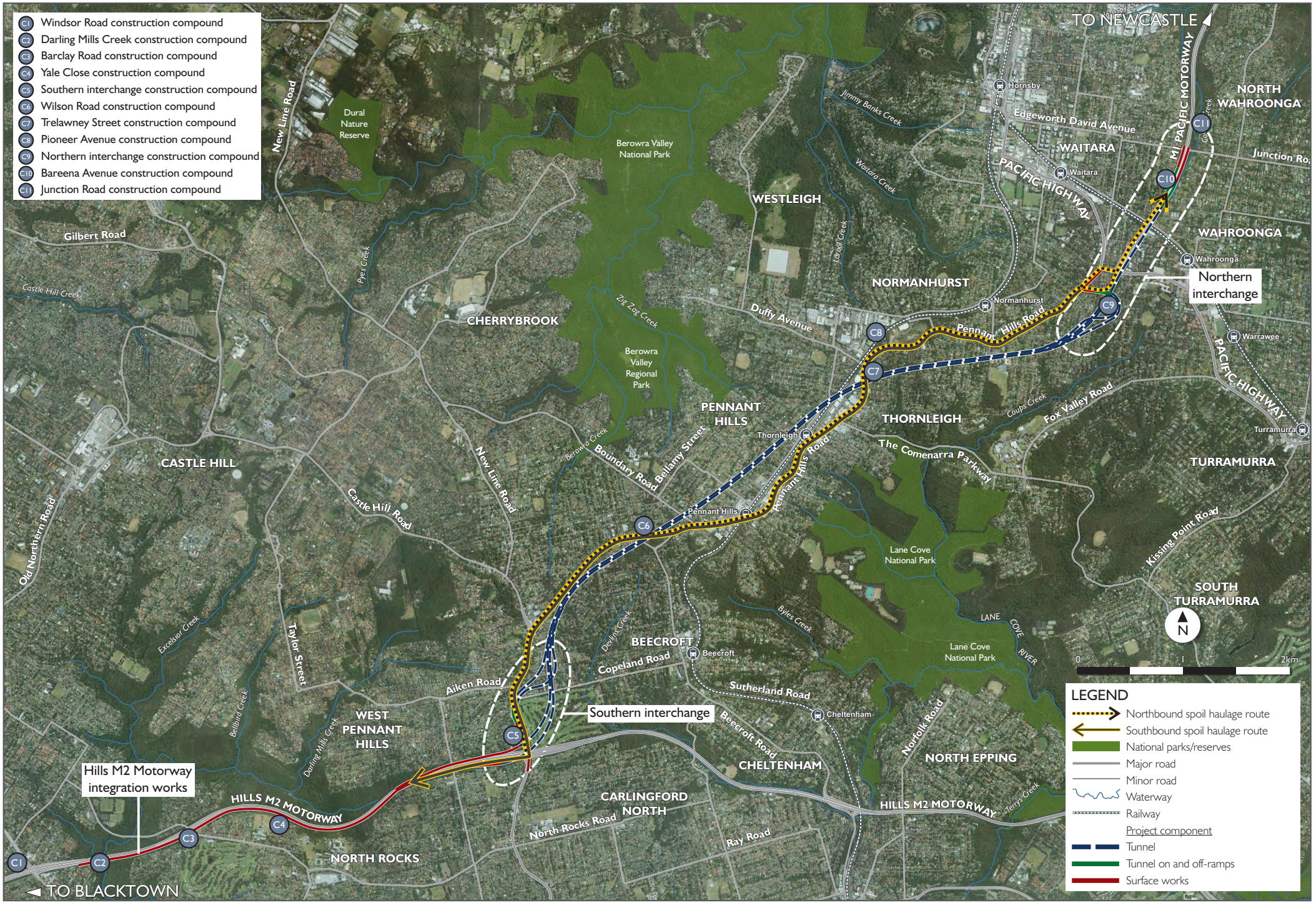

Figure 7-6 Spoil haulage routes

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