Richmond Road Upgrade between Elara Boulevard and Heritage Road

Traffic Impact Assessment Report

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Client: Roads and Maritime Services

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Prepared by

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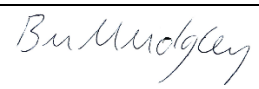
1	5-Jul-2019	Final issue	Ben Midgley Project Manager	

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Executive Summary

AECOM were engaged by Roads and Maritime in November 2018 to undertake SIDRA Intersection optioneering and modelling along Richmond Road between Elara Boulevard and Heritage Road, Marsden Park, for the primary purpose of determining the traffic impacts of future developments adjacent to the Richmond Road corridor and identifying any accessibility constraints.

The 2018 Base SIDRA models for the study area have been calibrated and verified in accordance with Roads and Maritime's modelling criteria. As shown in Appendix A, the weekday AM and PM and weekend SIDRA models are considered to provide a good representation of the current traffic conditions in the study area during the peak periods.

Future year network operation has been assessed for the 2026, 2031 and 2036 forecast demands for two scenarios - Without Project and With Project – using the 2018 models as a basis. Future year background demand was informed by the Roads and Maritime Sydney Strategic Traffic Forecasting Model (STFM).

The Without Project scenario represents a case in which the existing network layout is retained, along with other committed infrastructure projects such as the Garfield Road West extension and left in / left out accesses required as part of the Marsden Park Precinct development, Bandon Road (considered operational by 2031) and widening of Richmond Road from four to six lanes, which is expected to occur by 2036.

The With Project scenario includes the proposed signalised intersection of Richmond Road / Clydesdale Access Road, widening of Richmond Road from two lanes to four lanes for a stretch of approximately 1 km, and a number of minor intersection upgrades at existing signalised intersections of Richmond Road with Garfield Road and Elara Boulevard.

The intersections generally perform poorly for all three modelled peak hours in all scenarios. Scenario testing identified that the existing road network would not be capable of accommodating future year demands, with Do Minimum assessments highlighting significant congestion along the Richmond Road corridor. This congestion is a result of the combination of regional traffic growth forecasts and development traffic from Marsden Park and Marsden Park North.

Testing of potential solutions to resolve congestion, both within and beyond the immediate study area, was undertaken. Whilst these measures were found to improve network performance significantly, they were not sufficient in resolving all congestion in the network or bringing Levels of Service to acceptable levels. This in turn suggests that regardless of proposed road network upgrades, the anticipated demand for Richmond Road in future year exceeds the available road network capacity.

With intersections modelled as a network, the impact of poorly performing intersections on adjacent intersections has been captured. Given the major traffic movement from the study area is tidal towards and from the Sydney CBD, the southernmost intersection of Richmond Road / Garfield Road generally forms the pinch point from which congestion arises. Here, a combination of heavy Richmond Road through traffic, along with Marsden Park demand to the west and Marsden Park North traffic to the east results in oversaturated performance of the intersection.

Intersection capacity is expected to remain satisfactory until development of the adjacent precincts reaches a critical point, at which road network capacity is exceeded. Given the uncertainty over current rezoning and Development Applications in both these precincts, predicting the year of this 'critical point' would require use of changeable assumptions and would require further investigation, in which the land developers and the Department of Planning and Environment should be engaged.

A total of 36 casualty crashes were reported for the five-year period to December 2018 between intersections with Garfield Road West and Heritage Road, of which 30 occurred between vehicles travelling in the same direction along Richmond Road. Rear end collisions were the most common across the study area and three of the total 36 crashes resulted in serious injury, with no fatalities.

Whilst construction activities have not been assessed in detail given the project is in its early stages, their impact is expected to be minimal, with major arterial corridors of Richmond Road and Garfield Road expected to accommodate heavy vehicles associated with construction. Construction vehicle activity will be managed to ensure it does not coincide with network peak periods.

1.0 Introduction

AECOM were engaged by Roads and Maritime Services (Roads and Maritime) in November 2018 to undertake SIDRA Intersection modelling and optioneering along Richmond Road between Elara Boulevard and Heritage Road, Marsden Park, for the primary purpose of determining the traffic impacts of future developments adjacent to the Richmond Road corridor and identify any accessibility constraints.

1.1 Background

Richmond Road is a north-south arterial operating at 80km/h, linking the strategic centres of Blacktown and Windsor. This arterial road has already been upgraded to a dual carriageway with two lanes in each direction and a central median to enable future expansion to three lanes each way, from the southern boundary of the North West Growth Area (NWGA) to north of Elara Boulevard. Currently, Elara Boulevard provides the only access from the Marsden Park Precinct onto Richmond Road. With the approval for future developments on both sides of Richmond road (Marsden Park and Marsden Park North), additional access is required to service the future traffic generated by these developments.

The proposed section for upgrade along Richmond Road spans approximately 1km north of Elara Boulevard and Heritage Road. The upgraded section is planned to have a 4-way signalised intersection approximately 800m north of Elara Boulevard, to provide access to Marsden Park and Marsden Park North precincts. There are also plans for a single left in and a single left out access to and from Marsden Park precinct.

1.2 Study area

The study area spans two existing signalised intersections on Richmond Road and a further three proposed intersections to the north of these. The study area is illustrated in Figure 1.

Figure 1: Assessment study area

Source: Nearmap, 2019

Intersections are initially modelled in isolation before being combined into network models which are reported on later in this document, ensuring interaction of traffic between intersections is captured.

1.3 Purpose of this report

In assessing the impact developments along the Richmond Road corridor are expected to have on road performance, SIDRA Intersection traffic models have been developed. These models consider all anticipated development traffic demand and the expected future intersection layouts, to assess traffic performance in the future.

This report summarises the assessment undertaken via the following sections:

Section 1: Introduction provides the project background and intentions.

Section 2: Existing traffic and transport conditions establishes the existing transport context in the vicinity of the study area.

Section 3: 2018 Base year traffic modelling details the methodology and outputs of Base year assessment.

Section 4: Future demand estimation details the agreed approach for deriving future year traffic volumes.

Section 5: Proposed future transport infrastructure outlines the proposed road network upgrades and scenarios tested.

Section 6: Traffic impact assessment presents findings of the assessment of different road layouts and scenarios tested.

Section 7: Sustainable travel measures identifies public transport, walking and cycling measures considered.

Section 8: Summary, conclusion and recommendations summarises findings of the report.

In performing the assessments, the intention of Roads and Maritime is to identify intersection configurations along this section of Richmond Road that provide the optimum Level of Service (LOS) for traffic movements along Richmond Road, whilst maintaining appropriate access to the new developments.

2.0 Existing traffic and transport conditions

2.1 Demographics

Richmond Road is currently a commuter corridor and as such, demographics of road users are difficult to identify as they originate from and are destined for a wide geographical area. That said, the stretch of Richmond Road under consideration falls within Blacktown – North of the Blacktown Local Government Area (LGA) for which key census statistics are provided in Table 1.

Table 1: 2016 census statistics

Area	Population	Labour Force	Average no. of people per dwelling	Average no. of cars per dwelling
Blacktown – North	92,823	49,529	3.3	2.0
Blacktown LGA	336,962	163,375	3.2	1.8

The Blacktown – North statistical area has a slightly higher average number of people and cars per dwelling than the wider LGA, though it is reiterated that Richmond Road is primarily strategic in nature, with road users from multiple LGAs.

2.2 Existing travel patterns

Travel characteristics for NSW residents travelling to work are gathered from the journey-to-work (JTW) data extracted from the Australian Bureau of Statistics (ABS) 2016 census. The journey-to-work data set provides details of the origin and destination zones of trips, as well as characteristics of the journey such as mode of travel.

2.2.1 Mode split

The modal split of users along Richmond Road is difficult to ascertain in the absence of fully classified automatic tube counter data; however, Journey to Work (JTW) data for the Blacktown – North statistical area can again be assessed to give an indication of mode share, as presented in Table 2.

Table 2: 2016 JTW summary

Area	Total trips	Vehicle driver	Vehicle passenger	Train	Bus	Other
Greater Sydney	1,197,269	53%	7%	11%	6%	23%
Blacktown – North	37,919	62%	8%	7%	7%	16%

Residents within Blacktown – North have a much higher reliance on private vehicles than Greater Sydney. As a result, the public transport split is lower in Blacktown – North.

However, statistics also showed that there are areas within Blacktown LGA that are close to public transport facilities with much lower car use. Therefore, it is critical in the precinct planning process to design a precinct road network that is conducive to public transport access and operations and to propose progressive roll out of improved public transport services to train stations.

2.2.2 Trip origin and destination

In order to gain an understanding of where people travel in the area, the JTW data for Blacktown – North was analysed. Based on the 2011 JTW data, the majority of trips destined for Blacktown – North originated from Blacktown LGA, where Blacktown, Blacktown – North and Mount Druitt accounted for approximately 58 percent of trips, as demonstrated in Table 3.

Approximately 13 percent of residents in Blacktown – North, live and work in the same area. The majority of residents in Blacktown – North travel to surrounding SA3 areas including Baulkham Hills, Rouse Hill – McGraths Hill, Mount Druitt and Blacktown. However, it would seem safe to assume that the origins and destinations of trips associated with Marsden Park North may change as a result of the changes in the pattern in employment and residential growth in Western Sydney.

Whilst these figures reflect the current status of the area, it must be recognised that the addition of thousands of dwellings will significantly change the characteristics of the population and how it performs. Consequently, items such as car ownership, modal split, journey to work and employment centres are likely to be very different following completion of the various planned development areas in Western Sydney.

Table 3: Trip origin and destination

Origin		Destination	
SA3	**Proportion (%)**	**SA3**	**Proportion (%)**
Blacktown – North	44.0	Blacktown – North	12.7
Blacktown	8.5	Baulkham Hills	11.8
Baulkham Hills	6.5	Sydney Inner City	10.4
Mount Druitt	5.0	Parramatta	10.3
Penrith	4.8	Blacktown	9.2
Rouse Hill – McGraths Hill	4.7	Mount Druitt	4.7
Richmond – Windsor	4.6	Ryde – Hunters Hill	4.3
Hawkesbury	3.0	No fixed place of work	3.8
Parramatta	2.6	Auburn	3.3
St Marys	2.3	Rouse Hill – McGraths Hill	2.9

Source: Bureau of Transport Statistics

2.3 Road network

The key strategic road in the vicinity of the Marsden Park North precinct is Richmond Road which provides access to the wider road network in the NWGA and connectivity to Sydney's Orbital Network. Other key roads surrounding the precinct include Garfield Road West and Excelsior Avenue.

As illustrated by the Legend in Figure 2, no other roads within the vicinity of the study area are classified arterial or collector, thus all are currently designated local roads.

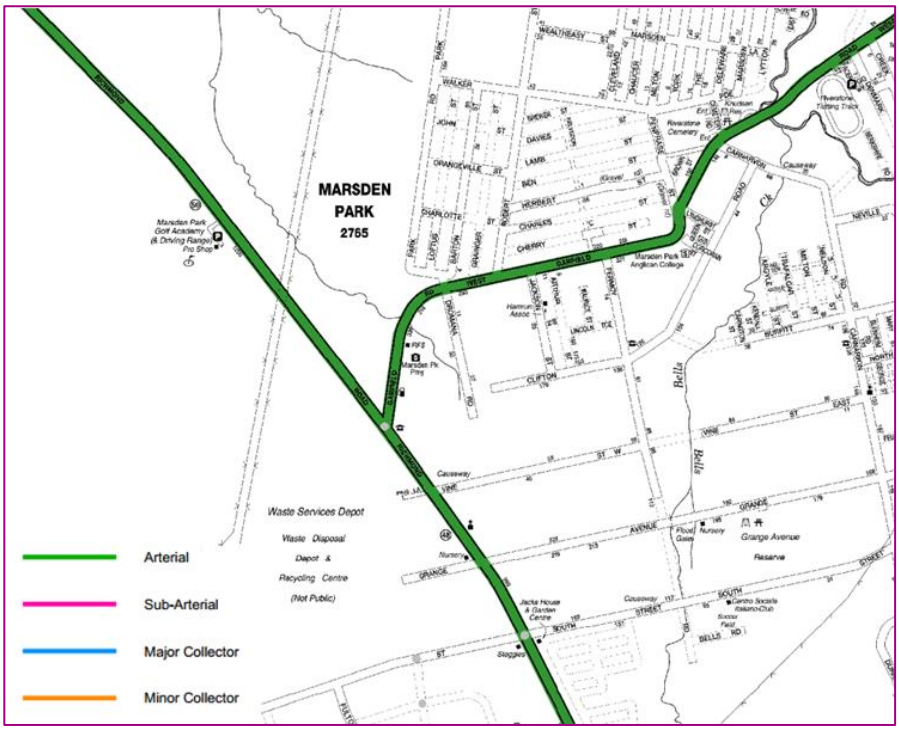


Figure 2: Road hierarchy
Source: Blacktown City Council, 2018

2.3.1 Richmond Road

Richmond Road is a major arterial road linking major urban and rural areas and carrying approximately 32,200 vehicles per day in the vicinity of Garfield Road West. Richmond Road provides connections to the M7 Motorway and Rooty Hill Road North to the south, as well as Blacktown Road and The Northern Road to the north.

Richmond Road has a sign posted speed limit ranging from 60 km/h to 80 km/h adjacent to the study area where the existing road experiences peak hour traffic congestion and delays. The existing rural/industrial activity in the area generates high volumes of heavy vehicles on the Richmond Road corridor.

Richmond Road was recently upgraded between Bells Creek and Elara Boulevard.

Given current ongoing construction activities in the NWGA including the nearby precincts of Marsden Park and Vineyard, there is currently increased construction traffic on the roads in the vicinity of Marsden Park, particularly along Richmond Road.

2.3.2 Garfield Road West

Garfield Road West is an arterial road with a sign posted speed limit ranging between 60km/h and 70km/hr in the vicinity of the study area. The two-lane road is currently the primary east-west connection between Richmond Road and Windsor Road providing access between Marsden Park, Riverstone and Box Hill. Garfield Road West also provides local access to existing residential areas in the form of priority intersections.

As part of the NWGA Land Use and Infrastructure Implementation Plan, Garfield Road West is proposed as a transit boulevard to meet the future transport needs of the NWGA. Garfield Road West will accommodate a significant volume of traffic and provide key public transport routes with connectivity to Riverstone Station on the T1 and T5 Lines, and the recently completed Rouse Hill Station as part of the Metro North West Link.

2.3.3 Elara Boulevard

Elara Boulevard is a recently constructed road with a sign posted speed limit of 60km/h into the Marsden Park Precinct. The two-lane road is currently the primary connection between Marsden Park and Richmond Road and the Greater Sydney road network.

2.3.4 Traffic volumes and composition

As SCATS data does not separate vehicle types, the heavy vehicle percentages were sourced from the *Marsden Park North Traffic and Transport Assessment report* (AECOM, 2018) to estimate traffic composition.

Richmond Road, in the vicinity of the study area, carries a total of 2,500 vehicles per hour in both directions in the AM peak (06:45 – 07:45) and 2,200 in the PM peak (16:30 – 17:30). The corridor carries a high volume of heavy vehicles and is an approved restricted access vehicle route providing links to rural and industrial activities in the area. Table 4 and Table 5 show the composition of traffic during the AM and PM peak (August 2017) respectively.

Table 4: AM peak traffic composition

Location	Total vehicles	Heavy vehicles (HV)	HV (%)
Northbound / Eastbound			
Richmond Road – south of Grange Avenue	1,064	192	18%
Richmond Road – north of Elara Boulevard	802	146	18%
Garfield Road West – east of Richmond Road	404	110	27%
Southbound / Westbound			
Richmond Road – south of Grange Avenue	1,080	192	18%
Richmond Road – north of Elara Boulevard	1,296	175	14%
Garfield Road West – east of Richmond Road	456	118	26%

Source: Marsden Park North Traffic & Transport Assessment (AECOM, 2018)

The August 2017 traffic surveys recorded approximately 18 percent of heavy vehicles in the northbound direction and approximately 14 to 18 percent of heavy vehicles in the southbound direction along Richmond Road during the AM peak. Garfield Road recorded a higher percentage of heavy vehicles with 27 percent in the eastbound direction and 26 percent in the westbound direction.

Table 5: PM peak traffic composition

Location	Total vehicles	Heavy vehicles (HV)	HV (%)
Northbound / Eastbound			
Richmond Road – south of Grange Avenue	1,161	234	20%
Richmond Road – north of Elara Boulevard	1,249	137	11%
Garfield Road West – east of Richmond Road	376	61	16%
Southbound / Westbound			
Richmond Road – south of Grange Avenue	1,259	137	11%
Richmond Road – north of Elara Boulevard	879	59	7%
Garfield Road West – east of Richmond Road	563	76	14%

Source: Marsden Park North Traffic & Transport Assessment (AECOM, 2018)

During the PM peak the percentage of heavy vehicles along Richmond Road reduced to approximately 11 to 20 percent in the northbound direction and approximately 7 to 11 percent in the

southbound direction. The percentage of heavy vehicles on Garfield Road also reduced, with 16 percent in the eastbound direction and 14 percent in the westbound direction.

The traffic recorded in the study area includes additional traffic that is associated with **construction activities** of the ongoing development of the surrounding NWGA precincts including Marsden Park and Vineyard, as well as the upgrade of Richmond Road and Schofields Road. This additional traffic has exacerbated the capacity constraints of the intersections assessed and contributes to the high heavy vehicle percentages outlined in Table 4 and Table 5. Wider construction activities, such as those associated with the large WestConnex motorway project, also influence the key arterial corridor of Richmond Road.

2.4 Historical traffic growth

Roads and Maritime have a 'permanent' count site on Richmond Road located north of Colebee Road, south of the study area; however counts have not been recorded since 2013. Further south, another count site is present just north of Knox Road, south of the M7 motorway. The historic Annual Average Daily Traffic (AADT) on Richmond Road at these locations is presented in Table 6.

Table 6: Richmond Road AADT traffic counts

Station	Location	2009	2011	2013	2015	2017	Growth per annum
71043	Richmond Road, Colebee – North of Rooty Hill Road	**30,255**	30,872	**31,533**	-	-	1.1%
71059	Richmond Road, Glendenning – North of Knox Road	**31,023**	31,972	33,873	**36,256**	35,721*****	2.8%

Source: Roads and Maritime, 2019

***** It is noted that 2017 data does not follow annual trends, with volumes in 2016 (37,542) and 2018 (38,208) higher; thus this value was excluded from annual growth percentage derivation and the 2015 value used in its place.

From 2009 to 2017, the AADT data indicates traffic on Richmond Road has increased at an annual rate of 1 – 3%. 2017 was the only year in which AADT decreased, which is attributed to upgrade works on Richmond Road and the wider road network.

It is noted that given the location of this permanent counter, historical traffic growth at the Richmond Road study area may differ considerably and so values presented in Table 6 should be used with caution.

2.5 Public transport

2.5.1 Bus services

Limited public transport connectivity is available within the Richmond Road corridor. Currently, two low frequency bus routes service a small portion of the corridor with average frequencies of one service per hour.

The following bus services operate along this section of Richmond Road, as illustrated in Figure 3:

- Route 747 Marsden Park to Rouse Hill via Riverstone
- Route 757 Riverstone to Mount Druitt via Marsden Park & Rooty Hill

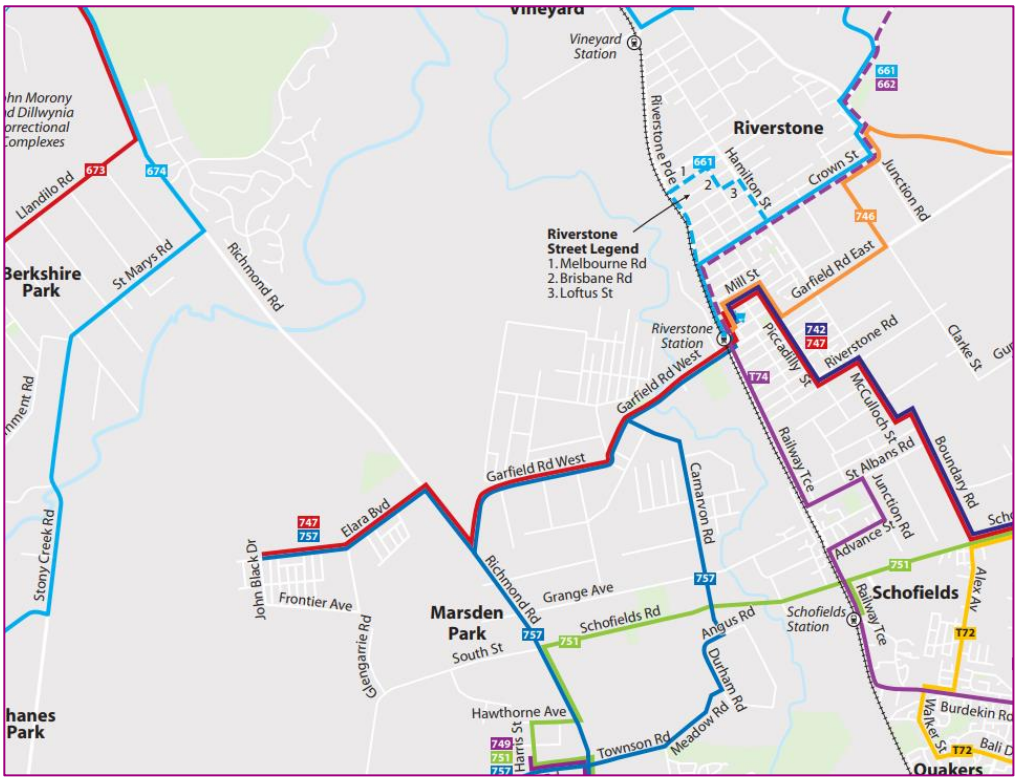


Figure 3: Bus Services in the study area

Source: TfNSW, Bus operator maps, 2019

Busways currently provide two bus routes in the vicinity of the Richmond Road corridor, which traverse along Garfield Road West and Richmond Road. Bus route 757 provides a service between Mount Druitt and Riverstone via Marsden Park. Bus route 747 travels from Marsden Park to Rouse Hill via Riverstone. Given the rural nature of the area, bus services are limited, though a number of bus stops are located along Garfield Road West.

Table 7 presents the frequency of bus services at the bus stops located at the Richmond Road intersection with Garfield Road West. It is noted that a number of services only run during public school term time.

Table 7: Frequency of bus services (minutes)

Route	Weekday public school term time services		
	AM peak (7:00 9:00)	PM peak (16:00 18:00)	Off peak (10:00 15:00)
Route 757: Mount Druitt to Riverstone	4	3	7
Route 757: Riverstone to Mount Druitt	4	4	5
Route 747: Marsden Park to Rouse Hill	0	1	5
Route 747: Rouse Hill to Marsden Park	0	1	5

Source: Busways, 2018

As part of recent upgrade works along Richmond Road, bus only 'through' lanes have been provided on approach to intersections in both directions along Richmond Road. These facilities provide short bays on approaches with downstream merges on intersection exits. On-carriageway cycle lanes are also provided adjacent to bus bays, as illustrated in Figure 4 below.

Figure 4: Richmond Road (S) approach to Garfield Road West, August 2017

2.5.2 Rail services

The Richmond Road corridor is situated west of Riverstone Station and Schofields Station providing connectivity to Sydney's suburban rail network. These stations are located approximately 3.4km and 5.1km from the corridor respectively. As such, they are not within a short walking distance (usually considered to be 800m to 1km) of the precinct.

Riverstone and Schofields Stations are serviced by the T1 North Shore, Northern and Western and T5 Cumberland Lines. Frequency of services of these two lines is provided in Table 8.

Table 8: Frequency of rail services (minutes)

Line	Service	Weekday services		
		AM peak (7:00 9:00)	PM peak (16:00 18:00)	Off peak (10:00 15:00)
T1 North Shore, Northern and Western	Richmond to City	4	4	10
	City to Richmond	4	4	10
T5 Cumberland	Schofields to Leppington	2	0	10
	Leppington to Schofields	1	0	10

Source: Transport; Sydney Trains, 2019

North West Rail Link

The opening of the Metro Northwest in late May 2019 has delivered eight new railway stations for the growing region of Sydney's North West. The 23km link (Figure 5) between Sydney's North West and Epping will provide reliable and efficient public transport links to a region which has the highest car ownership levels per household in Australia.

The Metro North West features single deck, fully automated rapid transit trains providing frequent rail services which connect with the existing Epping to Chatswood Rail Link.

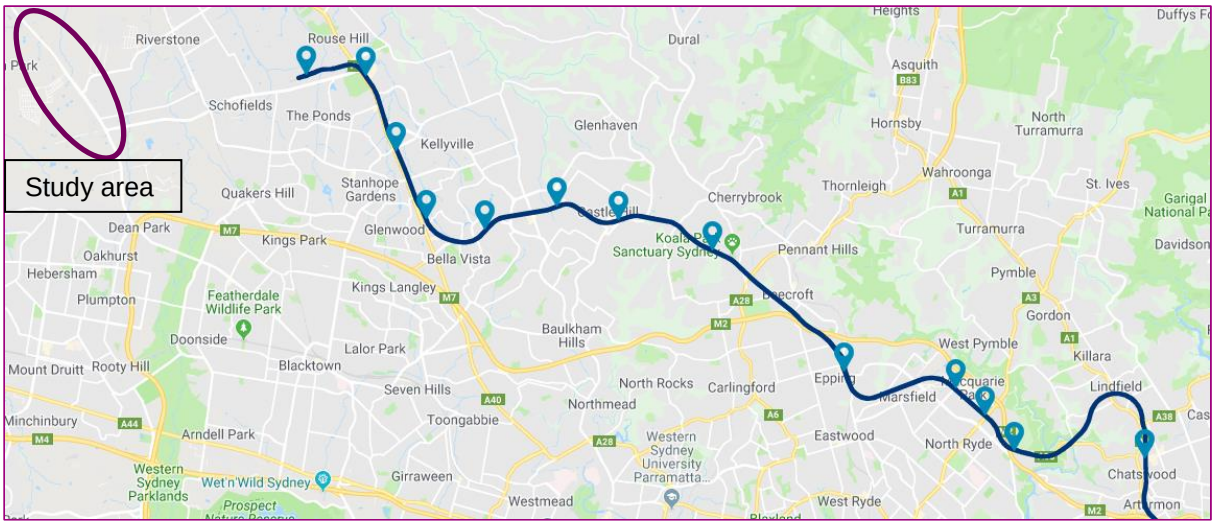


Figure 5: Sydney Metro North West route and station locations
Source: Sydney Metro, 2019

Despite being the closest Metro station to the Richmond Road study area, Tallawong is located almost 7km away and so does not form a convenient, local station for residents of directly adjacent precincts such as Marsden Park. That said, services are high frequency at every 3 – 5 minutes during AM and PM peak periods.

2.6 Walking and Cycling

Due to the current undeveloped, primarily rural nature of the areas surrounding the Richmond Road corridor, existing pedestrian and cycling routes and facilities along the corridor are limited. However, as part of the recent upgrade to Richmond Road, a shared cycle and footpath has been provided from South Creek to Elara Boulevard on the western carriageway, as illustrated in Figure 6 below.

Figure 6: Shared footpath along Richmond Road western carriageway, August 2017

This route along Richmond Road provides connections to regional cycle links on the surrounding network such as the M7 Motorway.

Signalised pedestrian and cycle facilities have been provided across all arms of the newly developed Richmond Road intersections in the vicinity of the study area, with wide central medians provided on Richmond Road to facilitate staged crossing operation.

3.0 2018 Base year traffic modelling

Methodology and findings of 2018 Base year traffic modelling are documented in *Memo Richmond Road Traffic Impact Assessment - 2018 Base SIDRA Models_v2*, issued to Roads and Maritime 18 January 2019 and provided in Appendix A.

4.0 Future demand estimation

The future year demand estimation has been undertaken for 2026, 2031 and 2036 assessment years. The future demand consists of 2018 calibrated demand and forecast demand growth. As agreed with Roads and Maritime, the future demand growth consists of:

- Background traffic demand growth;
- Marsden Park development traffic; and
- Marsden Park North development traffic.

The calculation and calibration of 2018 traffic demand for the SIDRA model network is described in *Memo Richmond Road Traffic Impact Assessment - 2018 Base SIDRA Models_v2*. This section outlines the methodology adopted for demand estimation. The same future demand has been applied to future Do-minimum and option scenarios to ensure a like-for-like comparison.

4.1 Background traffic demand growth

The background traffic demand growth was estimated based on turning volumes from the Roads and Maritime Sydney Strategic Traffic Forecasting Model (STFM).

The following steps were taken to estimate the background traffic growth all future years for a **With Project** scenario, in which the STFM EMME model was coded to reflect a four-lane arrangement on Richmond Road northwards to the intersection with St Mary's Road.

*Step 1: Derive absolute background growth between **2017** and years 2026/2031/2036*

- 2017 to 2026 STFM background growth = 2026 STFM turning volumes – 2017 STFM turning volumes
- 2017 to 2031 STFM background growth = 2031 STFM turning volumes – 2017 STFM turning volumes
- 2017 to 2036 STFM background growth = 2036 STFM turning volumes – 2017 STFM turning volumes

*Step 2: Calculate absolute background growth between **2018** and years 2026/2031/2036*

- 2018 to 2026 STFM background growth = 2017 to 2026 background growth / (2026-2017)*(2026-2018)
- 2018 to 2031 STFM background growth = 2017 to 2031 background growth / (2031-2017)*(2031-2018)
- 2018 to 2036 STFM background growth = 2017 to 2036 background growth / (2036-2017)*(2036-2018)

Step 3: Estimate background flows for years 2026, 2031 and 2036

- 2026 SIDRA background flow = 2018 SIDRA background flow – existing Elara volume + 2018 to 2026 STFM background growth
- 2031 SIDRA background flow = 2018 SIDRA background flow – existing Elara volume + 2018 to 2031 STFM background growth
- 2036 SIDRA background flow = 2018 SIDRA background flow – existing Elara volume + 2018 to 2036 STFM background growth

This scenario contains an element of induced demand resulting from the road widening, and so a respective STFM model was run in which the widening wasn't applied, to represent a **Without Project** case.

The difference in traffic flow along Richmond Road was subtracted from the volumes calculated for the With Project scenario to derive Without Project volumes. The difference in volumes travelling along Richmond Road between Without and With Project scenarios are presented in Table 9.

Table 9: Difference in background traffic volumes along Richmond Road With and Without Project

Year	Direction	Volume (veh)		
		AM	PM	SAT*
2026	Northbound	22	41	32
	Southbound	79	43	61
2031	Northbound	35	37	36
	Southbound	98	36	67
2036	Northbound	39	94	67
	Southbound	142	37	90

** Saturday differences were derived as an average of AM and PM peak*

4.2 Marsden Park development

The latest yield plans from the Marsden Park developers were obtained to estimate the future trip generation. The trip generation rates used, as agreed with Roads and Maritime, are below:

- Low density dwelling: 0.95 trips / unit for AM and 0.99 trips / unit for PM
- Medium density dwelling: 0.5 trips / unit for AM and PM

There are no high density dwellings planned for the Precinct.

It was agreed with Roads and Maritime that residential precincts 5 and 6 of Marsden Park would not be accounted for in assessment, thus demand from much of the Newpark Precinct, as well as Rawson Horizon, Elara, Universal/Bathla and Allam/Fernlea Precincts is omitted. The Clydesdale and Stockland Elara Precincts that were considered as part of this assessment are illustrated in Figure 7.

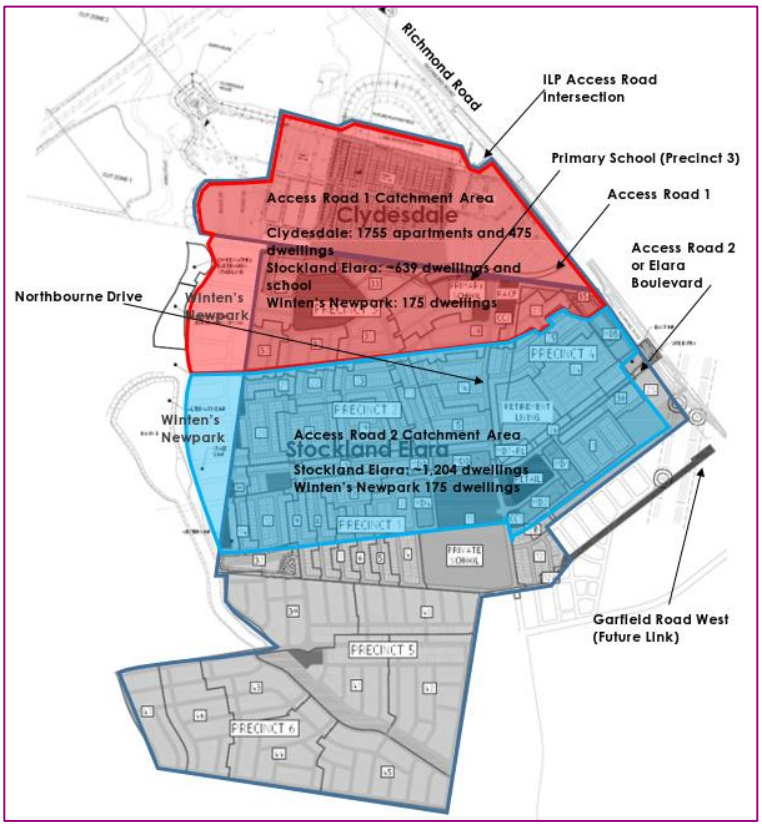


Figure 7: Marsden Park Precincts

Source: The Transport Planning Partnership, 2017

Having derived the volume of trips from each Precinct, the type of trip (inbound or outbound) was derived by adopting a 20:80 split for consistency with assessment of the adjacent Precinct of Marsden Park, with 80% of trips in the AM peak departing the Precinct and 20% travelling to the Precinct, with the converse proportions adopted in the PM peak. The resultant trip generation from Marsden Park is provided in Table 10.

Table 10: Marsden Park trip generation

Precinct	AM generation		PM generation	
	Inbound	Outbound	Inbound	Outbound
Stockland Elara	504	2016	2087	522
Newpark	73	292	304	76
School	90	63	63	90
Clydesdale	165	660	674	169
Total	**832**	**3031**	**3129**	**856**

Traffic from these Precincts was distributed to the available side arms initially via geographical proximity, with refinements then made to better balance use of the available accesses.

Upon reaching Richmond Road, trips were then routed north, south or eastbound (where possible) through use of STFM future year intersection turn volume plots.

Marsden Park is assumed as complete by 2026, thus demand from the Marsden Park Precinct is consistent across all future years assessed. The exception is that in 2036, the Garfield Road West extension through to Stoney Creek Road is expected to have been completed, thus there is additional route choice residents of Marsden Park could adopt.

Based on the assessment of STFM outputs under 2036 conditions, the proportions of Precinct traffic ultimately using Richmond Road and other routes are as set out in Table 11.

Table 11: 2036 Route choice of Marsden Park Precinct traffic

Peak period	Routing	Proportion	
		Inbound	Outbound
AM	South via a new link road to Palmyra Avenue	13%	13%
	West to Stoney Creek Road via Garfield Road West	11%	14%
	Remaining to Richmond Road	**74%**	**73%**
PM	South via a new link road to Palmyra Avenue	13%	14%
	West to Stoney Creek Road via Garfield Road West	15%	11%
	Remaining to Richmond Road	**72%**	**75%**

4.3 Marsden Park North development

Marsden Park North trip generation was informed by the 2018 Traffic and Transport Assessment of the Precinct. In this assessment, the same trip rates as those used for Marsden Park (Section 4.2) were adopted, with the same inbound / outbound proportion also adopted.

Marsden Park North is primarily residential, though there is a sizable commercial land use set aside which is to be accessed via the proposed signalised intersection north of Elara Boulevard. Trip generation of the Precinct is provided in Table 12.

Table 12: Marsden Park North trip generation

Trip type	AM generation		PM generation	
	Inbound	Outbound	Inbound	Outbound
Residential	1198	4793	4994	1248
Stage 1	*330*	*1321*	*1376*	*344*
Stage 2	*126*	*503*	*524*	*131*
Stage 3	*521*	*2084*	*2172*	*543*
Stage 4	*221*	*885*	*922*	*230*
Commercial	396	140	381	899
Total	**1594**	**4933**	**5375**	**2147**

Development of the Precinct is set to be staged, with Stages 1 & 2 completed prior to 2026, Stage 3 by 2031 and Stage 4 by 2036, thus trips generated by each stage are reflected accordingly in future year modelling.

The approach recommended by Roads and Maritime was to assume that construction of Bandon Road will not commence until after 2026; thus in 2026 modelling all Marsden Park North trips access the Precinct via Garfield Road. In 2031 and 2036, both Bandon Road and Garfield Road are used. Given accessibility north/eastbound along Garfield Road and Bandon Road in 2031 and 2036, a proportion of trips generated by the Precinct do not use Richmond Road and so are not considered in assessment.

4.4 Summary of future demand estimation

The future traffic demand was estimated using background growth calculated from the STFM and additional traffic demand likely to be generated by the Marsden Park and Marsden Park North developments. The future demand was assigned to the respective intersections based on its proximity to the access and egress points to the development zones and likely trip distribution.

An estimation of Average Daily Traffic (ADT) has been made using the existing 24-hour flow profile at the Richmond Road Garfield Road intersection.

SCATS detector count data for a number of weekdays in September, October and November 2018 was averaged to derive the turn counts used in 2018 Base year modelling. This average was compared to the individual day data to identify the single day which most closely resembles the average; that day was identified as Tuesday 11 September 2018.

Data for the Richmond Road through movement detectors at the Garfield Road intersection was assessed to derive a 24-hour Richmond Road (both directions) profile.

Comparing the AM and PM peak hour volumes used in modelling for the Richmond Road north and southbound movements for all future years allows for future year ADT to be estimated. Given the minor difference in demand between Without and With Project scenarios, the With Project scenarios were used.

Future ADT estimations are provided in Table 13 below.

Table 13: Average Daily Traffic estimate

	2018	2026	2031	2036
Average Daily Traffic (ADT)	34,300	65,600	78,500	80,500

Table 13 demonstrates that traffic demand along Richmond Road is expected to increase significantly over the coming years, with regional background traffic growth and the two adjacent developments of Marsden Park and Marsden Park North the primary contributors.

5.0 Proposed future transport infrastructure

Sections 5.1, 5.2 and 5.3 outline the layouts modelled for the signalised intersections of Richmond Road with Garfield Road, Elara Boulevard and Clydesdale Access Road.

The model also includes the two unsignalized intersections of Richmond Road with minor side roads namely Heritage Road north of Clydesdale Access Road which is left **out** only and Access Road 1 between Clydesdale Access Road and Elara Boulevard which is left **in** only. All locations are assessed using a Network model, such that interaction between them is accounted for.

Two scenarios have been assessed, namely Without Project and With Project. Each of these scenarios reflect modifications to the road network that are **not** being delivered by this project, such as provision of Bandon Road in future years. These are kept consistent across Without and With Project scenarios, to ensure that the comparison being presented is isolated solely to upgrades being proposed as part of this project (Table 14).

The intersection layouts at each site are assessed for the three future years of 2026, 2031 and 2036. Layouts and assumptions are the same at each site for these three future years, with the following exceptions:

- The Garfield Road West extension through to Stoney Creek Road is only made available in 2036.
- Widening of Richmond Road in the With Project scenario is to four lanes in 2026 and 2031, but a separate project will widen to six lanes by 2036 (thus this widening to six lanes is present in Without and With Project scenarios).
- Bandon Road is not included in 2026 scenarios, with opening assumed by 2031.
- Extensions to certain turn bays With Project are not implemented in 2026, but come into effect in 2031 and 2036 scenarios.

Measures assessed at each intersection are summarised in Table 14.

Table 14: Proposed measures assessed in each scenario

Proposed upgrade	Without	With
Bandon Road	- 2031 2036	- 2031 2036
Clydesdale Access Road / Richmond Road signalised intersection	- - -	2026 2031 2036
Left in / left out accesses	2026 2031 2036	2026 2031 2036
Garfield Road West extension (Marsden Park access only)	2026 2031 2036	2026 2031 2036
Garfield Road West extension (connection through to Stoney Creek Road)	- - 2036	- - 2036
Widening of Richmond Road to four lanes (merging ~200m north of Heritage Road)	- - -	2026 2031 -
Widening of Richmond Road to six lanes (no merging – unconstrained)	- - 2036	- - 2036
Lengthening of short exit lane on Elara Boulevard	- -	2026 2031

Proposed upgrade	Without	With
	-	2036
Lengthening of southern approach right turn lanes to 200m at intersection with Elara Boulevard	- - -	- 2031 2036
Lengthening of southern approach right turn lanes to 200m at intersection with Garfield Road	- - -	2026 2031 2036
Additional right turn lane on northern approach to Garfield Road, lengthening lanes to 130m	- - -	- 2031 2036

5.1 Garfield Road: Without and With Project layouts

Layouts for With and Without Project fur all future years are provided in Figure 8, with descriptions outlining changes from the current layout provided below.

Without Project

The layout for this scenario is almost the same for all future years tested. It differs from the existing layout in that the Garfield Road West extension, serving the Marsden Park Precinct, is open to traffic. This means all other approaches are modified accordingly to allow access to and from the extension.

By 2036, an additional through lane is provided along Richmond Road in both directions.

With Project

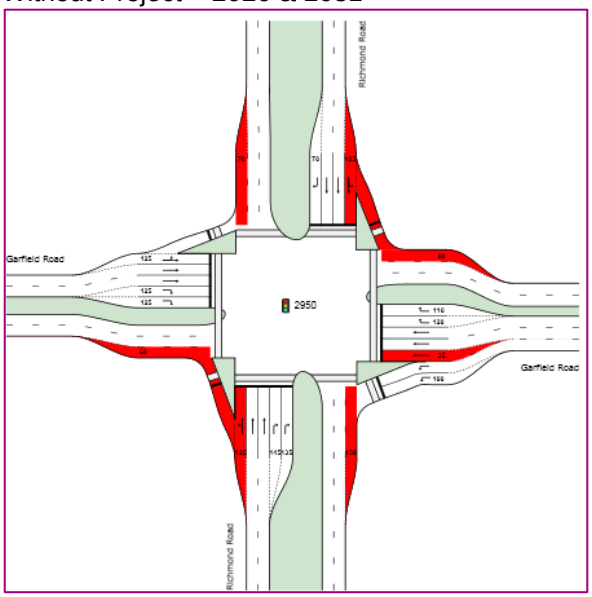
The below comments are changes from the respective Without Project scenario.

Richmond Road southern approach right turn lanes are increased in length from ~140m to ~200m in all future years.

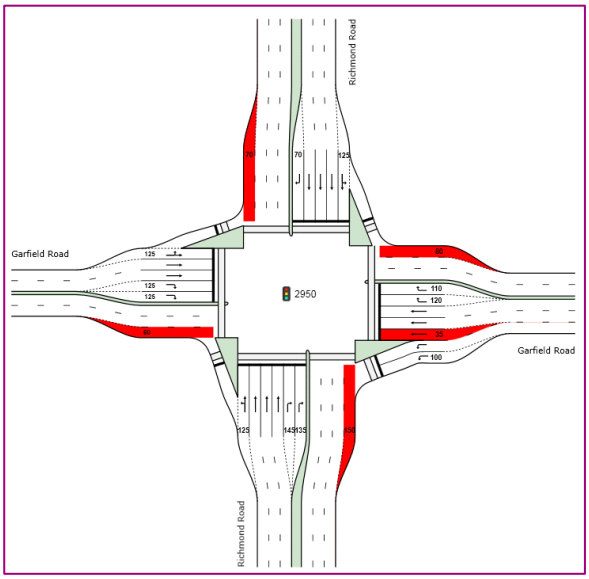
Richmond Road northern approach right turn lane is duplicated and increased in length from ~70m to ~125m in 2031 and 2036 scenarios.

It was assumed that the Garfield Road West extension to Stoney Creek Road is completed by 2036, resulting in a reduction in demand to / from Marsden Park via Richmond Road of approximately 25%.

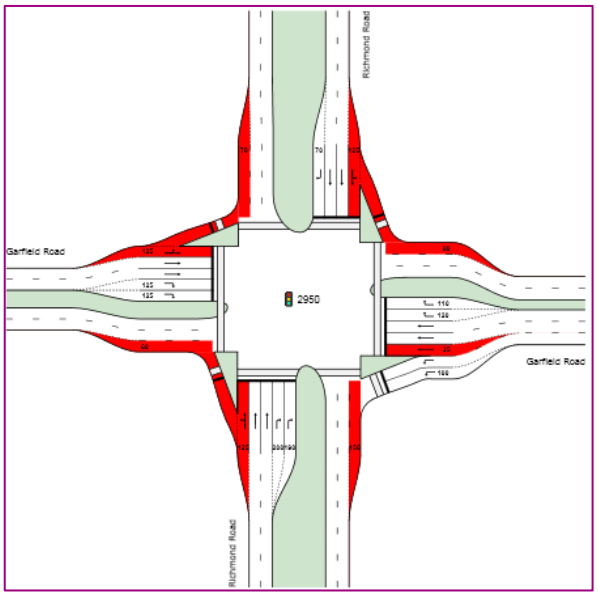
Without Project – 2026 & 2031



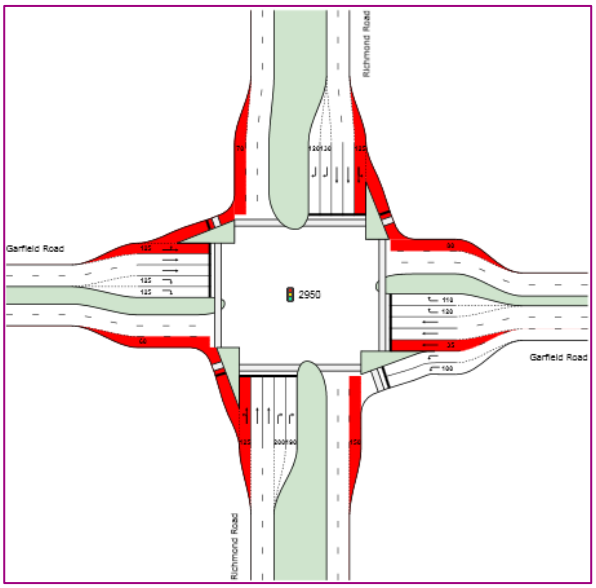
Without Project – 2036



With Project - 2026



With Project – 2031



With Project – 2036

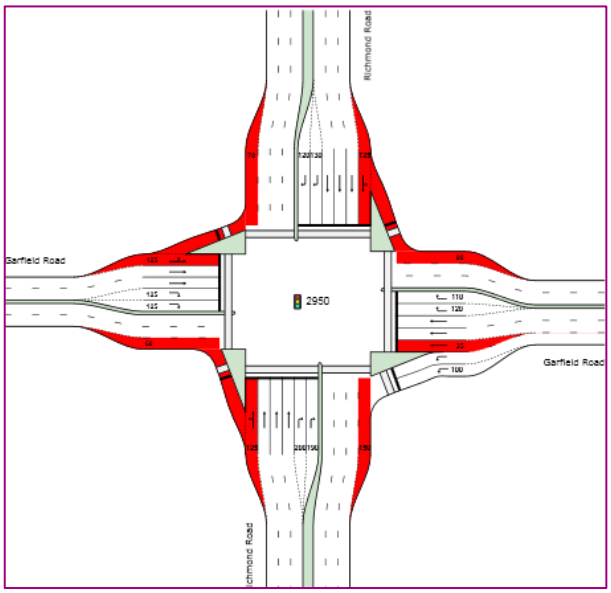


Figure 8: Richmond Road/Garfield Road intersection layout for all scenarios

5.2 Elara Boulevard: Without and With Project layouts

Layouts for With and Without Project fur all future years are provided in Figure 9, with descriptions outlining changes from the current layout provided below.

Without Project

In the 2026 future year, the intersection layout is per existing. In 2031 and 2036 Bandon Road, serving the Marsden Park North Precinct, is open to traffic. This means all other approaches are modified accordingly to allow access to and from the extension.

By 2036, an additional through lane is provided along Richmond Road in both directions.

With Project

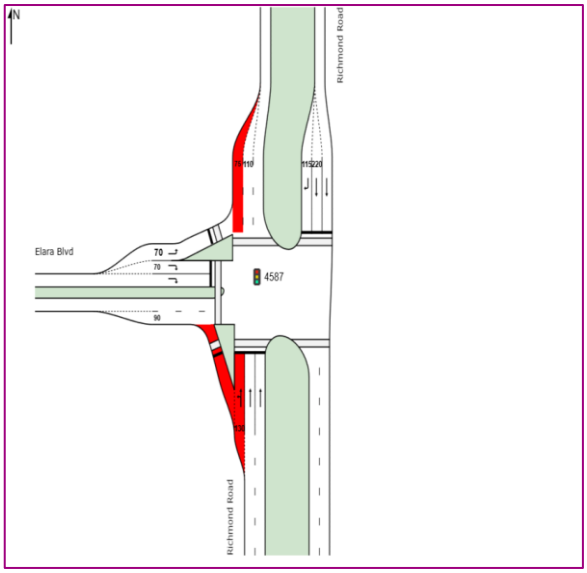
The below comments are changes from the respective Without Project scenario.

In 2026, Richmond Road has been widened to four lanes further to the north, meaning there is no longer a merge to a single lane in each direction ~100m north of the intersection; instead Richmond Road comprises two full through lanes in each direction.

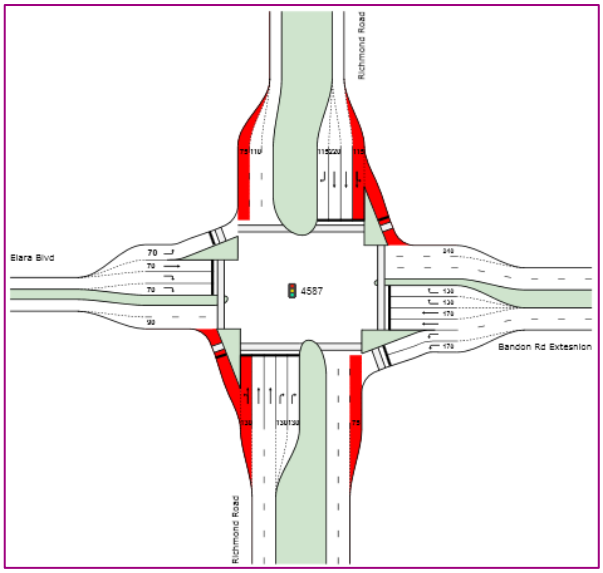
In 2031 and 2036, the Richmond Road southern approach right turn bays are lengthened from ~130m to ~150m.

For all years, the exit merge on Elara Boulevard is lengthened from ~90m to ~150m.

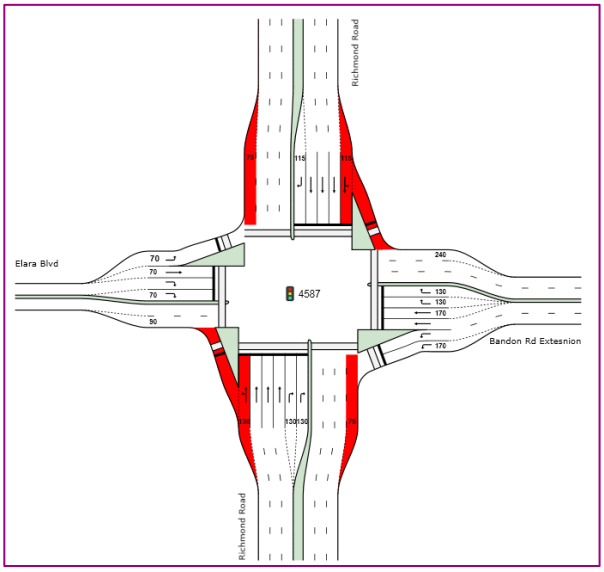
Without Project – 2026



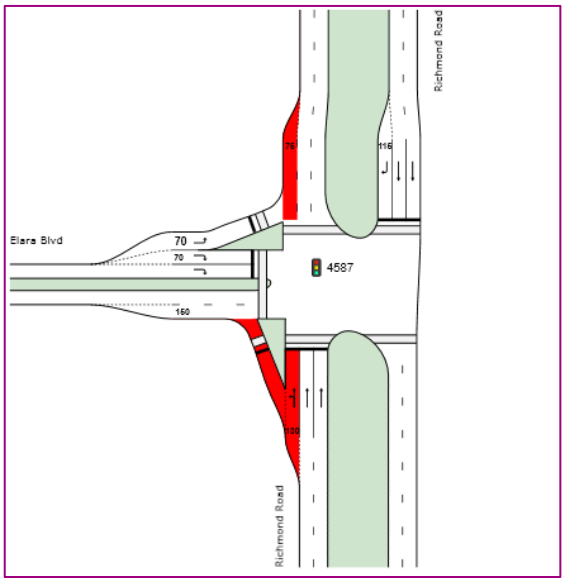
Without Project – 2031



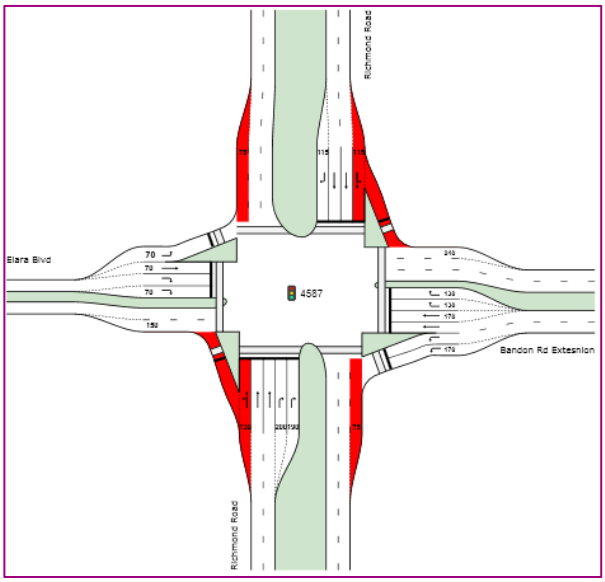
Without Project - 2036



With Project – 2026



With Project – 2031



With Project – 2036

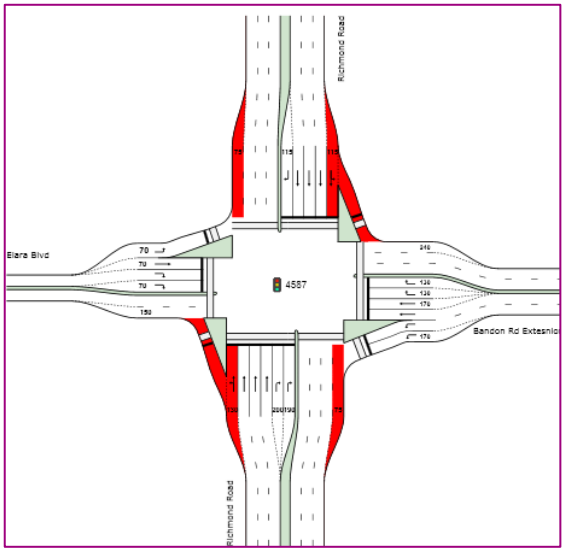


Figure 9: Richmond Road/Elara Boulevard intersection layout for all scenarios

5.3 Clydesdale Access Road: Without and With Project layouts

Layouts for With and Without Project fur all future years are provided in Figure 10 with descriptions outlining changes from the current layout provided below.

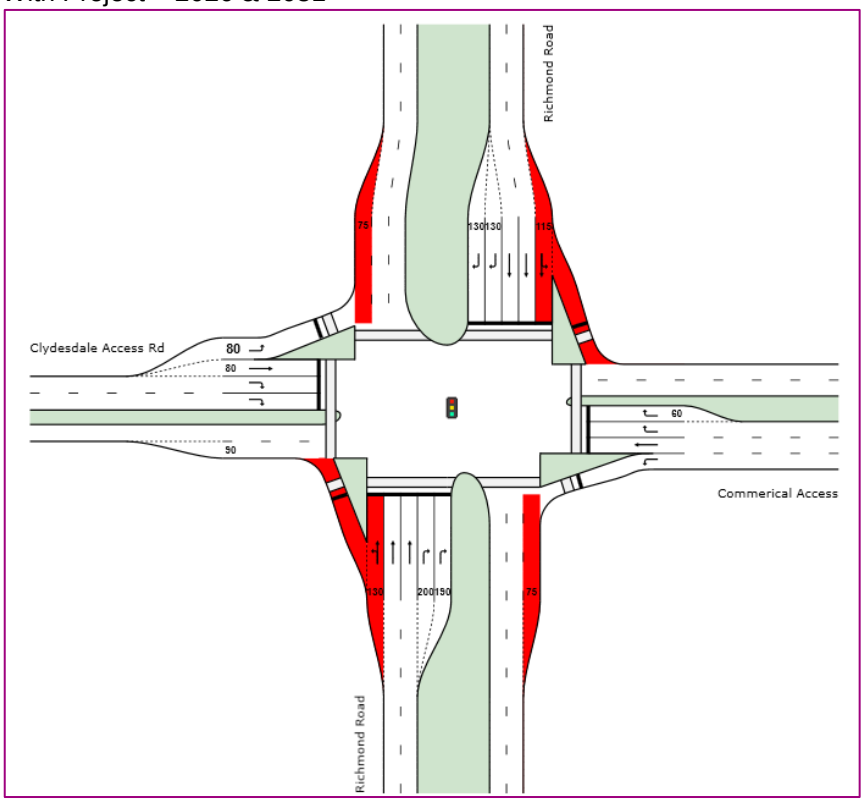
Without Project

N/A

With Project

The proposed intersection layout is consistent across the three future years; however by 2036 an additional through lane is provided along Richmond Road in both directions.

With Project – 2026 & 2031



With Project – 2036

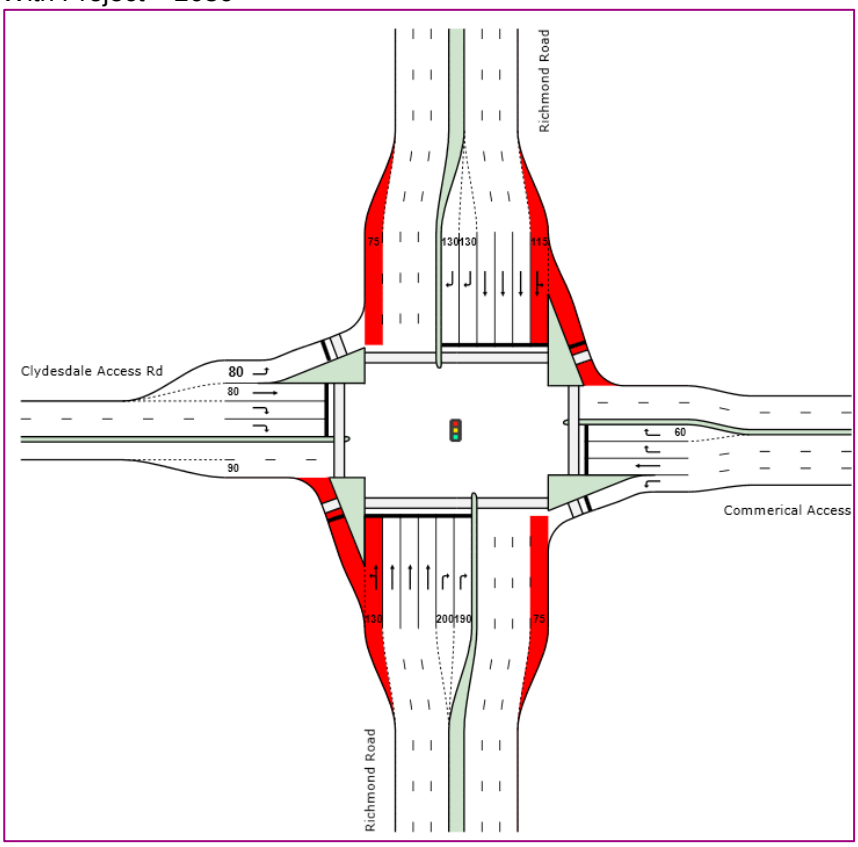


Figure 10: Richmond Road/Clydesdale Access Road intersection layout With Project

5.4 Network upgrade summary

Figure 11 below summarises the proposed project upgrades set to occur over the three future years.

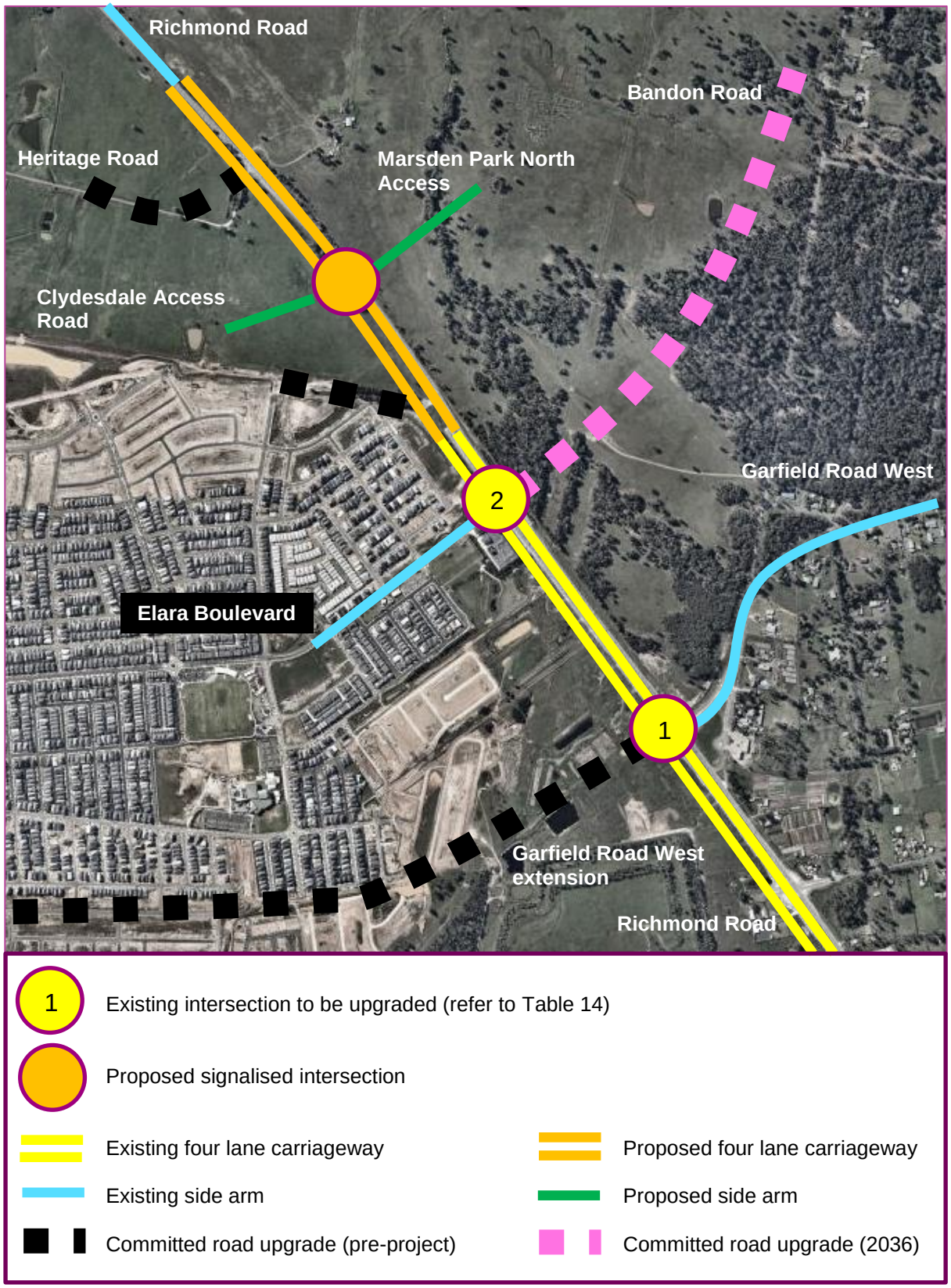


Figure 11: Proposed project upgrades

6.0 Sustainable travel measures

6.1 Future public transport

With the rapid development of the NWGA and its accompanying future public transport improvements such as the opening of the Sydney Metro North West line, public transport patronage is set to significantly increase in the area. The increased utilisation of public transport is expected to reduce private vehicle reliance and alleviate traffic on the Richmond Road corridor.

6.1.1 Rail services

The NWGA Land Use and Infrastructure Implementation Plan maps a rail network that is expected to form an attractive alternative to private vehicles in the area. Existing services will be supplemented by enhancements such as the future public transport corridor from Cudgegong Road Station to Marsden Park and Sydney Metro Northwest (formerly North West Rail Link), as illustrated in Figure 12 below.

Figure 12 Regional rail connections *(Source: NWGA Land Use and Infrastructure Implementation Plan)*

Sydney's Rail Future

Major improvements to the existing rail network are required to meet current customer needs and to cater for future capacity demands. *Sydney's Rail Future* is proposing to deliver a three-tier network to respond to customer needs of shorter journey times and services that are more regular and reliable.

The three-tier system comprises of a rapid transit, suburban and intercity networks. Sydney Metro North West has recently formed part of the rapid transit network providing frequent and high capacity links between employment and commercial areas of Sydney.

A second rail harbour crossing has been announced by the NSW Government as part of the expansion of the rapid transit network extending the rail line from Chatswood into the Sydney CBD.

6.1.2 Bus services

Sydney's Bus Future is the NSW Government's long-term plan to redesign the city's bus network to meet customer needs now and into the future. A three-tier network is proposed comprising of rapid, suburban and local service routes.

Rapid service routes are designed as frequent 'turn up and go' services, stopping every 800 metres to 1km with investment in bus priority infrastructure to ensure a fast and reliable journey between major centres.

Suburban routes are designed as a mix of frequent 'turn up and go' and timetabled services, stopping every 400 metres. Bus priority measures will be targeted at key pinch point areas to speed up services.

Local bus routes will operate as timetabled services improving access to local destinations with stops every 400 metres.

6.1.3 Opportunities and constraints

Opportunities

- *Sydney's Bus Future* has identified one rapid bus route and two suburban routes providing connectivity to and from Marsden Park, which has the potential to serve Marsden Park North and provide links to surrounding key centres such as Blacktown, Rouse Hill and Penrith (including surrounding transport interchanges).
- Proximity of transport interchanges including Riverstone Station, Schofields Station and Tallawong Station with appropriate public transport connections to surrounding precincts has the potential to encourage future residents of nearby developments in Marsden Park and Marsden Park North to use public transport.
- Opportunity to re-route existing bus services through Marsden Park North precinct and off Richmond Road.
- The development of the NWGA will improve public transport provision in the area which will encourage a shift to sustainable transport modes, particularly with the operation of the NWRL (with the nearest station located approximately 6.8km to the east).
- The bus interchange at Schofields Station has been designed to cater for a future increase in bus demand.
- Proximity to proposed transit boulevards on Garfield Road West and a reserved public transport corridor extension to Marsden Park could improve attractiveness to public transport.
- The proposed Bandon Road corridor as part of the NWGA Road Strategy provides potential connectivity to any potential future bus routes from Richmond Road through to Vineyard Station. It would also provide connectivity with an alternate crossing for pedestrians and cyclists across Eastern Creek to Riverstone West Precinct, Vineyard Railway Station and Windsor Road.

Constraints

- Minimal public transport and active travel provision within the neighbouring precincts due to the nature of existing land use in the area.
- The Richmond Road corridor is located outside the walking catchment of surrounding railway stations.
- Design of internal power-line and riparian crossings need to maximise public transport access and connections.

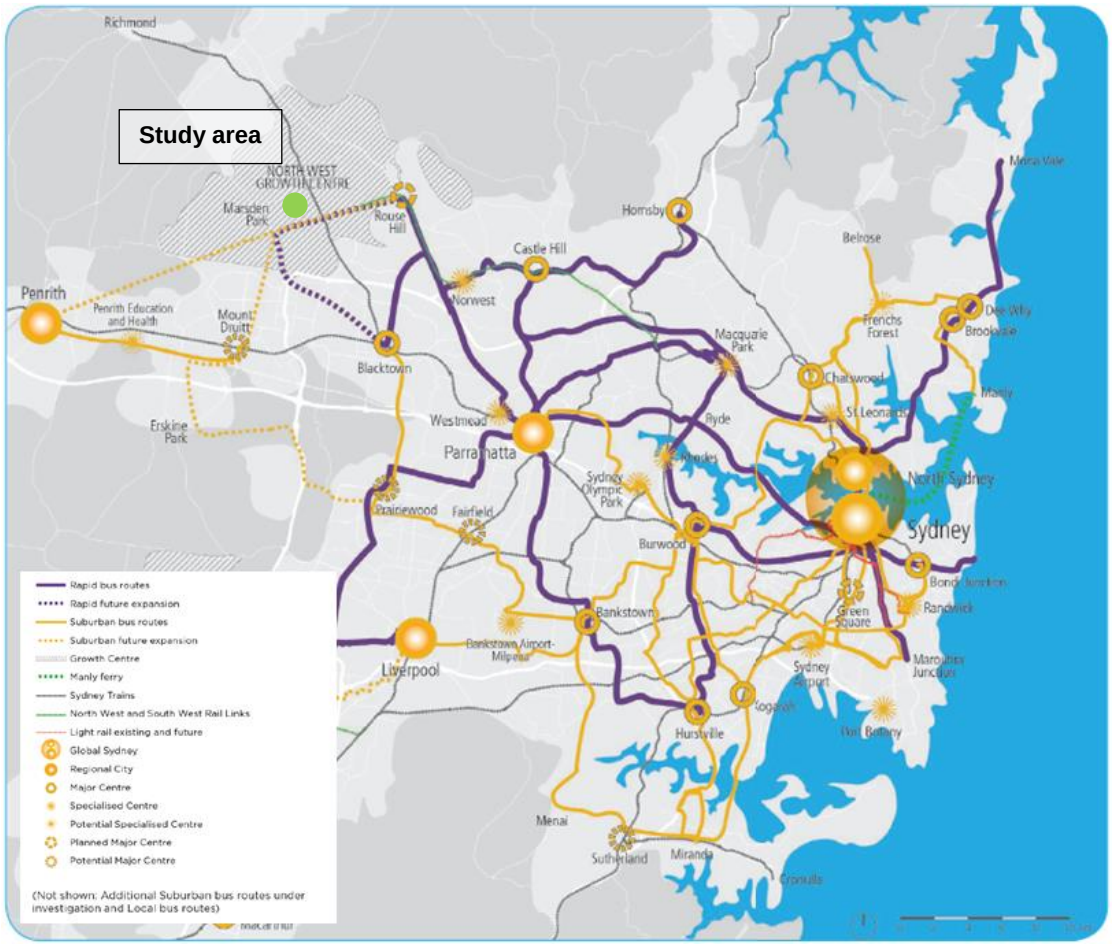


Figure 13: Sydney's Bus Future *(Source: NSW Government, 2013)*

Sydney's Bus Future has identified future bus routes in the NWGA, which may potentially provide bus services to the Marsden Park North precinct. These include:

- Rouse Hill – Blacktown via Marsden Park (rapid bus route) using major roads including Schofields Road and Richmond Road
- Penrith – Rouse Hill via Schofields and Marsden Park (suburban bus route)
- Marsden Park – Prairiewood via Western Sydney Employment Area and Mount Druitt (suburban bus route)

The exact routes and locations of bus stops for these potential routes are yet to be finalised.

Bus stops within the study area should be designed to provide shelter, seating and information such as timetables and a network map. The facilities provided at each bus stop will be determined by surrounding land uses and will account for service frequency and potential patronage. Bus stops should also consider accessibility of all road users and the Disability Discrimination Act (DDA).

6.2 Future infrastructure for pedestrians and cyclists

A number of proposed cycleways are planned in the vicinity of the Marsden Park and Marsden Park North precincts which will provide connectivity to future major and local centres as the NWGA develops and vital links to public transport interchanges with trip end facilities for cyclists.

Blacktown City Council's *2016 Bike Plan*, illustrating existing and proposed upgrades, is illustrated in Figure 14.

Figure 14: Blacktown City Council 2016 Bike Plan *(Source: Blacktown City Council, 2019)*

6.2.1 Opportunities and constraints

Opportunities

- Cycle routes should be provided throughout the study area to connect between residential and commercial areas of surrounding suburbs and nearby public transport stops. The routes will provide high quality infrastructure designed to make bicycle travel attractive, convenient, safe and efficient.
- Provide initiatives to encourage future residents to travel by active modes of transport to reduce car dependency and increase sustainable travel patterns.
- Consideration should be given to providing cycle links throughout the neighbouring precincts which enhances the connectivity to the existing and proposed cycle network.
- Improve pedestrian crossing facilities across Richmond Road, Bandon Road and Garfield Road.
- As surrounding precincts are developed, pedestrian and cycle links will be further enhanced providing links to surrounding centres and destinations.
- To maximise cycle use throughout the area, the provision of end of trip facilities, such as bicycle parking, at key locations is essential. Bicycle parking is proposed to be provided at the major retail attractors in the area, the local public transport stops, and will also be encouraged as part of the development of employment and other commercial uses. Other areas of key open space will also have bicycle parking for leisure and recreational use.

Constraints

- Limited pedestrian and cycling provisions in the vicinity of the precincts which are not desirable for pedestrian activity or cyclists.
- Future widening of Richmond Road and Garfield Road West may create barriers for pedestrian and cycle movements.

6.3 Parking restraint measures

6.3.1 Restrained parking rates for higher density residential development

The higher density residential development in the area should have good quality pedestrian and cycle networks, and a good range of local shops, services and facilities in close proximity, thereby reducing residents' need to own and operate a car.

Parking requirements for higher density residential should be restrained to account for the availability of other travel options, as well as accessibility to local services. This will lead to reduced car dependence and encourage uptake of other modes. The implementation of this measure will require further discussion with Blacktown City Council.

6.3.2 Co-sharing parking provision

The provision of parking should be co-ordinated and, where possible, shared across multiple land uses that do not have similar peak parking demands. This will create a more walkable, liveable area, which is not car dominated and ensure balanced access across all modes.

Parking provision should encourage short stay trips, with some limited long stay parking for commuters around the rail station. Any on-street parking should be limited to short term, accessible and taxi parking.

7.0 Traffic impact assessment

This section provides findings of the traffic assessment in terms of average delay (s) and Level of Service (LOS).

Output comparisons are only provided for signalised intersections in the study area, as left in / left out priority intersection performance is relatively consistent across all Options and assessment years.

Level of Service is a performance parameter used to describe the operation of an intersection. Levels of Service range from A to F, with Table 15 outlining the delay performance thresholds.

Table 15: Roads and Maritime LOS criteria

Level of Service	Average delay (seconds per vehicle)	Traffic Signals, Roundabout	Give Way and Stop Signs
A	Less than 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 capacity; requires other control mode
F	Greater than 71	At signals, incidents will cause excessive delays	Unsatisfactory with excessive queuing; requires other control mode

7.1 Overall intersection performance comparison

Table 16 provides overall intersection average delay and LOS comparisons Without Project against With Project, for the three future years assessed.

Table 16 Future year intersection capacity for all scenarios

Year	Peak	Intersection	Without Project		With Project	
			LOS	Delay	LOS	Delay
2026	AM	Garfield Rd	F	408	F	268
		Elara Blvd	F	1,472	F	103
		Access Rd 1	A	9	A	4
		Clydesdale Access Rd	-	-	F	1,536
		Heritage Rd	F	123	A	7
	PM	Garfield Rd	F	1,510	F	976
		Elara Blvd	F	95	F	112
		Access Rd 1	A	9	A	4
		Clydesdale Access Rd	-	-	F	177
		Heritage Rd	F	156	A	5

Year	Peak	Intersection	Without Project		With Project	
			LOS	Delay	LOS	Delay
	SAT	Garfield Rd	F	893	F	396
		Elara Blvd	F	303	A	13
		Access Rd 1	A	9	A	4
		Clydesdale Access Rd	-	-	F	801
		Heritage Rd	E	61	A	5
2031	AM	Garfield Rd	F	358	F	303
		Elara Blvd	F	1,286	F	1,224
		Access Rd 1	A	9	A	4
		Clydesdale Access Rd	-	-	F	1,199
		Heritage Rd	D	54	A	5
	PM	Garfield Rd	F	1,150	F	775
		Elara Blvd	A	1,076	F	447
		Access Rd 1	A	5	A	4
		Clydesdale Access Rd	-	-	F	576
		Heritage Rd	A	6	A	5
	SAT	Garfield Rd	F	653	F	425
		Elara Blvd	F	1,249	F	584
		Access Rd 1	A	5	A	4
		Clydesdale Access Rd	-	-	F	587
		Heritage Rd	A	6	A	5
2036	AM	Garfield Rd	F	286	F	542
		Elara Blvd	F	1,222	F	904
		Access Rd 1	A	4	A	4
		Clydesdale Access Rd	-	-	F	630
		Heritage Rd	A	5	A	5
	PM	Garfield Rd	F	764	F	695
		Elara Blvd	F	696	F	435

Year	Peak	Intersection	Without Project		With Project	
			LOS	Delay	LOS	Delay
		Access Rd 1	A	4	A	4
		Clydesdale Access Rd	-	-	F	188
		Heritage Rd	A	4	A	4
	SAT	Garfield Rd	F	405	F	475
		Elara Blvd	F	769	F	602
		Access Rd 1	A	4	A	4
		Clydesdale Access Rd	-	-	F	201
		Heritage Rd	A	5	A	4

Without Project Scenario

Table 16 demonstrates that future year performance for the network is generally poor under both scenarios, with LOS of F at some or all major intersections during all assessment years. This is due to the significant traffic growth forecast (Section 4.0).

Performance of Heritage Road, however, improves after 2026 given opening of the Bandon Road extension and connection of the Garfield Road West extension to Stoney Creek Road by 2026; each of these measures contributes towards rerouting of Marsden Park Precinct traffic, reducing the northbound demand as traffic routes elsewhere.

With Project Scenario

Under 2026 conditions, the With Project scenario demonstrates significant performance improvements when compared to the Without Project scenario for all peak periods. Despite this, the three signalised intersections in the study area each operate at LOS F under With Project conditions.

In the AM peak the intersection with the highest delay is Clydesdale Access Road, which is the first intersection the majority southbound movement reaches in the study area. In the PM peak, this trend is present with the intersection of Garfield Road, again the first intersection the priority northbound movement reaches in the study area, has the highest delays.

Construction of the Clydesdale Access Road intersection will provide an additional access to the Marsden Park Precinct, thus easing pressure on the Elara Boulevard approach by reducing traffic demand. This in turn spreads the impact to traffic on Richmond Road across two intersections as opposed to isolating them to one.

The Project also widens Richmond Road from two to four lanes for approximately 1km north of the current merge point; this additional carriageway space provides capacity and limits the impact the northbound merge to one lane has on upstream intersections of Elara Boulevard and Garfield Road West.

Local intersection upgrades, including provision and extension of turn bays, will limit the likelihood of turn movement queues exceeding the respective turn bay and thus impacting on adjacent traffic movements. This improves capacity and also reduces the likelihood of rear end collisions.

Comparison between Without and With Project Scenarios

By 2031, the Bandon Road extension is complete and so Marsden Park North traffic no longer accesses the development via Garfield Road. The result is a significant deterioration of performance of the Elara Boulevard intersection when compared to 2026, both Without and With Project, which now caters for significantly higher demand.

By 2036, performance deterioration caused by increased demand is offset somewhat by the provision of a third through lane in each direction along Richmond Road, resulting in relatively comparable With Project delays between 2031 and 2036 future years, albeit with all signalised intersections performing well over LOS F.

7.2 Intersection performance summary

Overall intersection average delay (seconds) comparisons at the three signalised intersections of Garfield Road, Elara Boulevard and Clydesdale Access Road for the three future years assessed are provided in Figure 15 below.

Figure 15: Intersection performance summary

7.3 Crash analysis

The latest crash data was obtained for a five-year period from January 2014 to December 2018 to estimate the recent accident patterns across Richmond Road and the project study area. The data captured along Richmond Road spans between South Creek (North) and the M7 Interchange (South).

A review of the crash data indicates 98 reported crashes have been recorded on the assessed road sections; these include 89 injury crashes.

Assessment of the project study area between and inclusive of Richmond Road intersections with Garfield Road West and Heritage Road identified 36 casualty crashes reported over the 5-year period, as illustrated on Figure 16.

Figure 16: Five-year (2014 - 2018) crash severities - Garfield Road West to Heritage Road

Source: Roads and Maritime Services, 2019

30 crashes (76.9%) occurred with vehicles travelling in the same direction along Richmond Road:

- 19 rear-end crashes, two of which were serious and six moderates.

Analysis of the type of crashes indicates:

- Over the five-year period, rear-end crashes were the most common crash type within the study area. Seven out of 19 rear-end crashes involved a heavy vehicle (heavy rigid, light truck and semi-trailer);
- Three crashes exclusively took place at Elara Boulevard and 28 occurred at the Garfield Road West intersection.

7.4 Construction impacts

A detailed construction traffic impact assessment has not been undertaken because details related to the construction activities and sequence of work are not currently known. A more detailed construction traffic impact assessment will be required once a detailed construction plan has been developed.

For the purposes of this assessment, it is expected that the proposal would be built between 2023 and 2024, subject to funding. The majority of the work would take place during daytime in accordance with the recommended standard hours for construction work set by the *NSW Interim Construction Noise Guidelines 2009*, which are:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm

There may be the need to work outside of these hours to minimise disruption to traffic. Potential locations of the site that could be subject work outside standard construction hours include:

- Pavement tie-in work and line marking along the existing section of Richmond Road; and
- Intersection tie-ins with Elara Boulevard.

This work would ensure that there would be minimal disruption to road users, including businesses and residents in the study area.

The potential construction vehicle haulage routes would be via:

- North and south of the proposal site on Richmond Road; and
- Garfield Road.

A sketch showing construction vehicle routes is provided in Figure 17.

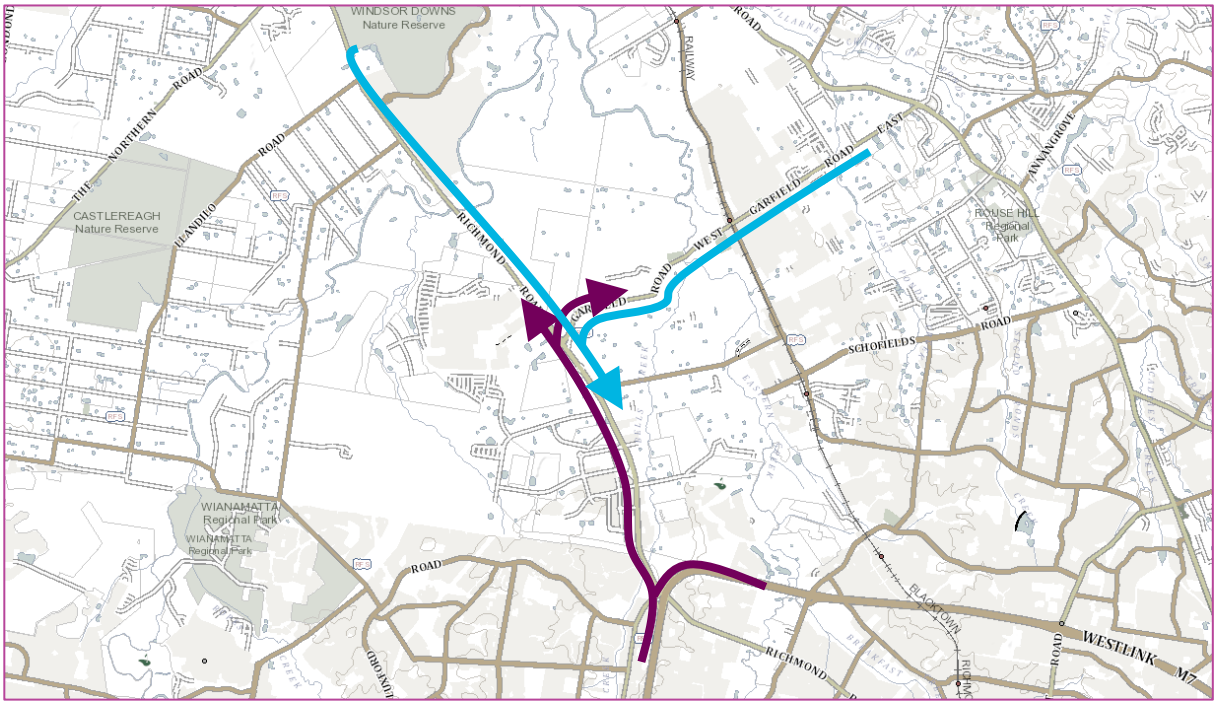


Figure 17: Potential construction vehicle haulage routes

While up to 100 people may be required to build the proposal it is likely that there would only be about 25 people onsite on average at any one time. The personnel would likely drive to site and park near Elara Boulevard.

The plant and equipment required to build the proposal would vary on the construction activity being undertaken. The equipment would be shared across the indicative construction stages and not all

plant and equipment would need to be used in a given location at a given time. The movement of materials would be managed through scheduling to minimise the number trips during peak traffic periods.

As the site is well situated for access to motorways and arterial roads, the impact on local roads would be minimal, while the proposed construction vehicle routes already have high volumes of heavy vehicles and the impact of additional construction vehicles would be negligible.

8.0 Summary, conclusion and recommendations

8.1 Summary and conclusion

AECOM were engaged by Roads and Maritime in November 2018 to undertake SIDRA Intersection optioneering and modelling along Richmond Road, Marsden Park, for the primary purpose of determining the traffic impacts of future developments adjacent to the Richmond Road corridor and identify any accessibility constraints.

The 2018 Base SIDRA models for the study area have been calibrated and verified in accordance with Roads and Maritime's modelling criteria. As shown in Appendix A, the weekday AM and PM and weekend SIDRA models are considered to provide a good representation of the current traffic conditions in the study area during the peak periods.

Future year network operation has been assessed for the 2026, 2031 and 2036 forecast demands for four scenarios - a Do Minimum and three Option scenarios, using the 2018 models as a basis.

The Without Project scenario represents a case in which the existing network layout is retained, along with other committed infrastructure projects like Garfield Road West extension and left in / left out accesses required as part of the Marsden Park Precinct development, Bandon Road (considered operational by 2031) and widening of Richmond Road from four to six lanes, which is expected to occur by 2036.

The With Project scenario includes the proposed signalised intersection of Richmond Road / Clydesdale Access Road, widening of Richmond Road from two lanes to four lanes for a stretch of approximately 1 km, and a number of minor intersection upgrades at existing signalised intersections of Richmond Road with Garfield Road and Elara Boulevard.

The intersections generally perform poorly for all three modelled peak hours in all scenarios. Scenario testing identified that the existing road network would not be capable of accommodating future year demands, with Do Minimum assessments highlighting significant congestion along the Richmond Road corridor. This congestion is a result of the combination of regional traffic growth forecasts and development traffic from Marsden Park and Marsden Park North.

Testing of potential solutions to resolve congestion, both within and beyond the immediate study area, was undertaken. Whilst these measures were found to improve network performance significantly, they were not sufficient in resolving all congestion in the network or bringing Levels of Service to acceptable levels. This in turn suggests that regardless of proposed road network upgrades, the anticipated demand for Richmond Road in future year exceeds the available surface road network capacity.

With intersections modelled as a network, the impact of poorly performing intersections on adjacent intersections has been captured. Given the major traffic movement from the study area is tidal towards and from the Sydney CBD, the southernmost intersection of Richmond Road / Garfield Road generally forms the pinch point from which congestion arises. Here, a combination of heavy Richmond Road through traffic, along with Marsden Park demand to the west and Marsden Park North traffic to the east results in oversaturated performance of the intersection.

Intersection capacity is expected to remain satisfactory until development of the adjacent precincts reaches a critical point, at which road network capacity is exceeded. Given the uncertainty over current rezoning and Development Applications in both these precincts, predicting the year of this 'critical point' would require use of changeable assumptions and would require further investigation, in which the land developers and the Department of Planning and Environment should be engaged.

A total of 36 casualty crashes were reported for the five-year period to December 2018 between intersections with Garfield Road West and Heritage Road, of which 30 occurred between vehicles travelling in the same direction along Richmond Road. Rear end collisions were the most common across the study area and three of the total 36 crashes resulted in serious injury, with no fatalities.

Whilst construction activities have not been assessed in detail given the project is in its early stages, their impact is expected to be minimal, with major arterial corridors of Richmond Road and Garfield

Road expected to accommodate heavy vehicles associated with construction. Construction vehicle activity will be managed to ensure it does not coincide with network peak periods.

8.2 Recommendations

Based on the assessment findings, it is recommended that the upgrades and measures outlined in the With Project scenario be progressed for further investigation. The Project provides significant performance improvements when compared to the Without Project scenario.

Whilst the report concludes that intersections will exceed capacity by the future assessment years, there are still significant performance improvements that can be achieved to extend the lifespan of the current surface road network prior to more significant interventions being required. These improvements are summarised in Table 14 and discussed more generally in Section 5.0.

Besides surface road network interventions discussed and tested, broader strategic considerations should be made to ensure the long-term serviceability of the NSW Government's North West Growth Area plan. The below considerations were developed as part of the Marsden Park North Traffic & Transport Assessment (AECOM, 2018) and have since been circulated separately to Roads and Maritime and the Department of Planning and Environment.

1. **Improved bus provision in the North West region**

   Currently public transport provision in the study area is minimal, given the currently low population. As the area develops and population increases, an improved bus network would be expected and should be investigated to reduce car dependency.

2. **Improved rail network**

   Current heavy rail services are infrequent, with T1 and T5 services running on a single track in each direction near the study area. Should the rail network be enhanced, increased services may facilitate a greater mode-shift away from cars and onto public transport.

   Sydney Metro has recently been completed, however terminates at Tallawong to the east. A proposed extension of the line from St Marys to Rouse Hill via Schofields, crossing Richmond Road, could create a significant modal shift from private vehicles within the study area, especially if a station is provided close by.

   This is somewhat supported by initial anecdotal experiences of arterial roads such as the M2 post-metro opening. Furthermore, should light rail services be extended further, potentially with a view to connecting to Western Sydney at key locations such as Badgerys Creek, this would likely improve access to rail services for the Marsden Park and Marsden Park North Precincts.

3. **Outer Sydney Orbital and Castlereagh Freeway (Bells Line of Road)**

   These large-scale infrastructure projects have been announced but as yet have no firm commitment, and so are not accounted for in future year traffic flow forecasts and trip distribution provided by Roads and Maritime. These two potential new link roads are likely to have a significant impact on traffic routeing along Richmond Road.

Other potential opportunities which have not been investigated in this analysis include:

1. **Peak spreading**

   This is the phenomenon of people leaving earlier or later in an attempt to avoid 'peak' congestion, 'widening' the peak traffic period in the morning and evenings. It is a logical, human response and occurs naturally as population increases and motorists become unwilling to stick to original travel habits in the face of increased generalised 'cost' (temporal and monetary) of travel.

   Whilst difficult to quantify and predict, peak spreading is a legitimate means of managing forecast congestion and has been measured in other expanding global cities.

2. **Management of development yields**

   It's recommended that a sensitivity test based on development yields within the precincts be conducted to more precisely determine the point of maximum development yield and background growth at which the surface road network reaches capacity. This will require

liaison with private developers of the land, as well as the Department of Planning and Environment and Council to obtain further clarity over the progress of ongoing rezoning and Development Application activities.

APPENDIX A

2018 Base SIDRA Models Assessment Report

AECOM Imagine it. Delivered.

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Memorandum

To	Siva Satchi	Page	1
CC	Greg Aouad, Ben Midgley, Andy McGregor		
Subject	Richmond Road Traffic Impact Assessment - 2018 Base SIDRA Models		
From	Bill Chen		
File/Ref No.		Date	18-Jan-2018

1.0 Introduction

As part of Richmond Road traffic impact assessment, AECOM has been commissioned by Roads and Maritime Services (Roads and Maritime) to undertake traffic modelling using SIDRA software to assess the traffic operation on Richmond Road between Garfield Road West in the south and Heritage Road in the north. The modelling will provide an input for the subsequent Benefit Cost Ratio (BCR) analysis and other planning studies.

This technical memo describes the 2018 existing traffic conditions within the study area and outlines the development of the 2018 base SIDRA models for the weekday AM and PM peak hours and weekend peak hour.

2.0 SIDRA software

As required by Roads and Maritime, SIDRA software is selected as a suitable platform for this traffic modelling exercise. SIDRA is a Roads and Maritime approved modelling micro-analytical software package, capable of analysing isolated and coordinated intersections. The key performance indicators extracted from SIDRA model for this study include:

- average delay and Level of Service (LoS)
- degree of saturation (DoS)
- 95 percentile (95^{tile}) queue length.

3.0 Study area

The study area for the SIDRA models is shown in Figure 1, which includes the following critical, current and proposed intersections:

- Richmond Road / Elara Boulevard (existing layout and proposed fourth leg configuration)
- Richmond Road / Access Road 1 (proposed left-in intersection)
- Richmond Road / Clydesdale Access Road (proposed four-arm intersection)
- Richmond Road / Heritage Road (proposed re-alignment and left-out intersection)
- Richmond Road / Garfield Road West

Of these intersections, Richmond Road/Elara Boulevard and Richmond Road/Garfield Road West are currently in operation and as such form the subject of this existing conditions analysis.

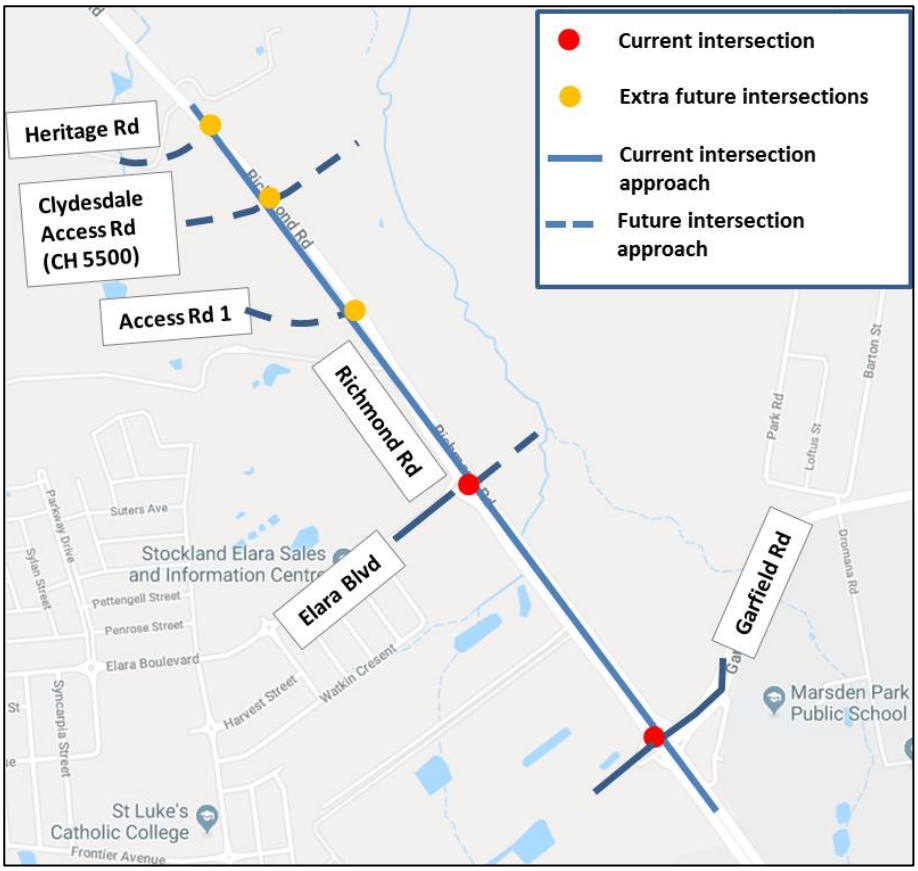

Figure 1 Study area and key intersections

4.0 Data source

AECOM was supplied with the following data from Roads and Maritime to assist with the development of the 2018 base SIDRA models:

- SCATS signal and detector count data

In addition to the SCATS data, AECOM has obtained the bus data from public domain and undertook site inspections for the study area to observe the traffic conditions during weekday AM and PM peak hours and weekend peak hour. The videos and site observations are used in the process of model calibration/verification.

4.1 SCATS data

SCATS data was provided for the following signalised intersections within the study area:

- Richmond Road / Garfield Road West
- Richmond Road / Elara Boulevard.

The following weekday SCATS data was collected during 10-14 and 17-21 September and 29 October-2 November 2018, and weekend data on 15-16 and 22-23 September and 3-4 November 2018:

- detector counts and lane saturation flows
- signal data including phasing arrangements, phase times, offset data, intergreen and minimum green time, late/early starts.

The detector data was collected for 24 hours and binned at 15-minute intervals. The signal phase times were collected for 24 hours and at 15-minute intervals.

As SCATS data does not separate vehicle types, the heavy vehicle percentages were sourced from the *Marsden Park North Traffic and Transport Assessment report* (AECOM, 2018) to estimate the light and heavy vehicles demand for this modelling exercise.

Figure 2 and Figure 3 show the current network demand profiles during typical weekdays and weekends for the study area. The light blue shaded areas show a distinct AM peak period of 6:30 – 8:30am, and a PM peak period of 3:00 – 5:30pm for typical weekdays. The traffic demand for Saturdays is generally higher than Sundays and the peak period for typical Saturdays occurs between 11.30am – 1:30pm.

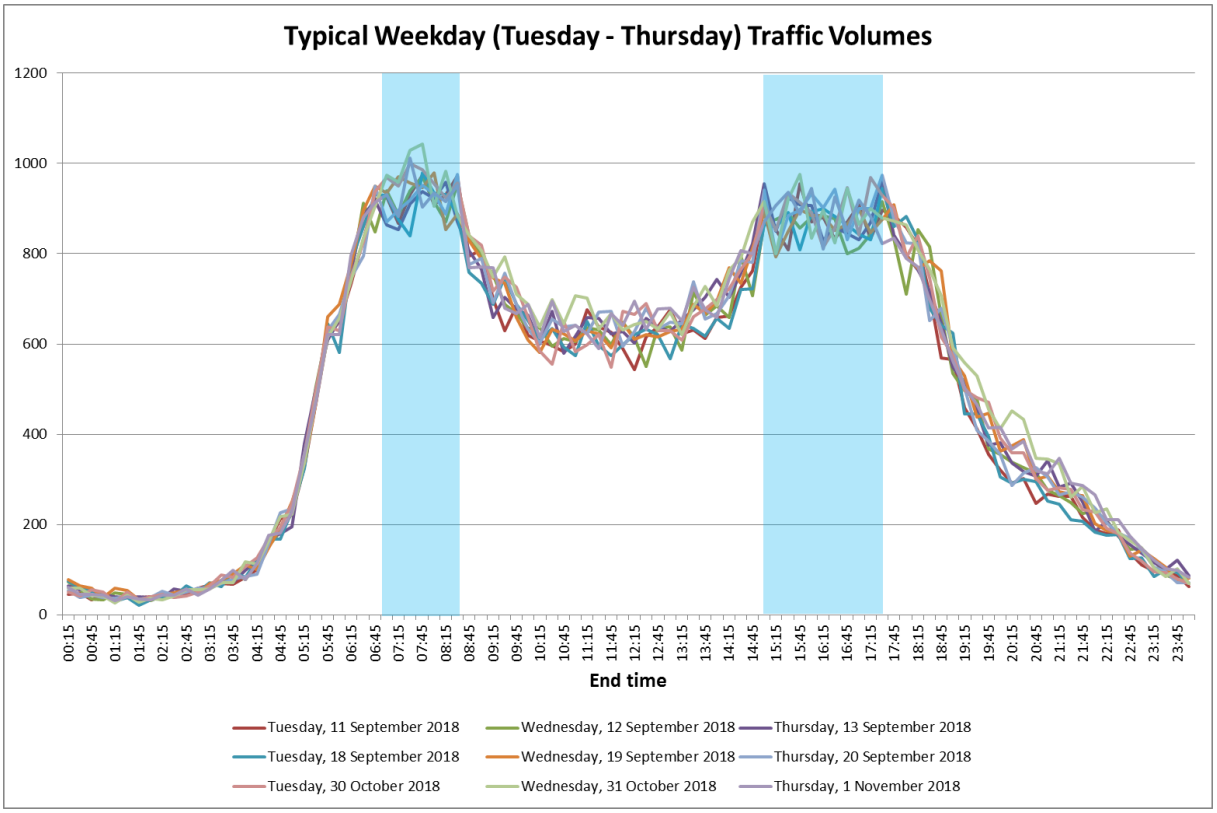

Figure 2 Typical weekday demand profiles

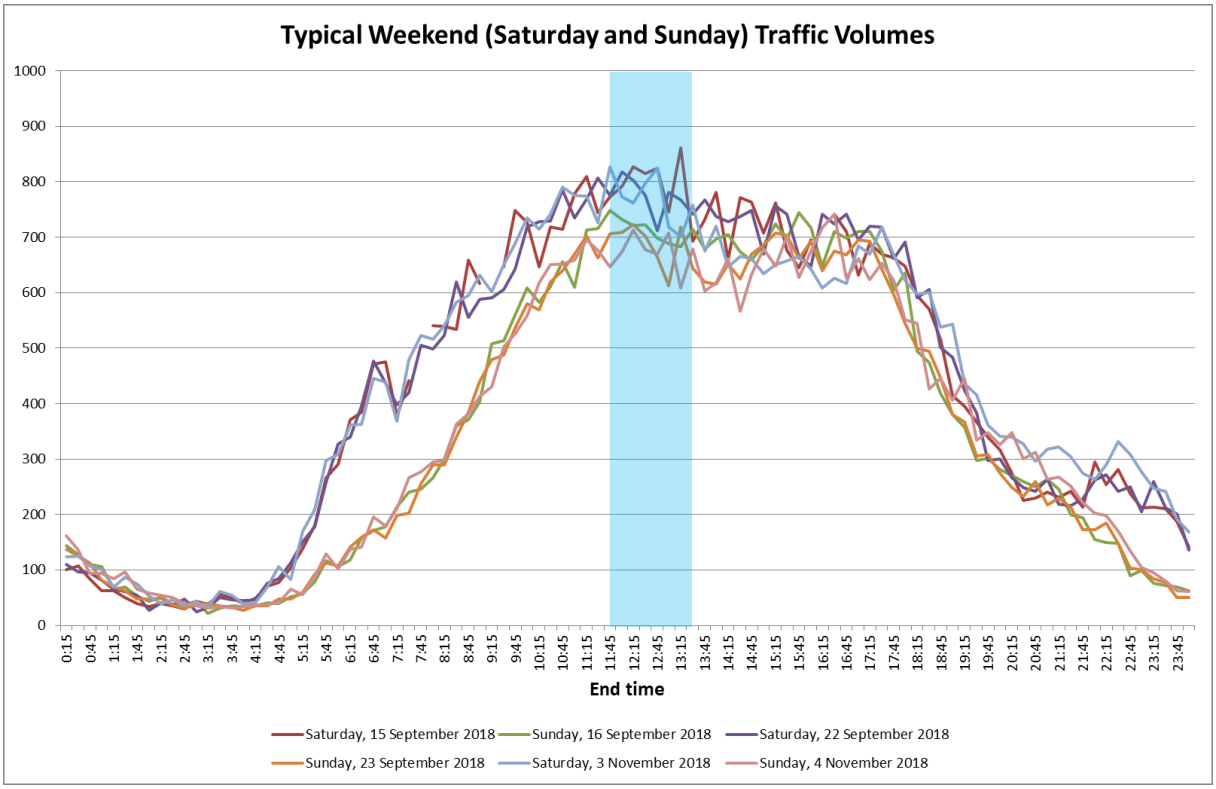

Figure 3 Typical weekend demand profiles

4.2 Bus data

Bus routes and timetable data have been obtained from the Transport for NSW (TfNSW) website. The number of buses operating during weekday AM and PM peak hours and Saturday peak hour have been included in the base SIDRA models.

4.3 Site inspections

Site inspections have been undertaken by AECOM during the weekday AM and PM peaks on 22 November 2018 and Saturday peak on 24 November 2018 to observe the current traffic conditions within the study area. Specific note was made of the following:

- road geometry and intersection layout
- speed limits
- driver behaviour
- traffic signal operation
- queue conditions.

During the site inspections, the following congestion conditions were observed within the study area:

Weekday AM peak hour and Saturday peak hour

- No significant queuing issue was observed at both intersections.
- There were very few pedestrian movements at the two intersections.

PM peak

- The northbound exit blocking was observed at the Richmond Road/Elara Boulevard intersection due to a combination of a relatively high volume of traffic in the peak traffic direction and the exit lane merge (from 2 lanes to 1) on Richmond Road northbound north of Elara Boulevard. The northbound queue did not extend back to the upstream Richmond Road/Garfield Road West intersection.

- There were very few pedestrian movements at the two intersections.

The site observations have been used to aid in the calibration of the SIDRA models.

5.0 2018 Base SIDRA model development

AECOM has complied with the Roads and Maritime Traffic Modelling Guidelines (version 1.0, Section 14: Single intersection modelling) when developing the 2018 base SIDRA models.

5.1 SIDRA model network

The SIDRA model networks for the isolated intersections and network model are shown in Figure 4, Figure 5 and Figure 6.

It should be noted that the Garfield Road West eastbound approach is currently a no through road and has little / no traffic demand. To simplify the coding of the phasing arrangement for this intersection, the arm is excluded from the 2018 base SIDRA model. This does not have a significant impact on modelling of traffic performance for this intersection.

Note that this approach may require modelling in future scenario testing, depending upon its anticipated future use and strategic flow forecasts.

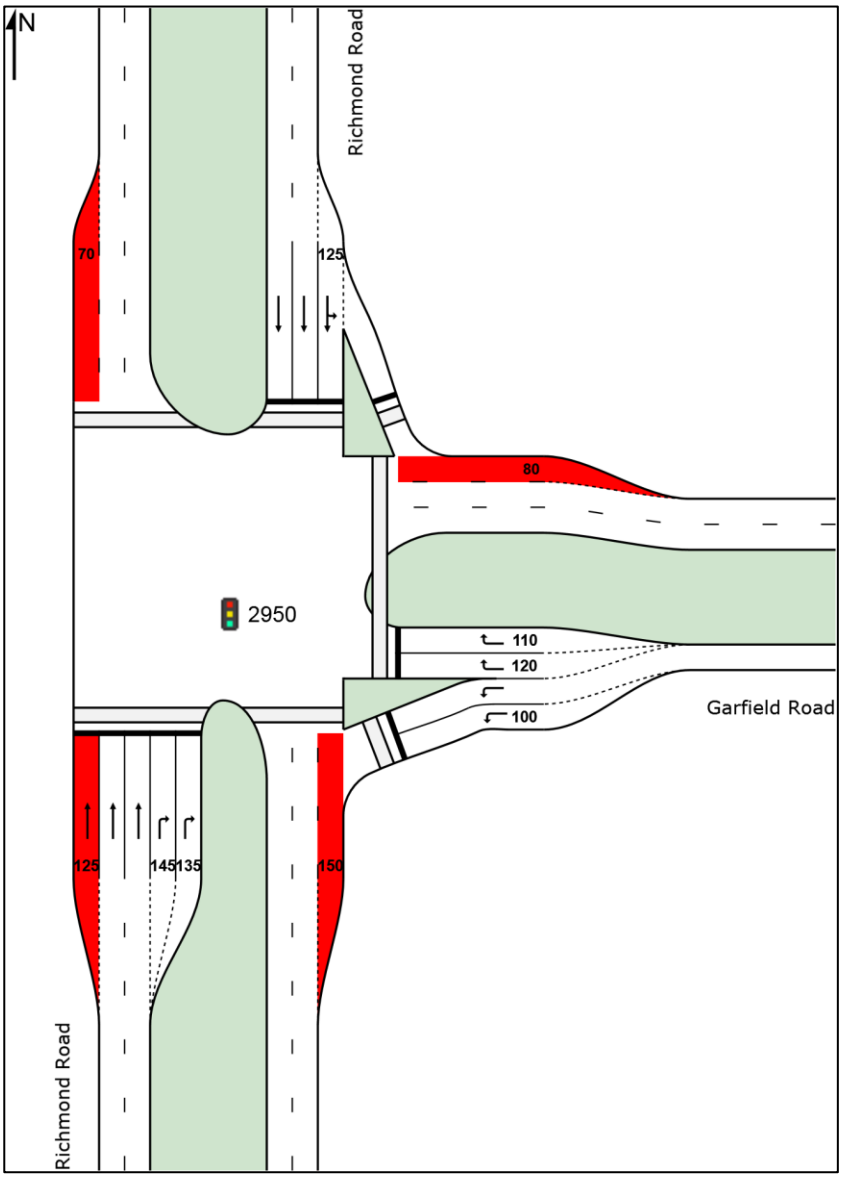

Figure 4 2018 Base layout of Richmond Road / Garfield Road West intersection

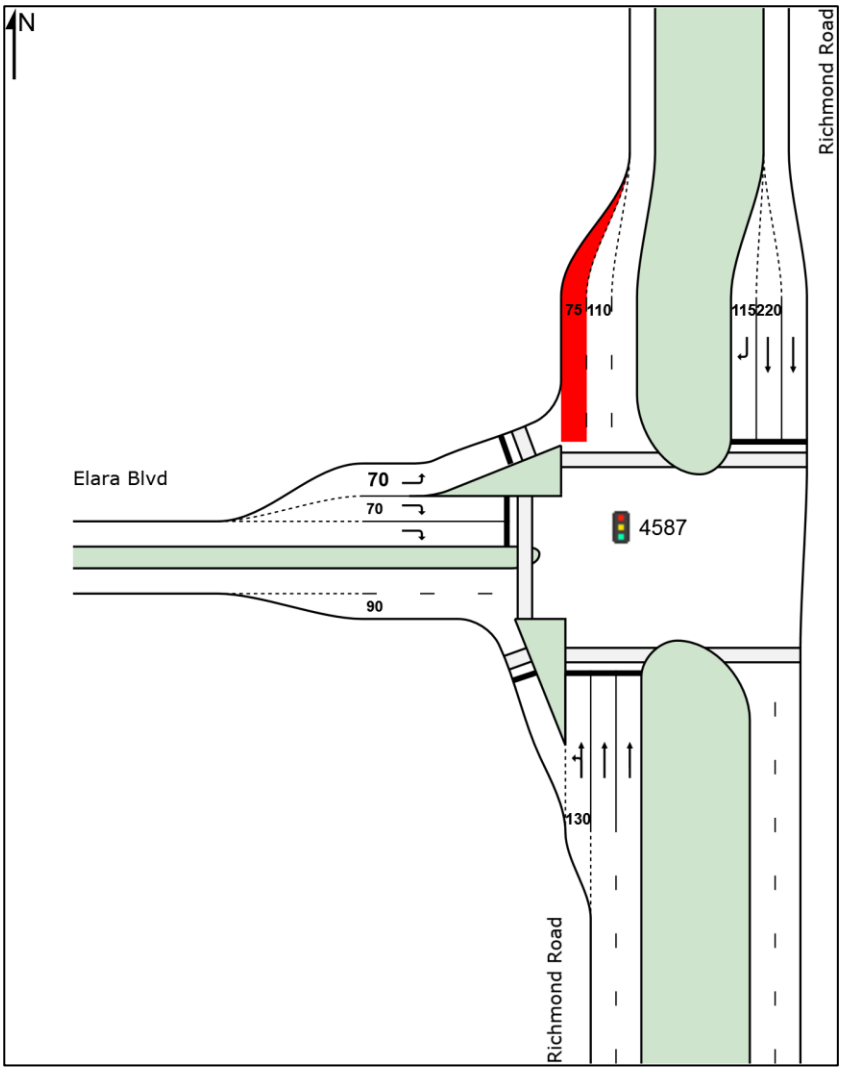

Figure 5 2018 Base layout of Richmond Road / Elara Boulevard intersection

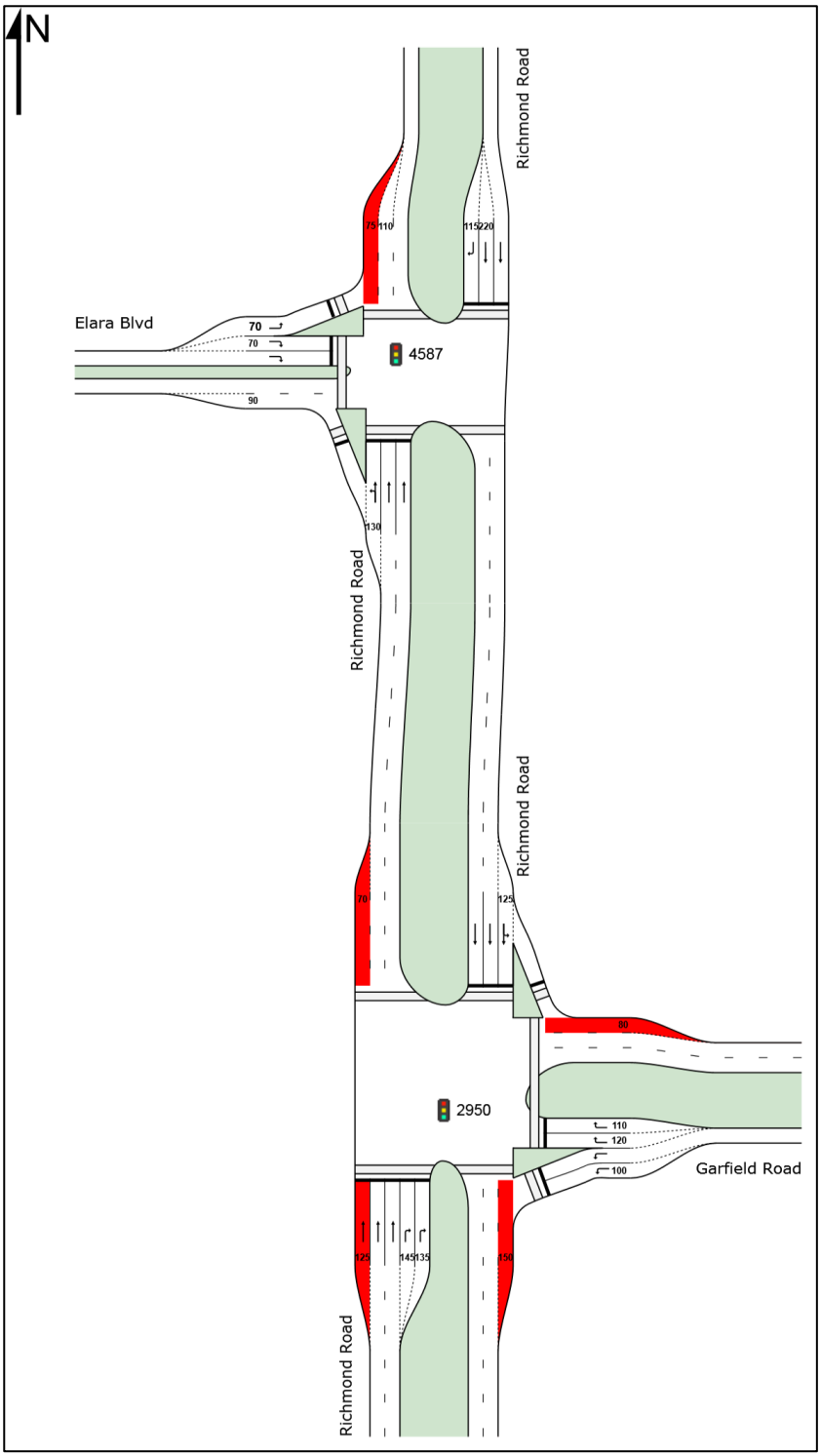

Figure 6 2018 Base network model

5.2 Modelled peak periods

The 2018 SIDRA models have been developed for the three peak hours; weekday AM and PM peak hours and Saturday peak hour.

5.3 Base year traffic demands

The base year traffic demands have been calculated in the following manner:

- The peak hour volumes during AM and PM peak hours for each typical weekday (Tuesday – Thursday) have been extracted from the SCATS count data supplied
- The peak hour volumes for all typical weekdays for which SCATS data was received have then been used to calculate the average of the peak hour volumes to more reasonably represent the peak conditions for typical weekday.
- A similar approach has been adopted to calculate the average of peak hour volumes for typical Saturday peak hour.

Figure 7, Figure 8 and Figure 9 show the average peak hour volumes for typical weekday AM and PM peaks and Saturday peak, which have been verified with our site observations.

It should be noted that SCATS count data does not distinguish light and heavy vehicles and therefore, the heavy vehicle percentages have been sourced from The *Marsden Park North Traffic and Transport Assessment report* (AECOM, 2018) and used to separate the light and heavy vehicles from the SCATS total vehicle count data.

As shown in Figure 4 and Figure 5, all the major traffic movements at these two intersections have their dedicated through or turn lanes. Although SCATS count data does not separate shared traffic lanes, it does not impact the calculation of 2018 base demand.

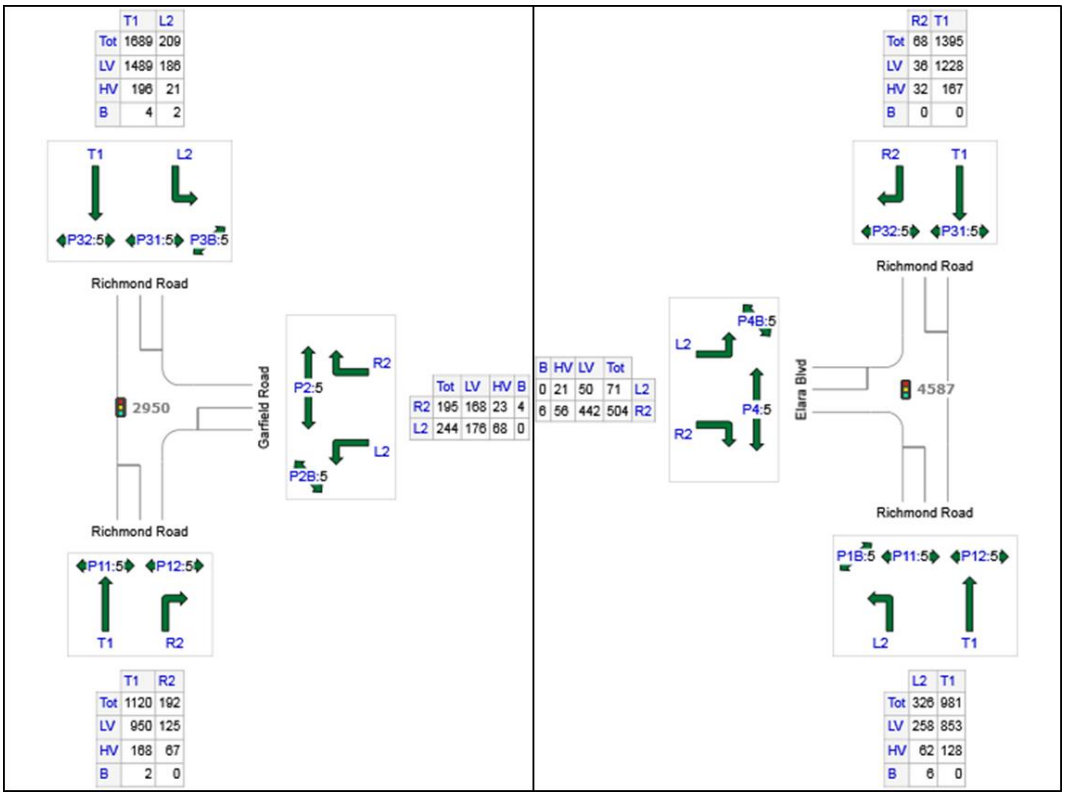

Figure 7 2018 Traffic demand at the intersections of Richmond Road with Garfield Road West and Elara Boulevard for weekday AM peak hour

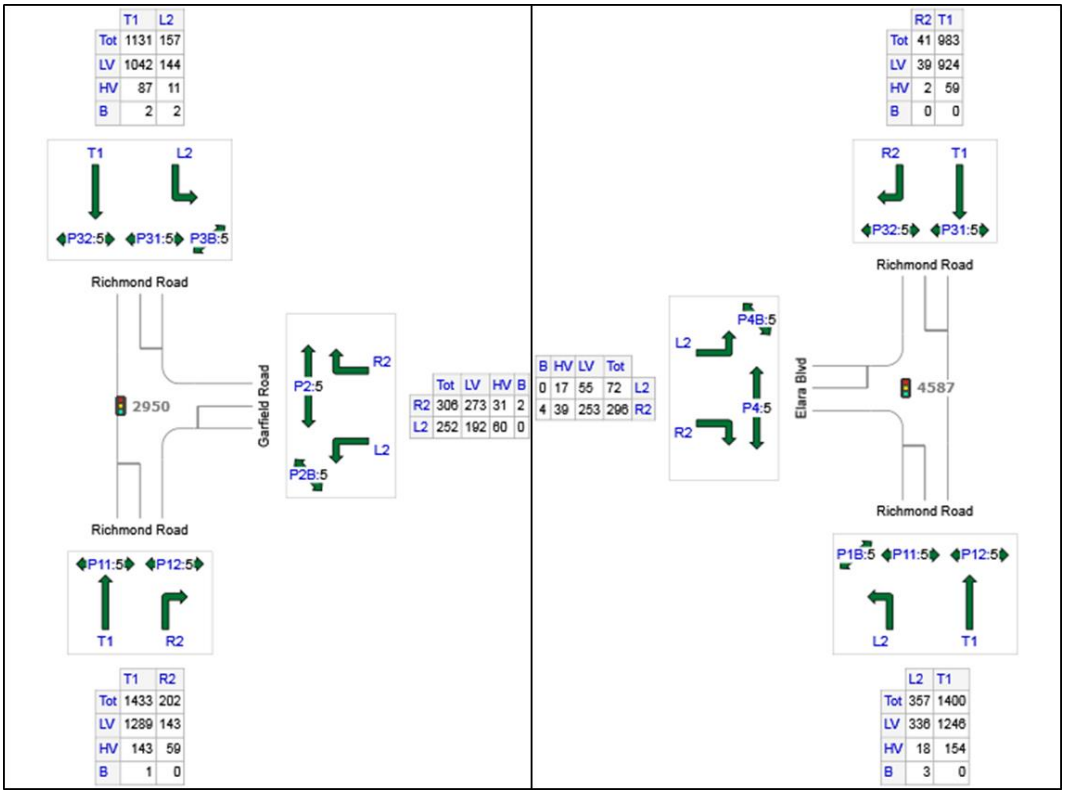

Figure 8 2018 Traffic demand at the intersections of Richmond Road with Garfield Road West and Elara Boulevard for weekday PM peak hour

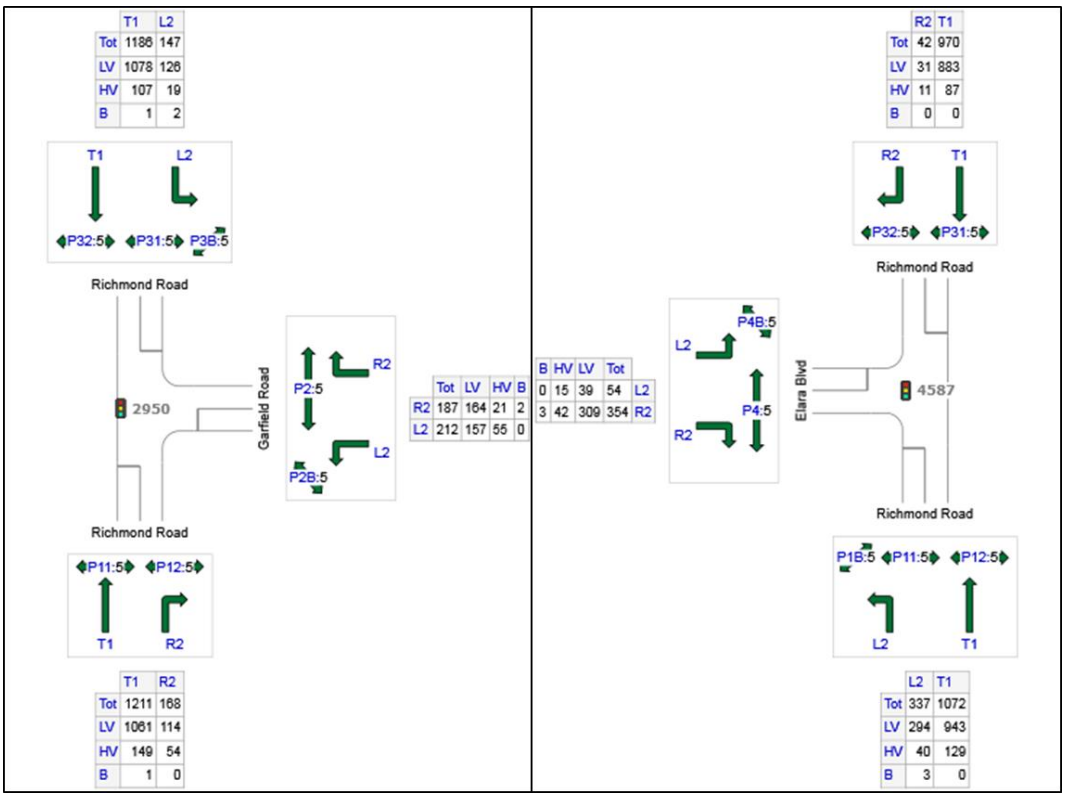

Figure 9 2018 Traffic demand at the intersections of Richmond Road with Garfield Road West and Elara Boulevard for Saturday peak hour

5.4 Traffic signal coding

Similar to the base demand, the average phase times have been calculated from the supplied SCATS IDM data to, more reasonably reflect the signal operation during typical weekday AM and PM peak hours and Saturday peak hour.

The existing activated phasing arrangements for the Richmond Road / Garfield Road West and Richmond Road / Elara Boulevard intersections are shown in Figure 10 and Figure 11, which have been verified with our site observations. It should be noted that some pedestrian phases only operate in Phase G1 at the Richmond Road / Garfield Road West intersection and Phase C1 at the Richmond Road / Elara Boulevard and SIDRA software requires that pedestrian phases for all pedestrian crossings must run. Therefore, the two phases have been included in the SIDRA models with very low frequency of activation.

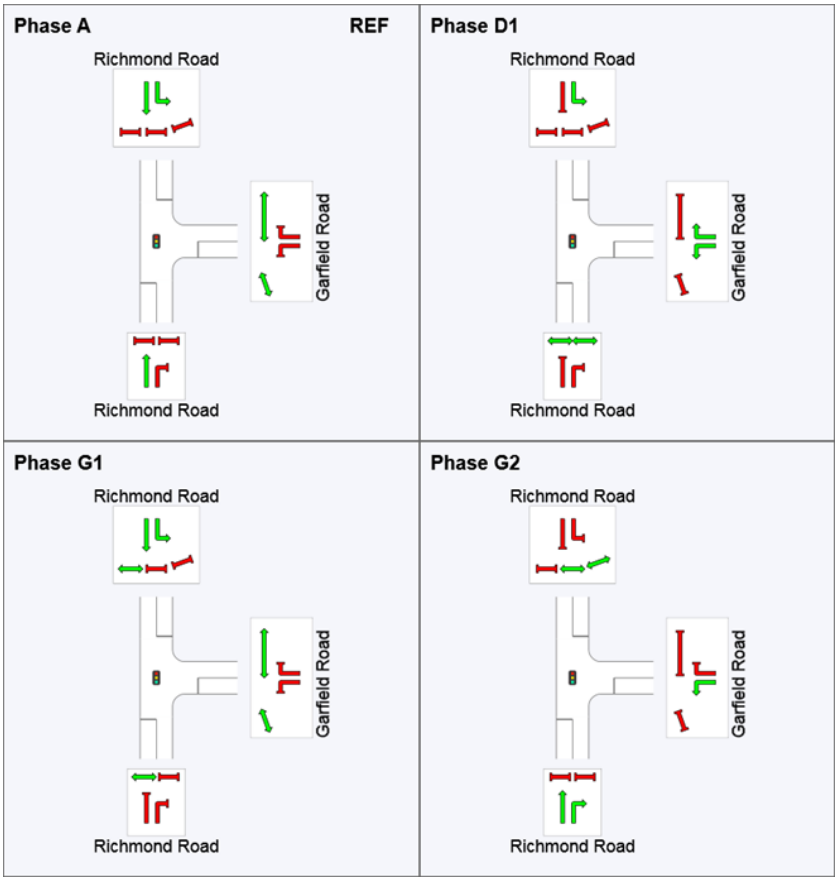

Figure 10 Activated phasing arrangement for the Richmond Road / Garfield Road West intersection

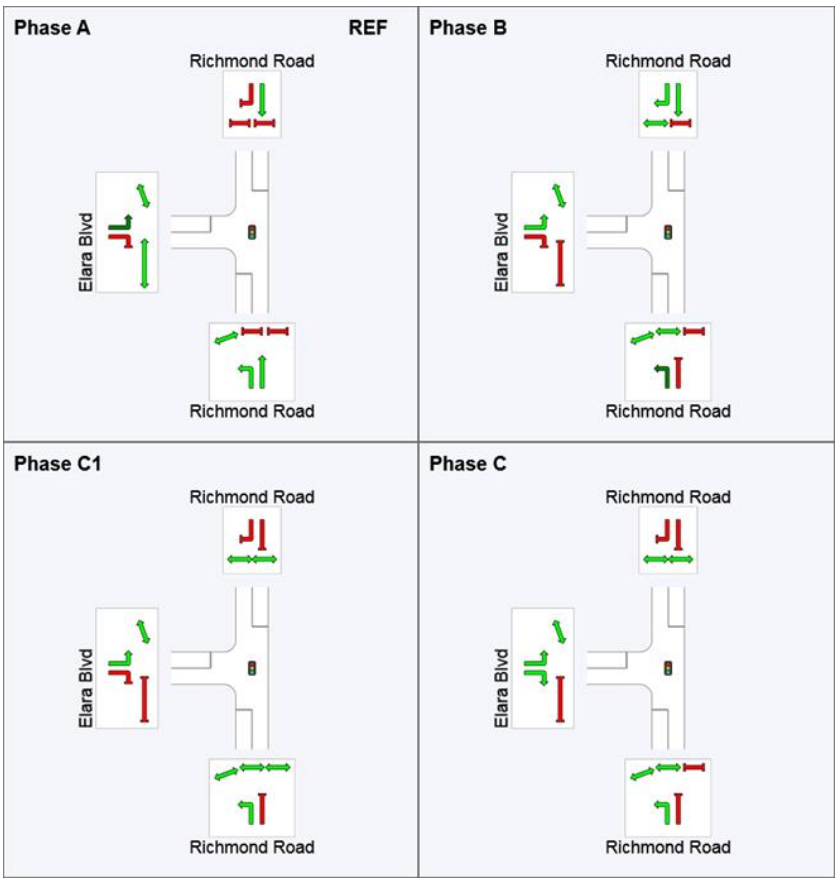

Figure 11 Activated phasing arrangement for the Richmond Road / Elara Boulevard intersection

The intergreen times for each signal phase sourced from SCATS have been also incorporated into the SIDRA models, which are shown in Figure 12 and Figure 13.

Phase Data

Phase:	A	D1	G1	G2
Variable Phase	☐	☐	☐	☐
Reference Phase	◉	○	○	○
Phase Time (optional)	88 sec	19 sec	21 sec	21 sec
Phase Frequency	Program	Program	Input	Program
			5.0 %	
Yellow Time	5 sec	4 sec	5 sec	5 sec
All-Red Time	4 sec	5 sec	4 sec	4 sec
Dummy Movement Data:				
Dummy Movement Exists	☐	☐	☐	☐
Minimum Green Time				
Maximum Green Time				

Figure 12 Intergreen times for the Richmond Road / Garfield Road intersection

Phase Data

Phase:	A	B	C1	C
Variable Phase	☐	☐	☐	☐
Reference Phase	◉	○	○	○
Phase Time (optional)	79 sec	19 sec	30 sec	30 sec
Phase Frequency	Program	Program	Input	Program
			5.0 %	
Yellow Time	5 sec	5 sec	4 sec	4 sec
All-Red Time	2 sec	2 sec	4 sec	4 sec
Dummy Movement Data:				
Dummy Movement Exists	☐	☐	☐	☐
Minimum Green Time				
Maximum Green Time				

Figure 13 Intergreen times for the Richmond Road / Elara Boulevard intersection

5.5 Pedestrian movements

According to AECOM site inspections and supplied SCATS IDM data, currently there are very low pedestrian volumes at both intersections and therefore pedestrians have little impact on the intersection operation. As SIDRA does not allow zero pedestrian demand for the pedestrian crossings, 5 people on each crossing have been used in this modelling exercise.

6.0 2018 Base model calibration

In the process of model calibration, the base models have been compared with the traffic conditions observed during the site inspections. The following model parameters have been verified / calibrated until the model outputs represent the observed network operation:

- lane saturation flow
- terminating exit lane

6.1 Lane saturation flow

The default basic lane saturation flow (1,950 PCUs / hour) have been used in the 2018 base SIDRA model. The SCATS saturation flows extracted from the SIDRA results have been verified with the SCATS saturation flows calculated from the SCATS maximum flows provided by Roads and Maritime. It is noted that the SCATS lane maximum flow data provides stop line maximum flows during effective green times (including start loss and end gain) and therefore, it should be increased slightly to take into account intergreen times.

Table 1 shows the comparison of the SCATS lane saturation flows between the SIDRA models and Roads and Maritime's data, and indicates a good correlation between them.

Table 1 Lane saturation flow used in the SIDRA models

Movement	SCATS saturation flow in the model (PCUs / hour)	Calculated SCATS saturation flow using Roads and Maritime's data (PCUs / hour)
Richmond Road through movements	1,970	Approximately 1,950
Richmond Road left turning movements	1,876	Not available
Richmond Road right turning movements	1,876	Approximately 1,800
Garfield Road West left turning movements	1,876	Not available
Garfield Road West right turning movements	1,876	Approximately 1,900
Elara Boulevard left turning movements	1,973	Not available
Elara Boulevard right turning movements	1,876	Approximately 1,900

6.2 Terminating exit lane

As shown in Figure 14, there is currently a lane merge (from 2 lanes to 1) for the general traffic lanes on Richmond Road northbound at approximately 110 metres north of Elara Boulevard. According to the site observations, the lane merge resulted in northbound exit blocking at the Richmond Road / Elara Boulevard intersection and significant queuing on the Richmond northbound approach in PM peak hour. However, this traffic queue did not extend back to the Richmond Road / Garfield Road West intersection.

Figure 14 also shows the coding of the terminating lane in the SIDRA base model. SIDRA automatically reduces the lane utilisation for the corresponding entry lane on the northbound Richmond Road approach by 37% due to the terminating exit lane. To more accurately reflect the exit blocking and maximum queuing observed, the lane capacity for both general traffic entry lanes (Lane 2 and 3) has been further reduced by 15%. As a consistent approach, the reduction of lane capacity has been applied in the SIDRA base models for all three peak hours.

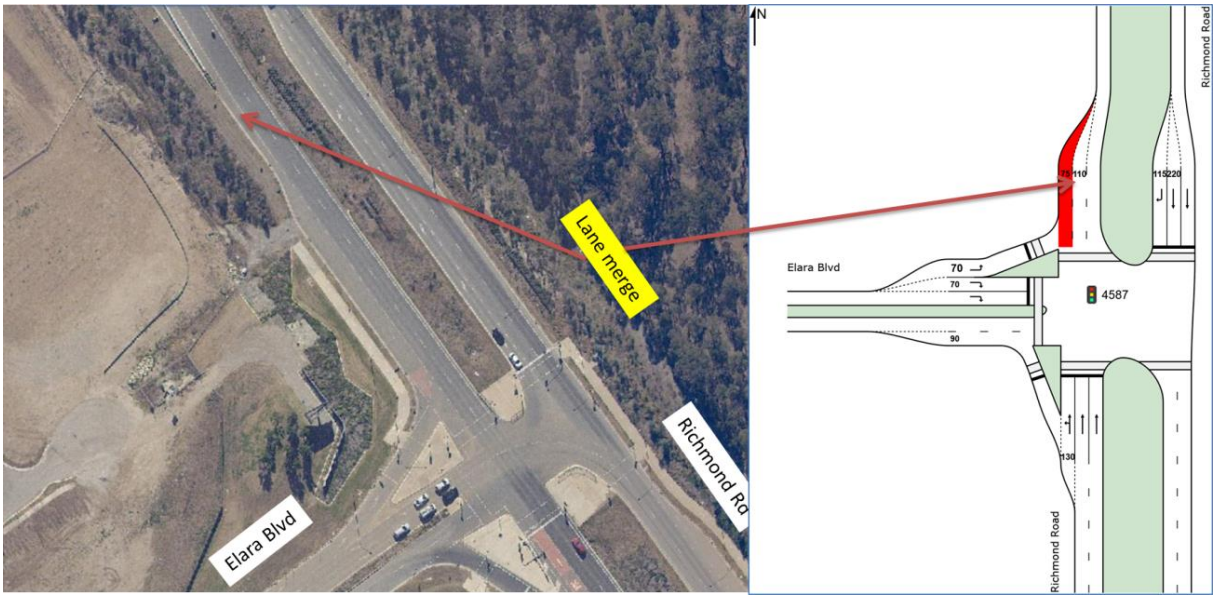

Figure 14 Lane merge on Richmond Road northbound, north of Elara Boulevard

7.0 2018 Base model verification

No queue length data was provided by Roads and Maritime for this project. Therefore, in the process of model verification, the queue length results in the SIDRA models have been compared with the queuing conditions observed during site inspections.

Table 2 shows the 95^{tile} queue length results for the weekday AM and PM peak hours and Saturday peak hour, which indicate the following findings:

- The 95^{tile} queue lengths are contained in the available storage space for the two intersections for all three modelled peak hours.
- Significant queuing on Richmond Road northbound at the Elara Boulevard intersection during PM peak hour.

The 95^{tile} queue results in the base SIDRA models generally reflect the observed conditions mentioned in Section 4.3.

Table 2 The 95^{tile} queue results (metre) for weekday AM and PM peak hours and Saturday peak hour

Intersection	Approach	Storage space (metre) to neighbouring signalised intersection	95^{tile} queue length (metres) from the network model		
			AM peak hour	PM peak hour	Saturday peak hour
Richmond Road / Garfield Road West	Richmond Road (SB)	725	298	134	120
	Garfield Road West (WB)	150	61	108	52
	Richmond Road (NB)	460	99	138	90
Richmond Road / Elara Boulevard	Elara Boulevard (EB)	240	164	92	93
	Richmond Road (SB)	> 500	176	75	84
	Richmond Road (NB)	725	217	407	240

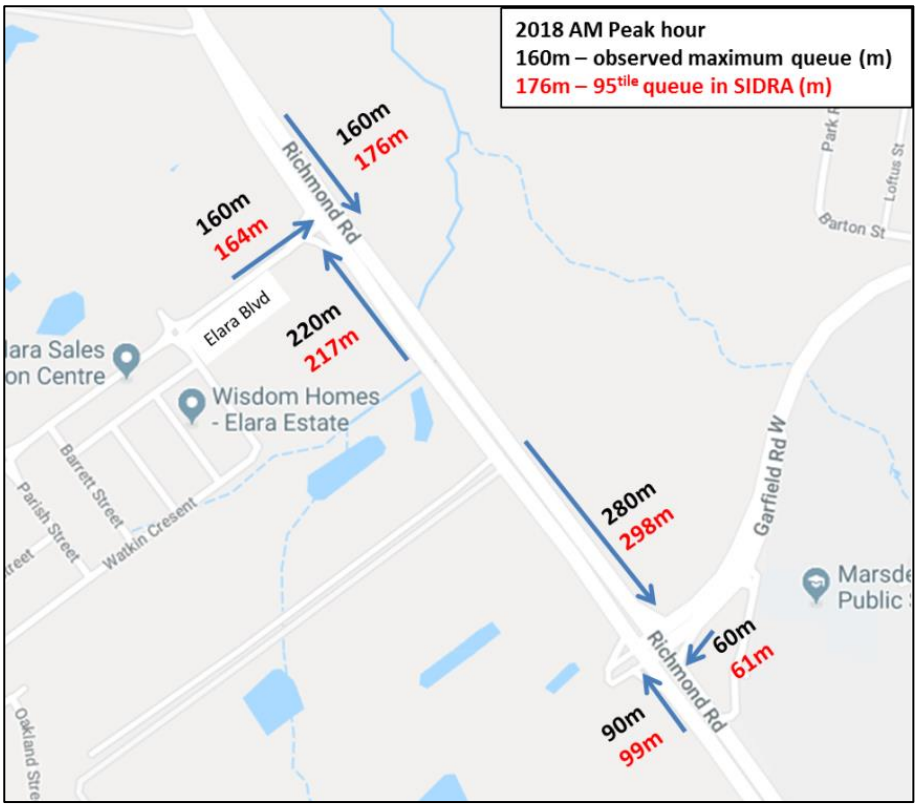

Figure 15 Comparison of observed maximum queue (m) and 95^{tile} queue (m) in the SIDRA network model for weekday AM peak hour

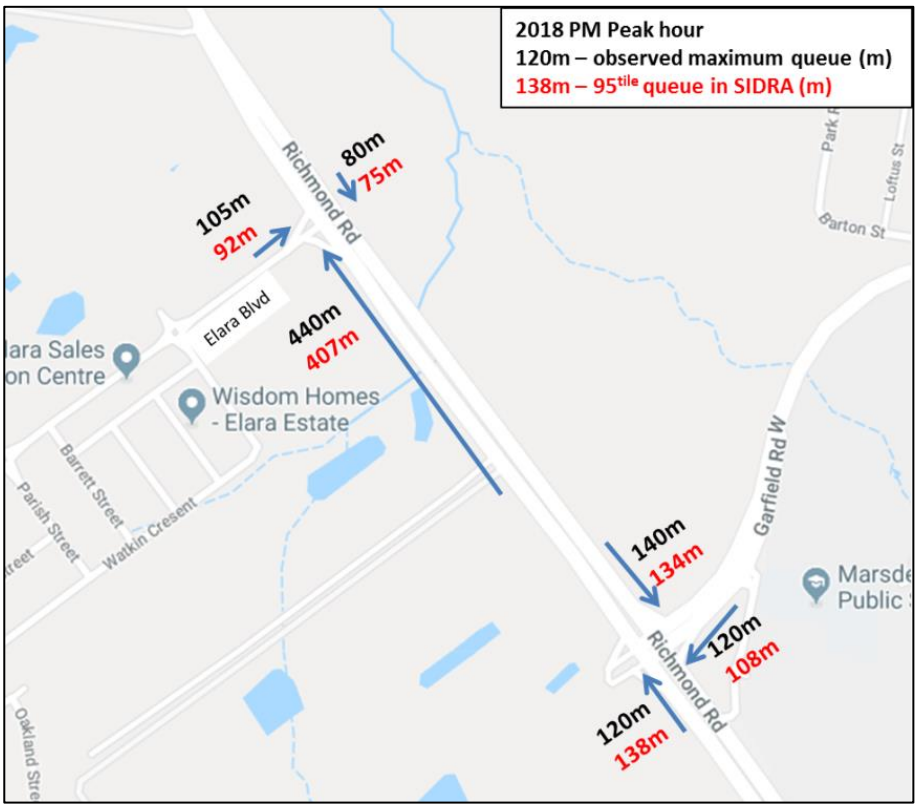

Figure 16 Comparison of observed maximum queue (m) and 95^{tile} queue (m) in the SIDRA network model for weekday PM peak hour

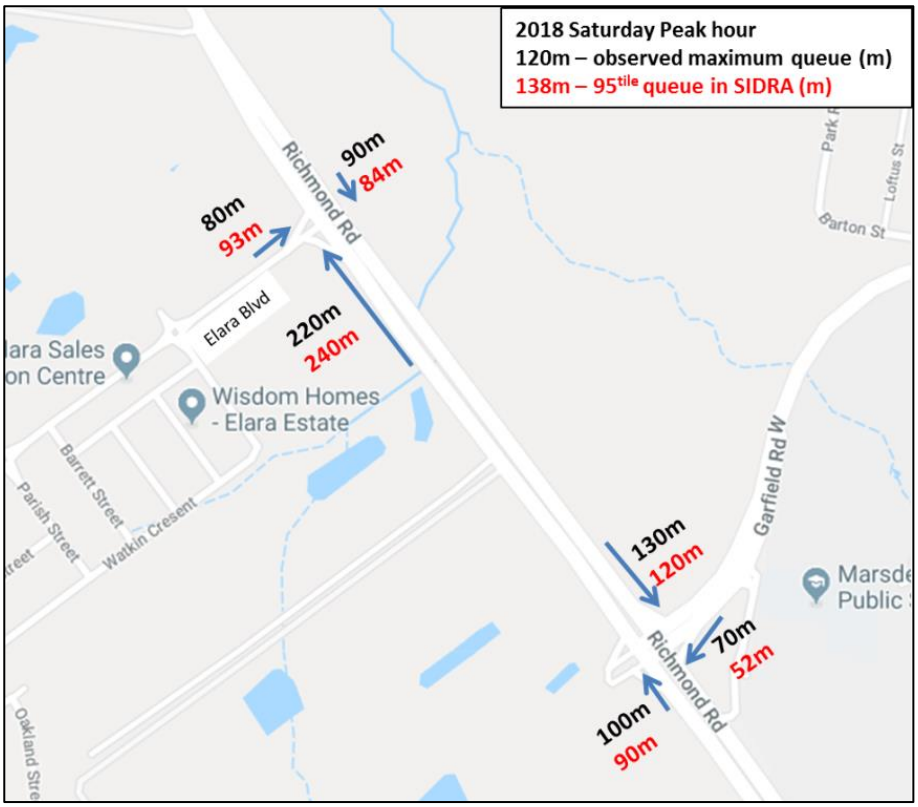

Figure 17 Comparison of observed maximum queue (m) and 95tile queue (m) in the SIDRA network model for Saturday peak hour

8.0 Existing intersection performance

Once the SIDRA models had been calibrated and verified, the existing intersection performance has been assessed. In order to do this, the delays on each intersection approach in the network have been determined and a LoS has been derived. In addition, the 95tile queue lengths and DoS by approach have been extracted from the models to quantify the existing capacity and queuing conditions within the study area.

LoS is a basic performance parameter used to describe the operation of an intersection. Levels of service range from A (indicating good intersection operation) to F (indicating conditions with long delays and queues). Table 4 outlines the Roads and Maritime levels of service table obtained from Roads and Maritime Services Guide to Traffic Generating Developments (Version 2.2, October 2002).

Table 3 Roads and Maritime's Level of Service (LoS) criteria

Level of Service	Average delay (seconds per vehicle)	Traffic Signals, Roundabout	Give Way and Stop Signs
A	Less than 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 capacity; requires other control mode
F	Greater than 71	At signals, incidents will cause excessive delays	Unsatisfactory with excessive queuing; requires other control mode

8.1 2018 AM peak model results

Table 4 and Table 5 show the existing intersection performance (by intersection and approach) for the weekday AM peak hour, which indicates:

- Overall, both intersections operate well (at LoS D or better) during the weekday AM peak hour.
- Garfield Road West westbound and Elara Boulevard eastbound operate at/overcapacity (at LoS E / F), as the priority of the traffic signals green time is given to the predominant Richmond Road through movements.

Detailed movement results are provided in Appendix A.

Table 4 Intersection performance (network model) for weekday AM peak hour

Intersection	Delay (second)	LoS	DoS
Richmond Road/Garfield Road West	22	B	0.777
Richmond Road/Elara Boulevard	27	B	0.950

Table 5 Intersection performance (network model) by approach for weekday AM peak hour

Intersection	Approach	Delay	LoS	DoS	95^{tile} queue (m)
Richmond Road / Garfield Road West	Richmond Road (NB)	16	B	0.729	99
	Garfield Road West (WB)	61	E	0.651	61
	Richmond Road (SB)	18	B	0.777	298
Richmond Road / Elara Boulevard	Richmond Road (NB)	18	B	0.740	217
	Richmond Road (SB)	13	A	0.574	176
	Elara Boulevard (EB)	81	F	0.950	164

8.2 2018 PM peak model results

Table 6 and Table 7 show the existing intersection performance (by intersection and approach) for the weekday PM peak hour, which indicates:

- Overall, both intersections operate well (at LoS D or better) during weekday PM peak hour.

- The Richmond Road northbound through movement experiences relatively long queues in the weekday PM peak hour due to a combination of the relatively high volumes compared to other peak hours and the northbound exit blocking as a result of the downstream lane merge. The queue does not block back to the upstream Richmond Road / Garfield Road West intersection.
- Garfield Road West westbound and Elara Boulevard eastbound operate over capacity (at LoS F), as the priority of traffic signals is given to the predominant Richmond Road through movements.

Detailed movement results are provided in Appendix A.

Table 6 Intersection performance (network model) for weekday PM peak hour

Intersection	Delay (second)	LoS	DoS
Richmond Road/Garfield Road West	26	B	1.001
Richmond Road/Elara Boulevard	22	B	0.916

Table 7 Intersection performance (network model) by approach for weekday PM peak hour

Intersection	Approach	Delay	LoS	DoS	95^{tile} queue (m)
Richmond Road/Garfield Road West	Richmond Road (NB)	14	A	0.593	138
	Garfield Road West (WB)	85	F	1.001	108
	Richmond Road (SB)	15	B	0.528	134
Richmond Road/Elara Boulevard	Richmond Road (NB)	20	B	0.873	407
	Richmond Road (SB)	8	A	0.442	75
	Elara Boulevard (EB)	74	F	0.916	92

8.3 2018 Saturday peak model results

Table 8 and Table 9 show the existing intersection performance (by intersection and approach) for the Saturday peak hour, which indicate:

- Overall, both intersections operate well (at LoS D or better) during the Saturday peak hour.
- Garfield Road West westbound and Elara Boulevard eastbound operate at capacity (at LoS E), as the priority of the traffic signals is given to the predominant Richmond Road through movements.

Detailed movement results are provided in Appendix A.

Table 8 Intersection performance (network model) for Saturday peak hour

Intersection	Delay (second)	LoS	DoS
Richmond Road/Garfield Road West	18	B	0.792
Richmond Road/Elara Boulevard	20	B	0.796

Table 9 Intersection performance (network model) by approach for Saturday peak hour

Intersection	Approach	Delay	LoS	DoS	95^{tile} queue (m)
Richmond Road/Garfield Road West	Richmond Road (NB)	12	A	0.557	90
	Garfield Road West (WB)	63	E	0.792	52
	Richmond Road (SB)	12	A	0.524	120
Richmond Road/Elara Boulevard	Richmond Road (NB)	15	B	0.704	240
	Richmond Road (SB)	9	A	0.582	84
	Elara Boulevard (EB)	61	E	0.796	93

8.4 Comparison of SIDRA and VISSIM base model results

Table 10 shows a comparison of delays and LoS results between the 2018 Base SIDRA models and 2017 Base VISSIM models (developed to support the development application of the Marsden Park North Precinct) for the two intersections of Richmond Road with Garfield Road West and Elara Boulevard for Weekday AM and PM peak hours.

As can be seen from Table 10, the two sets of models have similar intersection performance for both intersections during weekday AM and PM peak hours

Note that the 2017 VISSIM base models did not include any Saturday scenario and therefore, no comparison has been undertaken for Saturday peak hour.

Table 10 Intersection performance (network model) for weekday AM and PM peak hours

Peak hour	Intersection	2018 Base SIDRA		2017 Base VISSIM	
		Delay (second)	LoS	Delay (second)	LoS
AM peak hour	Richmond Road/Garfield Road West	22	B	22	B
	Richmond Road/Elara Boulevard	27	B	19	B
PM peak hour	Richmond Road/Garfield Road West	26	B	29	C
	Richmond Road/Elara Boulevard	22	B	13	A

9.0 Summary and conclusions

The 2018 base SIDRA models for the study area have been calibrated and verified in accordance with Roads and Maritime's modelling criteria.

Both the weekday AM and PM and weekend SIDRA models are considered to provide a good representation of the current traffic conditions in the study area during the peak periods.

Overall, the intersections of Richmond Road with Garfield Road West and Elara Boulevard operate well for all three modelled peak hours. Garfield Road West and Elara Boulevard operate at/over capacity in all three peak hours as the priority of the traffic signals is given to the predominant through movements on Richmond Road.

The Richmond Road northbound through movement experiences relatively long queues in the weekday PM peak hour due to a combination of the relatively high volumes compared to other peak hours and the northbound exit blocking caused by the downstream lane merge. The queue does not block back to the upstream Richmond Road / Garfield Road West intersection.

The models developed will provide a robust basis on which to assess the future network operations within the study area.

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Appendix A

MOVEMENT SUMMARY

Site: 2950 [2018 Base AM Richmond Rd | Garfield Rd] Network: N101 [AM Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles														
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
2	T1	1179	15.2	1179	15.2	0.426	5.4	LOS A	12.5	98.8	0.37	0.34	0.37	64.2
3	R2	202	34.9	202	34.9	0.729	75.2	LOS F	6.8	61.4	1.00	0.85	1.15	21.1
Approach		1381	18.1	1381	18.1	0.729	15.6	LOS B	12.5	98.8	0.46	0.41	0.49	46.8
East: Garfield Road														
4	L2	257	27.9	257	27.9	0.444	52.0	LOS D	7.0	60.6	0.93	0.79	0.93	25.0
6	R2	205	13.8	205	13.8	0.651	71.5	LOS F	6.6	52.0	1.00	0.81	1.06	7.7
Approach		462	21.6	462	21.6	0.651	60.7	LOS E	7.0	60.6	0.96	0.80	0.99	17.9
North: Richmond Road														
7	L2	220	11.0	220	11.0	0.156	9.5	LOS A	2.6	20.0	0.21	0.64	0.21	60.8
8	T1	1778	11.8	1778	11.8	0.777	19.3	LOS B	38.7	297.7	0.79	0.77	0.99	59.1
Approach		1998	11.7	1998	11.7	0.777	18.2	LOS B	38.7	297.7	0.73	0.76	0.90	59.3
All Vehicles		3841	15.2	3841	15.2	0.777	22.4	LOS B	38.7	297.7	0.66	0.64	0.76	49.4

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 4587 [2018 Base AM Richmond Rd | Elara Blvd] Network: N101 [AM Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles															
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
1	L2	343	20.9	343	20.9	0.261	8.7	LOS A	2.5	20.3	0.19	0.66	0.19	59.1
2	T1	1033	13.0	1033	13.0	0.740	21.1	LOS B	27.9	217.3	0.69	0.62	0.69	58.1
Approach		1376	15.0	1376	15.0	0.740	18.0	LOS B	27.9	217.3	0.57	0.63	0.57	58.3
North: Richmond Road														
8	T1	1468	12.0	1468	12.0	0.574	10.3	LOS A	22.9	176.4	0.54	0.50	0.54	55.6
9	R2	72	47.1	72	47.1	0.552	72.3	LOS F	4.6	45.1	1.00	0.78	1.00	23.5
Approach		1540	13.6	1540	13.6	0.574	13.2	LOS A	22.9	176.4	0.57	0.51	0.57	51.0
West: Elara Blvd														
10	L2	75	29.6	75	29.6	0.110	15.2	LOS B	1.8	15.6	0.40	0.65	0.40	42.8
12	R2	531	12.3	531	12.3	0.950	90.1	LOS F	21.1	163.5	1.00	1.05	1.48	8.8
Approach		605	14.4	605	14.4	0.950	80.9	LOS F	21.1	163.5	0.93	1.00	1.34	11.5
All Vehicles		3521	14.3	3521	14.3	0.950	26.7	LOS B	27.9	217.3	0.63	0.64	0.70	43.4

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 2950 [2018 Base PM Richmond Rd | Garfield Rd] Network: N101 [PM Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles															
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
2	T1	1508	10.0	1508	10.0	0.530	6.1	LOS A	18.2	138.1	0.42	0.39	0.42	62.5
3	R2	213	29.2	213	29.2	0.593	69.1	LOS E	6.7	58.4	1.00	0.80	1.00	22.4
Approach		1721	12.4	1721	12.4	0.593	13.9	LOS A	18.2	138.1	0.49	0.44	0.49	49.0
East: Garfield Road														
4	L2	265	23.8	265	23.8	0.398	49.2	LOS D	7.0	58.9	0.91	0.78	0.91	26.1
6	R2	322	10.8	322	10.8	1.001	114.6	LOS F	14.2	108.3	1.00	1.11	1.75	5.0
Approach		587	16.7	587	16.7	1.001	85.0	LOS F	14.2	108.3	0.96	0.96	1.37	12.8
North: Richmond Road														
7	L2	165	8.3	165	8.3	0.117	9.5	LOS A	1.7	12.9	0.18	0.64	0.18	61.0
8	T1	1191	7.9	1191	7.9	0.528	15.7	LOS B	17.9	133.5	0.57	0.55	0.75	62.1
Approach		1356	7.9	1356	7.9	0.528	14.9	LOS B	17.9	133.5	0.52	0.56	0.68	62.0
All Vehicles		3664	11.4	3664	11.4	1.001	25.7	LOS B	18.2	138.1	0.58	0.57	0.70	44.1

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 4587 [2018 Base PM Richmond Rd | Elara Blvd] Network: N101 [PM Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 130 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles															
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
1	L2	376	5.8	376	5.8	0.248	8.2	LOS A	2.2	16.3	0.18	0.66	0.18	61.5
2	T1	1474	11.0	1473	11.0	0.873	23.1	LOS B	53.1	407.1	0.84	0.80	0.87	56.7
Approach		1849	9.9	1849	9.9	0.873	20.1	LOS B	53.1	407.1	0.70	0.77	0.73	57.4
North: Richmond Road														
8	T1	1035	6.0	1035	6.0	0.355	5.0	LOS A	10.1	74.7	0.34	0.31	0.34	66.0
9	R2	43	4.9	43	4.9	0.442	75.7	LOS F	2.8	20.6	1.00	0.74	1.00	23.8
Approach		1078	6.0	1078	6.0	0.442	7.8	LOS A	10.1	74.7	0.37	0.33	0.37	59.9
West: Elara Blvd														
10	L2	76	23.6	76	23.6	0.162	29.6	LOS C	2.9	24.4	0.64	0.71	0.64	35.7
12	R2	312	14.5	312	14.5	0.916	85.3	LOS F	11.6	91.6	1.00	1.01	1.46	9.3
Approach		387	16.3	387	16.3	0.916	74.4	LOS F	11.6	91.6	0.93	0.95	1.30	13.4
All Vehicles		3315	9.4		9.4	0.916	22.4	LOS B	53.1	407.1	0.62	0.65	0.68	50.0

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

N1 Arrival Flow value is reduced due to capacity constraint at oversaturated upstream lanes.

MOVEMENT SUMMARY

Site: 2950 [2018 Base Sat Richmond Rd | Garfield Rd] Network: N101 [WE Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 125 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles														
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
2	T1	1275	12.4	1275	12.4	0.436	4.0	LOS A	11.6	90.2	0.33	0.30	0.33	67.6
3	R2	177	32.1	177	32.1	0.557	68.0	LOS E	5.4	48.0	1.00	0.78	1.00	22.6
Approach		1452	14.8	1452	14.8	0.557	11.8	LOS A	11.6	90.2	0.41	0.36	0.41	51.8
East: Garfield Road														
4	L2	223	25.9	223	25.9	0.400	52.8	LOS D	6.0	51.6	0.93	0.77	0.93	24.9
6	R2	197	12.3	197	12.3	0.792	75.3	LOS F	6.5	50.4	1.00	0.88	1.26	7.4
Approach		420	19.5	420	19.5	0.792	63.3	LOS E	6.5	51.6	0.96	0.82	1.08	17.0
North: Richmond Road														
7	L2	155	14.3	155	14.3	0.112	9.5	LOS A	1.4	11.0	0.17	0.64	0.17	60.5
8	T1	1248	9.1	1248	9.1	0.524	11.7	LOS A	15.9	119.6	0.50	0.48	0.65	65.9
Approach		1403	9.7	1403	9.7	0.524	11.5	LOS A	15.9	119.6	0.47	0.50	0.60	65.4
All Vehicles		3275	13.2	3275	13.2	0.792	18.3	LOS B	15.9	119.6	0.51	0.48	0.58	51.5

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 4587 [2018 Base Sat Richmond Rd | Elara Blvd] Network: N101 [WE Network]

New Site
Site Category: (None)
Signals - Fixed Time Coordinated Cycle Time = 125 seconds (Network Site User-Given Phase Times)

Movement Performance Vehicles															
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Arrival Flows Total veh/h	Arrival Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Richmond Road														
1	L2	355	12.8	355	12.8	0.248	8.4	LOS A	2.3	17.8	0.20	0.66	0.20	60.4
2	T1	1128	12.0	1128	12.0	0.704	17.3	LOS B	31.1	239.9	0.75	0.68	0.75	61.1
Approach		1483	12.2	1483	12.2	0.704	15.2	LOS B	31.1	239.9	0.62	0.68	0.62	61.0
North: Richmond Road														
8	T1	1021	9.0	1021	9.0	0.373	6.3	LOS A	11.1	83.4	0.39	0.35	0.39	63.1
9	R2	44	26.2	44	26.2	0.582	76.4	LOS F	2.9	24.8	1.00	0.76	1.08	23.2
Approach		1065	9.7	1065	9.7	0.582	9.2	LOS A	11.1	83.4	0.42	0.37	0.42	57.2
West: Elara Blvd														
10	L2	57	27.8	57	27.8	0.099	17.3	LOS B	1.5	12.7	0.45	0.66	0.45	41.8
12	R2	373	12.7	373	12.7	0.796	67.9	LOS E	12.0	92.8	1.00	0.90	1.18	11.2
Approach		429	14.7	429	14.7	0.796	61.2	LOS E	12.0	92.8	0.93	0.87	1.08	14.5
All Vehicles		2978	11.7	2978	11.7	0.796	19.7	LOS B	31.1	239.9	0.59	0.60	0.61	50.9

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Network Data dialog (Network tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

APPENDIX B

Future year detailed outputs

2026 Without Project

Table 17 Intersection Approach Summary Without Project – 2026 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,163	525	F	1.3	1,833
	East: Garfield Road	1,655	279	F	1.2	570
	North: Richmond Road	3,479	429	F	1.2	1,183
	West: Garfield Road	988	330	F	1.3	479
Richmond Rd/Elara Blvd	South: Richmond Road	1,927	824	F	1.7	1,183
	North: Richmond Road	2,200	1,867	F	2.0	816
	West: Elara Blvd	1,758	1,635	F	2.0	2,648
Richmond Rd/Access Rd	South: Richmond Road	2,068	5	A	0.6	0
	North: Richmond Road	2,200	13	A	1.0	898
Richmond Rd/Heritage Road	South: Richmond Road	1,833	4	A	0.6	0
	North: Richmond Road	2,200	179	F	1.2	1,071
	West: Heritage Rd	301	163	F	1.1	209

Table 18 Intersection Approach Summary Without Project – 2026 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,259	2,311	F	2.4	7,174
	East: Garfield Road	2,509	1,367	F	2.1	1,754
	North: Richmond Road	2,141	66	E	1.0	442
	West: Garfield Road	337	65	E	0.5	42
Richmond Rd/Elara Blvd	South: Richmond Road	3,806	95	F	1.1	918
	North: Richmond Road	2,383	67	E	1.1	533
	West: Elara Blvd	340	256	F	1.1	170
Richmond Rd/Access Rd	South: Richmond Road	3,352	5	A	0.5	0
	North: Richmond Road	2,382	13	A	1.0	0
Richmond Rd/Heritage Road	South: Richmond Road	2,360	4	A	0.5	0
	North: Richmond Road	2,382	231	F	1.3	0

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
	West: Heritage Rd	208	18	B	0.5	16

Table 19 Intersection Approach Summary Without Project – 2026 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,105	1,397	F	1.8	4,512
	East: Garfield Road	1,994	949	F	1.8	1,245
	North: Richmond Road	2,551	156	F	1.1	837
	West: Garfield Road	662	531	F	1.5	433
Richmond Rd/Elara Blvd	South: Richmond Road	2,745	330	F	1.3	1,183
	North: Richmond Road	2,072	139	F	1.3	620
	West: Elara Blvd	1,046	519	F	1.3	870
Richmond Rd/Access Rd	South: Richmond Road	2,589	5	A	0.6	0
	North: Richmond Road	2,071	13	A	1.0	0
Richmond Rd/Heritage Road	South: Richmond Road	1,973	4	A	0.6	0
	North: Richmond Road	2,071	94	F	1.1	0
	West: Heritage Rd	254	25	B	0.7	27

2031 Without Project

Table 20 Intersection Approach Summary Without Project – 2031 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,457	491	F	1.2	2,317
	East: Garfield Road	536	72	F	0.9	79
	North: Richmond Road	4,277	176	F	1.4	838
	West: Garfield Road	888	560	F	1.3	488
Richmond Rd/Elara Blvd	South: Richmond Road	2,159	654	F	1.8	1,137
	North: Richmond Road	2,391	1,406	F	2.0	3,242
	West: Elara Blvd	1,994	1,424	F	2.0	816
Richmond Rd/Access Rd	South: Richmond Road	1,589	1,664	F	2.0	1,810
	North: Richmond Road	1,765	5	A	0.7	0
Richmond Rd/Heritage Road	South: Richmond Road	1,994	13	A	1.0	898
	North: Richmond Road	1,587	5	A	0.7	0
	West: Heritage Rd	1,994	83	F	1.1	1,016

Table 21 Intersection Approach Summary Without Project – 2031 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,082	1,807	F	2.0	7,400
	East: Garfield Road	1,061	888	F	1.6	817
	North: Richmond Road	3,171	354	F	1.4	1,183
	West: Garfield Road	703	177	F	1.1	238
Richmond Rd/Elara Blvd	South: Richmond Road	3,473	144	F	1.1	991
	North: Richmond Road	3,000	1,648	F	2.3	3,282
	West: Elara Blvd	1,786	1,355	F	2.0	816
Richmond Rd/Access Rd	South: Richmond Road	458	155	F	1.1	119
	North: Richmond Road	2,912	5	A	0.7	0
Richmond Rd/Heritage Road	South: Richmond Road	1,795	6	A	0.9	898
	North: Richmond Road	2,229	4	A	0.7	0

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
	West: Heritage Rd	1,795	5	A	0.9	0

Table 22 Intersection Approach Summary Without Project – 2031 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,177	854	F	1.5	3,871
	East: Garfield Road	709	635	F	1.4	535
	North: Richmond Road	3,507	388	F	1.3	1,183
	West: Garfield Road	794	636	F	1.4	553
Richmond Rd/Elara Blvd	South: Richmond Road	2,697	300	F	1.3	927
	North: Richmond Road	2,695	1,752	F	2.4	3,526
	West: Elara Blvd	1,675	1,456	F	2.1	816
Richmond Rd/Access Rd	South: Richmond Road	1,009	1,342	F	2.0	985
	North: Richmond Road	2,217	5	A	0.7	0
Richmond Rd/Heritage Road	South: Richmond Road	1,675	5	A	0.9	898
	North: Richmond Road	1,790	4	A	0.7	0
	West: Heritage Rd	1,675	5	A	0.9	0

2036 Without Project

Table 23 Intersection Approach Summary Without Project – 2036 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,802	294	F	1.1	1,167
	East: Garfield Road	791	58	E	0.7	110
	North: Richmond Road	4,208	332	F	1.2	1,086
	West: Garfield Road	1,171	330	F	1.2	494
Richmond Rd/Elara Blvd	South: Richmond Road	2,318	792	F	2.0	1,183
	North: Richmond Road	2,394	1,073	F	2.3	3,994
	West: Elara Blvd	1,938	1,436	F	2.0	816
	South: Richmond Road	1,655	1,741	F	2.0	2,245

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Access Rd	North: Richmond Road	1,833	4	A	0.3	0
Richmond Rd/Heritage Road	South: Richmond Road	1,938	4	A	0.4	898
	North: Richmond Road	1,666	4	A	0.3	0
	West: Heritage Rd	1,938	4	A	0.4	265

Table 24 Intersection Approach Summary Without Project – 2036 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,674	973	F	1.6	3,126
	East: Garfield Road	1,390	574	F	1.4	867
	North: Richmond Road	3,217	599	F	1.3	1,183
	West: Garfield Road	1,125	477	F	1.3	798
Richmond Rd/Elara Blvd	South: Richmond Road	3,459	60	E	0.9	242
	North: Richmond Road	3,046	1,053	F	2.3	3,819
	West: Elara Blvd	1,709	1,035	F	1.7	816
Richmond Rd/Access Rd	South: Richmond Road	432	66	E	0.9	110
	North: Richmond Road	2,877	5	A	0.3	0
Richmond Rd/Heritage Road	South: Richmond Road	1,709	4	A	0.3	405
	North: Richmond Road	2,293	4	A	0.3	0
	West: Heritage Rd	1,709	4	A	0.3	0

Table 25 Intersection Approach Summary Without Project – 2036 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,638	487	F	1.3	1,727
	East: Garfield Road	1,000	84	F	1.0	216
	North: Richmond Road	3,496	437	F	1.2	1,183
	West: Garfield Road	1,147	360	F	1.2	567
	South: Richmond Road	2,773	245	F	1.3	764

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Elara Blvd	North: Richmond Road	2,720	927	F	2.3	3,851
	West: Elara Blvd	1,604	1,070	F	1.7	816
Richmond Rd/Access Rd	South: Richmond Road	1,039	1,048	F	1.7	936
	North: Richmond Road	2,236	5	A	0.3	0
Richmond Rd/Heritage Road	South: Richmond Road	1,605	4	A	0.3	477
	North: Richmond Road	1,861	4	A	0.3	0
	West: Heritage Rd	1,605	4	A	0.3	0

2026 With Project

Table 26 Intersection Approach Summary With Project – 2026 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,186	316	F	1.2	1,200
	East: Garfield Road	1,514	228	F	1.2	595
	North: Richmond Road	3,557	246	F	1.1	1,072
	West: Garfield Road	988	264	F	1.2	403
Richmond Rd/Elara Blvd	South: Richmond Road	2,205	36	C	0.9	449
	North: Richmond Road	3,158	154	F	1.0	816
	West: Elara Blvd	598	171	F	1.1	236
Richmond Rd/Access Rd	South: Richmond Road	2,323	4	A	0.5	499
	North: Richmond Road	3,168	4	A	0.4	312
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,147	439	F	1.7	490
	East: Commerical Access	141	60	E	0.4	47
	North: Richmond Road	2,278	2,618	F	2.6	367
	West: Clydesdale Access Rd	1,242	1,565	F	2.0	1,812
Richmond Rd/Heritage Road	South: Richmond Road	1,937	4	A	0.5	0
	North: Richmond Road	2,278	4	A	0.6	3,562
	West: Heritage Rd	219	46	D	0.8	40

Table 27 Intersection Approach Summary With Project – 2026 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,301	1,446	F	2.0	5,351
	East: Garfield Road	1,609	878	F	1.6	966
	North: Richmond Road	2,564	236	F	1.1	1,131
	West: Garfield Road	337	66	E	0.4	40
Richmond Rd/Elara Blvd	South: Richmond Road	3,800	9	A	0.9	249
	North: Richmond Road	2,769	214	F	1.1	816

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
	West: Elara Blvd	25	72	F	0.3	7
Richmond Rd/Access Rd	South: Richmond Road	3,540	5	A	0.4	0
	North: Richmond Road	2,770	4	A	0.6	0
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,784	37	C	0.7	272
	East: Commerical Access	901	292	F	1.1	743
	North: Richmond Road	2,427	239	F	1.1	367
	West: Clydesdale Access Rd	358	92	F	1.0	87
Richmond Rd/Heritage Road	South: Richmond Road	2,442	4	A	0.4	0
	North: Richmond Road	2,425	4	A	0.6	1,870
	West: Heritage Rd	167	20	B	0.4	15

Table 28 Intersection Approach Summary With Project – 2026 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,137	624	F	1.4	2,453
	East: Garfield Road	1,473	326	F	1.3	374
	North: Richmond Road	2,850	184	F	1.1	959
	West: Garfield Road	662	113	F	1.0	140
Richmond Rd/Elara Blvd	South: Richmond Road	2,880	9	A	0.8	268
	North: Richmond Road	2,750	10	A	0.9	298
	West: Elara Blvd	310	69	E	0.9	67
Richmond Rd/Access Rd	South: Richmond Road	2,812	5	A	0.6	0
	North: Richmond Road	2,750	4	A	0.6	110
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,343	131	F	1.3	423
	East: Commerical Access	521	425	F	1.3	644
	North: Richmond Road	2,133	1,383	F	1.9	367

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
	West: Clydesdale Access Rd	799	1,017	F	1.6	933
Richmond Rd/Heritage Road	South: Richmond Road	2,067	4	A	0.5	0
	North: Richmond Road	2,133	4	A	0.6	1,908
	West: Heritage Rd	193	27	B	0.6	23

2031 With Project

Table 29 Intersection Approach Summary With Project – 2031 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,492	376	F	1.3	1,741
	East: Garfield Road	536	69	E	0.7	77
	North: Richmond Road	4,376	244	F	1.1	1,183
	West: Garfield Road	888	397	F	1.2	410
Richmond Rd/Elara Blvd	South: Richmond Road	2,485	371	F	1.6	923
	East: Bandon Rd Extension	2,251	1,503	F	2.5	3,749
	North: Richmond Road	2,760	1,845	F	2.1	816
	West: Elara Blvd	837	1,237	F	1.9	1,526
Richmond Rd/Access Rd	South: Richmond Road	2,075	4	A	0.4	0
	North: Richmond Road	2,760	4	A	0.5	490
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	1,943	115	F	1.4	220
	East: Commerical Access	141	62	E	0.4	49
	North: Richmond Road	2,105	2,028	F	2.2	367
	West: Clydesdale Access Rd	784	1,201	F	1.7	1,041
Richmond Rd/Heritage Road	South: Richmond Road	1,652	4	A	0.3	0
	North: Richmond Road	2,091	4	A	0.6	2,966
	West: Heritage Rd	85	15	B	0.2	5

Table 30 Intersection Approach Summary With Project – 2031 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,120	1,191	F	1.7	5,253
	East: Garfield Road	1,061	762	F	1.5	737
	North: Richmond Road	3,207	192	F	1.1	1,029
	West: Garfield Road	703	117	F	1.0	177
	South: Richmond Road	3,804	110	F	1.2	400

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Elara Blvd	East: Bandon Rd Extension	2,101	562	F	1.6	1,579
	North: Richmond Road	2,459	790	F	1.5	816
	West: Elara Blvd	273	64	E	0.8	129
Richmond Rd/Access Rd	South: Richmond Road	3,147	5	A	0.4	0
	North: Richmond Road	2,464	4	A	0.5	490
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,627	30	C	0.6	267
	East: Commerical Access	901	735	F	1.5	1,625
	North: Richmond Road	1,831	954	F	1.6	367
	West: Clydesdale Access Rd	245	753	F	1.4	244
Richmond Rd/Heritage Road	South: Richmond Road	2,282	4	A	0.4	0
	North: Richmond Road	1,831	4	A	0.5	1,473
	West: Heritage Rd	87	16	B	0.2	6

Table 31 Intersection Approach Summary With Project – 2031 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,214	564	F	1.3	2,928
	East: Garfield Road	709	439	F	1.3	456
	North: Richmond Road	3,574	180	F	1.1	1,002
	West: Garfield Road	794	521	F	1.3	474
Richmond Rd/Elara Blvd	South: Richmond Road	3,024	140	F	1.2	480
	East: Bandon Rd Extension	2,175	709	F	1.7	2,388
	North: Richmond Road	2,385	1,037	F	1.6	816
	West: Elara Blvd	529	396	F	1.2	682
Richmond Rd/Access Rd	South: Richmond Road	2,491	4	A	0.4	0
	North: Richmond Road	2,393	4	A	0.5	490

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,166	121	F	1.3	284
	East: Commerical Access	520	660	F	1.4	885
	North: Richmond Road	1,749	896	F	1.5	367
	West: Clydesdale Access Rd	515	911	F	1.5	585
Richmond Rd/Heritage Road	South: Richmond Road	1,849	4	A	0.4	0
	North: Richmond Road	1,742	4	A	0.5	1,320
	West: Heritage Rd	86	14	A	0.2	5

2036 With Project

Table 32 Intersection Approach Summary With Project – 2036 AM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	2,823	227	F	1.5	952
	East: Garfield Road	790	78	F	0.9	137
	North: Richmond Road	4,350	837	F	1.5	1,183
	West: Garfield Road	1,171	948	F	1.6	959
Richmond Rd/Elara Blvd	South: Richmond Road	2,630	361	F	1.5	1,183
	East: Bandon Rd Extension	2,255	1,155	F	2.1	3,454
	North: Richmond Road	2,723	1,267	F	1.7	816
	West: Elara Blvd	916	916	F	1.5	1,736
Richmond Rd/Access Rd	South: Richmond Road	2,118	4	A	0.3	0
	North: Richmond Road	2,733	4	A	0.4	490
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	1,992	137	F	1.4	267
	East: Commerical Access	141	61	E	0.4	45
	North: Richmond Road	2,080	941	F	1.5	367
	West: Clydesdale Access Rd	768	926	F	1.5	893
Richmond Rd/Heritage Road	South: Richmond Road	1,715	4	A	0.3	0
	North: Richmond Road	2,080	4	A	0.4	1,029
	West: Heritage Rd	66	16	B	0.2	5

Table 33 Intersection Approach Summary With Project – 2036 PM

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	4,768	591	F	1.6	2,226
	East: Garfield Road	1,390	869	F	1.6	1,105
	North: Richmond Road	3,254	775	F	1.5	1,183
	West: Garfield Road	1,125	751	F	1.5	1,033
	South: Richmond Road	3,860	70	F	1.1	345

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Elara Blvd	East: Bandon Rd Extension	2,147	465	F	1.5	1,601
	North: Richmond Road	2,337	927	F	1.5	816
	West: Elara Blvd	272	60	E	0.7	123
Richmond Rd/Access Rd	South: Richmond Road	3,102	4	A	0.4	0
	North: Richmond Road	2,337	4	A	0.4	490
Richmond Rd /Clydesdale Access Rd	South: Richmond Road	2,658	38	C	0.5	222
	East: Commerical Access	901	243	F	1.1	768
	North: Richmond Road	1,746	311	F	1.1	367
	West: Clydesdale Access Rd	223	262	F	1.1	113
Richmond Rd/Heritage Road	South: Richmond Road	2,402	4	A	0.3	0
	North: Richmond Road	1,746	4	A	0.4	6
	West: Heritage Rd	33	15	B	0.1	2

Table 34 Intersection Approach Summary With Project – 2036 SAT

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd/Garfield Rd	South: Richmond Road	3,696	345	F	1.5	1,229
	East: Garfield Road	1,000	324	F	1.2	531
	North: Richmond Road	3,424	579	F	1.3	1,183
	West: Garfield Road	1,147	856	F	1.5	954
Richmond Rd/Elara Blvd	South: Richmond Road	3,128	135	F	1.2	592
	East: Bandon Rd Extension	2,200	666	F	1.7	2,191
	North: Richmond Road	2,306	1,160	F	1.7	816
	West: Elara Blvd	570	337	F	1.2	674
Richmond Rd/Access Rd	South: Richmond Road	2,491	4	A	0.3	0
	North: Richmond Road	2,316	4	A	0.4	490
	South: Richmond Road	2,207	40	C	0.6	217

Intersection	Approach	Demand (veh/hr)	Delays	LOS	DoS	95%ile queue
Richmond Rd /Clydesdale Access Rd	East: Commerical Access	520	258	F	1.2	465
	North: Richmond Road	1,693	311	F	1.1	367
	West: Clydesdale Access Rd	495	297	F	1.1	285
Richmond Rd/Heritage Road	South: Richmond Road	1,940	4	A	0.3	0
	North: Richmond Road	1,694	4	A	0.3	99
	West: Heritage Rd	50	13	A	0.1	3