TRAFFIC IMPACT ASSESSMENT

PROPOSED RESIDENTIAL SUBDIVISION

PREPARED FOR MIRVAC HOMES

21/02/2019

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REVISION SCHEDULE

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02	24/01/19	Final draft for approval	TG	KM	TG	TG
03	21/02/19	Final	TG	KM	TG	TG

Mirvac Homes

Proposed Residential Subdivision

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1. Introduction

Stantec has been commissioned by Mirvac Homes to assess the traffic implications of a residential subdivision located on the corner of Menangle Road and Station Street in Menangle, NSW.

Stage 1 of the proposed subdivision comprises 97 residential lots varying in area between 500m^2 and 807m^2, with vehicle access via both Menangle Road and Station Street. Stages 2-4 of the proposed subdivision will increase the number of lots to approximately 350, and will include the provision of a local centre and a recreational area. An area immediately to the north of the site, labelled Lot 3 on the proposed subdivision plans, has been identified as a suitable place for a neighbourhood centre, however this is not included as part of this proposal. The potential traffic impacts of the later stages and neighbourhood centre have been considered as part of this assessment.

The scope of this Traffic Impact Assessment is to assess the capacity of both the existing and proposed road network to accommodate the proposed residential subdivision in its entirety based on the latest plans and identify any elements of the surrounding road network that may require improvements or upgrades.

By way of summary, it is determined that Stage 1 of the proposed residential subdivision can be accommodated by the existing road network and that the traffic generation associated with the development will have a no more than minor impact on the Menangle Road / Station Street intersection.

2. Existing Conditions

2.1 Site Location

The subject site is located in the north-eastern corner of the Menangle Road / Station Street intersection, with Stage 1 bordered by Stevens Road to the east. **Figure 2-1** below shows the location of the site in relation to the surrounding transport network, while **Figure 2-2** shows a recent aerial photograph of the site.

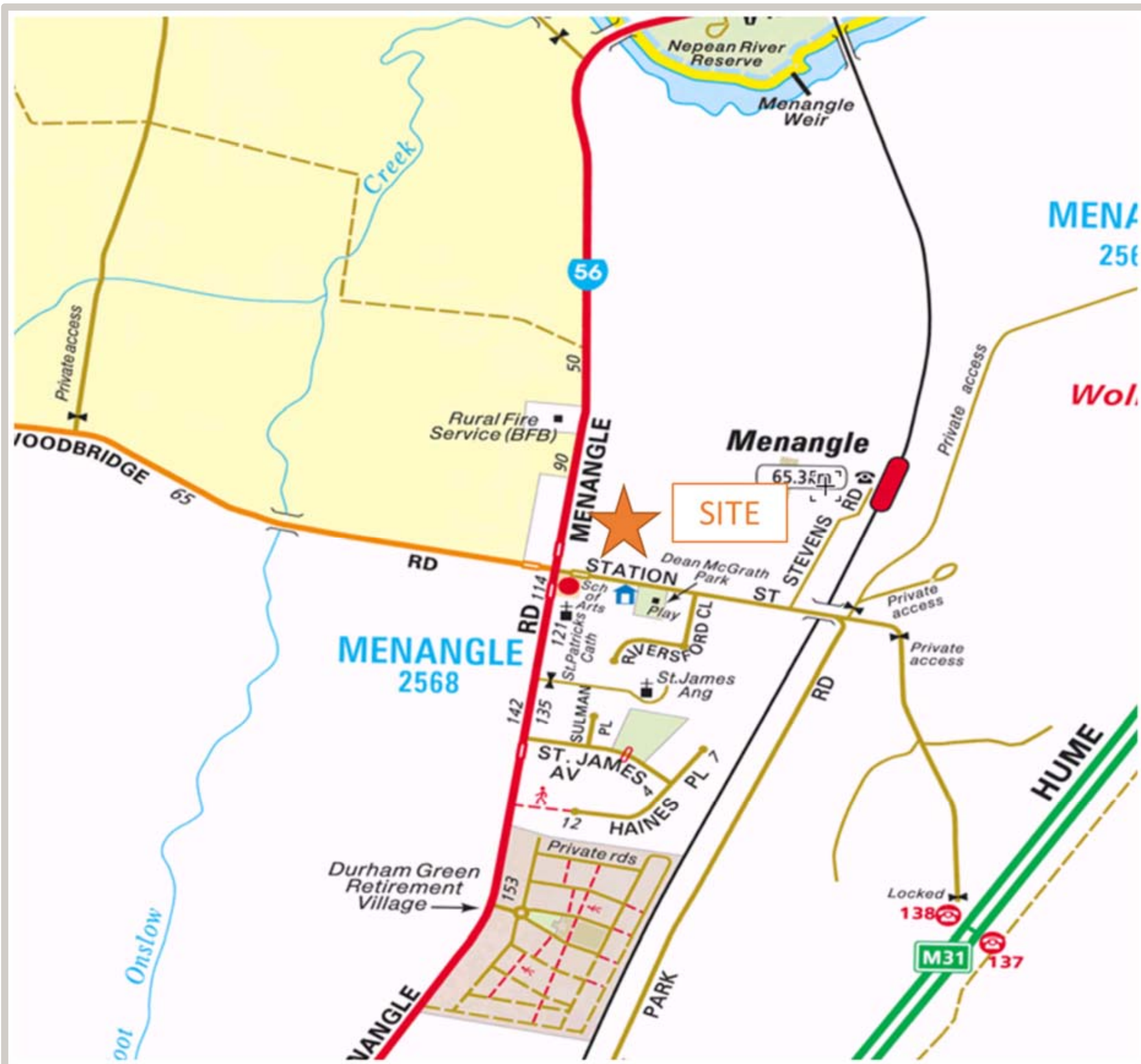
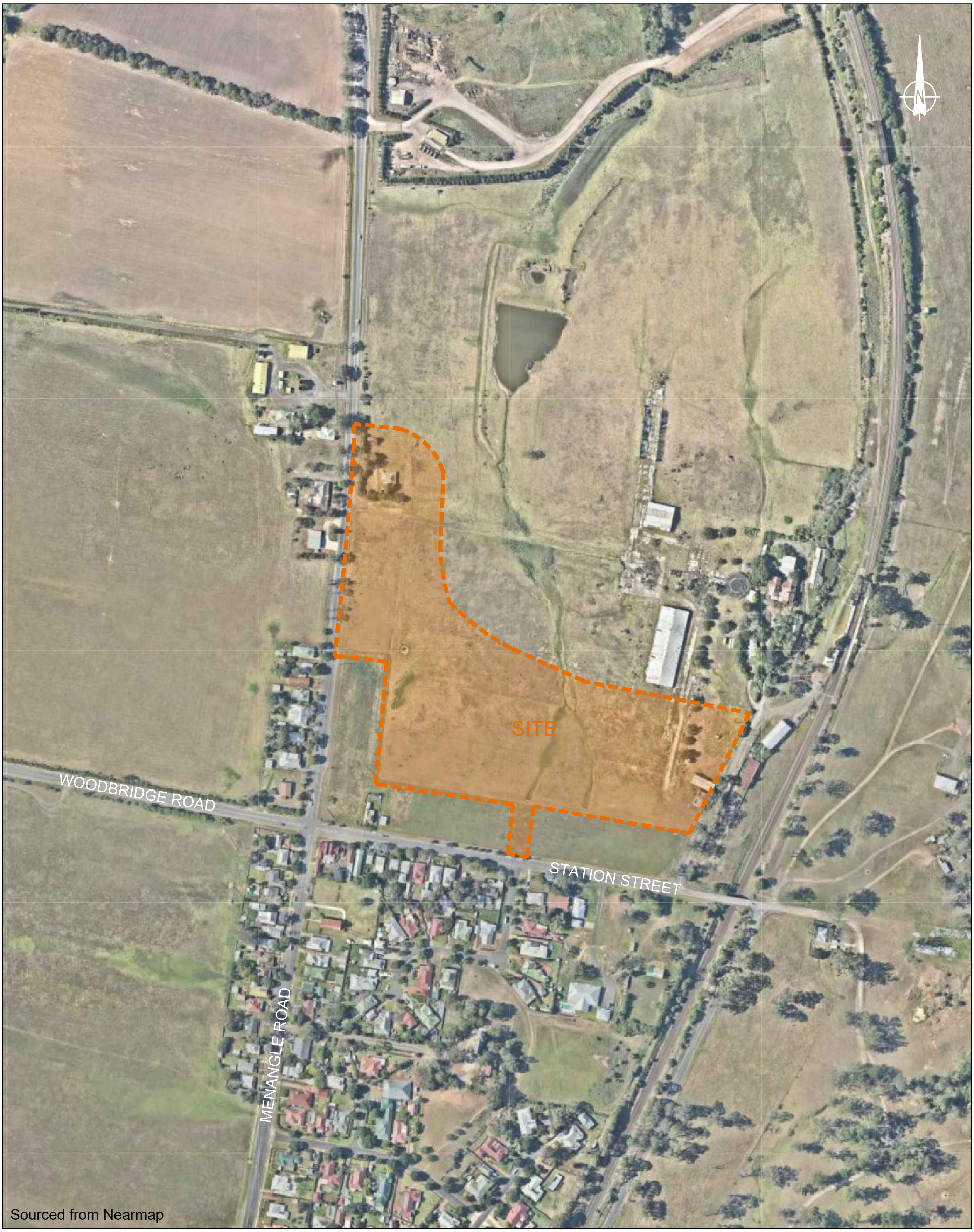


Figure 2-1: Site Location[1]

The majority of the site is currently undeveloped, with two existing buildings located in the north-western corner, whilst the remainder of the site is covered in vegetation. There are several private unsealed access roads linking the site to the surrounding road network, one located on Menangle Road and several via Stevens Road along the western side of the site.

Notable facilities in the vicinity of the site include the Menangle Railway Station, located along Stevens Road approximately 150 metres from the subdivision, and the Menangle Store, located on the south-eastern corner of the Menangle Road / Station Street intersection.

[1] Source: www.street-directory.com.au



Proposed Residential Subdivision - Menangle, NSW

Site Location

Stantec

2-2

NTS

2.2 Land Use Zoning

The subject site has recently been rezoned from RU1 to R2 (Low Density Residential) and is shown below in **Figure 2-3**.

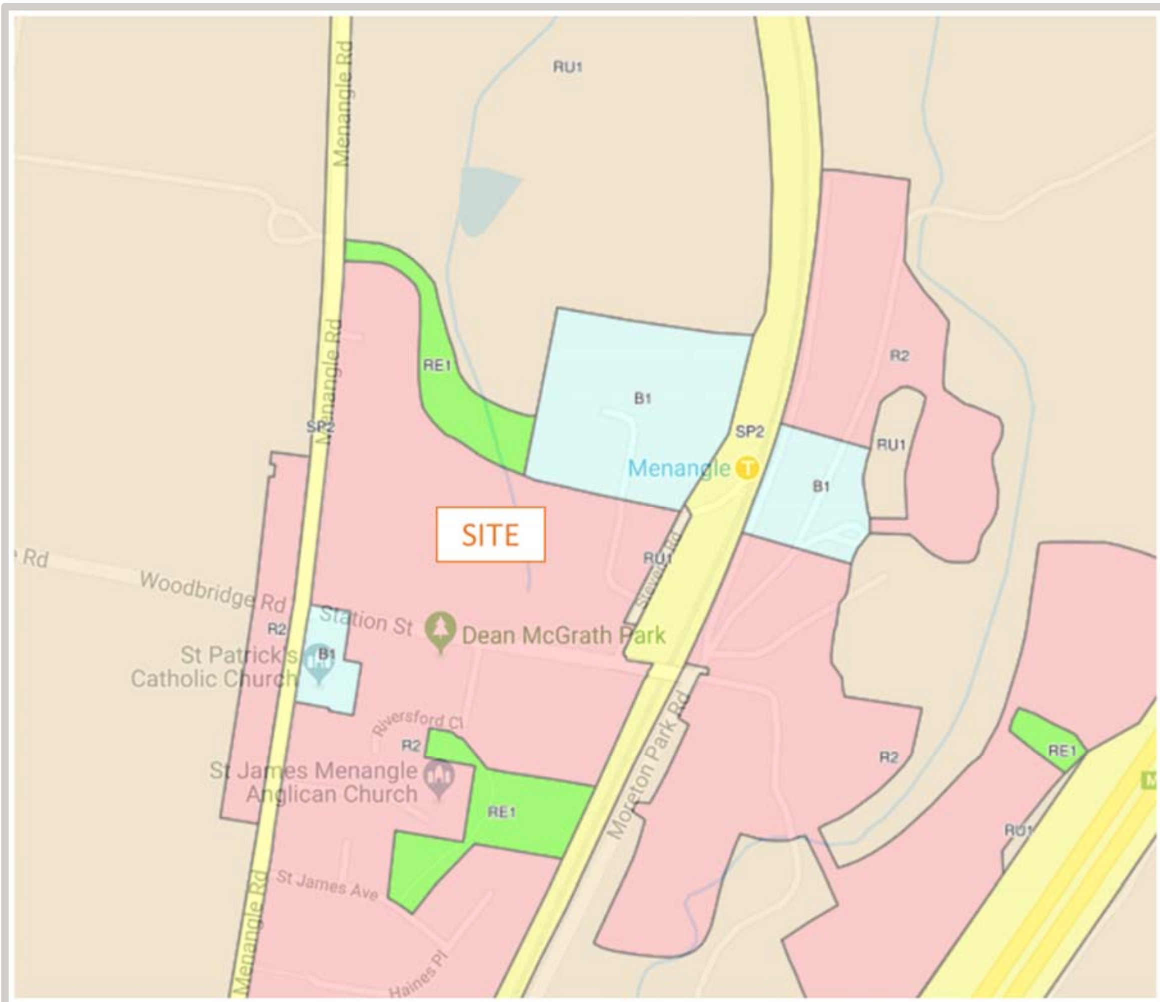


Figure 2-3: Land Use Zoning[2]

2.3 Local Road Network

Menangle Road is classified as a Regional Road and is under the care and maintenance of Wollondilly Shire Council (Council). It runs in a general northeast-southwest alignment between Picton Road in Maldon and its terminus in Campbelltown. In the vicinity of Menangle township, Menangle Road is a two-lane, two-way road, with each traffic lane being approximately 3.5 metres wide, and has a total carriageway width of approximately 8.9 metres. Menangle Road has a speed limit of 50km/h through Menangle township, and a speed limit of 80km/h to the north and south of Menangle.

Station Street is a local road under the care and maintenance of Council. It runs in an east-west alignment, extending west from Menangle Road to its intersection with Moreton Park Road where it terminates. In the vicinity of Menangle township, Station Street is a two-lane, two-way road, with a total carriageway width of approximately 9.5 metres. At the intersection of Menangle Road / Station Street, it widens to approximately 13 metres, catering for on-street parking on both sides of the road, and an approximate 2.0-metre-wide painted median.

Stevens Road is a local road, extending north from the northern side of Station Street. It runs parallel to the Southern Highlands Railway line and provides public access to the Menangle Railway Station. It has an

[2] www.planningportal.nsw.gov.au

approximate sealed width of 5.2 metres near Station Street, narrowing to approximately 4.0 metres further north.

2.4 Sustainable Transport

The site has good access to sustainable transport modes primarily due to it being located in close proximity to the Menangle Railway Station, which services the Southern Highlands Line.

Bus stops are located on Menangle Road and Station Street within vicinity of the site. The bus routes that service the bus stops include:

- Route 49 - Camden to Menangle and Razorback (Loop Service);
- Route 899 - Menangle to Campbelltown via Menangle Park; and
- Route 900 - Picton to Campbelltown via Narellan.

The bus network maps for these bus routes are shown in **Figure 2-4** and **Figure 2-5.**

2.5 Walking and Cycling

Pedestrian footpaths are established along Station Street and Menangle Road in the vicinity of the Menangle Local Store. Wide grassed berms are provided on both sides of the roads in the wider area. No dedicated cycle facilities are provided in the vicinity of the site.

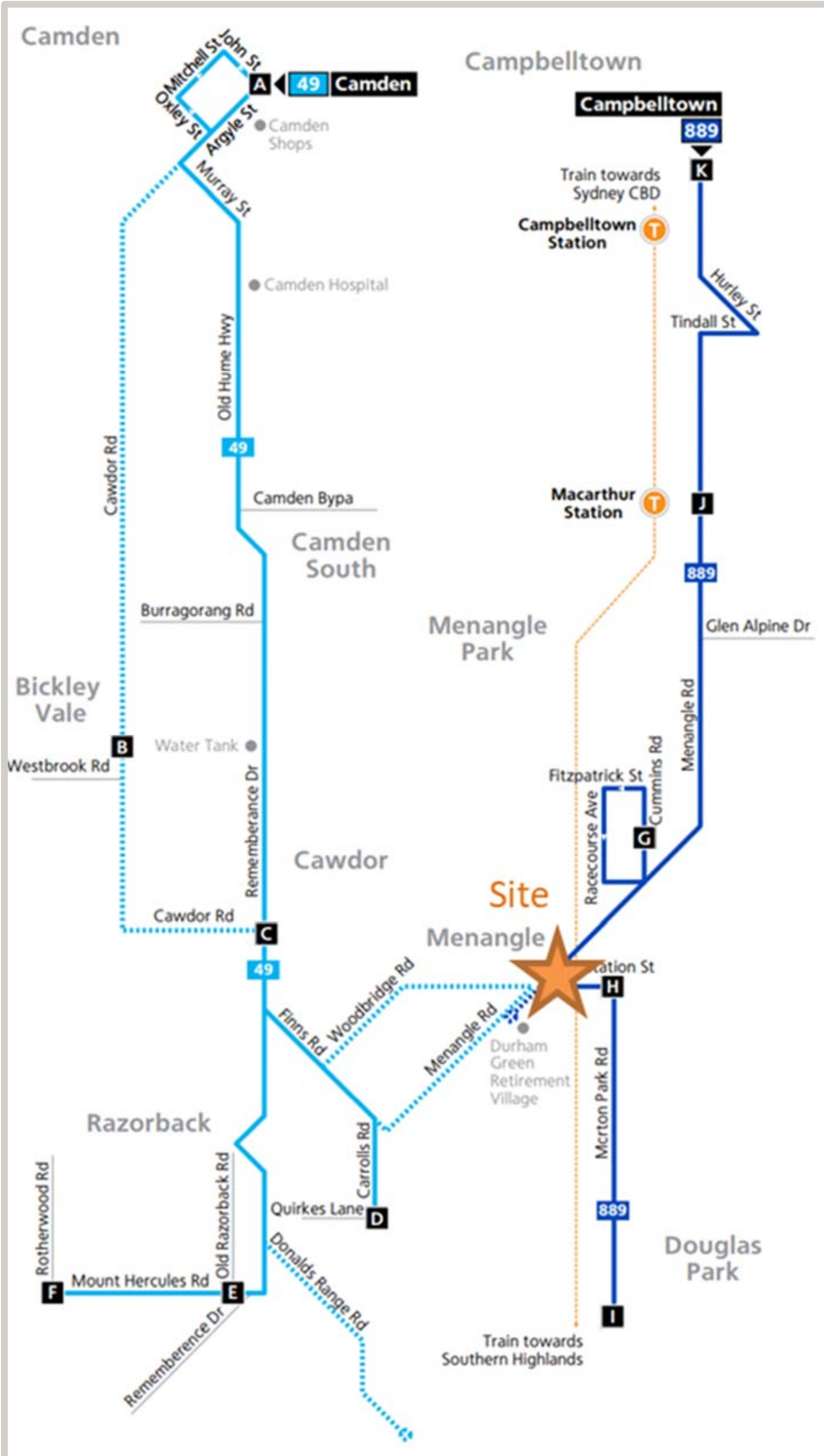


Figure 2-4: Bus Routes 49 and 889[3]

3 Source: https://busabout.com.au/pdf/timetables/49_889_timetable.pdf

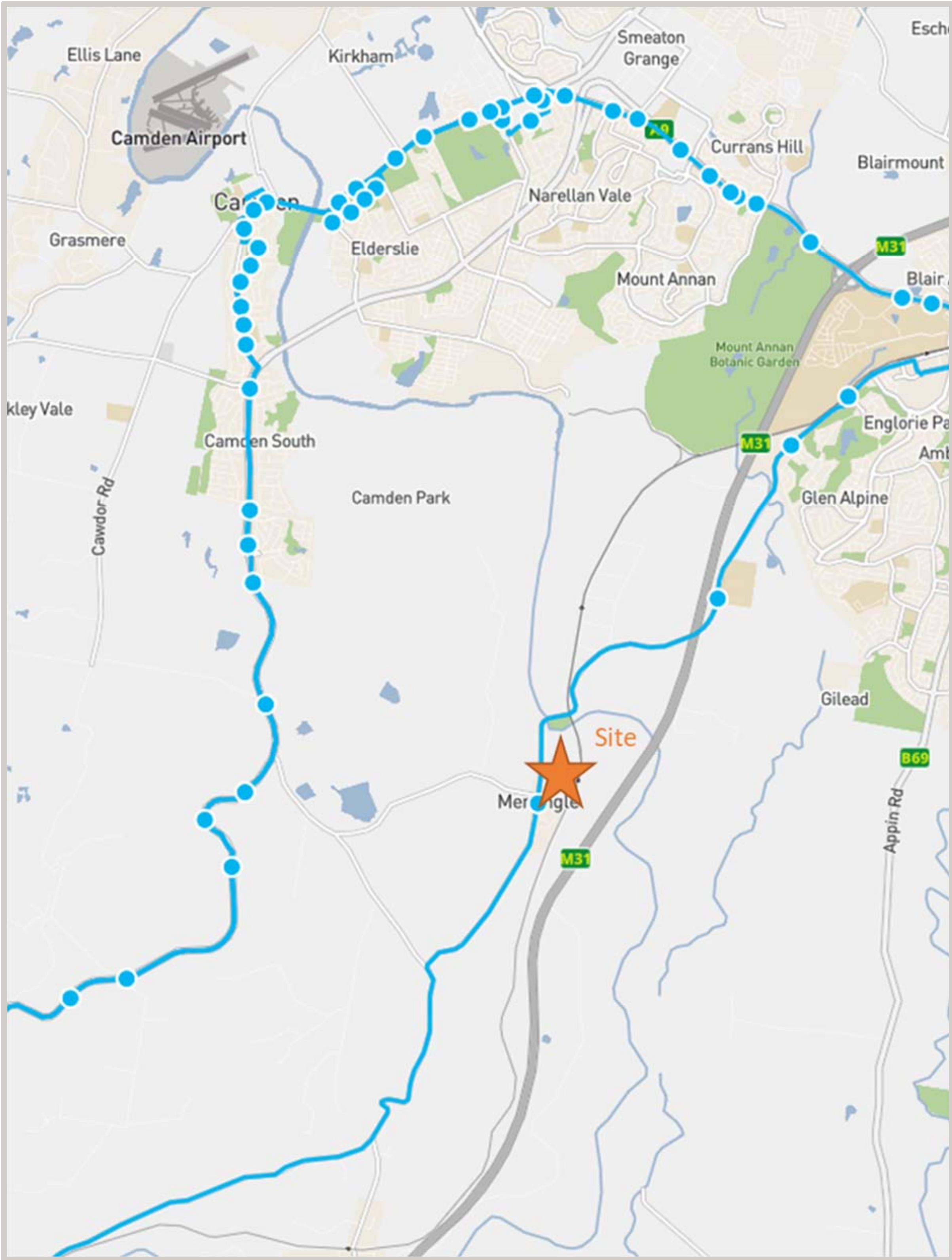


Figure 2-5: Bus Route 900[4]

[4] Source: https://transportnsw.info/routes/details/private-bus-services/900/08900

2.6 Road Safety

A search of the Road Safety Crash and Casualty Statistics Portal has been undertaken for the most recent five-year period 2013 to 2017 inclusive. A search area fronting the subject site has been assessed.

A total of two crashes have been identified within the crash area over the five-year period from 2013 to 2017. The crashes are summarised below:

- Both crashes occurred within 20 metres of the intersection of Menangle Road, Station Street and Woodbridge Road, as follows:
  - One cross-traffic crash resulting in no injuries; and
  - One off-road crash to the left resulting in a collision with an object, resulting in no injuries.
- No crashes occurred at the intersection of Station Street and Moreton Park Road;
- There were zero crashes recorded along Moreton Park Road within the search area; and
- Zero fatalities were recorded over the five-year period.

Figure 2-6 below shows the location of the recorded crashes between 2013 and 2017.

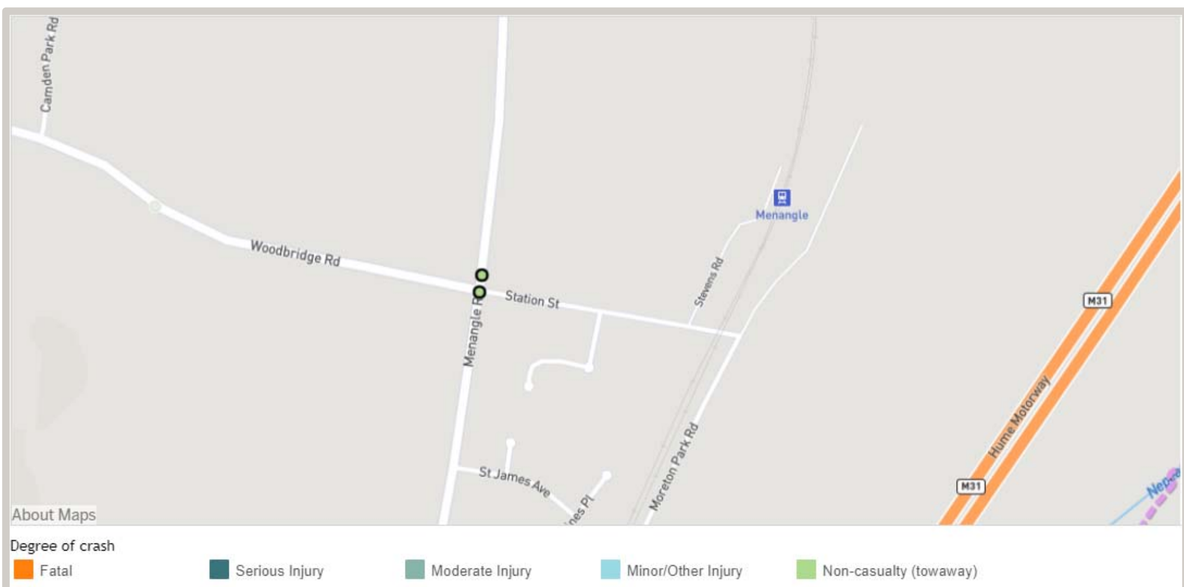


Figure 2-6: Crash Locations[5]

Accordingly, it is considered that there is no apparent evidence of a recurrent, persistent or adverse road crash history within the vicinity of the site that would raise a particular local road safety concern.

[5] Source: NSW Transport for NSW – Centre for Road Safety (http://roadsafety.transport.nsw.gov.au/index.html)

3. The Proposal

It is proposed to develop the subject site on the north-eastern corner of the Menangle Road / Station Street intersection into a 97-lot residential subdivision. More specifically, the proposal comprises the following:

- 97 residential lots, ranging in lot area between 500m^2 and 807m^2;
- 3 x internal roads, with road reserve widths between 15 metres and 20 metres;
- 4 x new site access points, as follows:
  - A left-in/left-out access on Menangle Road, approximately 400 metres north of Station Street;
  - An all-way priority-controlled intersection on Station Street, approximately 200 metres east of Menangle Road; and
  - Two all-way priority-controlled intersections on Stevens Road, approximately 95 metres and 180 metres north of Station Street

Civil plans have been provided for reference in **Appendix A**.

4. Site Access

Two primary site access locations are proposed for the subdivision, comprising an all-ways access proposed for Station Street, and a left-in/left-out access proposed along Menangle Road. Two secondary accesses are proposed to be provided on Stevens Road along the east of the site, which are expected to accommodate a much lower level of development traffic relative to the primary accesses.

As discussed above, Menangle Road has a speed limit to the north of 80 km/h, reduced to 50 km/h through Menangle township. As the site access on Menangle Road is proposed to accommodate all vehicles arriving at the site from the north via left-in movements, a left-turn treatment is proposed and is discussed further below.

4.1 Menangle Road Left-Turn Treatment

Due to the proximity of the proposed intersection to the posted speed limit change, the intersection has been designed with a design speed of 90km/h. While there is some degree of conservativeness to this, the left turn treatment will provide access to both residential as well as potentially some commercial developments in the future. While residents will be familiar with the deceleration and turning movement, visitors of the commercial developments may not, and accordingly a 90km/h design speed is recommended to be adopted.

4.1.1 Austroads Requirements

Figure 2.26 of the Austroads' *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings* (Austroads Part 6) provides guidance on the preferred turning treatments on major roads at unsignalised intersections. The warrants for a design speed of between 70km/h and 100km/h are shown below in **Figure 4-1**.

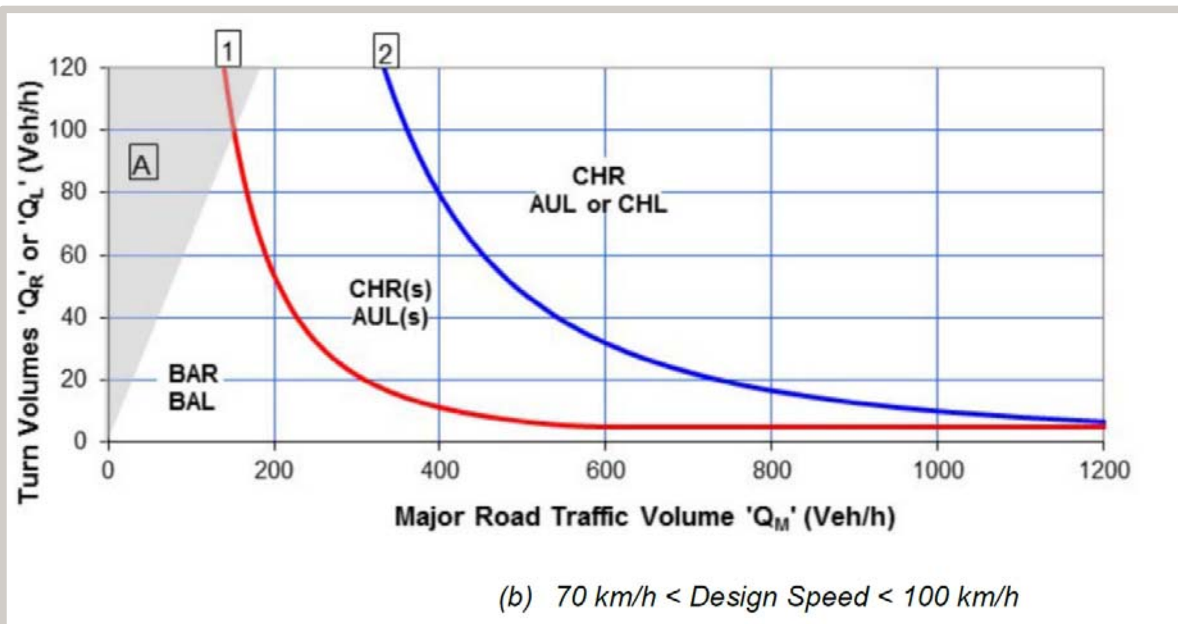


Figure 4-1: Figure 2.26(b) of Austroads Guide to Traffic Management Part 6

As discussed further in Section 6 of this report, the peak hour major road through traffic volume in the southbound direction is approximated at 566 vph, and the turning volume is 11 vph based on the volumes provided within **Figure 6-2**. Therefore, the preferred turning treatment at the intersection is a Rural Auxiliary Left-turn Treatment – Short Turn Lane [AUL(s)].

4.1.2 Auxiliary Lane Length

Figure 8.3 of the Austroads' *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* (Austroads Part 4A) specifies the dimensions for an AUL(s) turning treatment. Based on a design speed of 90km/h, the required diverge length is 55 metres, comprising a taper length of 25 metres and a storage length of 30 metres.

4.1.3 Sight Distance Assessment

Observations on-site indicate that sight distance along Menangle Road at the intersection is in excess of 250 metres, as illustrated in **Photograph 1** below.

Photograph 1: View Looking North on Menangle Road from Access Road Location

Austroads Part 4A recommends a minimum Safe Intersection Sight Distance (SISD) of 214 metres for a design speed of 90 km/h. Accordingly, the sight distance at the intersection exceeds the recommendation, with excellent sight distance available along Menangle Road at the intersection.

5. Subdivision Layout

5.1 Internal Road Network

The proposed subdivision plans have been considered against Council's Design Specification *Subdivision & Engineering Standard 2016* (SES) document and are discussed below.

The three internal roads are proposed to serve slightly different functions, and accordingly have differing road reserve widths. The road reserve widths range from 15m to 20m, and in accordance with the SES, the roads would likely fall under Category D1, or Urban Residential.

Table D.1.5 states that Category D1 roads have a road reserve width of 15 metres, which includes an 8.0 metre wide carriageway width alongside 3.5m wide verges on both sides of the road. Category D2 roads require an 18.0 metre wide road reserve, allowing for a 10 metre wide carriageway width alongside 4.0 metre wide verges on both sides of the road.

It is considered that the road providing access to the subdivision from Station Street would be classified as a Category D1 road, with an extra wide reserve for visual heritage reasons, while the other roads would be standard Category D1 roads.

All internal intersections are proposed to be unsignalised, with traffic from the minor roads expected to give way to traffic along the more major roads within the subdivision. The roads will eventually cater for the neighbourhood centre, however it is anticipated that vehicles travelling to and from the neighbourhood centre can do so without travelling through the entire subdivision.

5.2 Walking and Cycling

Footpaths are proposed to be provided on one side of all new roads. In the cases of the 16 metre and 20 metre wide roads, there is opportunity to provide a wider footpath which will allow for a shared walking and cycling path to be provided. A cycleway will be provided along the northern side of Road No. 01, which is the east-west road along the northern boundary of the development.

As discussed in Section 3.5 of this report, the Menangle area does not currently have any dedicated cycling facilities. However, it is considered a good opportunity to provide for such facilities within the proposed subdivision to cater for future development within the Menangle area.

6. Traffic Assessment

6.1 Existing Traffic Volumes

Traffic movement counts were commissioned by Stantec on Thursday 3 May 2018 for the intersection of Menangle Road / Station Street. Full results are included for reference in **Appendix B**.

The results have been summarised into AM and PM peak hour turning movement counts (**Figure 6-1**) and peak hour road volumes (**Table 6-1**), given in vehicles per hour (vph).

Table 6-1: Traffic Volumes Along Menangle Road (North) and Station Street

Approach Road	Direction	AM Peak Hour (vph)	PM Peak Hour (vph)
Menangle Road (North)	Northbound	753	285
	Southbound	218	566
Station Street	Eastbound	19	31
	Westbound	41	24

The road volumes, as shown in the table above, are estimated to be accurate on the roads at locations adjacent to the intersection. Due to the small number of developments along Menangle Road to the north of the intersection and Station Street to the east of the intersection, these peak hour volumes are also considered to be applicable for both of these roads.

6.2 Trip Generation

RMS' *Guide to Traffic Generation Developments – Technical Direction 2013 04a* (TDT 2013/04a) specifies traffic generation rates for different land uses. For low density residential dwellings in regional areas, as is being considered for the proposed subdivision, TDT 2013/04a recommends trip rates of 0.71 trips per dwelling per hour during the morning peak, and 0.78 trips per dwelling per hour during the evening peak. It is noted that these trips are the trips made external to the subdivision, and do not include the internal trips.

As such, the expected trip generation for the subdivision is shown below in **Table 6-2** based on an estimated 97 dwellings.

Table 6-2: Trip Generation for Proposed Subdivision

Proposed Development	Trip Generation Rate (vph per dwelling)		Estimated Subdivision Trip Generation (vph)	
	AM Peak	PM Peak	AM Peak	PM Peak
97 Low Density Residential Dwellings	0.71	0.78	69	76

As can be seen from above, a 97-dwelling residential subdivision could be expected to generate 69 vph and 76 vph in the AM and PM peak hours respectively.

6.3 Trip Distribution

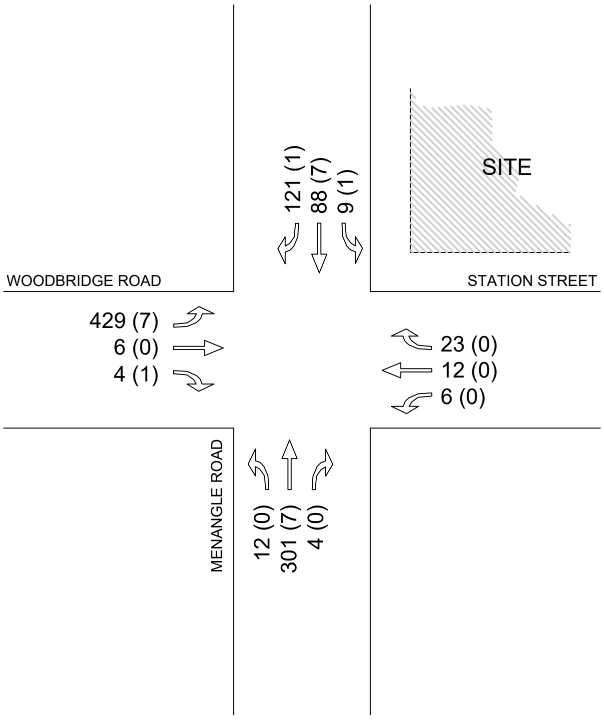
Trip distribution percentages have been established based on the traffic survey results. For the purposes of this assessment, the following trip distribution percentages have been adopted, shown below in **Table 6-3**.

Table 6-3: Trip Distribution

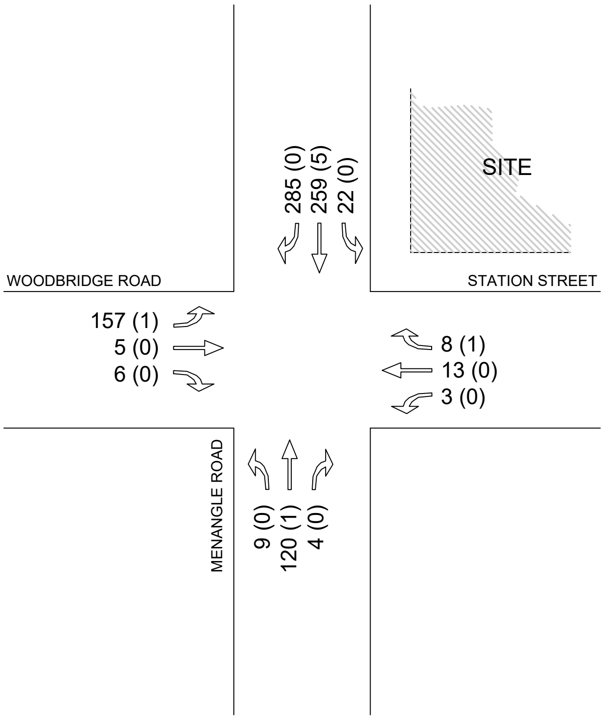
Peak Hour	Traffic Distribution		Inbound Movements		Outbound Movements	
	Inbound	Outbound	Menangle Road (left-in)	Station Street	Menangle Road (left-out)	Station Street
AM Peak Hour	20%	80%	20%	80%	20%	80%
PM Peak Hour	70%	30%	70%	30%	30%	70%

Accordingly, the trips expected to be generated by the proposed development shown in **Figure 6-2** have been adopted for the purposes of this assessment.

Legend
xx Total Vehicles
(xx) Heavy Vehicles



AM PEAK HOUR
7:30-8:30am



PM PEAK HOUR
4:30-5:30pm

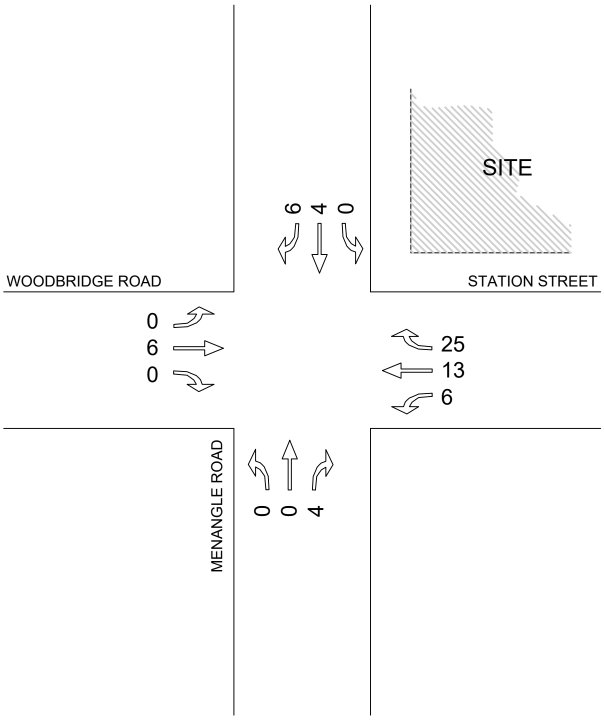
Menangle Road / Station Street Intersection

Surveyed Traffic Volumes - Thursday 3 May 2018

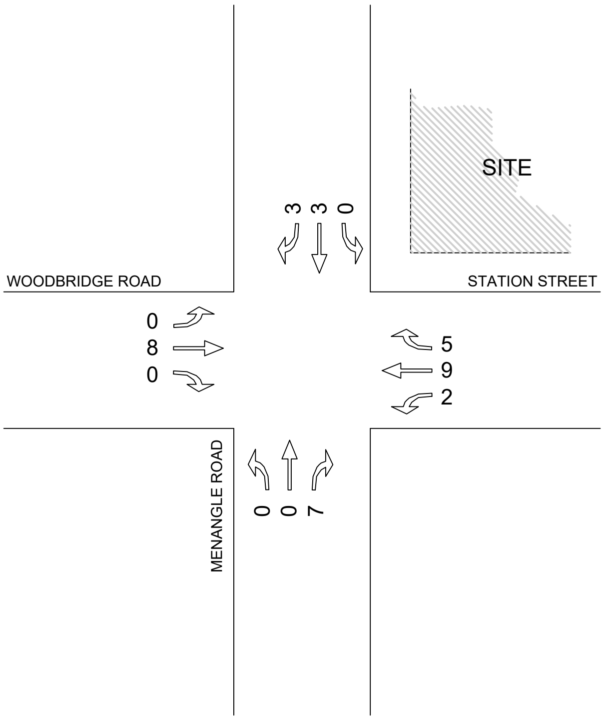
Stantec

6-1

Legend
xx Total Vehicles
(xx) Heavy Vehicles



AM PEAK HOUR
7:30-8:30am



PM PEAK HOUR
4:30-5:30pm

Menangle Road / Station Street Intersection

Proposed Development Peak Hour Trip Generation

Stantec

6-2

As Figure 6-2 shows, there is estimated to be a relatively low volume of trips associated with Stage 1 of the proposed residential subdivision that will utilise the Menangle Road / Station Street intersection during both the AM and PM peak hours.

6.4 Future Traffic Growth

A 2% annual growth rate has been adopted for future year traffic analyses, which is considered to be conservative given the rural nature of the area. It is estimated that the proposed development will take approximately two years to be complete, and therefore 2020 has been assumed as the post-development year, allowing for two and a half years of traffic growth for background volumes.

Although Stages 2-4 of the subdivision do not form part of this Development Application, they are being considered for future traffic analyses to ensure that the Menangle Road / Station Street intersection has capacity to handle future development.

Stages 2-4 represent a total of approximately 350 residential lots (including Stage 1) for the subdivision, and will be developed to the east of Stage 1, with construction estimated to be complete by the end of 2022. This number is based on the recently approved planning proposal, subject to further assessment in future Development Applications. Accordingly, four and half years of traffic growth have been applied to the existing volumes for the 2022 model scenario, with the peak hour traffic volumes shown in **Figure 6-3**.

Preliminary traffic analysis has been undertaken for the planned neighbourhood centre which is located to the north of the proposed Stage 1 subdivision. The neighbourhood centre is expected to be completed shortly following Stage 1 of the proposed subdivision, and for the purposes of this report it is assumed that this would be in 2021. It is conservatively estimated that during the weekday AM and PM peak hours, the neighbourhood centre would generate in the order of 186 and 330 vph, respectively. A separate Development Application is being submitted which further details the expected traffic generation of this development. These peak hour traffic volumes are shown in **Figure 6-4**.

A 2032 model scenario has also been analysed, which represents a 10-year period after the completion of Stages 2-4 of the subdivision. Similarly, 14.5 years of traffic growth have been applied to the existing volumes for the 2032 model scenario. These volumes are shown in **Figure 6-5**.

6.5 Heavy Vehicle Percentage

It is assumed that the current heavy vehicle percentages at each of the movements at the Menangle Road / Station Street intersection will stay the same in future modelling years. It is not expected that the proposed development will typically generate any heavy vehicle movements during the weekday AM and PM peak hours.

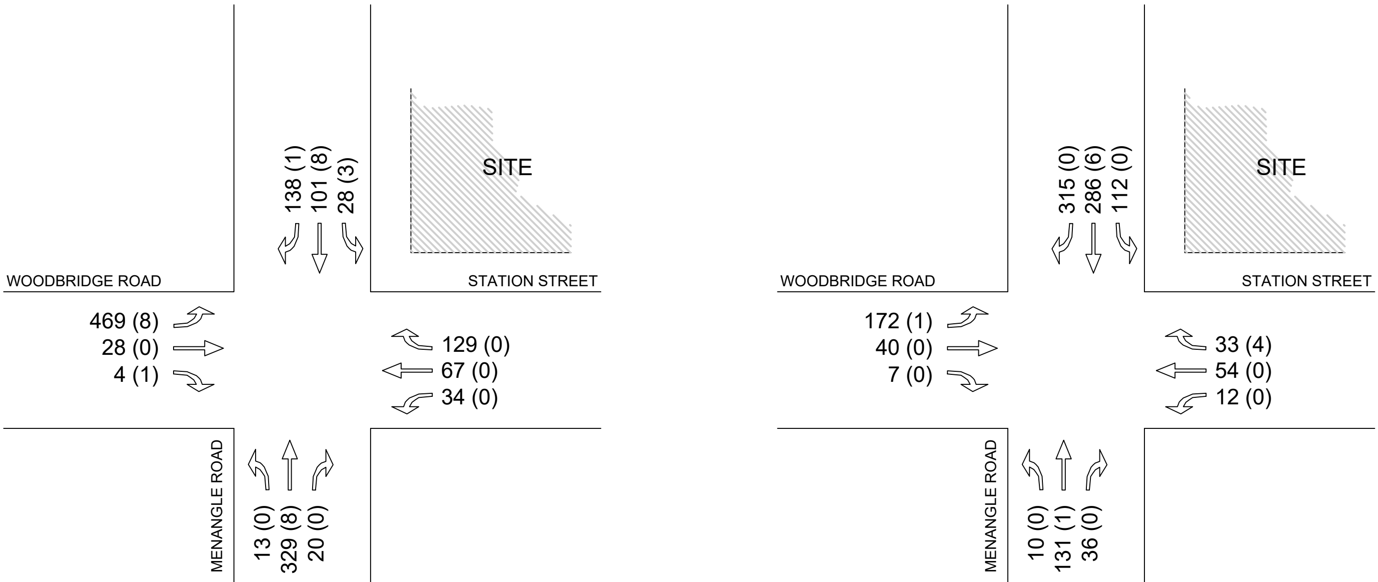
6.6 SIDRA Analysis

Intersection analysis for the Menangle Road / Station Street intersection was undertaken for the existing modelling scenarios described in the following sections, using the software package SIDRA (Signalised and unsignalised Intersection Design and Research Aid). The full SIDRA movement summaries have been included for reference in **Appendix C**, while the concepts of intersection delay and level of service are included in **Appendix D**.

6.6.1 Existing Volumes (2018)

The intersection was analysed using the layout as shown in **Figure 6-6**.

Legend
xx Total Vehicles
(xx) Heavy Vehicles



AM PEAK HOUR
7:30-8:30am

PM PEAK HOUR
4:30-5:30pm

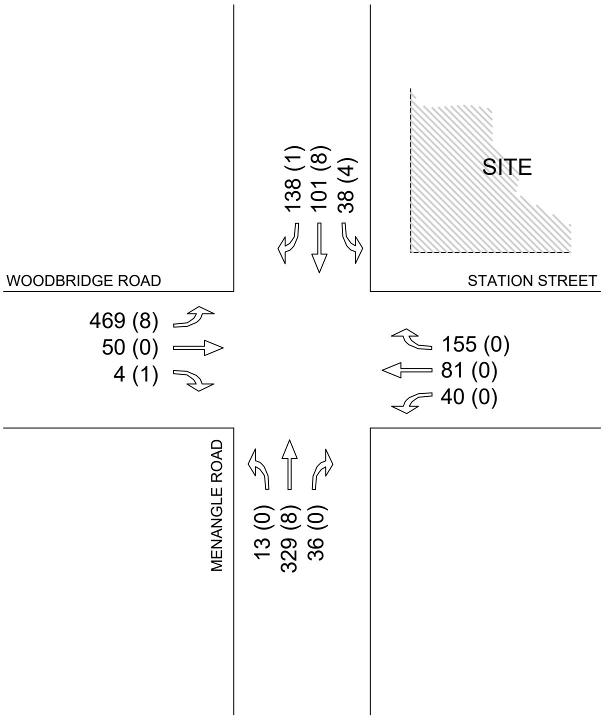
Menangle Road / Station Street Intersection

2022 Peak Hour Trip Generation - w/ Proposed Subdivision

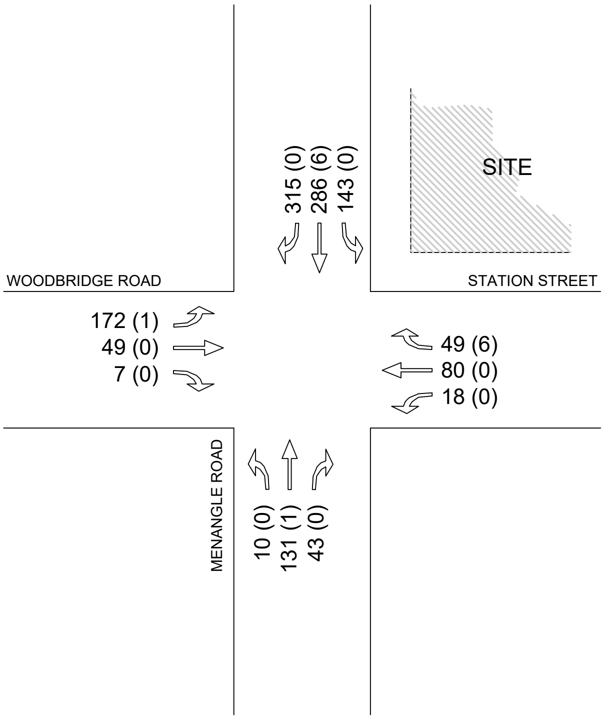
Stantec

6-3

Legend
xx Total Vehicles
(xx) Heavy Vehicles



AM PEAK HOUR
7:30-8:30am



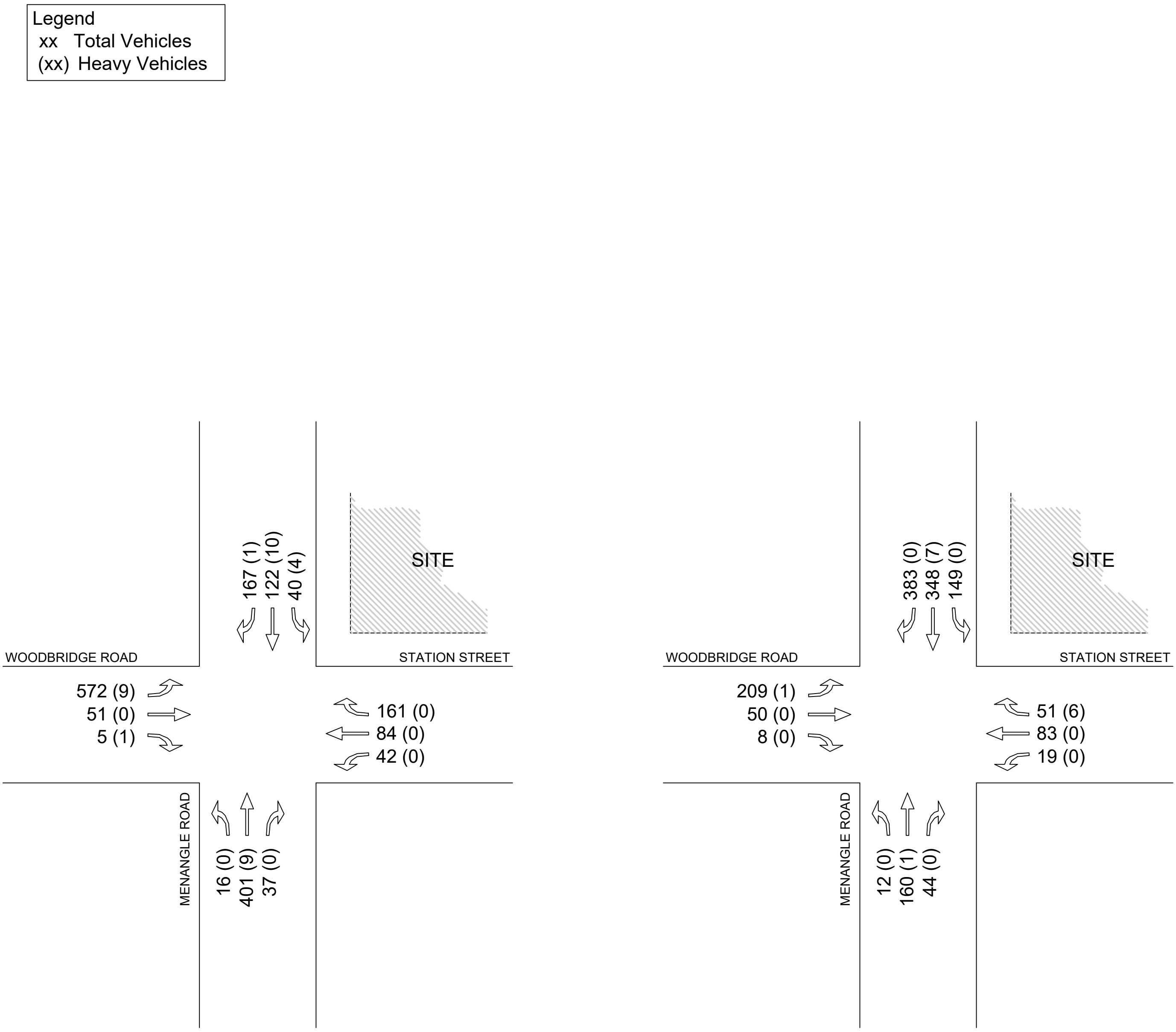
PM PEAK HOUR
4:30-5:30pm

Menangle Road / Station Street Intersection

2022 Peak Hour Trip Generation - w/ Proposed Subdivision plus Neighbourhood Centre

Stantec

6-4



AM PEAK HOUR
7:30-8:30am

PM PEAK HOUR
4:30-5:30pm

Menangle Road / Station Street Intersection

2032 Peak Hour Trip Generation - 10 Year Horizon

Stantec

6-5

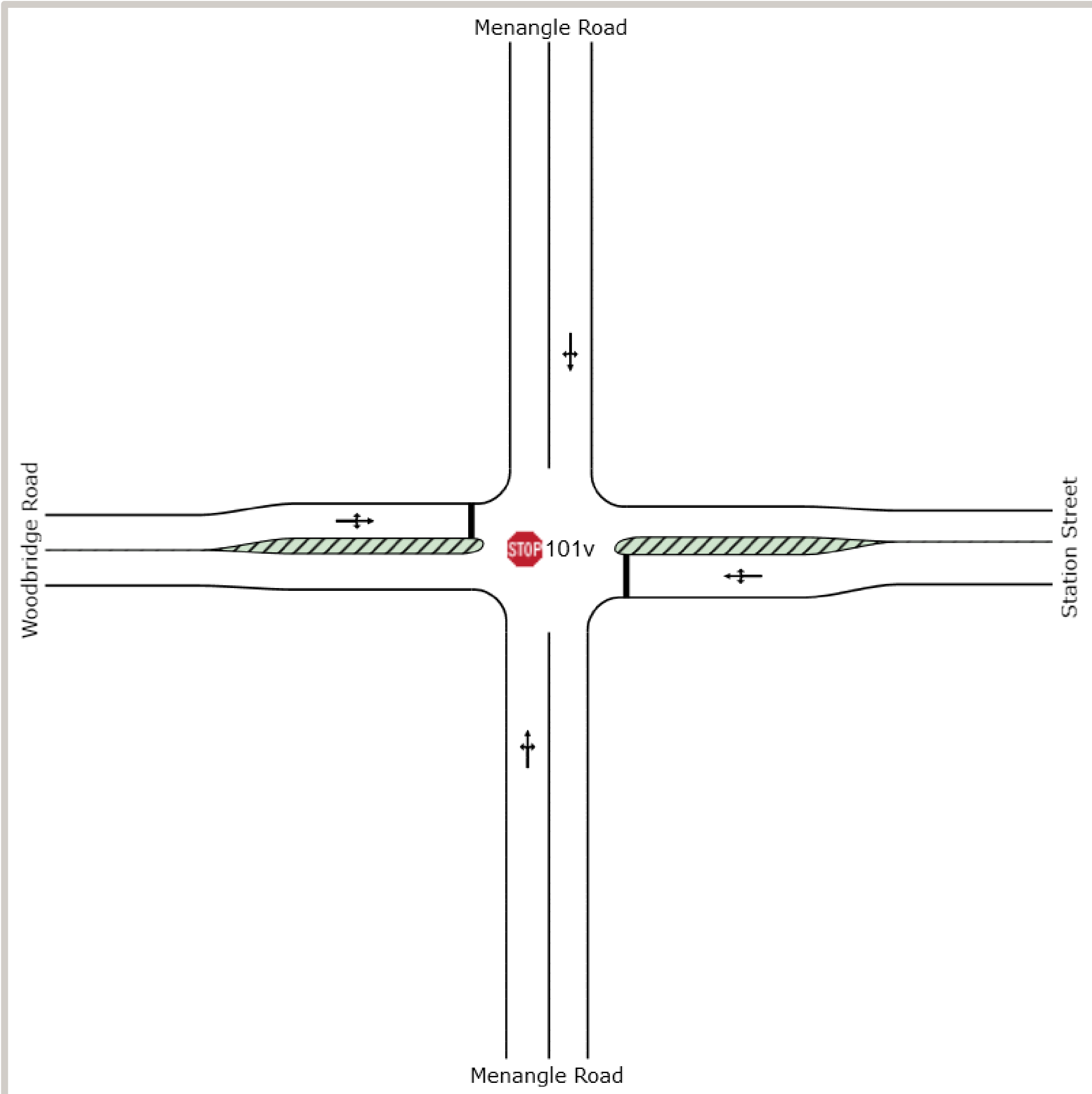


Figure 6-6: Adopted SIDRA Existing Intersection Layout

The intersection was analysed using single lanes on each approach to conservatively estimate a worst-case scenario, whereby vehicles wishing to turn in opposite directions of each other (e.g. left and right) on the same approach would be forced to queue, rather than being able to perform the manoeuvre simultaneously. The SIDRA results for the existing scenario are summarised in **Table 6-4**.

Table 6-4: Menangle Road / Station Street SIDRA Analysis - Existing

Approach Road	Turning Movement	AM Peak Hour			PM Peak Hour		
		Level of Service	Delay (sec)	95%ile Queue (m)	Level of Service	Delay (sec)	95%ile Queue (m)
Menangle Road (South)	Left	A	4.7	0.3	A	4.9	0.3
	Through	A	0.0		A	0.1	
	Right	A	4.9		A	5.6	
Station Street (East)	Left	A	7.8	2.6	A	8.6	1.5
	Through	A	10.9		A	12.9	
	Right	B	19.4		B	19.3	
Menangle Road (North)	Left	A	5.9	5.6	A	5.1	14.0
	Through	A	1.1		A	0.5	
	Right	A	5.9		A	5.2	
Woodbridge Road (West)	Left	A	10.3	22.6	A	8.0	4.6
	Through	A	13.5		A	14.0	
	Right	B	18.4		B	15.6	

As can be seen from the table above, the intersection currently operates at a very good LoS 'B', with the largest 95%ile queue length occurring on Woodbridge Road in the AM peak, and Menangle Road (north) in the PM peak. These queue lengths are relatively small and represent two to three vehicles attempting to either left turn (merge) onto Menangle Road from Woodbridge Road, or perform a right turn from Menangle Road onto Woodbridge Road across traffic.

In reality, the queue lengths observed on Woodbridge Road in the AM period were larger than those reflected in the existing scenario SIDRA model shown in Table 6-4. It is believed that this was due to one or two vehicles showing hesitation to take gaps in the northbound vehicle flow which would be considered to be acceptable, thereby causing longer than normal queues to form. In some cases, the queues are not at rest, but more moving at slow speeds while each vehicle navigates the 90 degree turn onto Menangle Road.

6.6.2 Stage 1 Completion (2020)

As discussed in Section 6.4 of this report, a 2% annual growth rate was applied for two and a half years for the existing light vehicle volumes, assuming that the proposed subdivision is complete by end of 2020. The intersection layout is unchanged from the layout modelled in the existing model. **Table 6-5** summarises the SIDRA analysis for the 2020 model year.

Table 6-5: Menangle Road / Station Street SIDRA Analysis – Stage 1 Completion (2020)

Approach Road	Turning Movement	AM Peak Hour			PM Peak Hour		
		Level of Service	Delay (sec)	95%ile Queue (m)	Level of Service	Delay (sec)	95%ile Queue (m)
Menangle Road (South)	Left	A	4.8	0.6	A	5.3	0.8
	Through	A	0.0		A	0.1	
	Right	A	5.0		A	5.7	
Station Street (East)	Left	A	8.8	7.1	A	8.7	2.9
	Through	A	12.6		A	13.8	
	Right	B	23.2		B	21.3	
Menangle Road (North)	Left	A	6.0	6.3	A	5.2	15.2
	Through	A	1.2		A	0.5	
	Right	A	6.0		A	5.2	
Woodbridge Road (West)	Left	A	10.8	27.0	A	8.0	5.5
	Through	B	14.7		B	15.1	
	Right	B	20.7		B	16.9	

As can be seen from the table above, all movements at the intersection continue to operate at their levels of service, apart from the Woodbridge Road through movement during both peak hours, which sees the average vehicle delay increase slightly to shift it from and excellent LoS 'A' to a still very good LoS 'B'. The intersection itself retains its overall LoS 'B'.

Accordingly, it is considered that the development at completion (2020) would have a less than minor impact on the peak hour operations of the Menangle Road / Station Street intersection.

6.6.3 Neighbourhood Centre (2021)

As discussed in Section 6.4 of this report, a neighbourhood centre is planned to the north of the subdivision. Whilst the exact land use details of the neighbourhood centre are still being finalised, approximate traffic analysis estimates trip generations of 186 vph and 330 vph during the AM and PM peak hours respectively. **Table 6-6** below summarises the SIDRA analysis for the 2021 model year.

Table 6-6: Menangle Road / Station Street SIDRA Analysis – Stage 1 Completion plus Neighbourhood Centre (2021)

Approach Road	Turning Movement	AM Peak Hour			PM Peak Hour		
		Level of Service	Delay (sec)	95%ile Queue (m)	Level of Service	Delay (sec)	95%ile Queue (m)
Menangle Road (South)	Left	A	5.0	2.7	A	5.8	4.8
	Through	A	0.1		A	0.8	
	Right	A	5.1		A	5.8	
Station Street (East)	Left	A	12.7	16.2	A	11.8	11.2
	Through	B	17.5		B	19.1	
	Right	C	30.6		C	29.8	
Menangle Road (North)	Left	A	6.0	6.9	A	5.2	15.8
	Through	A	1.2		A	0.5	
	Right	A	6.0		A	5.2	
Woodbridge Road (West)	Left	A	11.1	30.1	A	8.1	7.3
	Through	B	16.2		B	17.3	
	Right	B	23.3		B	19.9	

As can be seen from the table above, the additional movements generated by the neighbourhood centre increase the delays of the Station Street approach, increasing the LoS of the through and right turn movements to 'B' and 'C' respectively in both peak hours. As such, the intersection could be expected to operate at a LoS 'C' following completion of the neighbourhood centre in both the AM and PM peak hours.

Accordingly, it is considered that the combined impacts of the proposed Stage 1 subdivision development and the neighbourhood centre (2021) would slightly increase delays at the intersection, however it is expected that the intersection in its current unsignalised form would be able to continue operating at acceptable levels at this time.

6.6.4 Stages 2-4 Completion (2022)

As discussed in Section 5.4 of this report, a 2% annual growth rate was applied for four and half years for all existing volumes, assuming that the subdivision is expanded to a total of 350 residential lots by 2022. The intersection layout is unchanged from the layout modelled in the existing model. **Table 6-7** below summarises the SIDRA analysis for the 2022 model year.

Table 6-7: Menangle Road / Station Street SIDRA Analysis – Stages 2-4 Completion (2022)

Approach Road	Turning Movement	AM Peak Hour			PM Peak Hour		
		Level of Service	Delay (sec)	95%ile Queue (m)	Level of Service	Delay (sec)	95%ile Queue (m)
Menangle Road (South)	Left	A	5.1	3.3	A	6.4	7.0
	Through	A	0.1		A	1.5	
	Right	A	5.2		A	6.4	
Station Street (East)	Left	F	> 70.5	209.8	C	29.9	34.0
	Through	F	> 70.5		C	40.6	
	Right	F	> 70.5		D	56.4	
Menangle Road (North)	Left	A	6.1	7.8	A	5.2	19.5
	Through	A	1.2		A	0.6	
	Right	A	6.1		A	5.3	
Woodbridge Road (West)	Left	A	11.6	33.8	A	8.5	10.8
	Through	B	17.7		B	22.3	
	Right	B	26.8		B	23.1	

As can be seen from the table above, the additional movements generated by Stages 2-4 of the subdivision, particularly the outbound movements, have a considerable impact on the operation of the Station Street leg of the intersection. The right turn and through movements, and by flow on effect the left turn movement, would all be expected to experience the most significant delays, with a LoS 'F' during the AM peak hour. During the PM peak hour, a 56.4 second average vehicle delay could be expected to be experienced during the for the right turn movement coming out of Station Street, resulting in an LoS 'D' for the intersection. All other movements continue to operate at very good levels of service.

Accordingly, it is considered that the development at completion of Stages 2-4 (2022) would have enough of an impact on the peak hour operations of the Station Street leg of the Menangle Road / Station Street intersection to warrant a capacity increase and/or upgrading of the intersection.

6.6.5 10-Year Horizon Model (2032)

As discussed in Section 6.4 of this report, a 2% annual growth rate was applied for 14.5 years to 2032 for all existing volumes, and assumes that the subdivision is complete at a total of 350 residential lots and the neighbourhood centre is complete.

The intersection layout is unchanged from the layout modelled in the existing model. **Table 6-8** below summarises the SIDRA analysis for the 2032 model year.

Table 6-8: Menangle Road / Station Street SIDRA Analysis – Plus 10 Year Model (2032)

Approach Road	Turning Movement	AM Peak Hour			PM Peak Hour		
		Level of Service	Delay (sec)	95%ile Queue (m)	Level of Service	Delay (sec)	95%ile Queue (m)
Menangle Road (South)	Left	A	5.3	3.7	A	6.9	8.2
	Through	A	0.1		A	1.8	
	Right	A	5.4		A	6.9	
Station Street (East)	Left	F	> 70.5	631.5	F	> 70.5	217.2
	Through	F	> 70.5		F	> 70.5	
	Right	F	> 70.5		F	> 70.5	
Menangle Road (North)	Left	A	6.6	1.4	A	5.6	28.2
	Through	A	1.7		A	0.9	
	Right	A	6.6		A	5.7	
Woodbridge Road (West)	Left	B	15.8	9.4	A	10.9	21.5
	Through	B	25.7		C	33.9	
	Right	C	38.0		C	34.3	

As can be seen from the table above, a further 10 years of background traffic growth to the intersection would cause Woodbridge Road movements to increase in average vehicle delay, and all Station Street movements increase to LoS 'F'.

It is evident that some intersection upgrades or capacity improvements are required at the intersection following completion of the neighbourhood centre (and the proposed development) in order to accommodate future traffic movements through Menangle.

7. Menangle Road / Station Street Intersection

7.1 Intersection Upgrade

As discussed in Section 6.6.4 of this report, the intersection of Menangle Road / Station Street is expected to approach capacity by 2022 following the completion of Stages 2-4 of the residential subdivision, given the assumptions listed in the sections above.

Preliminary intersection modelling has been undertaken based on the 2032 projected traffic volumes, and it was found that there are a number of intersection layouts/options that may be implemented at the intersection to allow for improved vehicle delay times, shorter queue lengths and overall better levels of service.

Further investigation is required to establish exactly what degree of expansion and/or upgrading is necessary at the intersection in order to accommodate the future development within the area.

7.2 Intersection Upgrade – Traffic Signals

RMS' *Traffic Signal Design Section 2 – Warrants* lists five warrants that would typically allow consideration for an intersection to be upgraded to a signalised intersection. Two of the warrants involve traffic volumes, two involve pedestrian volumes, and the fifth involves crash history.

By way of summary, the intersection with its projected 2032 volumes is not expected to satisfy any of these warrant conditions, and accordingly it is not anticipated that the intersection would be required to be upgraded to a signalised intersection as a result of the proposed development.

8. Conclusion

Stantec has been asked by Mirvac Homes to undertake an assessment of the proposed residential subdivision in Menangle, NSW.

Turning movement count results from Thursday 3 May 2018 revealed that each intersection currently experiences a relatively low level of traffic during these peak hours, and SIDRA analysis suggests that the intersection operates at a very good level of service ‘B’ in both the weekday AM and PM peak hours.

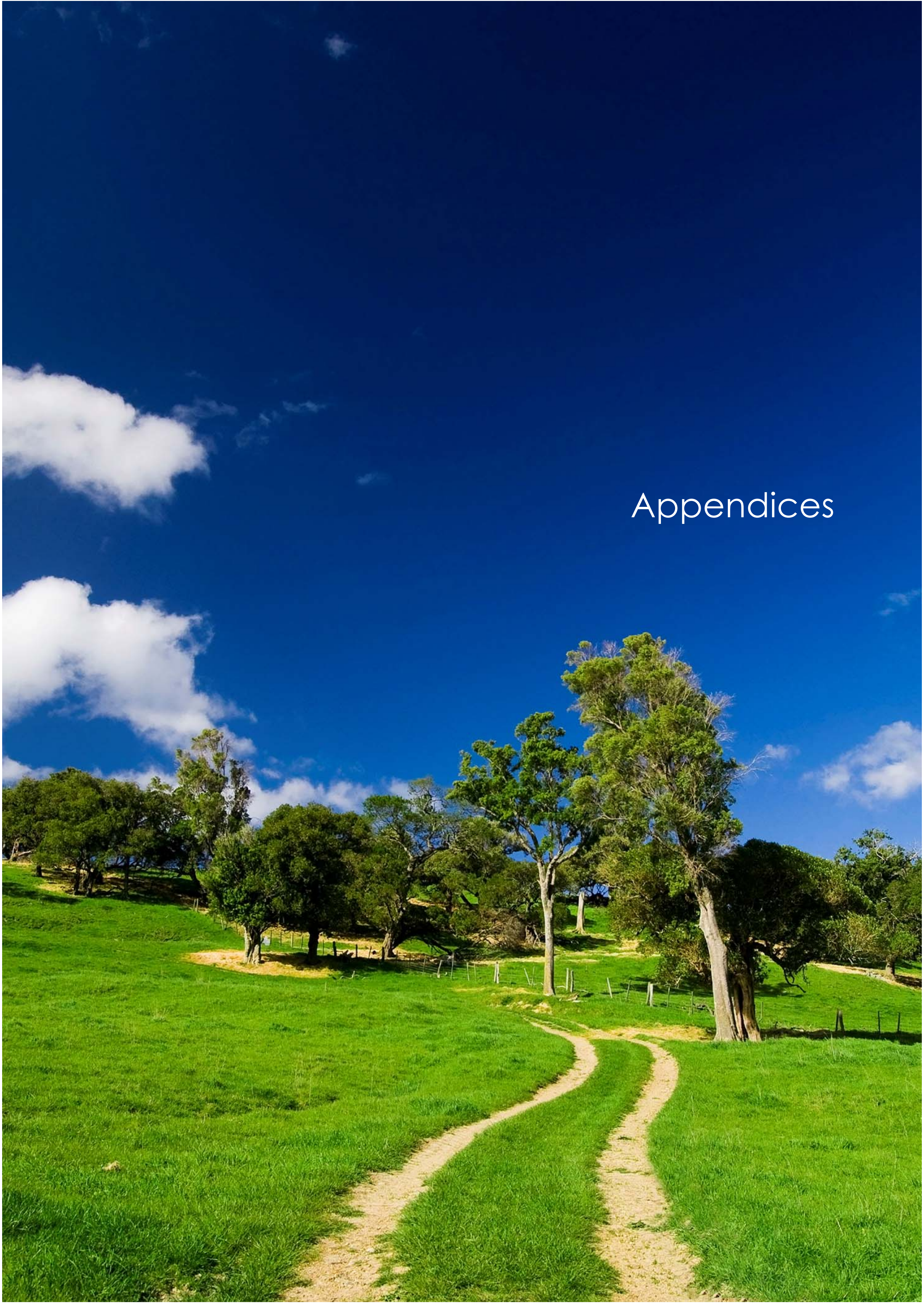
The proposed 97-lot residential subdivision is expected to generate in the order of 69 vph and 76 vph during the AM and PM peak hours, respectively.

With the addition of this traffic to the existing intersection operations, and allowing for an annual growth rate of 2%, it was found that all the intersection could be expected to remain operating at a very good LoS ‘B’ following completion of the subdivision. The intersection LoS increased to ‘C’ with the addition of the neighbourhood centre.

The consideration of the traffic associated with Stages 2-4 of the residential subdivision on the eastern side of the rail line results in an increased LoS of ‘F’ in the AM peak hour and ‘D’ in the PM peak hour.

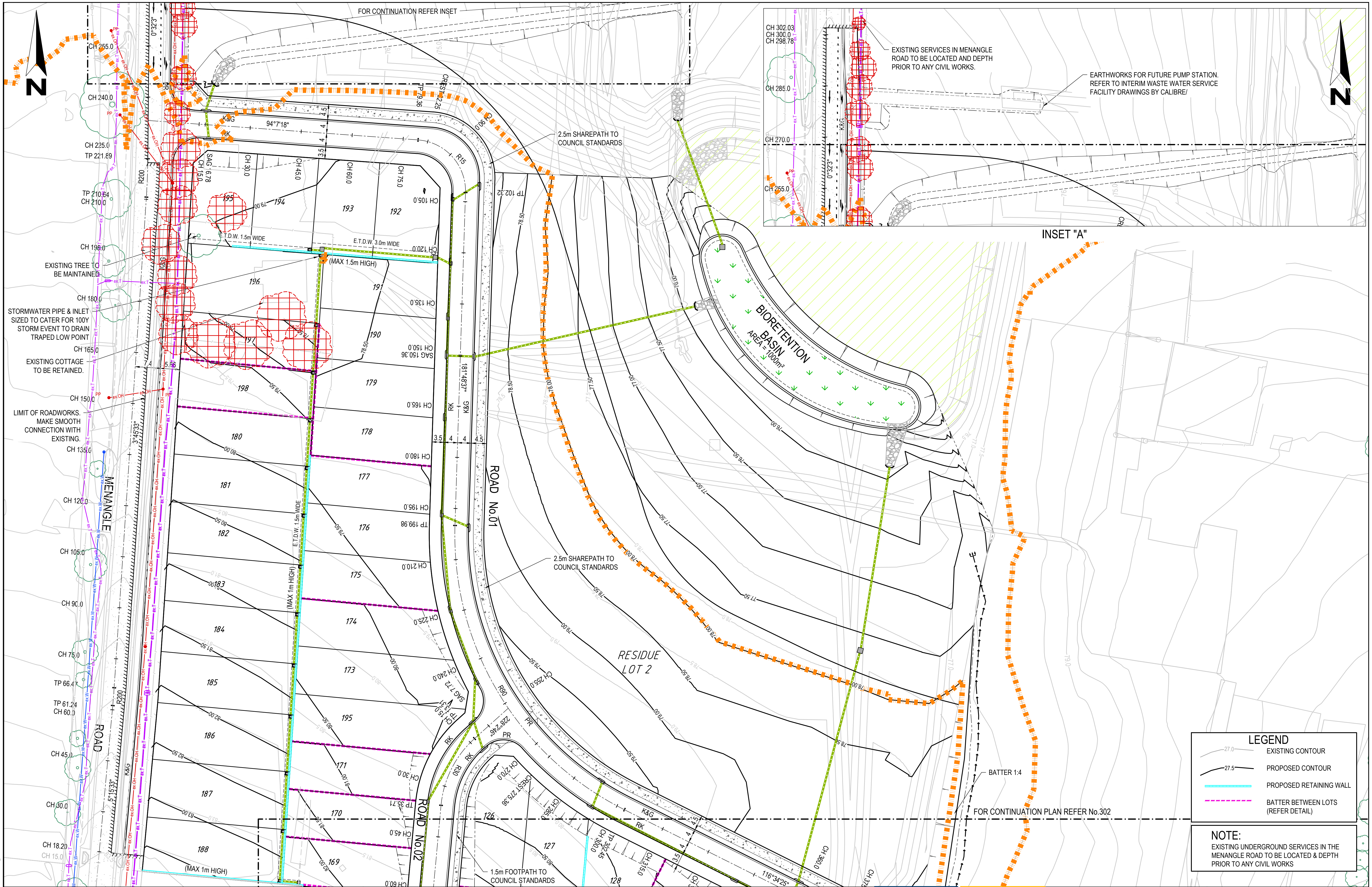
The intersection of Menangle Road / Station Street is expected to approach capacity by 2022, during construction of Stages 2-4 of the residential subdivision. The intersection would require upgrading around this time in order to maintain acceptable levels of service at the intersection. Further investigation is required in order to establish what the appropriate type of intersection upgrade would be to accommodate the projected future traffic volumes.

It is therefore concluded that Stage 1 of the proposed residential subdivision would not be expected to have any adverse impacts on the surrounding road network, and that there are no traffic engineering reasons that would preclude the proposed development to proceed.



Appendices

Appendix A Civil Plans



FIRST ISSUE		DESIGN	DRAWN	CHECK	APPD	DATE	AMENDMENT DETAILS
A	1	LF	VS	MC	JM	20/08/2018	ISSUE FOR DEVELOPMENT APPLICATION
A	1	LF	JS	EF	JM	23/01/2019	ISSUE FOR DEVELOPMENT APPLICATION
A	2	LF	BM	EF	JM	21/02/2019	ISSUE TO SUIT CLIENT COMMENTS

STATUS
ISSUED FOR DEVELOPMENT APPLICATION

AUTHORISED FOR ISSUE:
BY: JOSEPH MEKARY
BE (Civil) MIEAust. MBA MPM JP
SIGN:
DATE: 21/02/19

SCALE
0 5 10 15 20 25 30 35 40
SCALE 1:500 (A1) SCALE 1:1000 (A3)

CLIENT
mirvac

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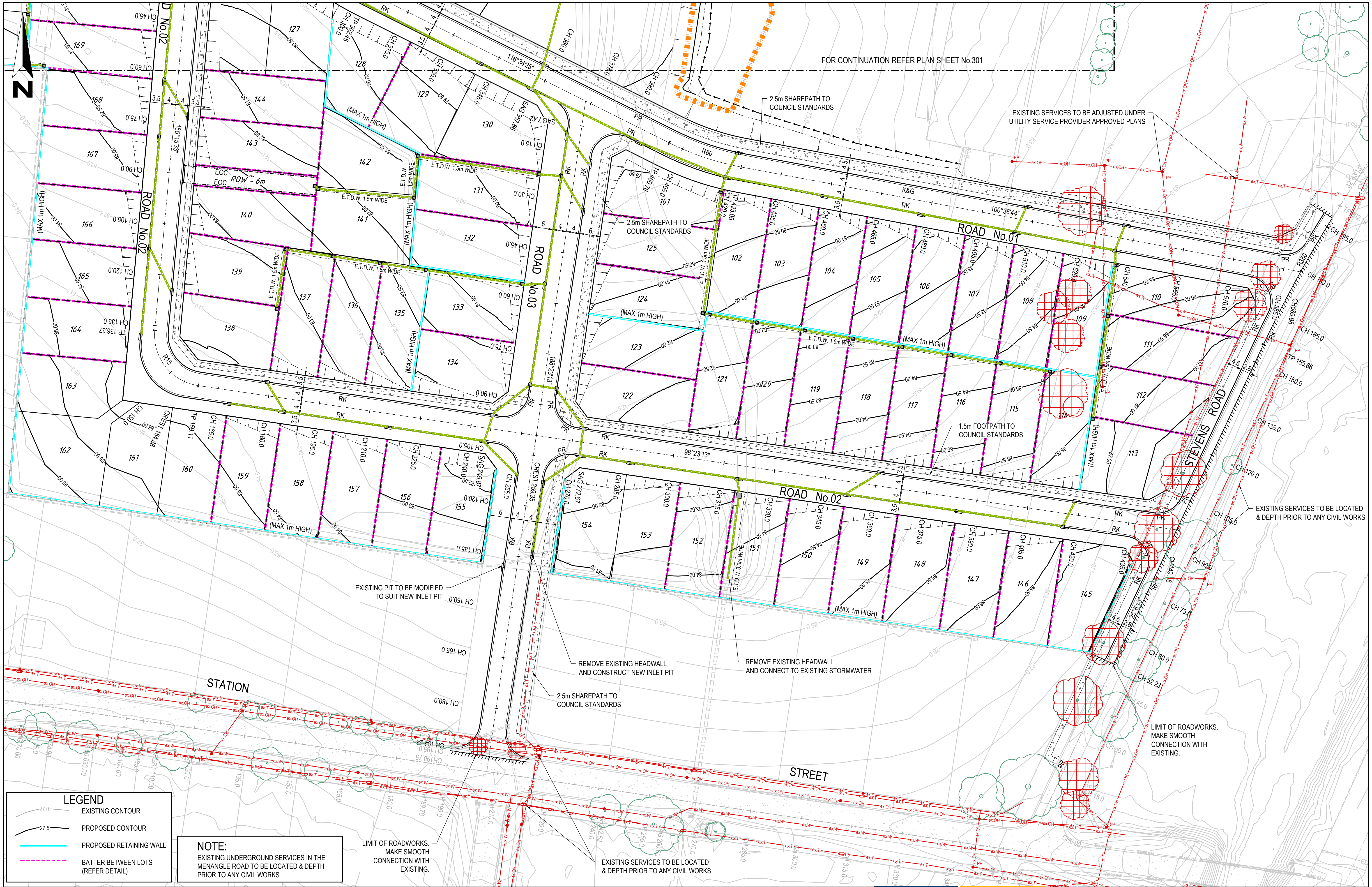
PROJECT
STATION ST, MENANGLE - STAGE 1
ROAD & DRAINAGE

DISCLAIMER
ALL DIMENSIONS TO BE CHECKED ON SITE BY CONTRACTOR PRIOR TO CONSTRUCTION. USE WRITTEN DIMENSIONS ONLY, DO NOT SCALE. NOT FOR CONSTRUCTION UNLESS STAMPED BY CERTIFYING AUTHORITY

DRAWING TITLE
ENGINEERING PLANS 01 OF 02

PROJECT No.	DRAWING No.	MILESTONE	REVISION
17-003293-01	301	DA	2

FILE: H:\17\17-003293 - STATION ST MENANGLE - UD\06_MODEL\AUTOCAD\CIVIL\STAGE 1\DA\ROAD & DRAINAGE\17-003293-01-UD-DA-301.DWG LAST SAVED BY:VISH KULKARNI



LEGEND

27.0	EXISTING CONTOUR
27.5	PROPOSED CONTOUR
	PROPOSED RETAINING WALL
	BATTER BETWEEN LOTS (REFER DETAIL)

NOTE:

EXISTING UNDERGROUND SERVICES IN THE MENANGLE ROAD TO BE LOCATED & DEPTH PRIOR TO ANY CIVIL WORKS

FILE: H:\17\17-003293 - STATION ST MENANGLE - UD\06_MODEL\AUTOCAD\CIVIL\STAGE 1\DA\ROAD & DRAINAGE\17-003293-01-UD-DA-302.DWG LAST SAVED BY:VIDHI KULKARNI

	DESIGN	DRAWN	CHECK	APPD	DATE	AMENDMENT DETAILS
FIRST ISSUE	LF	VS	MC	JM	20/08/2018	
1	LF	JS	EF	JM	23/01/2019	ISSUE FOR DEVELOPMENT APPLICATION
2	LF	BM	EF	JM	21/02/2019	ISSUE TO SUIT CLIENT COMMENTS

STATUS
ISSUED FOR DEVELOPMENT APPLICATION

AUTHORISED FOR ISSUE:
BY: JOSEPH MEKARY
BE (Civil) MIEAust. MBA MPM JP
SIGN:
DATE: 21/02/19

SCALE
0 5 10 15 20 25 30 35 40
SCALE 1:500 (A1) SCALE 1:1000 (A3)

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PROJECT
STATION ST, MENANGLE - STAGE 1
ROAD & DRAINAGE

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DRAWING TITLE
ENGINEERING PLANS 02 OF 02

PROJECT No.	DRAWING No.	MILESTONE	REVISION
17-003293-01	302	DA	2

Appendix B Traffic Survey Results

TRANS TRAFFIC SURVEY

TURNING MOVEMENT SURVEY

trafficsurvey.com.au

Intersection of Mengangle Rd and Station St, Menangle

Date:	Thu 03/05/18
Weather:	Fine
Suburban:	Menangle
Customer:	TDG

North:	Mengangle Rd
East:	Station St
South:	Mengangle Rd
West:	Woolbridge Rd

Survey Start	AM:	7:00	PM:	16:00
Vehicular Peakhour		**Pedestrians Peakhour**		
AM:	7:30 AM-8:30 AM	AM:	N/A	
PM:	4:30 PM-5:30 PM	PM:	N/A	

All Vehicles

Time		**North Approach Mengangle Rd**				**East Approach Station St**				**South Approach Mengangle Rd**				**West Approach Woolbridge Rd**				**Hourly Total**	
Period Start	**Period End**	**U**	**R**	**SB**	**L**	**U**	**R**	**WB**	**L**	**U**	**R**	**NB**	**L**	**U**	**R**	**EB**	**L**	**Hour**	**Peak**
7:00	7:15	0	23	16	1	0	4	0	1	0	1	42	4	0	1	1	75	809	
7:15	7:30	0	15	10	1	0	4	4	1	0	1	51	2	0	0	0	71	904	
7:30	7:45	0	24	13	2	0	5	2	0	0	0	66	5	0	0	0	101	1015	Peak
7:45	8:00	0	25	22	3	0	4	2	0	0	1	81	3	0	3	1	117	1014	
8:00	8:15	0	26	19	2	0	6	4	4	0	3	86	1	0	0	2	111	893	
8:15	8:30	0	46	34	2	0	8	4	2	0	0	68	3	0	1	3	100	775	
8:30	8:45	0	45	24	3	0	7	1	0	0	1	59	2	0	1	4	70	646	
8:45	9:00	0	30	13	1	0	5	0	2	0	2	45	3	0	3	2	35	552	
9:00	9:15	0	24	19	5	0	4	2	0	0	3	41	5	0	2	1	40	514	
9:15	9:30	0	20	15	4	0	2	2	0	0	1	42	3	0	4	3	46		
9:30	9:45	0	20	21	2	0	4	5	1	0	1	39	3	0	3	1	23		
9:45	10:00	0	16	14	2	0	2	1	0	0	0	32	3	0	2	3	28		
16:00	16:15	0	69	46	7	0	3	4	2	0	0	25	3	0	3	2	35	848	
16:15	16:30	0	75	56	6	0	3	5	0	0	1	31	1	0	2	0	32	871	
16:30	16:45	0	68	57	5	0	2	2	0	0	1	45	5	0	3	2	42	891	Peak
16:45	17:00	0	70	52	4	0	1	0	1	0	1	25	1	0	0	2	48	878	
17:00	17:15	0	70	75	4	0	2	10	2	0	2	25	1	0	1	1	29	884	
17:15	17:30	0	77	75	9	0	3	1	0	0	0	25	2	0	2	0	38	825	
17:30	17:45	0	55	72	6	0	3	1	2	0	1	30	2	0	2	0	45	748	
17:45	18:00	0	72	55	6	0	4	0	0	0	0	33	3	0	3	0	35	659	
18:00	18:15	0	64	40	6	0	1	3	1	0	1	18	5	0	3	0	21	565	
18:15	18:30	0	70	41	7	0	3	0	0	0	0	16	1	0	0	0	17		
18:30	18:45	0	46	35	3	0	1	1	0	0	0	18	1	0	2	0	23		
18:45	19:00	0	37	31	3	0	1	1	0	0	0	16	1	0	6	2	19		

Peak Time		**North Approach Mengangle Rd**				**East Approach Station St**				**South Approach Mengangle Rd**				**West Approach Woolbridge Rd**				**Peak**
Period Start	**Period End**	U	R	SB	L	U	R	WB	L	U	R	NB	L	U	R	EB	L	**total**
7:30	8:30	0	121	88	9	0	23	12	6	0	4	301	12	0	4	6	429	1015
16:30	17:30	0	285	259	22	0	8	13	3	0	4	120	9	0	6	5	157	891

Appendix C SIDRA Movement Summaries

MOVEMENT SUMMARY

Site: 101v [Menangle Road - Station Street - Existing - AM Peak]

Menangle Road / Station Street
Existing AM Peak - Priority Controlled
7:30am - 8:30am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	13	0.0	0.160	4.7	LOS A	0.0	0.3	0.01	0.03	49.3
2	T1	317	2.3	0.160	0.0	LOS A	0.0	0.3	0.01	0.03	49.8
3	R2	4	0.0	0.160	4.9	LOS A	0.0	0.3	0.01	0.03	49.3
Approach		334	2.2	0.160	0.2	NA	0.0	0.3	0.01	0.03	49.8
East: Station Street											
4	L2	6	0.0	0.117	7.8	LOS A	0.4	2.6	0.52	0.95	41.5
5	T1	13	0.0	0.117	10.9	LOS A	0.4	2.6	0.52	0.95	41.5
6	R2	24	0.0	0.117	19.4	LOS B	0.4	2.6	0.52	0.95	41.5
Approach		43	0.0	0.117	15.2	LOS B	0.4	2.6	0.52	0.95	41.5
North: Menangle Road											
7	L2	9	11.1	0.148	5.9	LOS A	0.8	5.6	0.41	0.36	46.5
8	T1	93	8.0	0.148	1.1	LOS A	0.8	5.6	0.41	0.36	47.1
9	R2	127	0.8	0.148	5.9	LOS A	0.8	5.6	0.41	0.36	46.6
Approach		229	4.1	0.148	3.9	NA	0.8	5.6	0.41	0.36	46.8
West: Woodbridge Road											
10	L2	452	1.6	0.461	10.3	LOS A	3.2	22.6	0.54	0.99	44.0
11	T1	6	0.0	0.461	13.5	LOS A	3.2	22.6	0.54	0.99	43.9
12	R2	4	25.0	0.461	18.4	LOS B	3.2	22.6	0.54	0.99	43.7
Approach		462	1.8	0.461	10.4	LOS A	3.2	22.6	0.54	0.99	44.0
All Vehicles		1068	2.4	0.461	6.1	NA	3.2	22.6	0.35	0.55	46.1

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Existing - PM Peak]

Menangle Road / Station Street
Existing PM Peak - Priority Controlled
4:30pm - 5:30pm
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	9	0.0	0.068	4.9	LOS A	0.0	0.3	0.04	0.05	49.1
2	T1	126	0.8	0.068	0.1	LOS A	0.0	0.3	0.04	0.05	49.6
3	R2	4	0.0	0.068	5.6	LOS A	0.0	0.3	0.04	0.05	49.1
Approach		140	0.8	0.068	0.5	NA	0.0	0.3	0.04	0.05	49.5
East: Station Street											
4	L2	3	0.0	0.063	8.6	LOS A	0.2	1.5	0.62	0.97	42.1
5	T1	14	0.0	0.063	12.9	LOS A	0.2	1.5	0.62	0.97	42.0
6	R2	8	12.5	0.063	19.3	LOS B	0.2	1.5	0.62	0.97	41.9
Approach		25	4.2	0.063	14.5	LOS A	0.2	1.5	0.62	0.97	42.0
North: Menangle Road											
7	L2	23	0.0	0.332	5.1	LOS A	2.0	14.0	0.28	0.29	47.2
8	T1	273	1.9	0.332	0.5	LOS A	2.0	14.0	0.28	0.29	47.6
9	R2	300	0.0	0.332	5.2	LOS A	2.0	14.0	0.28	0.29	47.1
Approach		596	0.9	0.332	3.0	NA	2.0	14.0	0.28	0.29	47.3
West: Woodbridge Road											
10	L2	165	0.6	0.157	8.0	LOS A	0.7	4.6	0.25	0.89	44.7
11	T1	5	0.0	0.157	14.0	LOS A	0.7	4.6	0.25	0.89	44.6
12	R2	6	0.0	0.157	15.6	LOS B	0.7	4.6	0.25	0.89	44.7
Approach		177	0.6	0.157	8.4	LOS A	0.7	4.6	0.25	0.89	44.7
All Vehicles		938	0.9	0.332	4.0	NA	2.0	14.0	0.25	0.38	47.0

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2020 - AM Peak]

Menangle Road / Station Street
Future 2020 AM Peak - Priority Controlled
7:30am - 8:30am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Menangle Road											
1	L2	14	0.0	0.172	4.8	LOS A	0.1	0.6	0.02	0.04	49.2
2	T1	333	2.2	0.172	0.0	LOS A	0.1	0.6	0.02	0.04	49.7
3	R2	9	0.0	0.172	5.0	LOS A	0.1	0.6	0.02	0.04	49.2
Approach		356	2.1	0.172	0.3	NA	0.1	0.6	0.02	0.04	49.7
East: Station Street											
4	L2	20	0.0	0.278	8.8	LOS A	1.0	7.1	0.55	0.97	40.2
5	T1	17	0.0	0.278	12.6	LOS A	1.0	7.1	0.55	0.97	40.2
6	R2	55	0.0	0.278	23.2	LOS B	1.0	7.1	0.55	0.97	40.2
Approach		92	0.0	0.278	18.1	LOS B	1.0	7.1	0.55	0.97	40.2
North: Menangle Road											
7	L2	11	10.0	0.164	6.0	LOS A	0.9	6.3	0.42	0.35	46.6
8	T1	106	7.9	0.164	1.2	LOS A	0.9	6.3	0.42	0.35	47.1
9	R2	136	0.8	0.164	6.0	LOS A	0.9	6.3	0.42	0.35	46.6
Approach		253	4.2	0.164	4.0	NA	0.9	6.3	0.42	0.35	46.8
West: Woodbridge Road											
10	L2	475	1.6	0.505	10.8	LOS A	3.8	27.0	0.57	1.03	43.7
11	T1	13	0.0	0.505	14.7	LOS B	3.8	27.0	0.57	1.03	43.7
12	R2	4	25.0	0.505	20.7	LOS B	3.8	27.0	0.57	1.03	43.4
Approach		492	1.7	0.505	11.0	LOS A	3.8	27.0	0.57	1.03	43.7
All Vehicles		1192	2.2	0.505	6.9	NA	3.8	27.0	0.37	0.58	45.7

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2020 - PM Peak]

Menangle Road / Station Street
Future 2020 PM Peak - Priority Controlled
4:30pm - 5:30pm
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	9	0.0	0.076	5.3	LOS A	0.1	0.8	0.09	0.07	48.8
2	T1	133	0.8	0.076	0.1	LOS A	0.1	0.8	0.09	0.07	49.3
3	R2	12	0.0	0.076	5.7	LOS A	0.1	0.8	0.09	0.07	48.8
Approach		154	0.7	0.076	0.9	NA	0.1	0.8	0.09	0.07	49.2
East: Station Street											
4	L2	8	0.0	0.123	8.7	LOS A	0.4	2.9	0.65	0.96	41.3
5	T1	16	0.0	0.123	13.8	LOS A	0.4	2.9	0.65	0.96	41.3
6	R2	19	11.1	0.123	21.3	LOS B	0.4	2.9	0.65	0.96	41.2
Approach		43	4.9	0.123	16.1	LOS B	0.4	2.9	0.65	0.96	41.2
North: Menangle Road											
7	L2	24	0.0	0.353	5.2	LOS A	2.2	15.2	0.30	0.29	47.2
8	T1	292	1.8	0.353	0.5	LOS A	2.2	15.2	0.30	0.29	47.6
9	R2	317	0.0	0.353	5.2	LOS A	2.2	15.2	0.30	0.29	47.1
Approach		633	0.8	0.353	3.0	NA	2.2	15.2	0.30	0.29	47.3
West: Woodbridge Road											
10	L2	174	0.6	0.187	8.0	LOS A	0.8	5.5	0.27	0.89	44.5
11	T1	14	0.0	0.187	15.1	LOS B	0.8	5.5	0.27	0.89	44.5
12	R2	6	0.0	0.187	16.9	LOS B	0.8	5.5	0.27	0.89	44.5
Approach		194	0.5	0.187	8.8	LOS A	0.8	5.5	0.27	0.89	44.5
All Vehicles		1023	0.9	0.353	4.4	NA	2.2	15.2	0.28	0.40	46.8

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2021 - AM Peak - With NC]

Menangle Road / Station Street
Future 2021 AM Peak with NC - Priority Controlled
7:30am - 8:30am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	14	0.0	0.196	5.0	LOS A	0.4	2.7	0.08	0.08	48.8
2	T1	336	2.2	0.196	0.1	LOS A	0.4	2.7	0.08	0.08	49.3
3	R2	44	0.0	0.196	5.1	LOS A	0.4	2.7	0.08	0.08	48.8
Approach		394	1.9	0.196	0.8	NA	0.4	2.7	0.08	0.08	49.2
East: Station Street											
4	L2	29	0.0	0.516	12.7	LOS A	2.3	16.2	0.66	1.06	37.4
5	T1	20	0.0	0.516	17.5	LOS B	2.3	16.2	0.66	1.06	37.4
6	R2	95	0.0	0.516	30.6	LOS C	2.3	16.2	0.66	1.06	37.4
Approach		144	0.0	0.516	25.1	LOS B	2.3	16.2	0.66	1.06	37.4
North: Menangle Road											
7	L2	20	10.5	0.178	6.0	LOS A	0.9	6.9	0.42	0.34	46.5
8	T1	117	8.1	0.178	1.2	LOS A	0.9	6.9	0.42	0.34	47.1
9	R2	140	0.8	0.178	6.0	LOS A	0.9	6.9	0.42	0.34	46.6
Approach		277	4.6	0.178	4.0	NA	0.9	6.9	0.42	0.34	46.8
West: Woodbridge Road											
10	L2	479	1.5	0.534	11.1	LOS A	4.2	30.1	0.59	1.05	43.5
11	T1	23	0.0	0.534	16.2	LOS B	4.2	30.1	0.59	1.05	43.4
12	R2	4	25.0	0.534	23.3	LOS B	4.2	30.1	0.59	1.05	43.2
Approach		506	1.7	0.534	11.5	LOS A	4.2	30.1	0.59	1.05	43.5
All Vehicles		1321	2.2	0.534	8.2	NA	4.2	30.1	0.41	0.61	44.9

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2021 - PM Peak - With NC]

Menangle Road / Station Street
Future 2021 PM Peak with NC - Priority Controlled
4:30pm - 5:30pm
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	11	0.0	0.140	5.8	LOS A	0.7	4.8	0.35	0.25	47.3
2	T1	134	0.8	0.140	0.8	LOS A	0.7	4.8	0.35	0.25	47.7
3	R2	93	0.0	0.140	5.8	LOS A	0.7	4.8	0.35	0.25	47.3
Approach		237	0.4	0.140	3.0	NA	0.7	4.8	0.35	0.25	47.5
East: Station Street											
4	L2	18	0.0	0.393	11.8	LOS A	1.5	11.2	0.78	1.06	37.9
5	T1	19	0.0	0.393	19.1	LOS B	1.5	11.2	0.78	1.06	37.8
6	R2	62	11.9	0.393	29.8	LOS C	1.5	11.2	0.78	1.06	37.7
Approach		99	7.4	0.393	24.5	LOS B	1.5	11.2	0.78	1.06	37.8
North: Menangle Road											
7	L2	25	0.0	0.364	5.2	LOS A	2.2	15.8	0.30	0.28	47.2
8	T1	304	2.1	0.364	0.5	LOS A	2.2	15.8	0.30	0.28	47.6
9	R2	322	0.0	0.364	5.2	LOS A	2.2	15.8	0.30	0.28	47.1
Approach		652	1.0	0.364	3.0	NA	2.2	15.8	0.30	0.28	47.3
West: Woodbridge Road											
10	L2	176	0.6	0.255	8.1	LOS A	1.0	7.3	0.30	0.89	44.0
11	T1	35	0.0	0.255	17.3	LOS B	1.0	7.3	0.30	0.89	43.9
12	R2	6	0.0	0.255	19.9	LOS B	1.0	7.3	0.30	0.89	44.0
Approach		217	0.5	0.255	9.9	LOS A	1.0	7.3	0.30	0.89	44.0
All Vehicles		1204	1.3	0.393	6.0	NA	2.2	15.8	0.35	0.45	45.8

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2022 - AM Peak]

Menangle Road / Station Street
Future 2022 AM Peak - Priority Controlled
7:30am - 8:30am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	14	0.0	0.209	5.1	LOS A	0.5	3.3	0.11	0.09	48.7
2	T1	346	2.4	0.209	0.1	LOS A	0.5	3.3	0.11	0.09	49.2
3	R2	55	0.0	0.209	5.2	LOS A	0.5	3.3	0.11	0.09	48.7
Approach		415	2.0	0.209	1.0	NA	0.5	3.3	0.11	0.09	49.1
East: Station Street											
4	L2	72	0.0	1.109	142.2	LOS F	30.0	209.8	1.00	2.79	15.5
5	T1	32	0.0	1.109	149.8	LOS F	30.0	209.8	1.00	2.79	15.5
6	R2	186	0.0	1.109	170.4	LOS F	30.0	209.8	1.00	2.79	15.5
Approach		289	0.0	1.109	161.2	LOS F	30.0	209.8	1.00	2.79	15.5
North: Menangle Road											
7	L2	43	12.2	0.196	6.1	LOS A	1.1	7.8	0.43	0.35	46.4
8	T1	120	7.9	0.196	1.2	LOS A	1.1	7.8	0.43	0.35	47.0
9	R2	144	0.7	0.196	6.1	LOS A	1.1	7.8	0.43	0.35	46.5
Approach		307	5.1	0.196	4.2	NA	1.1	7.8	0.43	0.35	46.7
West: Woodbridge Road											
10	L2	494	1.7	0.565	11.6	LOS A	4.8	33.8	0.61	1.09	43.2
11	T1	25	0.0	0.565	17.7	LOS B	4.8	33.8	0.61	1.09	43.2
12	R2	4	25.0	0.565	26.8	LOS B	4.8	33.8	0.61	1.09	42.9
Approach		523	1.8	0.565	12.0	LOS A	4.8	33.8	0.61	1.09	43.2
All Vehicles		1535	2.2	1.109	35.6	NA	30.0	209.8	0.51	0.99	33.5

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2022 - PM Peak]

Menangle Road / Station Street
Future 2022 PM Peak - Priority Controlled
4:30pm - 5:30pm
Stop (Two-Way)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	11	0.0	0.184	6.4	LOS A	1.0	7.0	0.46	0.32	46.8
2	T1	138	0.8	0.184	1.5	LOS A	1.0	7.0	0.46	0.32	47.3
3	R2	133	0.0	0.184	6.4	LOS A	1.0	7.0	0.46	0.32	46.8
Approach		281	0.4	0.184	4.0	NA	1.0	7.0	0.46	0.32	47.0
East: Station Street											
4	L2	36	0.0	0.785	29.9	LOS C	4.5	34.0	0.88	1.37	30.5
5	T1	23	0.0	0.785	40.6	LOS C	4.5	34.0	0.88	1.37	30.5
6	R2	99	12.8	0.785	56.4	LOS D	4.5	34.0	0.88	1.37	30.4
Approach		158	8.0	0.785	48.1	LOS D	4.5	34.0	0.88	1.37	30.4
North: Menangle Road											
7	L2	113	0.0	0.419	5.2	LOS A	2.8	19.5	0.32	0.30	47.0
8	T1	314	2.0	0.419	0.6	LOS A	2.8	19.5	0.32	0.30	47.4
9	R2	333	0.0	0.419	5.3	LOS A	2.8	19.5	0.32	0.30	46.9
Approach		759	0.8	0.419	3.3	NA	2.8	19.5	0.32	0.30	47.1
West: Woodbridge Road											
10	L2	181	0.6	0.341	8.5	LOS A	1.5	10.8	0.34	0.91	43.1
11	T1	46	0.0	0.341	22.3	LOS B	1.5	10.8	0.34	0.91	43.0
12	R2	7	0.0	0.341	23.1	LOS B	1.5	10.8	0.34	0.91	43.1
Approach		235	0.4	0.341	11.7	LOS A	1.5	10.8	0.34	0.91	43.1
All Vehicles		1433	1.5	0.785	9.8	NA	4.5	34.0	0.41	0.52	43.8

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2032 - AM Peak]

Menangle Road / Station Street
Future 2032 AM Peak - Priority Controlled
7:30am - 8:30am
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	17	0.0	0.248	5.3	LOS A	0.5	3.7	0.11	0.08	48.8
2	T1	422	2.2	0.248	0.1	LOS A	0.5	3.7	0.11	0.08	49.2
3	R2	56	0.0	0.248	5.4	LOS A	0.5	3.7	0.11	0.08	48.7
Approach		495	1.9	0.248	0.9	NA	0.5	3.7	0.11	0.08	49.2
East: Station Street											
4	L2	73	0.0	1.773	718.9	LOS F	90.2	631.5	1.00	5.46	4.5
5	T1	35	0.0	1.773	724.1	LOS F	90.2	631.5	1.00	5.46	4.5
6	R2	193	0.0	1.773	742.5	LOS F	90.2	631.5	1.00	5.46	4.5
Approach		300	0.0	1.773	734.6	LOS F	90.2	631.5	1.00	5.46	4.5
North: Menangle Road											
7	L2	45	11.6	0.245	6.6	LOS A	1.4	10.3	0.50	0.38	46.3
8	T1	142	8.1	0.245	1.7	LOS A	1.4	10.3	0.50	0.38	46.9
9	R2	175	0.6	0.245	6.6	LOS A	1.4	10.3	0.50	0.38	46.4
Approach		362	4.9	0.245	4.7	NA	1.4	10.3	0.50	0.38	46.6
West: Woodbridge Road											
10	L2	602	1.6	0.761	15.8	LOS B	9.4	66.6	0.77	1.41	41.3
11	T1	27	0.0	0.761	25.7	LOS B	9.4	66.6	0.77	1.41	41.2
12	R2	5	20.0	0.761	38.0	LOS C	9.4	66.6	0.77	1.41	41.0
Approach		635	1.7	0.761	16.4	LOS B	9.4	66.6	0.77	1.41	41.3
All Vehicles		1792	2.1	1.773	130.0	NA	90.2	631.5	0.57	1.51	17.8

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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: 101v [Menangle Road - Station Street - Future 2032 - PM Peak]

Menangle Road / Station Street
Future 2032 PM Peak - Priority Controlled
4:30pm - 5:30pm
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand 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 per veh	Average Speed km/h
South: Menangle Road											
1	L2	13	0.0	0.211	6.9	LOS A	1.2	8.2	0.48	0.31	46.8
2	T1	168	0.6	0.211	1.8	LOS A	1.2	8.2	0.48	0.31	47.3
3	R2	134	0.0	0.211	6.9	LOS A	1.2	8.2	0.48	0.31	46.8
Approach		315	0.3	0.211	4.2	NA	1.2	8.2	0.48	0.31	47.1
East: Station Street											
4	L2	36	0.0	1.287	304.8	LOS F	29.1	217.2	1.00	3.39	9.0
5	T1	27	0.0	1.287	318.0	LOS F	29.1	217.2	1.00	3.39	9.0
6	R2	101	12.5	1.287	339.5	LOS F	29.1	217.2	1.00	3.39	9.0
Approach		164	7.7	1.287	328.4	LOS F	29.1	217.2	1.00	3.39	9.0
North: Menangle Road											
7	L2	119	0.0	0.507	5.6	LOS A	4.0	28.2	0.40	0.30	46.8
8	T1	379	1.9	0.507	0.9	LOS A	4.0	28.2	0.40	0.30	47.2
9	R2	404	0.0	0.507	5.7	LOS A	4.0	28.2	0.40	0.30	46.7
Approach		902	0.8	0.507	3.7	NA	4.0	28.2	0.40	0.30	46.9
West: Woodbridge Road											
10	L2	220	0.5	0.483	10.9	LOS A	3.1	21.5	0.43	0.98	41.3
11	T1	47	0.0	0.483	33.9	LOS C	3.1	21.5	0.43	0.98	41.2
12	R2	8	0.0	0.483	34.3	LOS C	3.1	21.5	0.43	0.98	41.3
Approach		276	0.4	0.483	15.6	LOS B	3.1	21.5	0.43	0.98	41.3
All Vehicles		1657	1.3	1.287	37.9	NA	29.1	217.2	0.48	0.72	32.6

Site Level of Service (LOS) Method: Delay (RTA NSW). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road 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 D Concepts of Level of Service and Delay

Concepts of Carriageway Capacity and Level of Service

The capacity of major streets within an urban area can be based on an assessment of their operating Level of Service.

Level of service is defined within Austroads' *Guide to Traffic Management Part 3: Traffic Studies and Analysis* as:

'… a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level of service definition generally describes these conditions in terms of factors such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and safety.'

Levels of service (LoS) are designated from 'A' to 'F' from best (free flow conditions) to worst (forced flow with stop start operation, long queues and delays) as follows:

LEVELS OF SERVICE

A - Free flow (almost no delays)

B - Stable flow (slight delays)

C - Stable flow (acceptable delays)

D - Approaching unstable flow (tolerable delays)

E - Unstable flow (congestion; intolerable delays), and

F - Forced flow (jammed)

A service volume, as defined by Austroads, is the maximum number of vehicles that can pass over a given section of roadway in one direction during one hour while operating conditions are maintained at a specified level of service. It is suggested that ideally arterial and sub-arterial roads should not exceed service volumes at LoS 'C'. At this level, whilst most drivers are restricted in their freedom to manoeuvre, operating speeds are still reasonable and acceptable delays experienced. However, in urban situations, arterial and sub-arterial roads operating at LoS 'D' are still considered adequate. Traffic volumes along urban roads with interrupted and uninterrupted flow conditions are included in **Table D1** and **Table D2** respectively.

Table D1: Level of Service of Interrupted Flow Conditions along Urban Roads (One Way Hourly Volumes)

Reference	Description	Level of Service					
		A	B	C	D	E	F
2U	2 Lane Undivided	540	630	720	810	900	-
4UP	4 Lane Undivided with two parking lanes	540	630	720	810	900	-
4U	4 Lane Undivided with some parking	900	1050	1200	1350	1500	-
4UC	4 Lane Undivided with clearways	1080	1260	1440	1620	1800	-
4D	4 Lane Divided with clearways	1140	1330	1520	1710	1900	-
6U	6 Lane Undivided	1440	1680	1920	2160	2400	-
6D	6 Lane Divided with clearways	1740	2030	2320	2610	2900	-

Table D2: Level of Service of Uninterrupted Flow Conditions along Urban Roads (One Way Hourly Volumes)

Reference	Description	Level of Service					
		A	B	C	D	E	F
2U	2 Lane Undivided	760	880	1000	1130	1260	-
4UP	4 Lane Undivided with two parking lanes	1260	1470	1680	1890	2100	-
4U	4 Lane Undivided with some parking	1510	1760	2010	2270	2520	-
4UC	4 Lane Undivided with clearways	1600	1860	2130	2400	2660	-
4D	4 Lane Divided with clearways	2250	2620	3000	3380	3740	-
6U	6 Lane Undivided	2440	2840	3250	3660	4060	-
6D	6 Lane Divided with clearways	760	880	1000	1130	1260	-

Guidelines for Evaluation of Intersection Operation

The *RTA Guide to Traffic Generating Developments (October 2002, Issue 2.2)*, details the assessment of intersections. The assessment of the level of service of an intersection is based on the evaluation of the following Measures of Effectiveness:

(a) Average delay (seconds/veh) (all forms of control)

(b) Delay to critical movement (seconds/veh) (all forms of control)

(c) Degree of saturation (traffic signals and roundabouts)

(d) Cycle length (traffic signals)

SIDRA was used to calculate the relevant intersection parameters. The SIDRA software is an advanced lane-based micro-analytical tool for design and evaluation of individual intersections and networks of intersections including modelling of separate movement classes (light vehicles, heavy vehicles, buses, cyclists, large trucks, light rail / trams and so on). It provides estimates of capacity, level of service and a wide range of performance measures, including; delay, queue length and stops for vehicles and pedestrians, as well as fuel consumption, pollution emissions and operating costs.

It can be used to analyse signalised intersections (fixed-time / pretimed and actuated), signalised and unsignalised pedestrian crossings, roundabouts (unsignalised), roundabouts with metering signals, fully-signalised roundabouts, two-way stop sign and give-way / yield sign control, all-way stop sign control, single point interchanges (signalised), freeway diamond interchanges (signalised, roundabout, sign control), diverging diamond interchanges and other alternative intersections and interchanges. It can also be used for uninterrupted traffic flow conditions and merge analysis.

The best indicator of the level of service at an intersection is the average delay experienced by vehicles at that intersection. For traffic signals, the average delay over all movements should be taken. For roundabouts and priority control intersections (with Stop and Give Way signs or operating under the T-junction rule) the critical movement for level of service assessment should be that with the highest average delay.

With traffic signals, delays per approach tend to be equalised, subject to any over-riding requirements of signal co-ordination as well as to variations within individual movements. With roundabouts and priority - control intersections, the critical criterion for assessment is the movement with the highest delay per vehicle. With this type of control the volume balance might be such that some movements suffer high levels of delay while other movements have minimal delay. An overall average delay for the intersection of 25 seconds might not be satisfactory if the average delay on one movement is 60 seconds.

The average delay for LoS 'E' should be no more than 70 seconds. The accepted maximum practical cycle length for traffic signals under saturated conditions is 120 - 140 seconds. Under these conditions 120 seconds is near maximum for two and three phase intersections and 140 seconds near maximum for more complex phase designs. Drivers and pedestrians expect cycle lengths of these magnitudes and their inherent delays in peak hours. A cycle length of 140 seconds for an intersection which is almost saturated has an average vehicle delay of about 70 seconds, although this can vary. If the average vehicle delay is more than 70 seconds, the intersection is assumed to be at LoS 'F'.

Table C3 sets out average delays for different levels of service. There is no consistent correlation between definitions of levels of service for road links as defined elsewhere in this section, and the ranges set out in Table C3. In assigning a level of service, the average delay to the motoring public needs to be considered, keeping in mind the location of the intersection. For example, drivers in inner urban areas of Sydney have a higher tolerance of delay than drivers in country areas. Table C3 provides a recommended baseline for assessment.

Table D3: Level of Service Criteria for Intersections

Level of Service	Average Delay per Vehicle (sec/veh)	Traffic Signals	Priority Controlled
A	0 < x < 14	Good operation	Good operation
B	14 < x < 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	28 < x < 42	Satisfactory	Satisfactory, but crash history study required
D	42 < x < 56	Operating near capacity	Operating near capacity and crash history study required
E	56 < x	At capacity, incidents will cause excessive delays	At capacity, requires other control mode

The figures in Table D3 are intended as a guide only. Any particular assessment should take into account site-specific factors including maximum queue lengths (and their effect on lane blocking), the influence of nearby intersections and the sensitivity of the location to delays. In many situations, a comparison of the current and future average delay provides a better appreciation of the impact of a proposal, and not simply the change in the level of service.

The intersection degree of saturation (DoS) can also be used to measure the performance of isolated intersections. The DoS value can be determined by computer based assessment programs. At intersections controlled by traffic signals, both queue length and delays increase rapidly as DoS approaches 1.0. An upper limit of 0.900 is appropriate, however when DoS exceeds 0.850, overflow queues start to become a problem. Satisfactory intersection operation is generally achieved with a DoS of about 0.700 - 0.800. (Note that these figures are based on isolated signalised intersections with cycle lengths of 120 seconds. In co-ordinated signal systems DoS might be actively maximised at key intersections).

Although in some situations additional traffic does not alter the level of service, particularly where the level of service is 'E' or 'F', additional capacity may still be required. This is particularly appropriate for LoS 'F', where small increases in flow can cause disproportionately greater increases in delay. In this situation, it is advisable to consider means of control to maintain the existing level of absolute delay. Suggested criteria for the evaluation of the capacity of signalised intersections based on the DoS are summarised below in **Table D4**.

Table D4: Criteria for Evaluating Capacity of Signalised Intersections

Level of Service	Optimum Cycle Length (seconds)	Movement Degree of Saturation (DoS)	Intersection Degree of Saturation (DoS)
A – Very good	< 90	< 0.70	< 0.70
B – Good	< 90	< 0.70	< 0.70
C – Satisfactory	90 – 120	0.70 – 0.80	0.70 – 0.85
D - Poor	120 – 140	0.80 – 0.85	0.85 – 0.90
E/F – Extra capacity required	> 140	> 0.85	> 0.90

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