Camden Council

Leppington Town Centre and Precincts

Traffic Modelling Report

FINAL DRAFT

00 | 17 March 2022

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 273567

Arup Pty Ltd ABN 18 000 966 165

Arup
Level 5
151 Clarence Street
Sydney NSW 2000
Australia
www.arup.com

ARUP

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		Name	Nigel Chan	Stefan Ellis	
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		Name	Nigel Chan, Elliot Roberts	Stefan Ellis	
		Signature			
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List of Abbreviations

AADT : Annual Average Daily Traffic 33
DCP : Development Control Plan...22
DPIE : Department of Planning, Industry and Environment 1
GFA : Gross floor area..15
GLFA : Gross leasable floor area 16
GSC : Greater Sydney Commission 1
ILP : Indicative Layout Plan...2
LOS : Level of service...33
LSPS : Local Strategic Planning Statement..5
LTC : Leppington Town Centre 1
LTCP : Leppington Town Centre and Leppington Precinct.....................1
PCU : Passenger car units..23
PTPM : Public Transport Projects Model..1
RMS : Roads and Maritime Services (now Transport for NSW) 16
SA1 : Statistical Area Level 1..6
STFM : Sydney Traffic Forecasting Model...6
SWGCSP : South West Growth Centre Structure Plan 5
TDT 2013/04a : Technical Direction TDT 2013/04a (Roads and Maritime, 2013) 15
TfNSW : Transport for NSW...15
vtph : Vehicle trips per hour 16
WSIP : Western Sydney Infrastructure Program 29

1 Introduction

The Leppington Town Centre (LTC) has been identified with the aim to encourage a sustainable and liveable town centre based on the principles of transit-oriented development. The Department of Planning, Industry and Environment (DPIE) commissioned Arup in 2018 to develop the Leppington Town Centre Transport Plan, a holistic transportation and land use integration plan to support the principles of sustainable development for the centre. This work included the development of operational road network models of the LTC study area.

In 2019, DPIE released 'A new approach to precincts' summarising the outcomes of a review of roles and responsibilities in the undertaking of precinct planning, undertaken in partnership with the Greater Sydney Commission (GSC) and Government Architect NSW (GANSW). A key outcome of which being that local councils would be empowered to plan for their local areas because they know their people and communities best, with DPIE continuing to support and collaborate with each council to deliver great places while remaining focused on strategic issues and getting a coordinated approach from State agencies. As such, in November 2019, Arup's role and responsibilities in supporting the investigation into LTC were novated to Camden Council (Council), whilst DPIE also provided Council appropriate permissions to use the operational road network models already developed by Arup.

As part of this novation, Arup were requested by Council to expand the previously developed traffic model to include Leppington Precinct – a planned staged residential community immediately to the south of LTC.

To facilitate above, Arup have developed an operational transport model which covers both Leppington Town Centre and Leppington Precinct (LTCP) with a view to developing two outputs, namely:

- Future Year Operational Modelling Report: including an assessment of the full build-out of both areas by ±2041; and
- Leppington Town Centre Transport Plan: providing a more precinct-type multi-modal transport plan, with the above report as an attachment.

To enable an appropriate assessment of the development proposals, the traffic and transport assessment adopted a two-tiered modelling approach, namely:

- **Strategic modelling**, using outputs from the PTPM model provided by Transport for NSW to inform wider future year land use and travel demand forecasts.
- **Operational modelling**, using Aimsun to consider the time dynamics of traffic demand and network performance to ensure that the Precinct's road network is commensurate with the expected level of traffic forecasts.

1.1 Purpose

The purpose of the transport modelling stage of this study is three-fold:

- Firstly, to detail the development of the 2019 base year Aimsun mesoscopic models and to report on the levels of calibration and validation achieved.
- Secondly, to assess and test the transport impacts of the preferred development scenario, through modelling, as reflected in the draft Indicative Layout Plan (ILP) for future horizon years, taking into consideration potential development staging.
- Lastly, to recommend infrastructure upgrades and other measures to address identified impacts within the vicinity of the LTCP.

1.2 Report structure

The report is structured generally into two parts.

The first part describes the process, inputs and modelling result up to Camden Council's review of the draft *Traffic Modelling Report* in June 2021. These have retrospectively been labelled the initial results. It is set out in this report as follows:

- Section 2: Major milestones and decisions to date
- Section 3: Base year (2019) model development
- Section 4: Description of proposed development
- Section 5: Overview of the two-tiered modelling approach
- Section 6: Assessment of road network and initial modelling results

The second part describes the final results. They are based on updated inputs provided by Camden Council after Arup submitted the draft Traffic Modelling Report in June 2021, and it incorporates comments received from Council and from Transport for NSW in the same timeline. It is set out in this report as follows:

- Section 7: Overview of the final modelling inputs
- Section 8: Assessment of road network and final modelling results
- Section 9: Walking accessibility review
- Section 10: Conclusions and way forward

2 Major milestones and decisions to date

The outcomes presented in this document are the result of multiple iterations, interventions, evolving assumptions and information sources. While this document only reports a single set of results that is the culmination of the entire process, the timeline below provides some background on the process throughout.

November 2019

Arup's role and responsibilities in supporting the investigation into LTC were novated to Council. DPIE permits Council to use the operational road network models already developed by Arup.

Council requests Arup to expand the previously developed traffic model to include Leppington Precinct.

May 2020

Arup submits *Base Model Development Report* to Council.

July 2020

Advanced Analytics & Insights, working closely with Arup, provides future years strategic model outputs to inform wider area growth and distributions. Mesoscopic modelling for 2041 commences.

November 2020

Council facilitated a stakeholder workshop on 26 November 2020 to present draft model results and road network performance outcomes. Arup's presentation is included as Appendix A.

Workshop minutes are included in Appendix B. Major outcomes included:

- Rickard Road should be a four-lane transit boulevard in its entirety south of Bringelly Road, with only two lanes open to general traffic.
- Rickard Rd becomes the main bus corridor once the corridor is complete with buses every 5 mins or less. Planning should consider bus hierarchy, not only roadway hierarchy.
- Need to use trips for the mode split that aligns with the planning vision otherwise planning becomes car orientated development precincts.
- Heath Road should be reduced from four lanes total to two lanes total. Arup noted that capacity constraints necessitate four lanes. Council

highlighted that a 20m road reserve exists and that it is their preference to not acquire more land.

- The Public Transport Projects Model's Western Sydney Growth Infrastructure Compacts (PTPM5 WSGIC, dated July 2020) that supported the 2041 LTCP's mesoscopic modelling did not reflect the latest wider area strategic network vision. Manual adjustments or updating the strategic models were recommended.

Council commissions Arup to review the published Trip Generation Manual (2013) survey data to explore if adjustments to the rates are justifiable to account for the impacts of the Rickard Road transit boulevard on mode shares.

December 2020

Arup recommends reduced rates of 0.72 (AM) and 0.88 (PM) vehicle trips per low density dwelling within 800m of Rickard Road. Council decided not to adjust the rates, as the proposal reduces the overall trips by less than 10%. Arup's technical note, including the evidence base for the recommendation, is included as Appendix C.

January 2021

Previously, on 24 November 2020 prior to the stakeholder workshop, Council stated via e-mail:

> *"Perhaps we may be able to achieve better transport planning outcomes for Rickard Road and the broader road network, if south of Ingleburn Road, some of the North-South traffic volumes can be carried by Eastwood Road / Dickson Road ([to be determined by Arup's] modelling). Eastwood Road / Dickson Road can be the bypass around the town centre connecting Oran Park and Leppington carrying larger volumes of motor vehicles. We can explore this post the workshop scheduled for the 26th of November. This approach would be consistent with the South West Growth Centre Structure Plan prepared by [Jacobs]."*

Following Council's review of the draft traffic modelling presentation (hosted in November 2020), Council noted that the model prepared by Arup did not reflect Council's vision of the future Leppington area and that relevant adjustments were required. These adjustments related to both the road network's strategic layout and linkages, as well as the magnitudes of forecasted traffic flows along particular corridors. Council felt that the model prepared by Arup was based heavily on the PTPM and its strategic assumptions only, and in Council's opinion misrepresented future traffic flow magnitudes from areas such as Oran Park, Catherine Fields and Marylands. Council requested Arup to adjust the 2041 Aimsun model to align with various published strategic plans, such as:

- *South West Growth Centre Structure Plan* (SWGCSP, by Jacobs)[1]
- *South West Growth Centre Road Network Strategy* (Transport for NSW, 2011); and
- Council's own *2020 Local Strategic Planning Statement* (LSPS, March 2020).

Arup highlighted various inconsistencies between the road network assumptions from the existing planning sources, specifically the *South West Growth Centre Road Network Strategy*, the SWGCSP, the PTPM model (2036 and 2056 horizon years) and Council's LSPS. A detailed discussion of the discrepancies highlighted is included in Appendix D.

February 2021

It was agreed with Council that travel demand reductions/reallocations would manually be made to various origin-destination combinations pairs that would be influenced by the following infrastructure projects that were not included in the PTPM:

- Raby Road extension from Camden Valley Way westbound and north up to Bringelly Road
- Extension of Eastwood Road from Deepfields Road south through Catherine Field and then west toward The Northern Road
- Devonshire Road/King Street extension from Bringelly Road south to intersect with St. Andrews Road extension, which will run eat-west.

March 2021

On 4 March 2021, Transport for NSW released an updated vision for a future bus network throughout the Leppington Town Centre and wider Precinct area. The network is characterised by high-frequency north-south services along Rickard Road, connecting Oran Park in the south to the Leppington Station and Austral to the north. Transport for NSW indicated that the bus network was developed with a pronounced north-south focus. Buses are intended to fill the gap left by the low density of the rail network. The routes and frequencies were designed to serve trip origins/destinations within an 800m catchment area of the corridor in support of Transport for NSW mode share targets in Western Sydney. According to current plans the network will be able to support ±9,000 trips per hour into the Leppington interchange.

On 17 March 2021, Council signs off on the local area access management plan for the LTCP. It informs all subsequent modelling.

Council advised, on 19 March 2021, that the ongoing planning between the LTCP and the Oran Park modelling being delivered by other

[1] Council noted via e-mail to Arup on 24 November 2020 that the plan was not adopted.

consultants should align where the two commissions overlap along Eastwood, Dickson and Rickard Roads south of the future Raby Road extension. Based on evidence from the Sydney Traffic Forecasting Model (STFM, completed by other consultants for the Oran Park study), it was agreed to manually reallocate the external traffic demands along these three corridors in approximately the following proportions in the LTCP model:

Corridor	Before adjustment	Adjustment target
Eastwood Road	46%	30%
Dickson Road	39%	40%
Rickard Road	15%	30%
Total	**100%**	**100%**

Note: North and south directions combined for each link. The percentage reflects each link's share out of the combined volumes of the three corridors.

April 2021

Camden Council commissioned Arup to undertake a comprehensive desktop study to explore potential impacts that a high frequency bus services may have on the take up of bus ridership in adjacent land uses. The study considered various high frequency bus corridors in Sydney, Melbourne, Brisbane and Adelaide using Journey to Work (2016) data at the Statistical Area Level 1 (SA1).

Arup recommended Council employ a public transport mode share of at least 30%, which was in line with results observed in the Journey to Work data and would align with Transport for NSW's adopted Vision and Validate approach to sustainable planning. Council advised a 25% mode share is deemed to be more achievable for low density dwellings within 800m of Rickard Road. Arup's technical note is included in Appendix E.

This relates to updated trip rates of 0.79 (AM) and 0.76 (PM) vehicle trips per dwelling within 800m of Rickard Road. The standard rates of 0.95 (AM) and 0.99 (PM) are used for low density dwellings elsewhere.

May 2021

Transport for NSW advised that a 25% public transport model share along Rickard Road south of Ingleburn Road is too aggressive and committed to advising an alternative target.

June 2021

Arup submitted the draft *Traffic Modelling Report* to Camden Council on 01 June 2021 for review. It reflected the inputs and assumptions confirmed to date. **All results up to this date are referred to as <u>results based on the initial land use</u> in this report.**

July 2021

On 14 July 2021, Transport for NSW modelling specialists provided technical review comments on the 2019 base year mesoscopic model Arup developed and submitted to Council in May 2020, and which formed the basis of all further modelling work for the LTCP study.

On 16 July 2020, Transport for NSW advised a 15% bus mode share along Rickard Road south of Ingleburn Road should be adopted for the traffic modelling. They commented that:

- *"Traffic modelling has not been undertaken for 2031 and 2036 horizon years (i.e. 60% and 90% buildout).*
- *Frequent/rapid bus services and high bus mode share prior to 2036/2041 is unlikely and creates a risk that the network may performing at poor levels of service.*
- *No considerations were given for medium/high residential land-use near the high frequency bus stops (i.e. 800 metres catchment of Rickard Road, south of Ingleburn Road is low-density residential area).*

A trip generation rate of 0.91 vehicle trips per dwelling during AM peak and 0.88 vehicle trips per dwelling during PM peak can be applicable along Rickard Road for the 800m catchment only."

Camden Council endorsed the recommendation.

On 23 July 2021, Council issued updated land use information to Arup for both the LTC and the Precincts, which prompted an updating of the modelling. While the land use was spatially similar to the previous data, it presented different intensities. The largest change was the inclusion of multiple future schools and the conversion of existing ones.

September 2021

Transport for NSW provided recommendations on trip generation rates for schools via e-mail on 13 September 2021. In a technical summary titled "*School Trip Generation – Assessment*", they noted that Transport for NSW undertook a trip generation survey for 22 Schools in NSW, including Greater Sydney and regional area, in 2014. Further details are discussed in Section 5.2.3.

December 2021

On 17 December 2021, the updated 2019 base year mesoscopic model was submitted to Transport for NSW's modelling specialists for review.

January 2022

On 21 January 2022, Transport for NSW modelling specialists approve the updated 2019 base year mesoscopic model as meeting their technical standards. They endorse the same model as being suitable for future year assessments.

February 2022

Arup submitted the updated *Traffic Modelling Report* to Camden Council on 17 March 2022 for review. It reflected the inputs and assumptions confirmed to date.

All results since June 2021 and up to this date are referred to as results based on the final land use in this report.

3 Base year model development

The initial LTCP base model was developed as a mesoscopic model using Aimsun Next version 8.4.3.

Its development has been undertaken with an aim to achieve prescribed calibration and validation criteria published in the *Traffic Modelling Guideline* (Roads and Maritime, 2013), and to provide a strong evidence base from which to inform the identification of future road network infrastructure requirements of the LTCP. The prescribed calibration and validations metrics were met.

The base model calibration report was submitted to Council on 17th December 2021 and is included as Appendix F.

4 Initial Proposed Development

4.1 Leppington Town Centre

The 2041 land use scenario included approximately 11,118 dwellings, significant retail and other commercial floor space. Figure 1 shows the latest LTC draft structure plan, version 3.4.

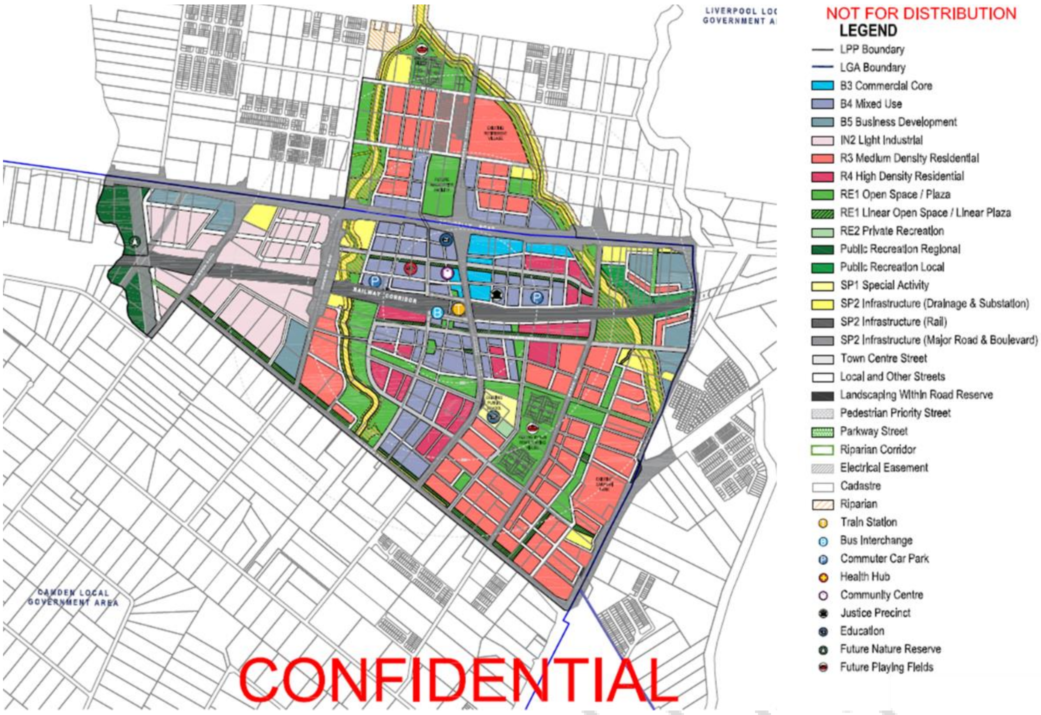


Figure 1: Draft Indicative layout plan (v3.4) for the LTC (Source: Camden Council, 25 September 2020)

4.2 Leppington Precincts

In addition to the LTC, the Leppington Precincts will be a residential area with a small scattering of retail land uses. It includes up to 14,552 dwellings and will be developed over five stages. Figure 2 presents the spatial arrangement of the stages, and Figure 3 shows the indicative layout plan.

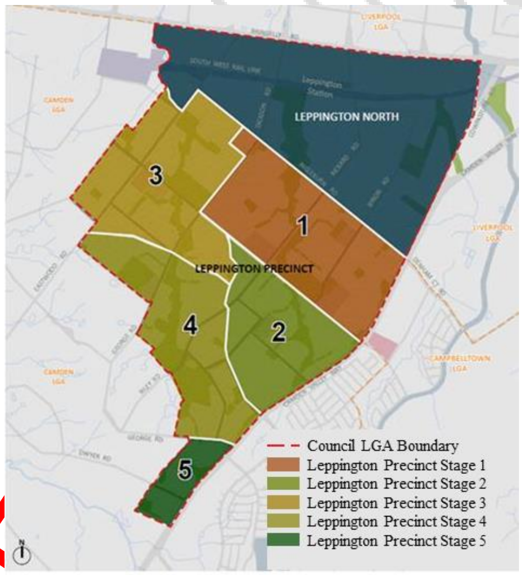


Figure 2: Leppington Precincts spatial arrangement and staging plan (Source: Camden Council, 29 September 2020)

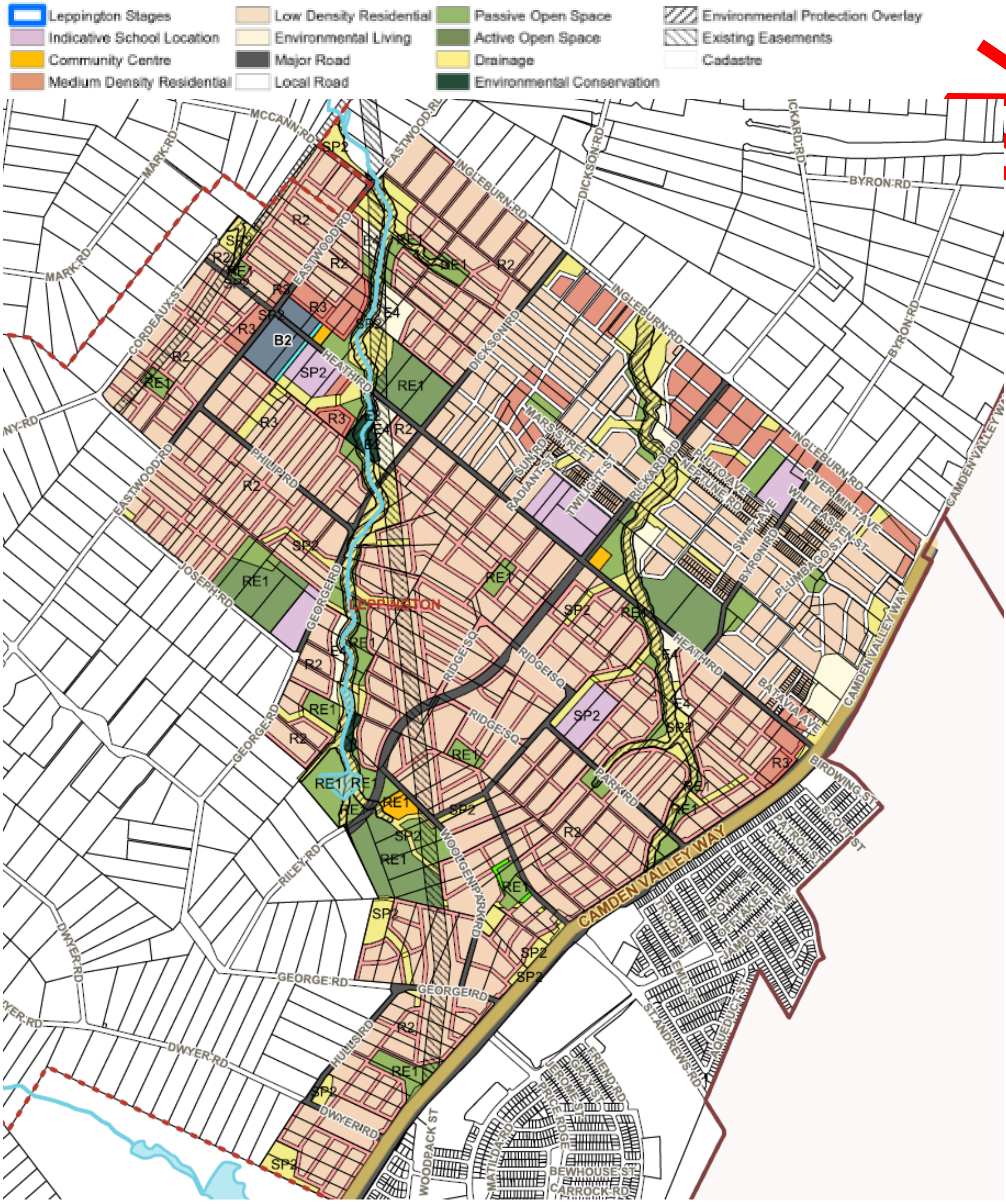


Figure 3: Draft Indicative Layout Plan for the Leppington Precincts (Source: Camden Council, 2020)

The combined planned rollout of the LTCP by 2041, is summarised below:

Area	Dwellings
Leppington Town Centre[1]	11,118
Leppington Precincts[2]	14,552
Total	**25,670**

Notes:
1. Source: Camden Council, 25 September 2020
2. Source: Camden Council, 30 September 2020

5 Future year model development

5.1 Overview

The future year road network assessment for the LTCP has been based on a two-tiered modelling approach - to generate the maximum assessment robustness and efficiency in the road network. Figure 4 illustrates the overall approach.

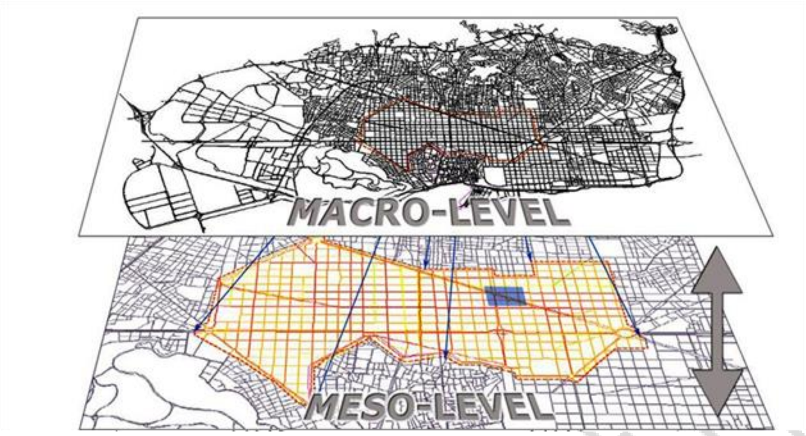


Figure 4: Two-tiered modelling approach

Tier 1: Macro-level (i.e. strategic) modelling using the PTPM to account for the strategic travel into, through and around the Leppington precinct.

Tier 2: Mesoscopic modelling using Aimsun to account for the time dynamics of traffic based on available road network capacity and route choice.

5.1.1 Strategic modelling

The PTPM is a multi-modal model owned and managed by Transport for NSW that is continuously updated to reflect Government plans and projects for all transport modes. Each future year scenario includes a series of assumptions regarding future transport provisions across the network. Most relevant to the study area, the model includes assumptions regarding the delivery of the planned road and rail network in the area, which were consistent with NSW Government planning at the time of initial project development. It is noted that the PTPM is being continuously updated to keep abreast of the latest plans particularly in the South West Growth Area.

Using the PTPM to inform the forecast year travel patters offers the following advantages:

- It incorporates the most up-to-date view on land use, developed in conjunction with DPIE, TfNSW and the GSC.
- It reflects current plans concerning the Western Parkland City and Future Transport.

- It is intended for use to serve the panning processes going forward for Western Sydney, i.e. future development work (councils, DPIE, developers, etc) is anticipated to be founded on this strategic modelling suite.

Concurrently, it should be recognised that the PTPM is a strategic model that is being used in conjunction with multiple other strategic models in Sydney. While it is continuously being updated to reflect the latest plans relevant to its planning applications, we highlight that the PTPM has a wider focus than simply Leppington; therefore, extracting detailed results for Leppington in isolation does carry the following risks:

- The land use (which is inherited by the PTPM from other strategic models) with regard to the Western parkland City and Future Transport does not reflect the latest vision for Leppington.
- The representation of the strategic road network in, through and immediately around the Leppington study area does not reflect the latest vision.
- There are inconsistencies with other recent projects such as Metro Greater West (Sydney Metro) and the GICs/PICs (Greater Sydney Commission / WSPP).

Having cognisance of the benefits and risks mentioned here, we note that Arup supplemented the PTPM data with multiple other planning sources and did so in conjunction with Camden Council. We did not over-rely on any single planning source.

Transport for NSW provided AM peak period trip matrices from the PTPM WSGIC (version 5) for 2019, 2026, 2036 and 2056 to Arup for light vehicle and heavy vehicle demands. The PTPM did not cover a PM period, therefore Arup extrapolated a PM equivalent by transposing the AM peak.

5.1.2 Mesoscopic modelling

Mesoscopic modelling provides a greater level of detail in terms of network operational capacity and performance than strategic modelling. Mesoscopic modelling was undertaken using Aimsun Next, version 8.4.3, and offers the following advantages:

- It considers the relationship between road network demand, supply and route choice in greater detail than strategic modelling.
- It allows for identification and testing of strategies of how to best allocate road network capacity against demand for each freight, private vehicles and public transport.
- It considers the time dynamics of traffic when finding routes between origins and destinations, thereby identifying parallel routes.
- Mesoscopic modelling allows the identification of road network pinch points (“bottlenecks”) and the development of a series of solutions and upgrades to optimise the infrastructure and unlock additional capacity.

5.1.3 Limitations

Numerous assumptions typically feed into traffic modelling projects and, as such, the modelling process contains numerous inherent limitations. The following key assumptions were made for this study:

- PTPM demand forecasts are not constrained by available roadway capacity, thereby providing a conservative estimate of future travel demands.
- PTPM provides metropolitan-wide forecasts of mode choice and assignment of trips across the transport network. By extension, it informs trip-making characteristics and likely distribution patterns of future trips generated by and around the Precinct. However, it is not typically considered fit-for-purpose for the assessment of road network performance at a localised or detailed level.
- The PTPM only provided AM demands. The PM demands were derived by Arup by transposing the AM matrices.
- The mesoscopic modelling focussed on the higher order road network in the LTCP network area, namely arterials, sub-arterials, town centre roads and the central transit boulevard.
- Mesoscopic modelling did not consider the details of the local roads within the Precinct - these will need to be refined further as part of the downstream planning process.
- Traffic modelling only considered morning and evening peak periods of a typical weekday.
- Due to utilising the Vision and Validate approach, it was assumed that higher public transport utilisation would in turn reduce the number of private vehicles in the network. More details regarding this are provided in the following sections.
- Conflicts with vehicles accessing kerbside parking spaces or with active transport modes were not modelled, though pedestrian start delays were assumed at relevant intersections.

5.2 Demand development

This section presents an overview of the methodology followed to derive the future vehicle-based transport demand for the LTCP. Additional details are included in Appendix G.

5.2.1 First principles approach

The traffic study component for the LTCP was approached from first principles.

The first principles approach generally follows the same sequence as the traditional four-step modelling methodology (i.e. trip generation, trip distribution, mode choice and network assignment). In the first principle's approach, however, trip generation and mode choice occur within the same step.

Figure 5 presents the general methodology followed in the traffic study component.

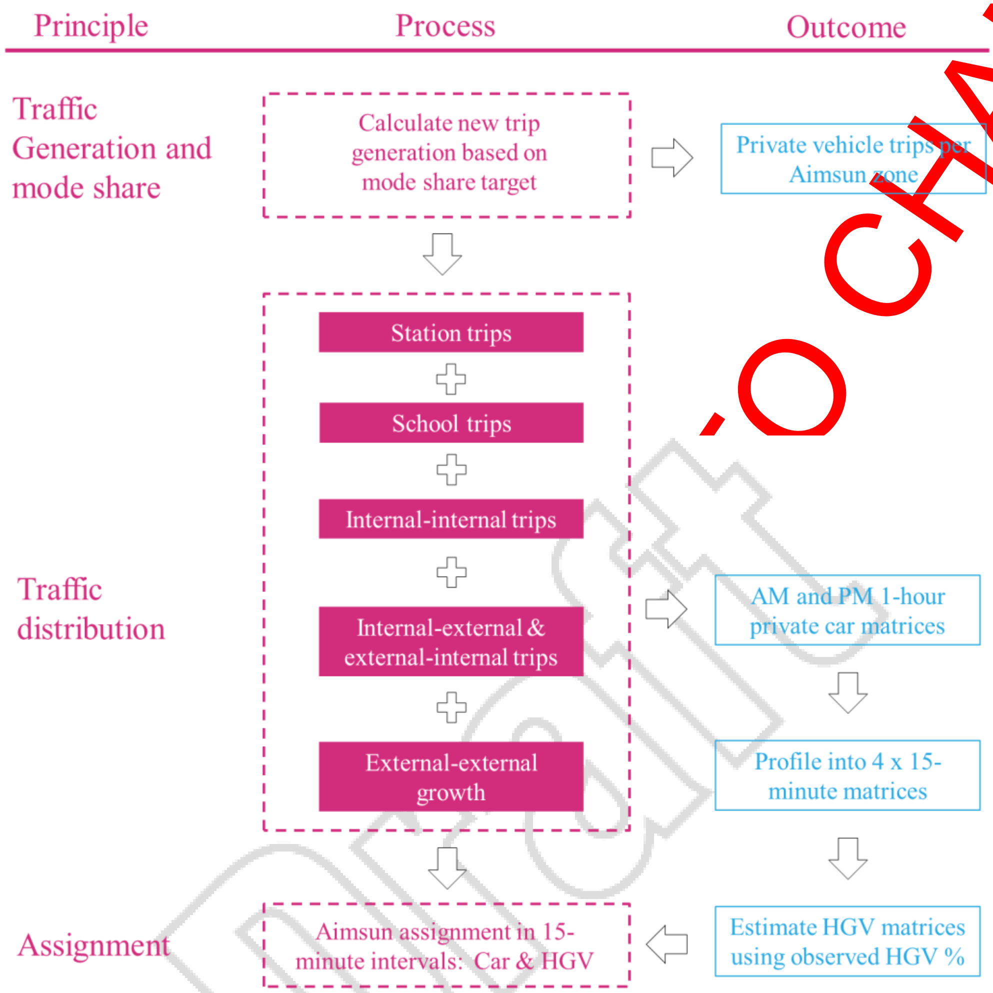


Figure 5: First principles approach to future traffic demand development

5.2.2 Demand profile

PTPM demands represent two-hour totals during both the AM and PM peak periods. Traffic profiles observed in December 2019 during traffic data collection suggest that the peak one-hour traffic volumes represent approximately 52% of the two-hour volumes. Accordingly, the two-hour PTPM matrices were factored by 0.52 to determine the peak one-hour demands to be modelled in Aimsun. The resulting matrices represent the same modelled peak hours as the base year Aimsun model.

5.2.3 Traffic generation and mode share

Initial trip generation rates (i.e. prior to applying adjustment factors)

Trip generation rates were principally based on the following sources:

- *Guide to Traffic Generating Development* (Roads and Maritime, 2002)

- *Technical Direction TDT 2013/04a* (Roads and Maritime, 2013)
- Transport for NSW's consolidated comments (dated 22 August 2019) on the LTC study, as well as Arup's response to them on 6 October 2019. See Appendix H for details.

The Technical Direction was generally the preferred source, because:

- The rates are relatively recent (i.e. 2011)
- It provides in-depth survey evidence of how and where its proposed trip rates were derived, thereby ensuring that the rates most applicable to the LTCP and its land use and transport context may be employed.

Where appropriate, the above rates were adapted based on the Transport for NSW comments received.

Table 1 summarises the trip generation rates extracted from the above sources.

Table 1: Trip generation rates prior to applying reduction factors

Land use	Zoning	AM peak hour rate	PM peak hour rate	Unit	Source
Residential (low density)	R2	0.95	0.99	per dwelling	TDT 2013/04a
Residential (medium density)[1]	R3	0.39	0.37	per dwelling	TfNSW comment
Residential (high density)	R4	0.19	0.15	per dwelling	TDT 2013/04a
Environmental living	E4	0.95	0.99	per dwelling	TDT 2013/04a
Office[2]	B3	2.02	1.63	per 100 m^2 GFA	TfNSW comment
Bulk goods[3]	B5	0	2.7	per 100 m^2 GFA	TfNSW comment
Industrial[4]	IND	0.52	0.56	per 100 m^2 GFA	TfNSW comment
Retail	B3 & B4	See Table 2		per 100 m^2 GFA	TDT 2013/04a
Schools		0.50	0.05	per student	LTC study, 2019

For the purposes of this study, we have adopted the following general definitions for residential dwellings.

- Low density residential dwellings are primarily single dwellings but can also be dual occupancies or multi dwelling houses.
- Medium density residential dwellings can be townhouses or villas but not residential flat buildings.
- High density residential dwellings mostly consist of residential flat buildings and is typically located in areas with convenient access to public transport and other amenities.

We note the following responses from Transport from NSW on appropriate trip generation rates on 22 August 2019, and shown in Table 1:

1. Recent surveys undertaken by RMS in 2013 of medium density residential dwellings recorded average of 0.39 vehicle trips per hour (vtph) and 85th percentile of 0.58vtph in AM peak, and average of 0.37vtph and 85th percentile of 0.65vtph in the PM peak, which represents close to 50/50 split of car and non-car mode share when compared to the person trips generated for the corresponding peaks.
2. The most comparable location to Leppington in TDT2013/04a is likely to be the Liverpool site surveyed which generated a rate of 2.02vtph per 100m^2 in the AM road peak and 1.63vtph per 100m^2 in the PM road peak.
3. For bulky goods stores (now specialised retail premises), RMS surveys in 2009 revealed average weekday peak hour vehicle trips of 2.7vtph per 100m^2 GFA in PM (higher in weekend peaks).
4. Surveys of business parks and industrial estates undertaken by RMS in 2012 revealed a Sydney average rate of 0.52vtph AM and 85th percentile of 0.91vtph, and 0.56 and 85th percentile of 1.01vtph PM.

Recommended retail trip rates are reported in Table 2. It is a known trend that for retail land use, trip generation rates are inverse to the amount of floor space contained within the shop/centre (i.e. rates decrease with increasing floor space).

Table 2: Retail trip generation rates per 100m^2 GFA (Source: TDT 2013/04a)

Range in total floor area (m^2 GLFA)	Thursday AM[1]	Thursday PM[2]
0 – 10,000 m^2 GLFA (i.e. 0 – 8,000 m^2 GFA)	5.54	12.3
10,000 – 20,000 m^2 GLFA (i.e. 8,000 – 16,000 m^2 GFA)	2.79	7.6 (6.2)
20,000 – 30,000 m^2 GLFA (i.e. 16,000 – 24,000 m^2 GFA)	2.70	5.9 (6.0)
30,000 – 40,000 m^2 GLFA (i.e. 24,000 – 32,000 m^2 GFA)	2.07	4.6
40,000 – 70,000 m^2 GLFA (i.e. 32,000 – 56,000 m^2 GFA)	1.98	(4.4)
70,000+ m^2 GLFA (i.e. 56,000+ m^2 GFA)	1.40	(3.1)

We note the following pertaining to Table 2:

1. TDT 2013/04a suggests that the Thursday AM peak traffic generation as a percentage of PM peak traffic ranges from around 34% - 68%, with an average of around 45%. We calculated the AM equivalent trip rate using the 45%.
2. Figures in brackets refer to 2011 surveys. Other figures are as per 1978 and 1990 surveys. Arup used the 2011 rates where multiple were published.

Directional splits

The trip generation assumed the directional splits shown in Table 3.

Table 3: Trip generation rates directional splits

Land use	AM peak hour		PM peak hour	
	In	Out	In	Out
Residential (low density)	20%	80%	80%	20%
Residential (medium density)	20%	80%	80%	20%

Land use	AM peak hour		PM peak hour	
	In	Out	In	Out
Residential (high density)	20%	80%	80%	20%
Environmental living	20%	80%	80%	20%
Office	80%	20%	20%	80%
Bulk goods	80%	20%	20%	80%
Industrial	80%	20%	20%	80%
Retail	50%	50%	50%	50%
Schools	50%	50%	50%	50%

Trip adjustment factors

The initial trip generation rates shown in Table 1, Table 2 and

were adjusted according to the following factors:

- A 10% reduction was applied to the trip generation rates for Office developments to account for containment (live and work in same area). We noted Transport for NSW's comment dated 22 August 2019 that it is inappropriate to assume Leppington would have a linked trip factor similar to established mixed use centres. We argued, however, that LTCP will be mature by 2041 and a linked trip factor is appropriate.
- The total size of adjacent or clustered retail zones were aggregated for the purposes of choosing appropriate local trip rates, while isolated zones were considered by their size individually. Reductions have been applied to retail trip generation rates to account for the effect of linked trips. This is based on the following guidance provided in section 3.6.1 of the *Guide to Traffic Generating Developments (2002):*

  "*The incidence of linked and multi-purpose trips can reduce overall trip generation rates. A linked trip is a trip taken as a side-track from another trip, for example, a person calling in to the centre on the way home from work. A multi-purpose trip is where more than one shop or facility is visited. Any trip discounts would apply differently in new free-standing centres and for new shops within existing centres. Discounts in the former case vary depending on the nature of the adjacent road network. With the latter case, an average discount of about 20% is suggested, with this figure reducing with increasing centre size, with rates of*

  - *25% (less than 10,000 m^2 GLFA),*
  - *20% (10,000-30,000 m^2 GLFA) and*
  - *15% (over 30,000 m^2 GLFA) indicative.*
- The LTCP adopted a Vision and Validate approach to future trip generation based on Rickard Road's anticipated future function as a high quality, high frequency transport boulevard. In discussions with Council and further to Arup's desktop study to this effect (see Appendix E for details), it was agreed that all low density residential dwellings within 800m of Rickard Road should use vehicular trip generation rates that cater for a 15% public transport mode

share. This is equivalent to vehicle trip rates of 0.79 (AM) and 0.76 (PM) per low density dwelling. Note that to account for impact, different rates were applied to the dwellings of the same land use zone depending on whether they were within or outside the 800m threshold. We note that the reduction applies to all low density residences within 800m on each side of Rickard Road, and only within Leppington Precincts 1 to 5.

- The first principles' trip generation approach was concerned with quantifying the anticipated total trips generated by the LTCP area between 2019 and 2041 horizon years. Areas that have already experienced some level of development in 2019 were assigned a reduction factor to "zero out" the risk of double counting.

The final trip generation rates, following the various aforementioned reductions, are shown in Table 4.

Table 4: Trip generation rates after applying reduction factors

Land use	**Zoning**	**AM peak hour rate**	**PM peak hour rate**	**Unit**
Residential (low density, ≤ 800m from Rickard Road)	R2	0.79	0.76	per dwelling
Residential (low density, > 800m from Rickard Road)	R2	0.95	0.99	per dwelling
Residential (medium density)[1]	R3	0.39	0.37	per dwelling
Residential (high density)	R4	0.19	0.15	per dwelling
Environmental living	E4	0.95	0.99	per dwelling
Office	B3	1.82	1.47	per 100 m^2 GFA
Bulk goods	B5	0	2.70	per 100 m^2 GFA
Industrial	IND	0.52	0.56	per 100 m^2 GFA
Retail, 0 – 8,000 m^2 GFA	B3 & B4	4.15	9.23	per 100 m^2 GFA
Retail, 8,000 – 16,000 m^2 GFA	B3 & B4	2.23	4.96	per 100 m^2 GFA
Retail, 16,000 – 24,000 m^2 GFA	B3 & B4	2.16	4.80	per 100 m^2 GFA
Retail, 24,000 – 32,000 m^2 GFA	B3 & B4	1.76	3.91	per 100 m^2 GFA
Retail, 32,000 – 56,000 m^2 GFA	B3 & B4	1.68	3.74	per 100 m^2 GFA
Retail, 56,000+ m^2 GFA	B3 & B4	1.19	2.64	per 100 m^2 GFA
Schools		0.50	0.05	per student

1. Medium density is confided within the range of duplexes to six storey RFBs.

Table 5 and Table 6 summarise the interim trip generation totals by land use type for the 2041 medium growth scenarios for the Leppington Town Centre and the Leppington Precincts for the AM peak hours. Table 7 and Table 8 present the corresponding data for the PM peak hours.

Table 5: Trip generation summary by land use for Leppington Town Centre's initial land use, AM peak hour (2041)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	-	-	-	-	-	-	-	-	-	-	-
Med Density Res	R3	4,915	-	-	-	-	364	1,455	-	-	364	1,455
High Density Res	R4	2,070	-	-	-	-	79	315	-	-	79	315
Commercial Core (office)	B3	-	-	49,792	-	-	-	-	1,019	476	1,019	476
Mixed Use	B4	4,202	-	43,493	-	-	160	639	1,072	597	1,231	1,236
Environmental Living	E4	-	-	-	-	-	-	-	-	-	-	-
Retail 0 – 8,000 m² GFA	B3 & B4	-	5,789	-	-	-	-	-	120	120	120	120
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	19,588	-	-	-	-	-	212	212	212	212
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail > 56,000 m² GFA	B3 & B4	-	67,908	-	-	-	-	-	403	403	403	403
Industrial	IND	-	-	-	-	171,171	-	-	712	178	712	178
Bulk goods	B5	-	-	-	46,701	-	-	-	-	-	-	-
School (0 students)		-	-	-	-	-	-	-	-	-	-	-
TOTAL		**11,188**	**93,285**	**93,285**	**46,701**	**171,171**	**602**	**2,408**	**3,537**	**1,986**	**4,140**	**4,394**

Table 6: Trip generation summary by land use for Leppington Precincts' initial land use: AM peak hour (2041)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	12,947	-	-	-	-	2,231	8,924	-	-	2,231	8,924
Med Density Res	R3	1,309	-	-	-	-	97	387	-	-	97	387
High Density Res	R4	-	-	-	-	-	-	-	-	-	-	-
Commercial Core (office)	B3	-	-	-	-	-	-	-	-	-	-	-
Mixed Use	B4	-	-	-	-	-	-	-	-	-	-	-
Environmental Living	E4	124	-	-	-	-	24	95			24	95
Retail 0 – 8,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	46,100	-	-	-	-	-	388	388	388	388
Retail > 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Industrial	IND	-	-	-	-	-	-	-	-	-	-	-
Bulk goods	B5	-	-	-	-	-	-	-	-	-	-	-
School (1,00 students)		-	-	-	-	-	-	-	250	250	250	250
TOTAL		**14,380**	**46,100**	**0**	**0**	**0**	**2,352**	**9,406**	**638**	**638**	**2,989**	**10,044**

Table 7: Trip generation summary by land use for Leppington Town Centre's initial land use, PM peak hour (2041)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	-	-	-	-	-	-	-	-	-	-	-
Med Density Res	R3	4,915	-	-	-	-	1,534	383	-	-	1,534	383
High Density Res	R4	2,070	-	-	-	-	248	62	-	-	248	62
Commercial Core (office)	B3	-	-	49,792	-	-	-	-	802	1,240	802	1,240
Mixed Use	B4	4,202	-	43,493	-	-	504	126	1,103	1,486	1,608	1,612
Environmental Living	E4	-	-	-	-	-	-	-	-	-	-	-
Retail 0 – 8,000 m² GFA	B3 & B4	-	5,789	-	-	-	-	-	267	267	267	267
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	19,588	-	-	-	-	-	470	470	470	470
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail > 56,000 m² GFA	B3 & B4	-	67,908	-	-	-	-	-	895	895	895	895
Industrial	IND	-	-	-	-	171,171	-	-	192	767	192	767
Bulk goods	B5	-	-	-	46,701	-	-	-	630	630	630	630
School (0 students)		-	-	-	-	-	-	-	-	-	-	-
TOTAL		**11,188**	**93,285**	**93,285**	**46,701**	**171,171**	**2,286**	**572**	**4,359**	**5,756**	**6,646**	**6,327**

Table 8: Trip generation summary by land use for Leppington Precincts' initial land use: PM peak hour (2041)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	12,947	-	-	-	-	8,938	2,234	-	-	8,938	2,234
Med Density Res	R3	1,309	-	-	-	-	408	102	-	-	408	102
High Density Res	R4	-	-	-	-	-	-	-	-	-	-	-
Commercial Core (office)	B3	-	-	-	-	-	-	-	-	-	-	-
Mixed Use	B4	-	-	-	-	-	-	-	-	-	-	-
Environmental Living	E4	124					99	25			99	25
Retail 0 – 8,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	46,100						862	862	862	862
Retail > 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Industrial	IND	-	-	-	-	-	-	-	-	-	-	-
Bulk goods	B5	-	-	-	-	-	-	-	-	-	-	-
School (1,000 students)		-	-	-	-	-	-	-	25	25	25	25
TOTAL		**14,380**	**46,100**	**0**	**0**	**0**	**9,445**	**2,361**	**887**	**887**	**10,332**	**3,248**

Table 9: Total trip generation summary by land use for the combined Leppington Town Centre and Precincts' initial land use, AM peak hour (2041)

Zone	**Zoning**	**Dwellings**	**Retail (m^2 GFA)**	**Office (m^2 GFA)**	**Bulk Goods (m^2 GFA)**	**Industrial (m^2 GFA)**	**Residential trips**		**Non-residential trips**		**Total trips**	
							In	**Out**	**In**	**Out**	**In**	**Out**
Low Density Res	R2	12,947	-	-	-	-	2,231	8,924	-	-	2,231	8,924
Med Density Res	R3	6,224	-	-	-	-	461	1,842	-	-	461	1,842
High Density Res	R4	2,070	-	-	-	-	79	315	-	-	79	315
Commercial Core (office)	B3	-	-	49,792	-	-	-	-	1,019	476	1,019	476
Mixed Use	B4	4,202	-	43,493	-	-	160	639	1,072	597	1,231	1,236
Environmental Living	E4	124	-	-	-	-	24	95	-	-	24	95
Retail 0 – 8,000 m^2 GFA	B3 & B4	-	5,789	-	-	-	-	-	120	120	120	120
Retail 8,000 – 16,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m^2 GFA	B3 & B4	-	19,588	-	-	-	-	-	212	212	212	212
Retail 24,000 – 32,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m^2 GFA	B3 & B4	-	46,100	-	-	-	-	-	388	388	388	388
Retail > 56,000 m^2 GFA	B3 & B4	-	67,908	-	-	-	-	-	403	403	403	403
Industrial	IND	-	-	-	-	171,171	-	-	712	178	712	178
Bulk goods	B5	-	-	-	46,701	-	-	-	-	-	-	-
School (0 students)		-	-	-	-	-	-	-	250	250	250	250
TOTAL		**25,568**	**139,385**	**93,285**	**46,701**	**171,171**	**2,954**	**11,814**	**4,175**	**2,624**	**7,129**	**14,438**

Table 10: Total trip generation summary by land use for the combined Leppington Town Centre and Precincts' initial land use, PM peak hour (2041)

Zone	**Zoning**	**Dwellings**	**Retail (m^2 GFA)**	**Office (m^2 GFA)**	**Bulk Goods (m^2 GFA)**	**Industrial (m^2 GFA)**	**Residential trips**		**Non-residential trips**		**Total trips**	
							In	**Out**	**In**	**Out**	**In**	**Out**
Low Density Res	R2	12,947	-	-	-	-	8,938	2,234	-	-	8,938	2,234
Med Density Res	R3	6,224	-	-	-	-	1,942	485	-	-	1,942	485
High Density Res	R4	2,070	-	-	-	-	248	62	-	-	248	62
Commercial Core (office)	B3	-	-	49,792	-	-	-	-	802	1,240	802	1,240
Mixed Use	B4	4,202	-	43,493	-	-	504	126	1,103	1,486	1,608	1,612
Environmental Living	E4	124	-	-	-	-	99	25	-	-	99	25
Retail 0 – 8,000 m^2 GFA	B3 & B4	-	5,789	-	-	-	-	-	267	267	267	267
Retail 8,000 – 16,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m^2 GFA	B3 & B4	-	19,588	-	-	-	-	-	470	470	470	470
Retail 24,000 – 32,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m^2 GFA	B3 & B4	-	46,100	-	-	-	-	-	862	862	862	862
Retail > 56,000 m^2 GFA	B3 & B4	-	67,908	-	-	-	-	-	895	895	895	895
Industrial	IND	-	-	-	-	171,171	-	-	192	767	192	767
Bulk goods	B5	-	-	-	46,701	-	-	-	630	630	630	630
School (1,000 students)		-	-	-	-	-	-	-	250	250	250	250
TOTAL		**25,568**	**139,385**	**93,285**	**46,701**	**171,171**	**11,731**	**2,933**	**5,472**	**6,868**	**17,203**	**9,801**

In interpreting the LTCP land use data for the purposes of trip generation, we assumed that:

- Land use designated as B2 (i.e. local town centre) in residential zones is retail.
- Land use designated as B3 ("Commercial core") includes office and retail space.
- Land use designated as B4 ("Mixed use") includes office, retail and high density residential areas.
- Retail land uses (functionally located in land use B3) are summarised separately and were clustered based on proximity to impose linked trip rates (as per Table 2).
- Non-residential components in mixed use areas B3 and B4 are 50% retail and 50% office.

5.2.4 Heavy vehicle growth

Heavy vehicles accounted for 8.3% of the total 2019 traffic according to the PTPM and are expected to grow by 2.3% per annum. These proportions were assumed to remain unchanged in future horizon years

5.3 Network development

This section overviews the road network development for mesoscopic modelling purposes. It discusses the representations of physical infrastructure within Aimsun, such as roadways, intersections and control types, and planned land use and traffic loading points.

5.3.1 Road hierarchy

Future road layouts were based on the indicative hierarchy shown in the *Camden and Liverpool Growth Centre Precincts Development Control Plan* (DCP), Schedule 2 Leppington Major Centre, (Liverpool Council, 2016). The result is show in Figure 6.

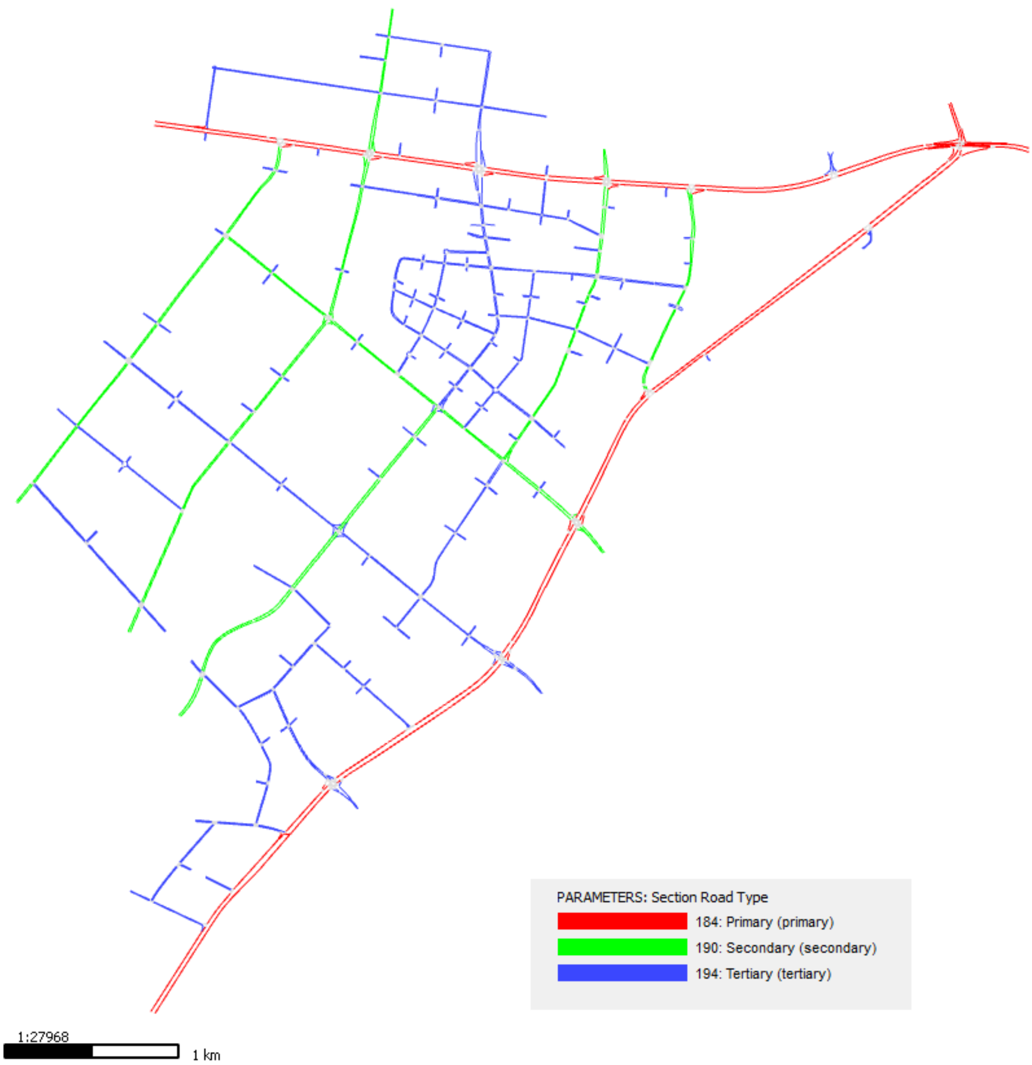


Figure 6: Road hierarchy in LTCP model

The road network characteristics that were coded in Aimsun to represent the future road network, are shown in Table 11. Additional details regarding the intended roadway hierarchy, number of lanes, roadway capacity and speed limits are discussed in the following sections.

Table 11: Mesoscopic modelling lane types and assumed capacities

Road type	**Aimsun road type**	**Lanes (per direction)**	**Capacity (PCU[2]/hr/lane)**
Arterial	*Primary*	2 to 3	1,800
Sub-arterial	*Secondary*	2	800
Transit boulevard	*Secondary*	1 general traffic 1 bus-only lane	800
Town centre main street	*Tertiary*	1	700
Town centre road	*Tertiary*	1	700

[2] Passenger car units. One car is considered as a single unit. Buses and heavy vehicles cause, because of their large size, are considered equivalent to multiple cars.

5.3.2 Access management

The vision for the road network access management plan was provided by Camden Council and is shown in Figure 7:

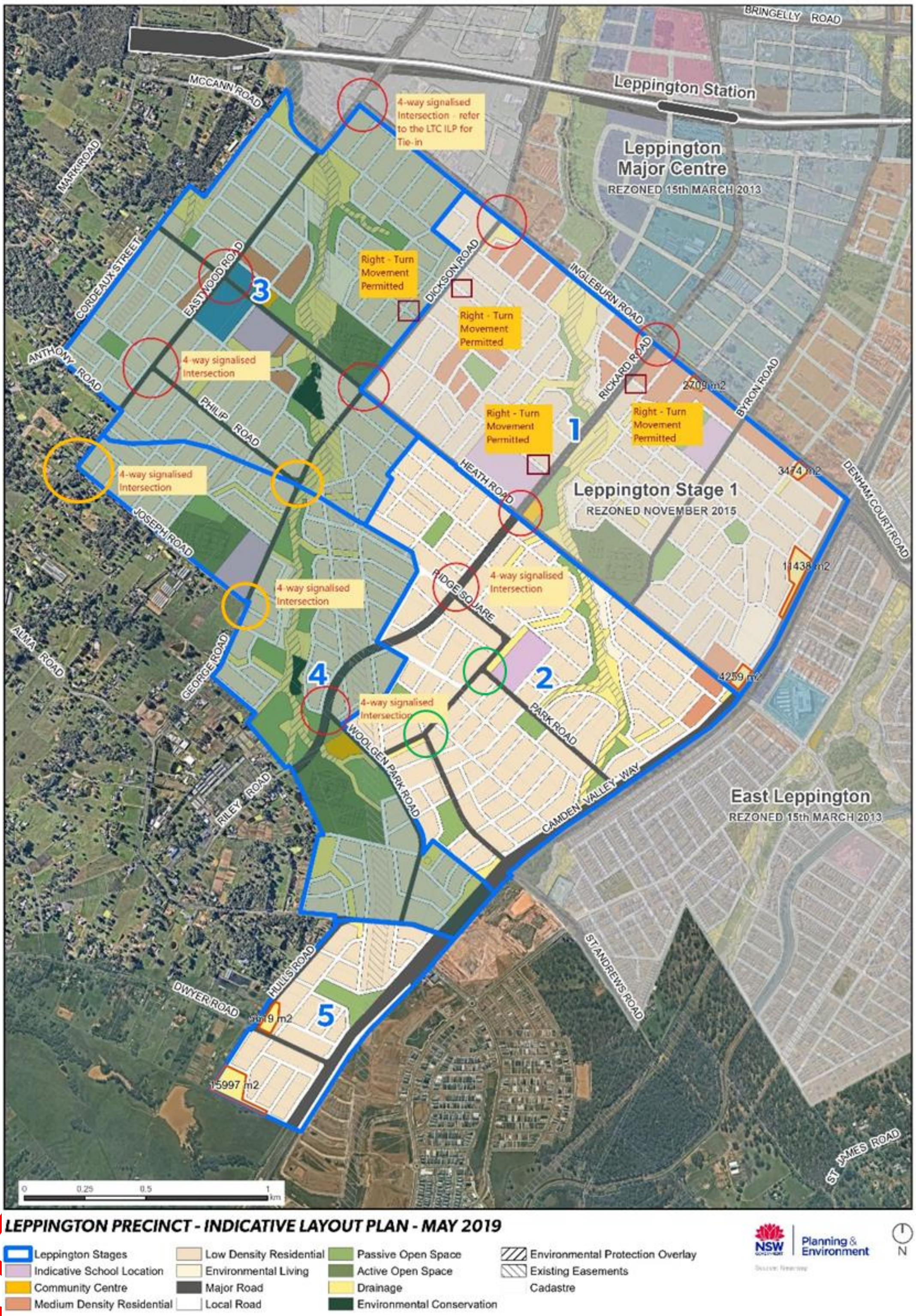


Figure 7: Precincts access management plan vision (Source: Camden Council, Jan 2020)

The following comments should be read in conjunction with Figure 7:

- Red circles indicate signalised intersections.
- As part of the review and development of access management, two signalised intersections were introduced (shown in green) and three signalised intersections have been modelled as three-way signalised intersection (shown in orange) instead of four-way signalised intersection.
- Maroon Squares indicate permitted right turn movements (facilitated via right hand turn bay within median)
- Rickard Road South of Ingleburn Road will be access denied, i.e. no driveway directly onto Rickard Road. Left in/left out movements will be allowed within Leppington precinct 1 (LP1). Parallel routes are planned adjacent to Rickard Road in LP2 and LP4, and direct access onto Rickard Road will be provided via signalised intersections at Ridge Square and Woolgen Park Road only. Two locations with proposed right turn movement shown on Rickard Road between Ingleburn Road and Heath Road.
- Dickson Road within LP1 is not access denied, i.e. driveways can access Dickson road directly. This will impact Dickson Road between Ingleburn Road and Heath Road southbound only, as half the road is in LP1 and the remaining within LP3. Within LP3 and LP4, Dickson Road is access denied. Left in/left out movements permitted onto Dickson road within LP1, LP3 and LP4. Two locations with proposed right turn movement shown on Dickson Road between Ingleburn Road and Heath Road.
- Eastwood Road south of Ingleburn Road is access denied. Some locations with permitted left in/left out movements within LP3 and LP4.
- We note that the blue lines represent Precinct boundaries, which do not necessarily follow the roads.

5.3.3 Road capacities

The number of future roadway lanes (per direction) within the modelled area are shown in Figure 8. The values shown in Figure 9 represent the capacity in vehicles per hour per direction.

5.3.4 Road space allocation

Road space was assigned to be commensurate with the intended roadway hierarchy and spatial allocations by time of day and mode. This included an initially conservative assumption that kerbside lanes in lower order streets would generally be for parking or other kerbside uses (freight loading, taxi's, buses) including during peak periods, except on approach to intersections.

Figure 11 presents the currently proposed typical section of the critical Rickard Road corridor, consisting of cross-sectional design between Bringelly Road and Ingleburn Road, and another south of Ingleburn Road.

Figure 8: Number of future roadway lanes (per direction)

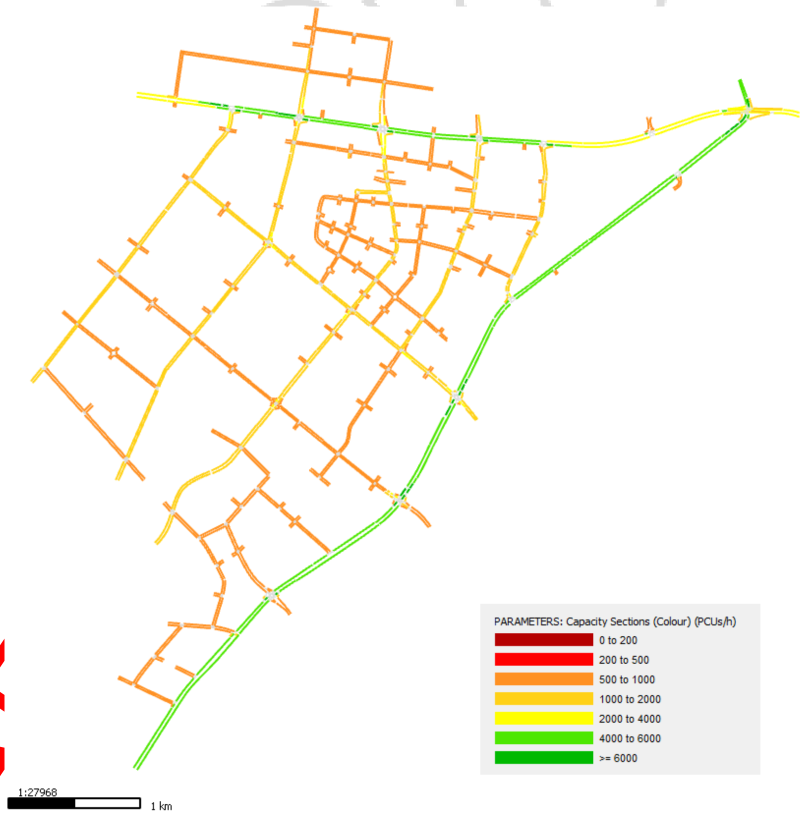


Figure 9: Roadway capacity for future roads (per direction)

Rickard Road was generally represented as two lanes per direction (one for general traffic, one for buses) in the modelling except at intersections where provisions were made for turning movements. For the purposes of preliminary modelling it was assumed that a bus interchange would be provided south of the Leppington Station. The general access and intersections arrangement can be seen in Figure 11.

In terms of other bus priority infrastructure, Transport for NSW has constructed bus jump lanes at various locations along Bringelly Road (including at the Bringelly Road and Rickard Road intersection) and Camden Valley Way. It is noted, in future, that Council do not want any additional bus jump lanes within Council's road network.

5.3.5 Speed limits

The roadway speed limits within Leppington precinct are shown in Figure 10. Note that all speed limits within the Leppington core – set approximately by the sub-arterial "ring-road" system of Bringelly Road, Dickson Road, Byron Road and Ingleburn Road – are proposed to be reduced to 40km/h to align with the *Road Safety Plan* (Transport for NSW, 2018) and Movement and Place framework, subject to further consultation with stakeholders.

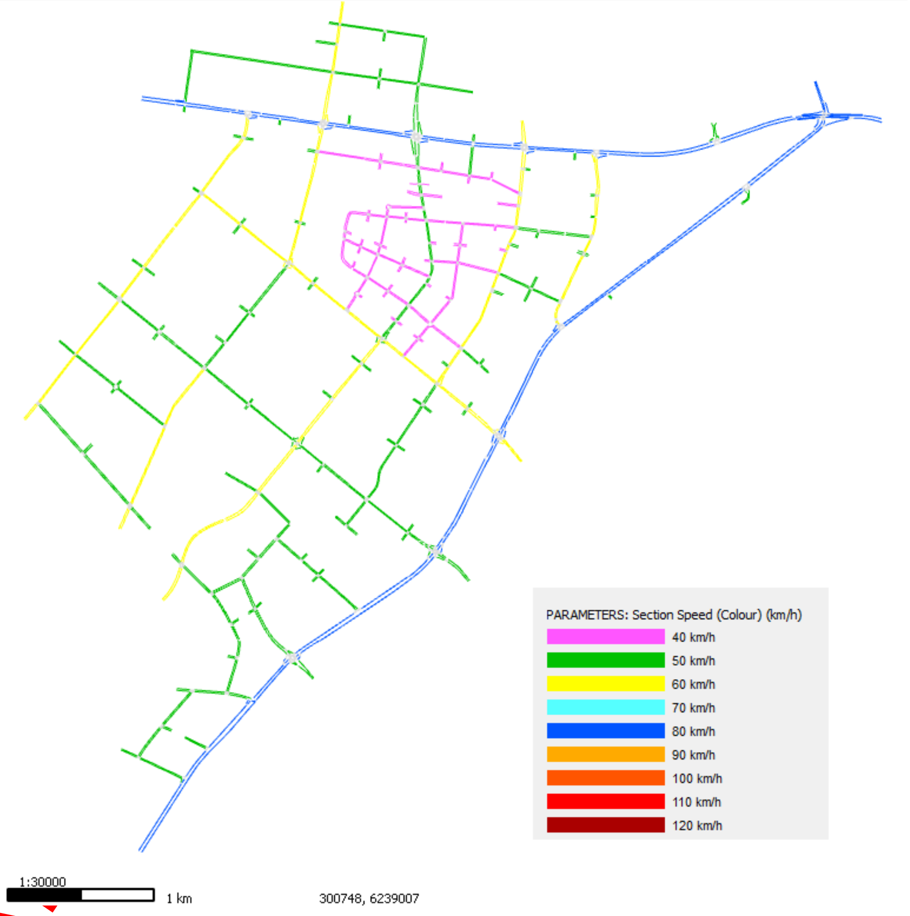


Figure 10: Speed limits in the future network

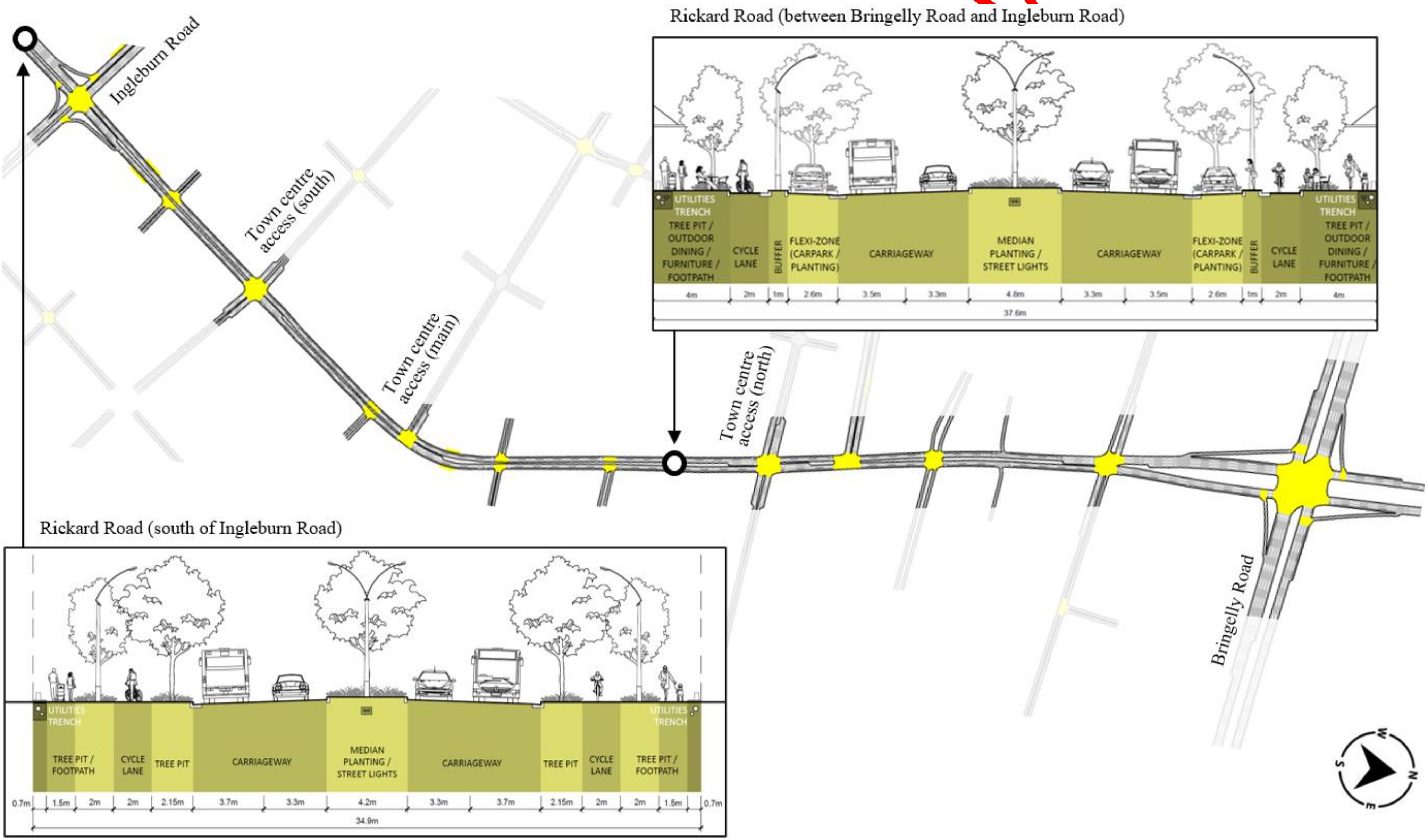


Figure 11: Rickard Road general cross-sections and future model representation between Bringelly Road and Ingleburn Road

5.3.6 Refinement and optimisation

Road network and intersection optimisation was an iterative process that considered intersection layouts, traffic volumes and signal settings and was completed entirely in Aimsun.

Along recently upgrade roads/sections, such as Bringelly Road, the objective was to avoid upgrades that may encroach beyond the existing intersection footprints, unless unavoidable.

5.3.7 Intersection operational assumptions

Signalised intersections were generally represented using the following assumptions:

- 140-second cycle times were assumed along high-volumes arterial roads, such as Camden Valley Way, Bringelly Road and Ingleburn Road.
- 90-140 second cycle times were assumed along north-south sub-arterials where they intersect with lower-order roads.
- Nominal pedestrian start delays were assumed at relevant in the network.

5.3.8 Proposed treatments

Intersection configurations were developed based on the refinement of the outcomes of Arup's 219 LTC study, as well as the targets discussed in section 5.3.7. Proposed intersection controls are shown in Figure 12.

Bringelly Road has recently been upgrades as part of the Western Sydney Infrastructure Program (WSIP) works. All 2041 modelling was undertaken with lane arrangements and intersection geometry matching the established kerb lines. The only change to Bringelly Road from its currently constructed arrangement was assumed to be at its intersection with Camden Valley Way, where grade separation before 2041 will likely be required.

Camden Valley Way was assumed to be widened to three lanes per direction by 2041, with localised capacity enhancements at intersections along its length.

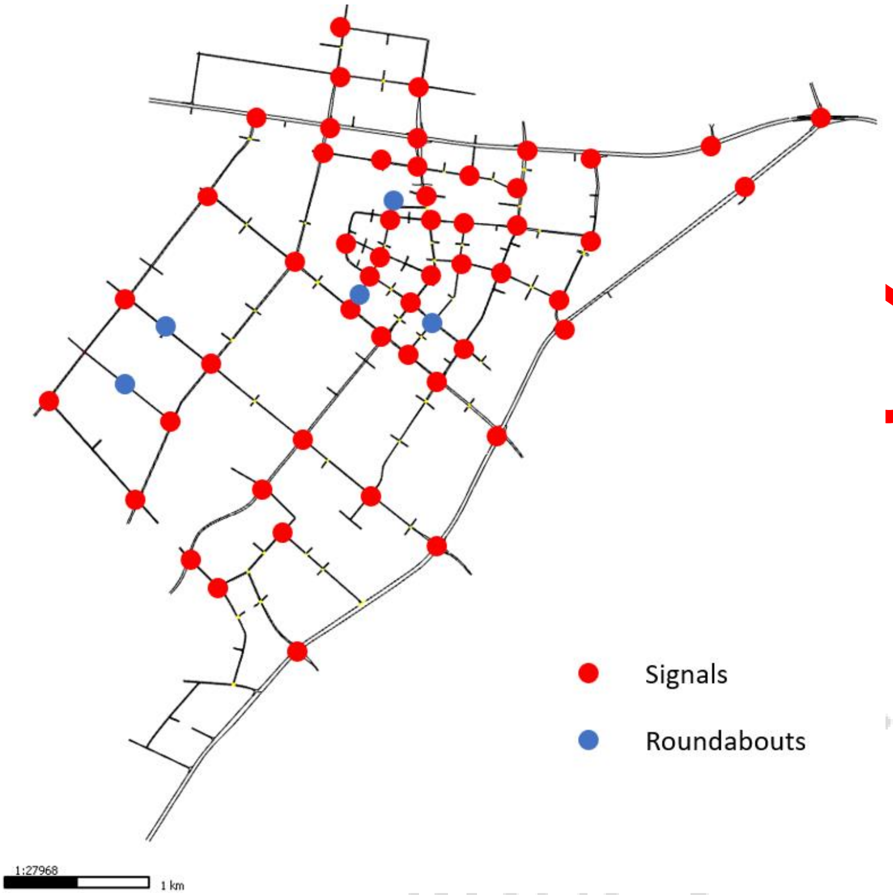


Figure 12: Proposed intersection controls

Table 12 summarises the assumed intersection treatments along both roads by 2041. The detailed 2041 network plan and intersection layouts are included in Appendix I.

Table 12: Future upgrades assumed along Bringelly Road and Camden Valley Way

Intersection	Assumed upgrades by 2041
Bringelly Road / Eastwood Road	No additional works required.
Bringelly Road / Dickson Road / Fourth Avenue	No additional works required.
Bringelly Road / Rickard Road / Edmonson Road	No additional works required.
Bringelly Road / Byron Road / Brown Road	Adding the southern (Byron Road) approach to the existing intersection along with associated turning movement lanes.
Bringelly Road / Cowpasture Road	No additional works required.
Bringelly Road / Camden Valley Way	Grade separation would likely be required at this location which represents the convergence point of two key arterial corridors in the area.
Camden Valley Way / Cowpasture Road	Widening of Camden Valley Way to achieve three through lanes in each direction, including localised capacity enhancements.

Camden Valley Way / Ingleburn Road	Widening of Camden Valley Way to achieve three through lanes in each direction, as well as the provision of a third westbound through lane from Denham Court and associated short downstream exit lane.
Camden Valley Way / Heath Road	Widening of Camden Valley Way to achieve three through lanes in each direction, including localised capacity enhancements.

All other roads were based on the ILP vision (see Figure 1 and Figure 3 in section 4), and Council's envisaged access management plan and intersection controls (see Figure 7 in section 5.3.2). Reasonable intersection arrangements were developed to provide local capacity.

5.4 Public transport

5.4.1 Bus services

In March 2021, Transport for NSW provided Council with a reference 2041 bus network throughout the Leppington Town Centre and wider Precinct area. The network is characterised by high-frequency north-south services along Rickard Road, connecting Oran Park in the south to the Leppington Station and Austral to the north.

While this latest vision is significantly different from previous iterations in terms of service provisions, it aligns well with Camden Council's vision for the functioning of the corridor in future. Council commissioned Arup to undertake a desktop study that explored the potential impacts that high frequency bus services may have on the uptake of bus ridership in adjacent land uses. The detailed assessment is included in Appendix E.

Transport for NSW's current 2041 planning suggests up to 34 buses per direction per hour (±2-minute headways) may traverse the Precinct along Rickard Road, while up to 52 per direction per hour (±1-minute headways) may enter the Town Centre along the same road. This presents a significantly different transport vision than what came before where 12 buses per hour were assumed and upon which all prior modelling was based.

Transport for NSW indicate that the bus network was developed with a pronounced north-south focus. Buses are intended to fill the gap left by the low density of the rail network. The routes and frequencies were designed to serve trip origins/destinations within an 800m catchment area of the corridor in support of Transport for NSW mode share targets in Western Sydney. According to current plans the network will be able to support ±9,000 trips per hour into the Leppington interchange.

While Transport for NSW has not committed to the delivery of this reference network, the plan is their latest iteration of the future strategic bus network for Leppington and is consistent with *Future Transport 2056 Strategy* and *A Metropolis of Three Cities Strategy*. We note that the reference network is strategic. As land use and the precinct planning becomes more refined bus routes may have interface through Leppington which is less focussed on the Rickard Road Corridor; however, the north-south movement will be critical for any delivery of future Rapid Bus Services as well as local bus services and will be the main point of focus into the train interchanges. There are many different scenarios which could take place; the scenario in Figure 13 is focused on reducing the total amount of bus routes but focusing on high levels of frequency across the network.

For the purposes of the mesoscopic modelling we assumed that:

- Existing bus stops along Bringelly Road and Camden Valley Way will remain in their current locations and with their current spacing in future. They are generally located in queue jump lanes.
- New bus stops will be placed every 400m along Rickard Road and Ingleburn Road. Indented bus bays were assumed along both roads; however, the final arrangement will be determined as part of the concept design process.

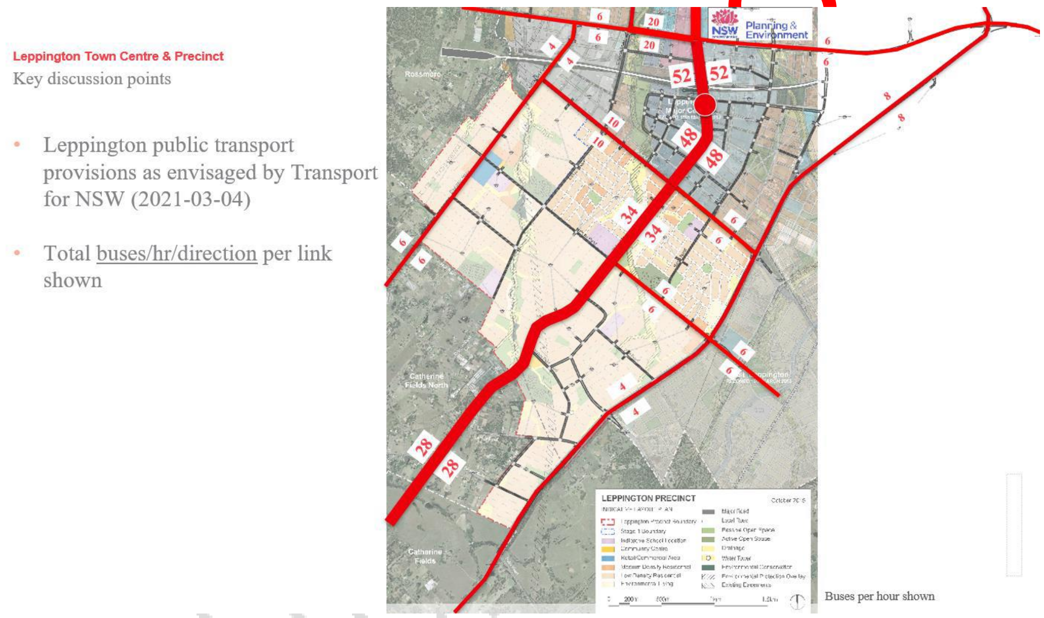


Figure 13: Proposed 2041 bus networks through LTCP (Source: TfNSW, March 2021)

6 Road network assessment based on the initial land use

6.1 Performance evaluation

The LTCP's future road network can be evaluated according to three main principles or criteria, namely:

- **Roadway classification**: How will traffic move within and through the Precinct and does the hierarchy support the proposed land use?
- **Roadway performance:** Are adequate numbers of lanes provided to support the intended roadway function(s) and does it help to accommodate traffic without significant congestion?
- **Intersection performance:** Are the intersections layouts optimal, are the delays acceptable and do they help to optimise the network capacity?

The modelling results were tested against each of these principles.

Roadway classification

The *Growth Centres Development Code* (Growth Centres Commission, 2006) classifies hierarchy based on anticipated levels of daily traffic, as summarised in Table 13. Each road's classification will dictate its physical form (i.e. number of lanes, road reserve width), function (what types of vehicles utilise the road) and the speed limit.

Table 13: Functional classification of roads

Roadway type	AADT(1)	Peak hour volume(2)	Functions and connections	Speed limit
Arterial Road	35,000 +	3,500 +	Connects large urban areas	> 80km/h
Sub Arterial Road	10,000-35,000	1,000 – 3,500	Arterial roads to town centres	≤ 70km/h
Town Centre Road	≤ 20,000	≤ 2,000	Pedestrian oriented	
Collector Road(3)	3,000-10,000	300 – 1,000	Carries major bus routes	≤ 60km/h
Local Road	1,000-3,000	100 – 300	Connects neighbourhoods	≤ 50km/h

1. Annual Average Daily Traffic
2. Peak 1-hour volume estimated as 10% of AADT as a rule of thumb
3. Including Rickard Road

Intersection performance

The performance of intersections in an urban environment is measured in terms of its LOS, which ranges from A (very good) to F (over capacity with significant delays). This is described in the *Guide to traffic Generating Developments* (Roads and Maritime, 2002) as summarised in Table 14.

For the purposes of this investigation, the applied desired performance target is LOS D, with an absolute minimum performance targe of LOS E.

Table 14: LOS criteria for intersections

LOS	Average delay per vehicle	Traffic signals and roundabouts	Give way and stops
A	< 14 sec	Good operation	Good operation
B	15 to 28 sec	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42 sec	Satisfactory	Satisfactory, but an accident study is required
D	43 to 56 sec	Operating near capacity	Near capacity and an accident study is required
E	57 to 70 sec	At capacity. Incidents will cause excessive delays at signals. Roundabouts require another control type.	At capacity. Requires another control mode.
F	> 70 sec	Over capacity. Unstable operations.	Over capacity. Unstable operations.

6.2 Road network performance

This section provides an assessment of the future road network that will support the Precinct and meet future traffic demands. It presents the preliminary Aimsun modelling results for the AM and PM peak hours in terms of traffic volumes and performance.

6.2.1 Roadway classification

Figure 14 and Figure 15 present the modelled link flows during the 2041 AM and PM peak hours respectively. High resolution plots of the results are included in Appendix J.

The outputs suggest:

- Traffic volumes are generally distributed along the network in proportion to the road hierarchy, meaning the heaviest volumes are shown along the higher order (primary arterial and sub-arterial) network.
- Bringelly Road and Camden Valley Way have more than 4,000 vehicles per hour (both directions combined) at their most trafficked sections. This which is commensurate with their functions as primary arterials. A significant portion of these volumes are external movements through the area and are not generated by the LTCP.
- Through traffic (i.e. trips not originating or terminating within the Leppington precinct) travel along the sub-arterial road network to circumnavigate the town

centre core. This suggests that the access management measures support the objectives of the precinct and functional road hierarchy.

- The sub-arterial roads carry volumes generally in line with their functional capacities (see Table 13) of 1,000 to 3,500 veh/h (both directions combined).
- Volumes along Rickard Road through the town centre vary between 700 and 1,100 veh/h (both directions combined), which is generally in line with its function as a collector-type road. From Ingleburn Road to a short distance south of Heath Road, the volumes increase to approximately 2,000 veh/h (both directions combined) as a result of the adjacent land uses that gain access directly onto this portion of Ricard Road.
- The internal roads within the town centre show low volumes, which supports their intended function within the pedestrianised and activated core area.

Figure 14: Modelled peak hour flows for the initial land use scenario: 2041 AM peak hour

Figure 15: Modelled peak hour flows for the initial land use scenario: 2041 PM peak hour

6.2.2 Roadway performance

Figure 16 and Figure 17 present the roadway simulated densities in vehicles per kilometre during the 2041 AM and PM peak hours, respectively. High resolution plots of the results are included in Appendix K.

Vehicle density should be interpreted relative to that of adjacent links. High density directly upstream of a signalised intersection, for example, is expected as part of the delay induced by red cycles. If the high density is localised and does not extend over multiple adjacent links, the result may suggest overall acceptable performance.

We note the following:

- The results suggest than Heath Road, between Rickard Road and Eastwood Road, may experience sub-optimal operations. It is expected that the two-lane cross-section could accommodate the 1,500 veh/h (both directions combined) traffic demand. This suggests that the poor performance along this section is due to localised capacity constraints at the intersections of Heath Road/Dickson Road and/or Heath Road/Eastwood Road.

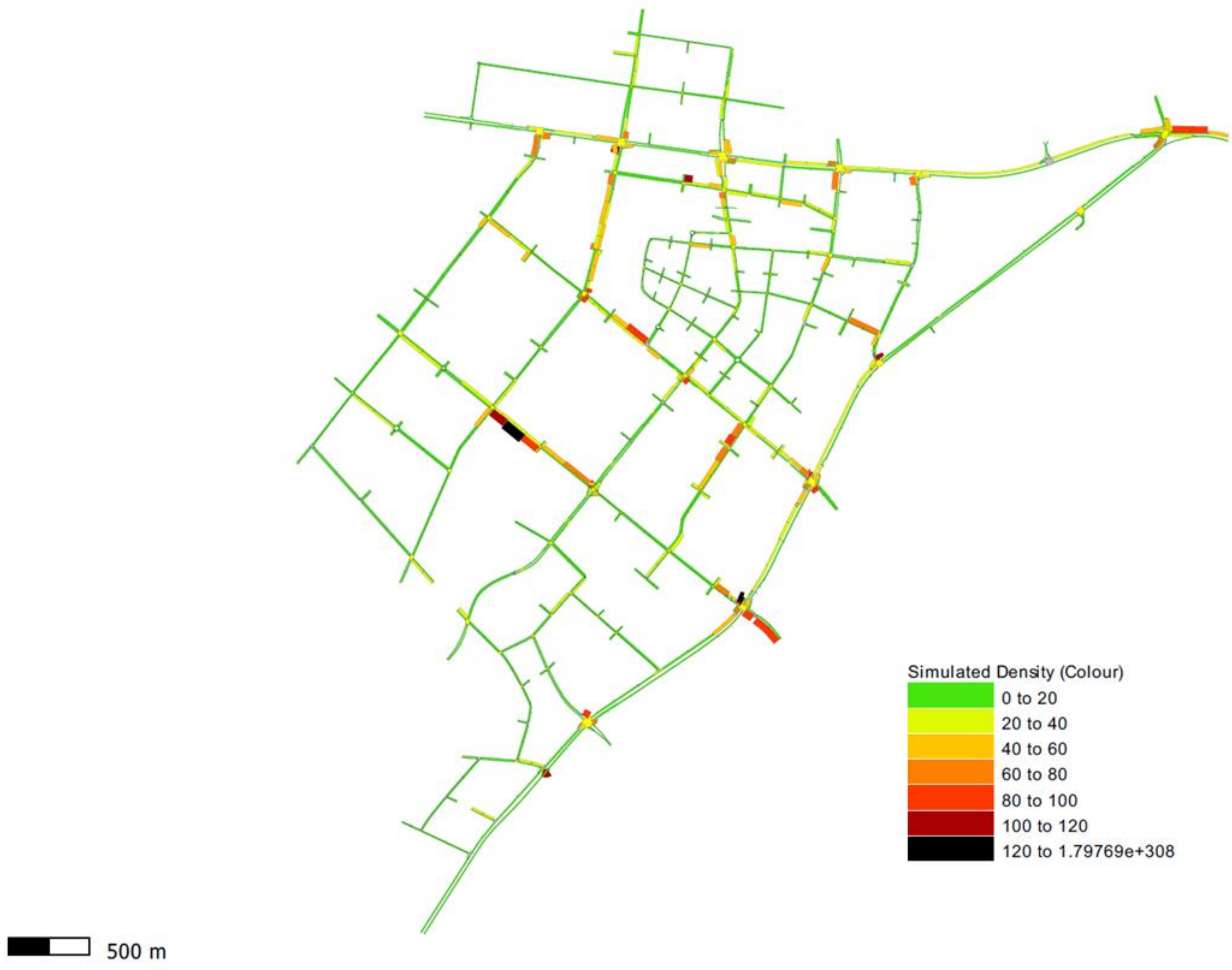


Figure 16: Modelled peak hour density for the initial land use scenario: 2041 AM peak hour

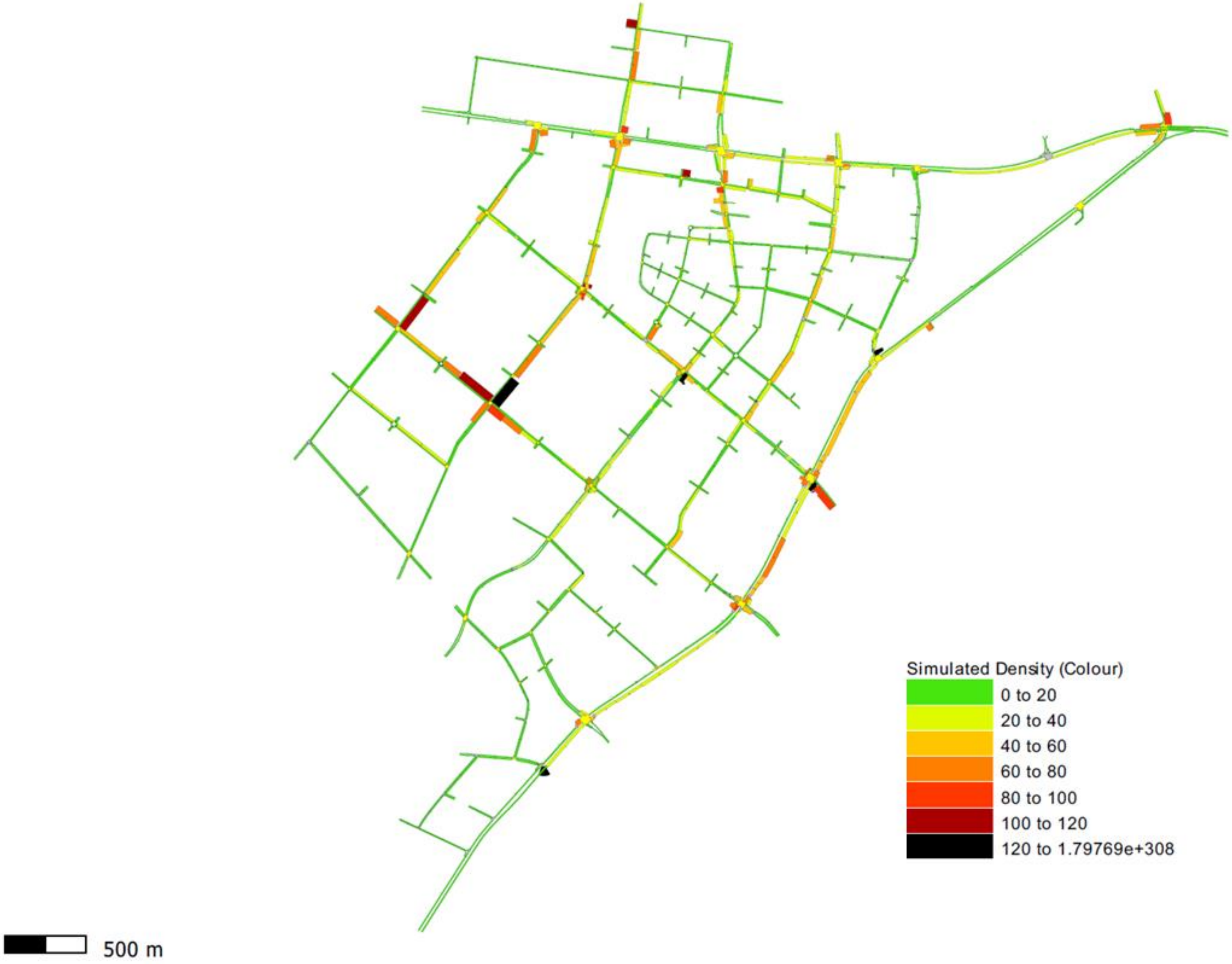


Figure 17: Modelled peak hour density for the initial land use scenario: 2041 PM peak hour

6.3 Intersection modelling results

Figure 18 and Figure 19 presents the average delay time per vehicle per link, for each the 2041 AM and PM peak hours. High resolution plots of the results are included in Appendix L.

Average delay should be interpreted relative to that of adjacent links. Delay is caused by forced stop times associated with intersections and their control types. A measure of delay is expected at signalised intersections because of the red cycles. If higher delays are localised to links adjacent to the intersection and do not extend over multiple additional upstream links, the result may suggest overall acceptable performance. In such cases it can be assumed that localised, geometric upgrades or optimised cycle times may be all that is required to further enhance the result. In cases where high delays wash over a range of adjacent links, the results may suggest overall cycle improvement or more dramatic network changes may be required.

Both figures indicate that the intersections within the Leppington Precinct generally operate at acceptable LOS D or better whilst low speeds are generally only observed in for short sections on approach to key intersections or in the lower order street network. Operational performance may be improved further from traffic signal improvements in future modelling iterations.

We note the following:

- Sub-optimal operations are suggested at the intersections of Heath Road/Dickson Road and/or Heath Road/Eastwood Road. This is likely due to localised capacity constraints at one or either of the intersections. Possible intervention may include improved geometric layouts, or widening Heath Road to a four-lane cross-section.

Figure 18: Modelled peak hour delay for the initial land use scenario: 2041 AM peak hour

Figure 19: Modelled peak hour delay for the initial land use scenario: 2041 PM peak hour

7 Results based on the final land use

This section presents the final modelling results that are based on updated inputs provided by Camden Council after Arup submitted the draft Traffic Modelling Report on 01 June 2021, and it incorporates comments received from Council and from Transport for NSW in the same timeline.

7.1 Land use

Council provided updated land use data to Arup on 13 July 2021. While the data included new yield totals by land use type for both the Town Centre and Precincts, the data was not available at the parcel area level as was previously provided in the ILP (discussed in Section 4); only aggregated totals were provided. Council confirmed that they did not envisage major land use changes compared to the ILP and that the same land uses would generally be in the same areas as before, but to different intensities.

With agreement from Council on 26 July 2021, Arup assumed that:

- Town Centre: In lieu of the having an updated ILP, the only reasonable approach would be to rely on the previous ILP and scale the totals to the new land use numbers pro rata. In this way, the spatial allocation of the previous ILP were inherited with scaled totals. The risk of this approach is if a major type of land use is being "moved" elsewhere, its spatial impact would not be captured.
- Precincts 1 to 5: Within each Precinct the land use was spread out by assuming uniform density, by land use type.

The updated land use totals are shown in Table 15 to Table 20.

Table 15: Final trip generation summary by land use for Leppington Town, AM peak hour (2041) (Source: Camden Council, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m^2 GFA)	Office (m^2 GFA)	Bulk Goods (m^2 GFA)	Industrial (m^2 GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	-	-	-	-	-	-	-	-	-	-	-
Med Density Res	R3	3,750	-	-	-	-	293	1,170	-	-	293	1,170
High Density Res	R4	2,500	-	-	-	-	95	380	-	-	95	380
Commercial Core (office)	B3	-	-	82,734	-	-	-	-	1,203	301	1,203	301
Mixed Use	B4	4,500	-	72,266	-	-	171	684	1,051	263	1,222	947
Environmental Living	E4	-	-	-	-	-	-	-	-	-	-	-
Retail 0 – 8,000 m^2 GFA	B3 & B4	-	9,308	-	-	-	-	-	193	193	193	193
Retail 8,000 – 16,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m^2 GFA	B3 & B4	-	31,496	-	-	-	-	-	340	340	340	340
Retail 24,000 – 32,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail > 56,000 m^2 GFA	B3 & B4	-	109,195	-	-	-	-	-	647	647	647	647
Industrial	IND	-	-	-	-	136,800	-	-	569	142	569	142
Bulk goods	B5	-	-	-	56,000	-	-	-	-	-	-	-
School (8,600 students)		-	-	-	-	-	-	-	299	161	299	161
TOTAL		**10,750**	**150,000**	**155,000**	**56,000**	**136,800**	**559**	**2,234**	**4,303**	**2,048**	**4,862**	**4,282**

Table 16: Final trip generation summary by land use for Leppington Precincts: AM peak hour (2041) (Source: Camden Council, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m^2 GFA)	Office (m^2 GFA)	Bulk Goods (m^2 GFA)	Industrial (m^2 GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	8,812	-	-	-	-	1,635	6,540	-	-	1,635	6,540
Med Density Res	R3	1,166	-	-	-	-	91	364	-	-	91	364
High Density Res	R4	-	-	-	-	-	-	-	-	-	-	-
Commercial Core (office)	B3	-	-	-	-	-	-	-	-	-	-	-
Mixed Use	B4	184	-	-	-	-	7	28	-	-	7	28
Environmental Living	E4	96	-	-	-	-	18	73	-	-	18	73
Retail 0 – 8,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 8,000 – 16,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 24,000 – 32,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m^2 GFA	B3 & B4	-	18,436	-	-	-	-	-	155	155	155	155
Retail > 56,000 m^2 GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Industrial	IND	-	-	-	-	-	-	-	-	-	-	-
Bulk goods	B5	-	-	-	-	-	-	-	-	-	-	-
School (8,600 students)		-	-	-	-	-	-	-	2,221	1,305	2,221	1,305
TOTAL		**10,258**	**18,436**	**0**	**0**	**0**	**1,751**	**7,005**	**2,377**	**1,460**	**4,128**	**8,465**

Table 17: Final trip generation summary by land use for Leppington Town Centre, PM peak hour (2041) (Source: Camden Council, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	-	-	-	-	-	-	-	-	-	-	-
Med Density Res	R3	3,750	-	-	-	-	1,110	278	-	-	1,110	278
High Density Res	R4	2,500	-	-	-	-	300	75	-	-	300	75
Commercial Core (office)	B3	-	-	82,734	-	-	-	-	243	971	243	971
Mixed Use	B4	4,500	-	72,266	-	-	540	135	212	848	752	983
Environmental Living	E4	-	-	-	-	-	-	-	-	-	-	-
Retail 0 – 8,000 m² GFA	B3 & B4	-	9,308	-	-	-		-	-	429	429	429
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-		
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	31,496	-	-	-			756	756	756	756
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail > 56,000 m² GFA	B3 & B4	-	109,195	-	-	-	-	-	1,439	1,439	1,439	1,439
Industrial	IND	-	-	-	-	136,800	-	-	153	613	153	613
Bulk goods	B5	-	-	-	56,000	-	-	-	756	756	756	756
School (8,600 students)		-	-	-	-	-	-	-	7	40	7	40
TOTAL		**10,750**	**150,000**	**155,000**	**56,000**	**136,800**	**1,950**	**488**	**3,995**	**5,851**	**5,945**	**6,339**

Table 18: Final trip generation summary by land use for Leppington Precincts: PM peak hour (2041) (Source: Camden Council, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	8,812	-	-	-	-	6,548	1,637	-	-	6,548	1,637
Med Density Res	R3	1,166	-	-	-	-	345	86	-	-	345	86
High Density Res	R4	-	-	-	-	-	-	-	-	-	-	-
Commercial Core (office)	B3	-	-	-	-	-	-	-	-	-	-	-
Mixed Use	B4	184	-	-	-	-	22	6	-	-	22	6
Environmental Living	E4	96	-	-	-	-	76	19	-	-	76	19
Retail 0 – 8,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	18,436	-	-	-	-	-	345	345	345	345
Retail > 56,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Industrial	IND	-	-	-	-	-	-	-	-	-	-	-
Bulk goods	B5	-	-	-	-	-	-	-	-	-	-	-
School (8,600 students)		-	-	-	-	-	-	-	58	331	58	331
TOTAL		**10,258**	**18,436**	**0**	**0**	**0**	**6,991**	**1,748**	**403**	**676**	**7,394**	**2,423**

Table 19: Final total trip generation summary by land use for the combined Leppington Town Centre and Precincts, AM peak hour (2041) (Source: Camden, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	8,812	-	-	-	-	1,635	6,540	-	-	1,635	6,540
Med Density Res	R3	4,916	-	-	-	-	383	1,534	-	-	383	1,534
High Density Res	R4	2,500	-	-	-	-	95	380	-	-	95	380
Commercial Core (office)	B3	-	-	82,734	-	-	-	-	1,203	301	1,203	301
Mixed Use	B4	4,684	-	72,266	-	-	178	712	1,051	263	1,229	975
Environmental Living	E4	96	-	-	-	-	18	73	-	-	18	73
Retail 0 – 8,000 m² GFA	B3 & B4	-	9,308	-	-	-	-	-	193	193	193	193
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	31,496	-	-	-	-	-	340	340	340	340
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	18,436	-	-	-	-	-	155	155	155	155
Retail > 56,000 m² GFA	B3 & B4	-	109,195	-	-	-	-	-	647	647	647	647
Industrial	IND	-	-	-	-	136,800	-	-	569	142	569	142
Bulk goods	B5	-	-	-	56,000	-	-	-	-	-	-	-
School (8,600 students)		-	-	-	-	-	-	-	2,520	1,466	2,520	1,466
TOTAL		**21,008**	**168,436**	**155,000**	**56,000**	**136,800**	**2,310**	**9,239**	**6,680**	**3,507**	**8,989**	**12,746**

Table 20: Final total trip generation summary by land use for the combined Leppington Town Centre and Precincts, PM peak hour (2041) (Source: Camden, 26 July 2021)

Zone	Zoning	Dwellings	Retail (m² GFA)	Office (m² GFA)	Bulk Goods (m² GFA)	Industrial (m² GFA)	Residential trips		Non-residential trips		Total trips	
							In	Out	In	Out	In	Out
Low Density Res	R2	8,812	-	-	-	-	6,548	1,637	-	-	6,548	1,637
Med Density Res	R3	4,916	-	-	-	-	1,455	364	-	-	1,455	364
High Density Res	R4	2,500	-	-	-	-	300	75	-	-	300	75
Commercial Core (office)	B3	-	-	82,734	-	-	-	-	243	971	243	971
Mixed Use	B4	4,684	-	72,266	-	-	562	141	212	848	774	989
Environmental Living	E4	96	-	-	-	-	76	19	-	-	76	19
Retail 0 – 8,000 m² GFA	B3 & B4	-	9,308	-	-	-	-	-	429	429	429	429
Retail 8,000 – 16,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 16,000 – 24,000 m² GFA	B3 & B4	-	31,496	-	-	-	-	-	756	756	756	756
Retail 24,000 – 32,000 m² GFA	B3 & B4	-	-	-	-	-	-	-	-	-	-	-
Retail 32,000 – 56,000 m² GFA	B3 & B4	-	18,436	-	-	-	-	-	345	345	345	345
Retail > 56,000 m² GFA	B3 & B4	-	109,195	-	-	-	-	-	1,439	1,439	1,439	1,439
Industrial	IND	-	-	-	-	136,800	-	-	153	613	153	613
Bulk goods	B5	-	-	-	56,000	-	-	-	756	756	756	756
School (8,600 students)		-	-	-	-	-	-	-	65	371	65	371
TOTAL		**21,008**	**168,436**	**155,000**	**56,000**	**136,800**	**8,941**	**2,235**	**4,398**	**6,527**	**13,339**	**8,762**

7.2 Trip generation and mode share

Transport for NSW advised an updated trip generation rate of 0.91 vehicle trips per dwelling during the AM peak hour, and 0.88 vehicle trips per dwelling during the PM peak hour for all low density residential units within 800m of Rickard Road south of Ingleburn Road.

They also provided recommendations on trip generation rates for schools via e-mail on 13 September 2021. In a technical summary titled "*School Trip Generation – Assessment*", they noted that Transport for NSW undertook a trip generation survey for 22 schools in NSW, including Greater Sydney and regional areas, in 2014. Their recommendations for Leppington were based on a subset of the 2014 data for one primary school and four secondary schools in the vicinity of Leppington. The recommended rates are reported in Table 21 and the technical note is attached as Appendix M.

Table 21: School trip generation rates (Source: TfNSW, 13 September 2021)

Type of school	AM peak	PM peak[1]	Unit
Primary school (K-6)	0.63	0.52	per student
Secondary school (Years 7-12)	0.59	0.31	per student
Primary and secondary combined (K-12)	0.61	0.41	per student

We note the following pertaining to Table 15:

- Observed average PM peak hour school trips occur between 15:00 and 16:00. This period falls outside the modelled 2041 PM peak period of 16:00 to 18:00.

Directional splits

The trip generation assumed the directional splits shown in Table 22.

Table 22: Trip generation rates directional splits (Source: TfNSW, 13 September 2021)

Land use	AM peak hour		PM peak hour	
	In	Out	In	Out
Primary school (K-6)	60%	40%	0%	0%
Secondary school (Years 7-12)	68%	32%	29%	71%
Primary and secondary combined (K-12)	65%	35%	15%	85%

The primary and secondary school rates were sourced from the *Lowes Creek Maryland Traffic and Transport Study* (GHD, 2018), which references the Institute of Transportation Engineers (ITE, 5th Edition) guidelines. The rates shown for the combined K-12 schools represent the averages of the ITE rates, rounded to the nearest 5%.

Trip adjustment factors:

- Transport for NSW supported a 25% reduction to the observed school trip rates, given that Leppington and the Precincts will provide all necessary infrastructure to support sustainable transport by 2041.

In addition, the average PM peak hour school trips rates were observed between 15:00 and 16:00, while the modelled 2041 PM peak period is between 16:00 and 18:00. As such, Transport for NSW recommended adopting 10% to 15% of the PM trip rates by assuming that:

- For primary schools: some teachers leave later and schools facilitate after-school care.
- For secondary schools: some teachers leave later, students participate in extra-curricular activities and the school may offer after-school classes.
- Combined K-12 schools are expected to exhibit a combination effect.

Arup conservatively assumed the highest value (15%) within that range.

The final trip generation rates, following the various reductions, are shown in Table 23.

Table 23: Trip generation rates after applying reduction factors (Source: TfNSW, 2021)

Land use	AM peak hour rate	PM peak hour rate	Unit
Residential (low density, ≤ 800m from Rickard Road)	0.91	0.88	per dwelling
Residential (low density, > 800m from Rickard Road)	0.95	0.99	per dwelling
Primary school (K-6)	0.47	0.059	per student
Secondary school (Years 7-12)	0.44	0.035	per student
Primary and secondary combined (K-12)	0.46	0.046	per student

All other assumptions and rates are consistent with Section 5.2.3 of this report.

7.3 Road network and access management

For the purposes of the final modelling, Arup has initially used the same road network and access management principles that are described in Sections 5.3 and the other infrastructure assumptions that are described in Section 5.4.

8 Road network performance

This section provides an assessment of the future road network that will support the Precinct and meet future traffic demands. It presents the preliminary Aimsun modelling results for the AM and PM peak hours in terms of traffic volumes and performance.

8.1 Roadway classification

Figure 14 and Figure 15 present the modelled link flows during the 2041 AM and PM peak hours respectively. High resolution plots of the results are included in Appendix N.

While the outputs are largely consistent with those based on the initial land use scenario and contained in Section 6.2.1, the following is noted:

- Overall, the travel demand in the AM is slightly higher for the final land use scenario in the AM, while the PM demand is slightly lower due to the final land use scenario.
- Slight reductions in northbound travel volumes along Eastwood Road and Dickson Road during the AM peak hour, as well as a slight decrease of eastbound volumes along Bringelly Road.
- South volumes along Dickson Road from Bringelly to Ingleburn Road increased slightly in the PM peak hour, while volumes along the equivalent section of Eastwood Road decreased. This is likely a route choice phenomenon.
- All of the aforementioned observations reinforce the role of the circulatory function that the combination of Ingleburn, Dickson, Eastwoods and, to a lesser extent, Byron Roads serve in diverting "through" trips away from the town centre.
- Rickard Road shows a slight increase in vehicle demand northbound between Heath Road and Ingleburn Road in the AM, largely as a result of the proposed school located just to the west.
- The town centre and the surrounding internal road network were shown to operate with consistently low volumes.

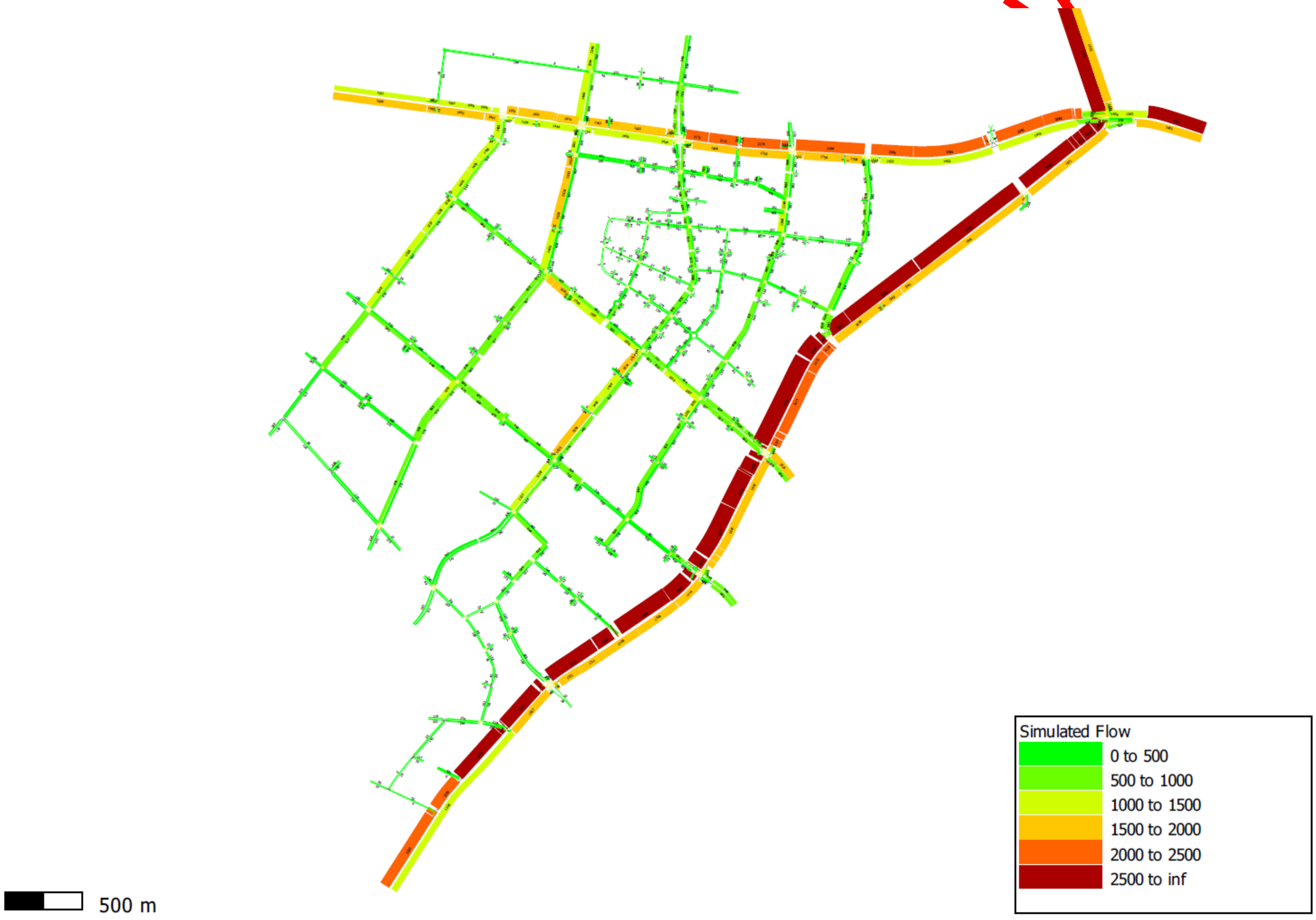


Figure 20: Modelled peak hour flows for the final land use scenario: 2041 AM peak hour

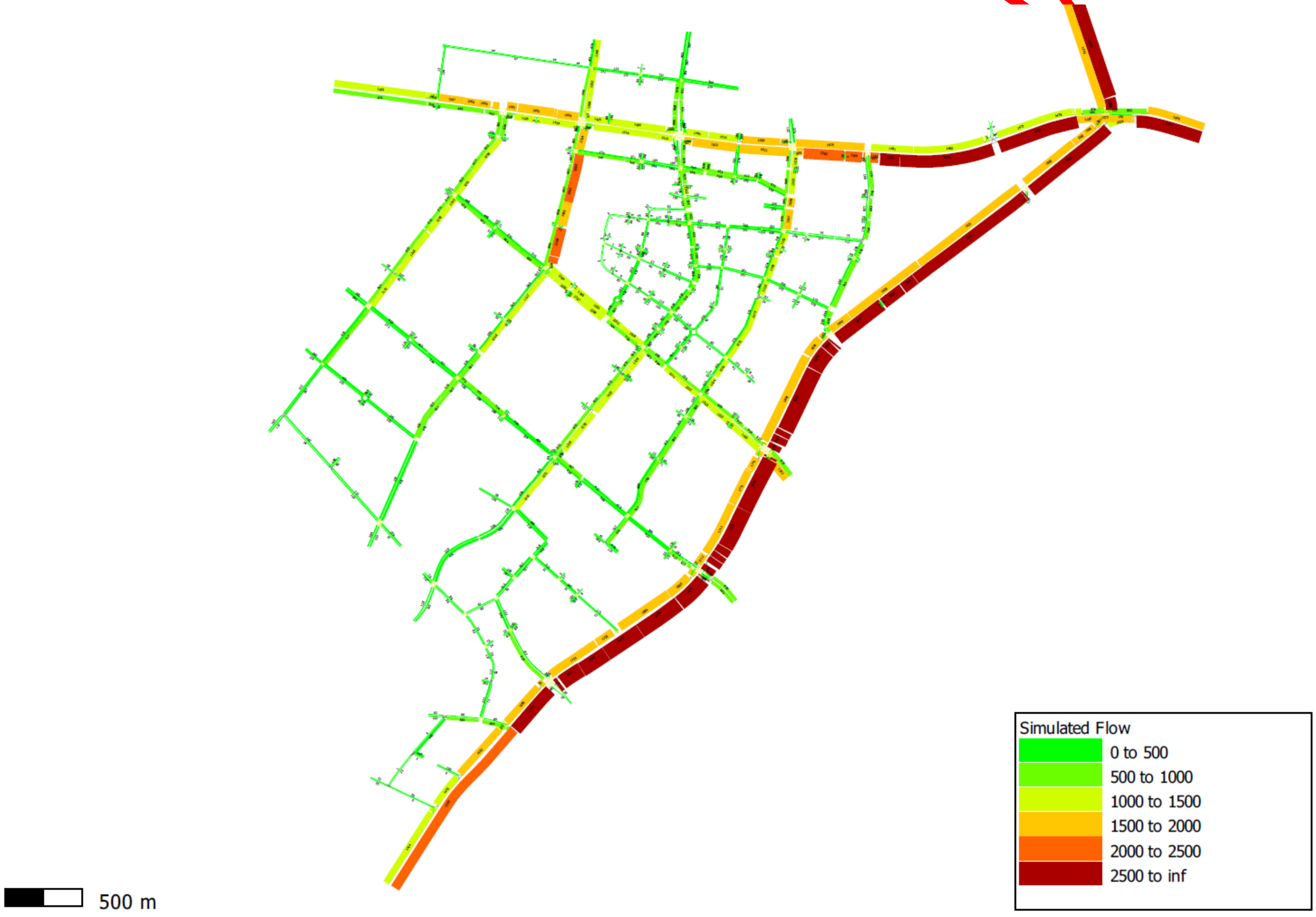


Figure 21: Modelled peak hour flows for the final land use scenario: 2041 PM peak hour

8.2 Roadway performance

Figure 16 and Figure 17 present the roadway simulated densities in vehicles per kilometre during the 2041 AM and PM peak hours, respectively. High resolution plots of the results are included in Appendix O.

For roadway performance, it is reiterated that vehicle density is arguably the most important and most revealing metric in a mesoscopic model. The density of any individual link should be interpreted relative to that of adjacent links. High density directly upstream of a signalised intersection, for example, is expected as part of the delay induced by red cycles and can imply the formation of queues. If the high density is localised and does not extend over multiple adjacent links, the result may suggest overall acceptable performance.

Overall, the outputs suggest a large improvement from the result previously based on the initial land use scenario and that were summarised in Section 6.2.2.

The results suggest high density may persist at the following locations, although to a lesser extent than what was the case for the initial land use scenario:

- Dickson Road / Heat Road intersection
- Ingleburn Road / Byron Road intersection
- Rickard Road at the first intersection south of Bringelly Road, and into the unnamed road continuing to the east of that intersection.

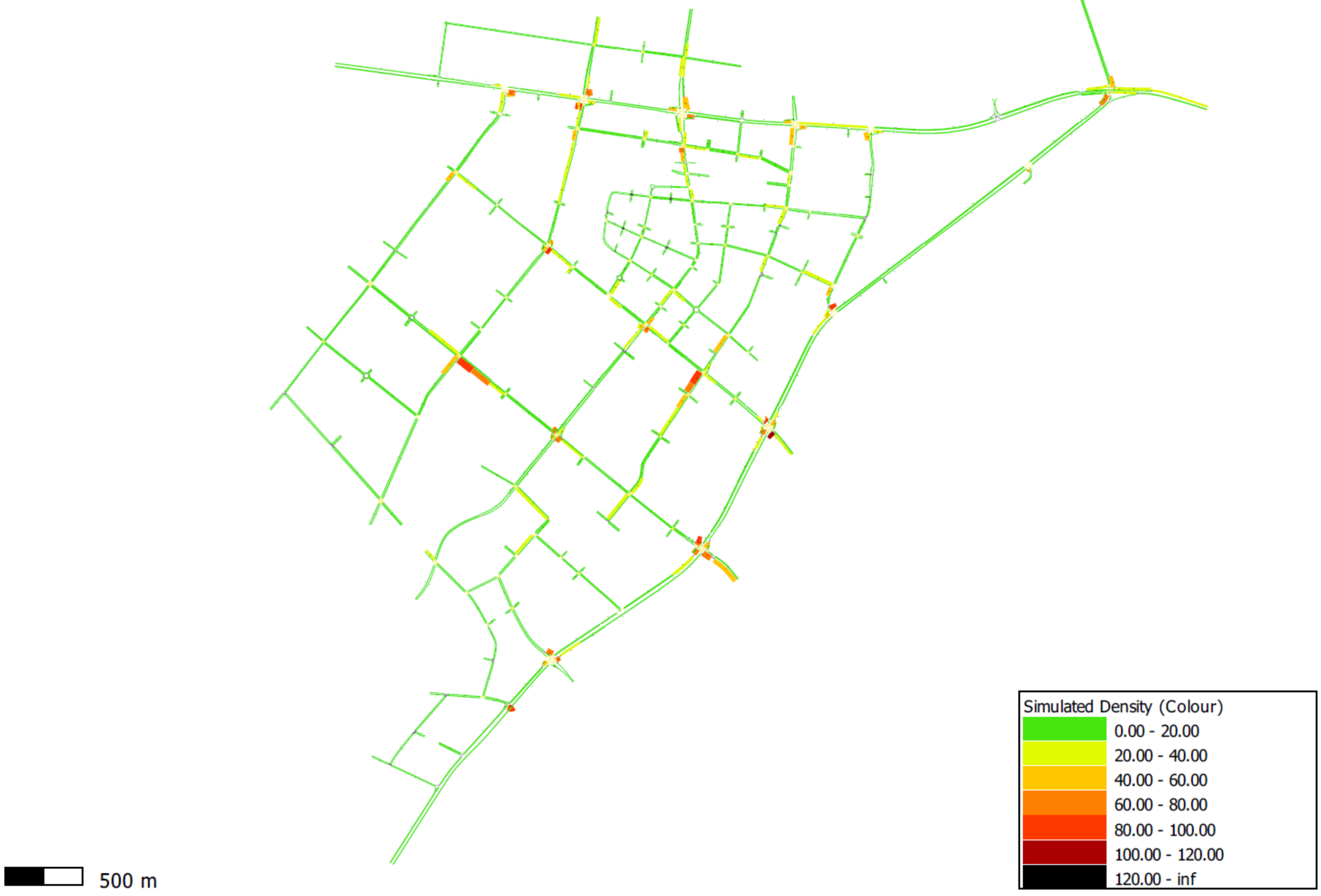


Figure 22: Modelled peak hour density for the final land use scenario: 2041 AM peak hour

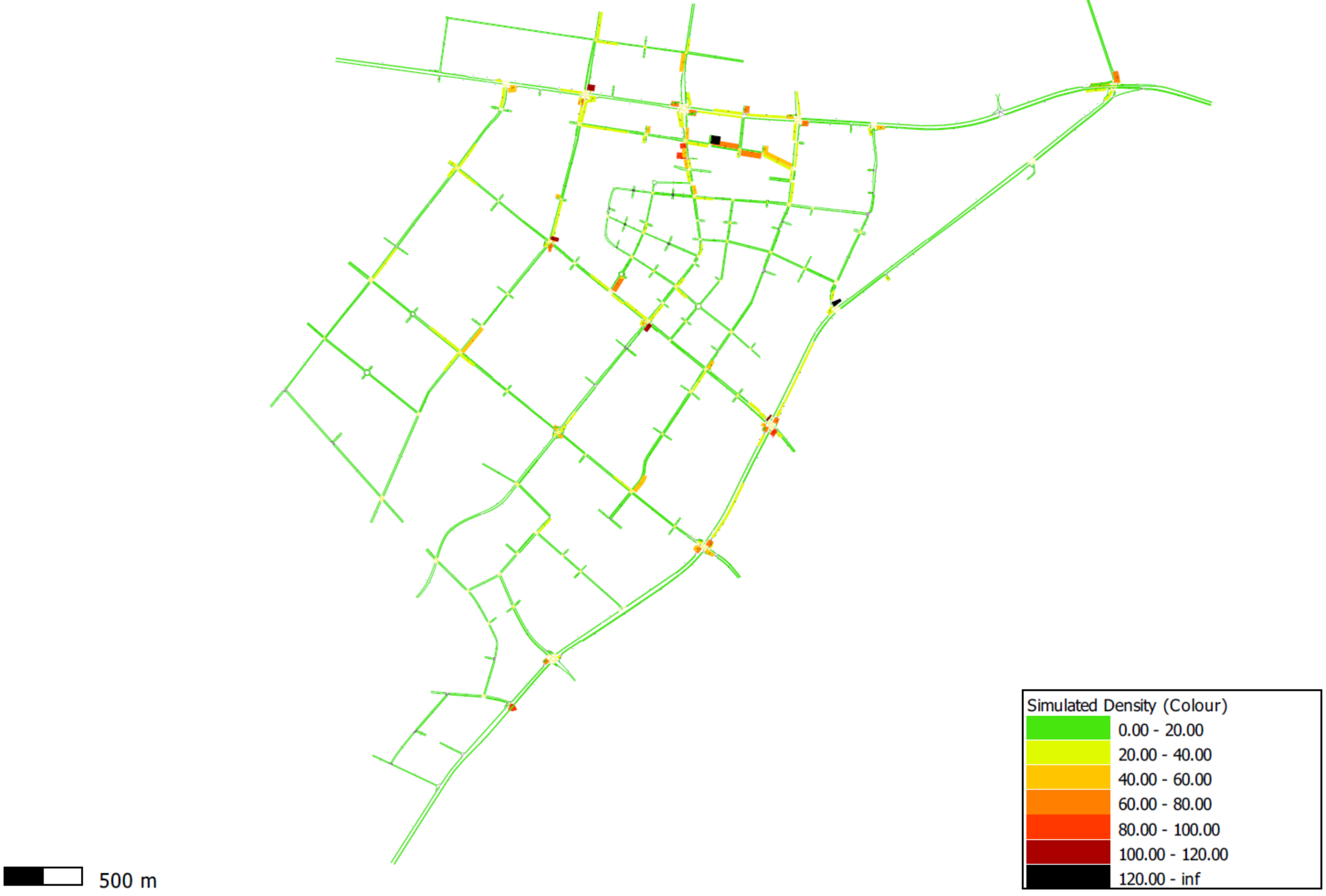


Figure 23: Modelled peak hour density for the final land use scenario: 2041 PM peak hour

8.3 Intersection modelling results

Figure 18 and Figure 19 presents the average delay time per vehicle per link, for each the 2041 AM and PM peak hours. High resolution plots of the results are included in Appendix P.

Overall, the outputs suggest a large improvement from the result previously based on the initial land use scenario and that were summarised in Section 6.3.

Consistent with the results of the density plots shown in Figure 22 and Figure 23, the results suggest intersection delays approaching sub-optimal operations may prevail at the locations listed below, although to a lesser extent than what was the case for the initial land use scenario:

- Dickson Road / Heat Road intersection
- Ingleburn Road / Byron Road intersection
- Rickard Road at the first intersection south of Bringelly Road, and into the unnamed road continuing to the east of that intersection up to Byron Road .

Following a review of the aforementioned results, Camden Council instructed Arup to proceed with assessing the performance of the following intersections in greater detail:

a – Rickard Road / Ingleburn Road

b – Dickson Road / Heath Road

c – Byron Road / Ingleburn Road (PM only)

d – Local Road

e – Rickard Road / Local Road

f – Dickson Road / Ingleburn Road

g – Rickard Road / Heath Road (AM only)

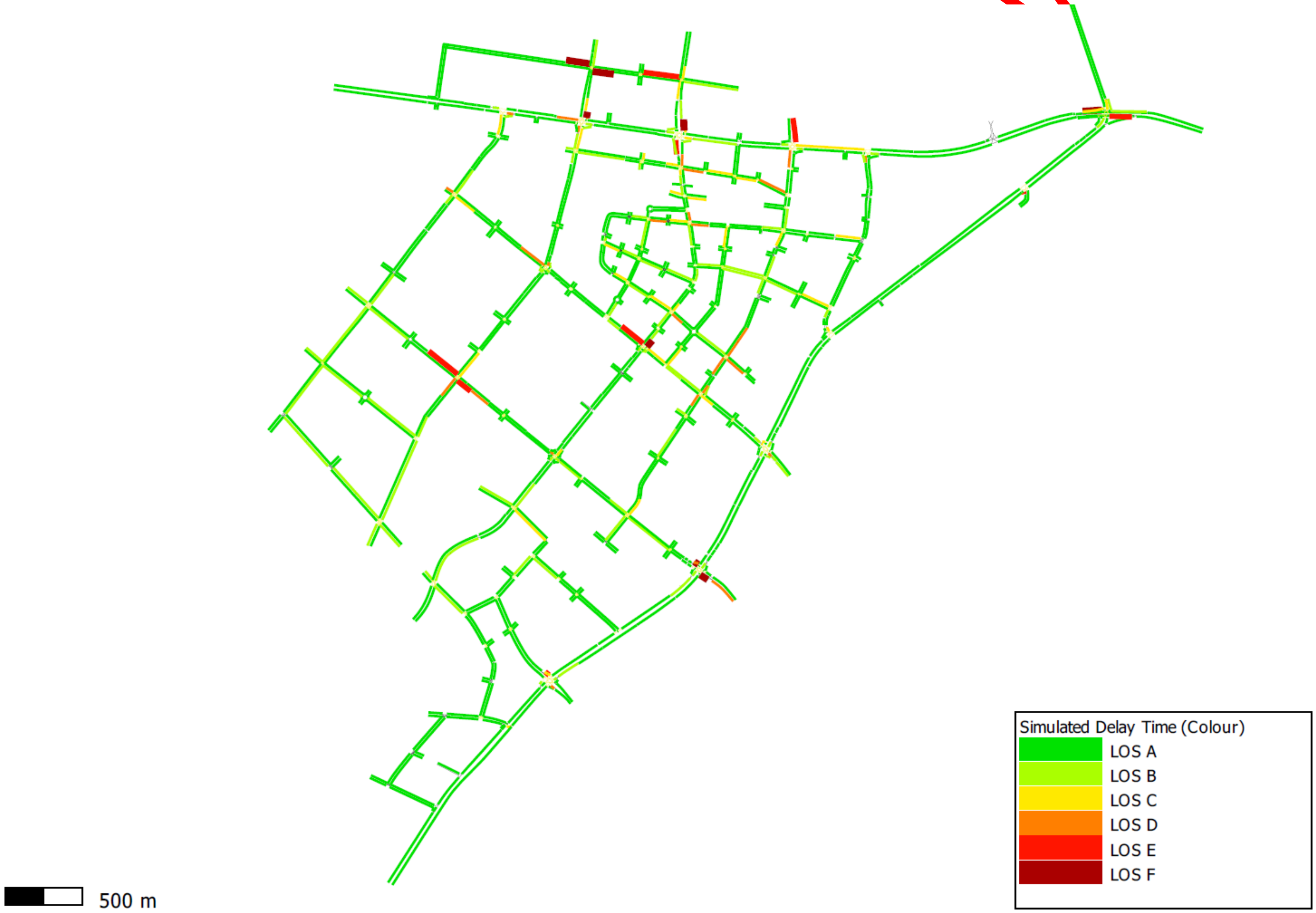


Figure 24: Modelled peak hour delay for the final land use scenario: 2041 AM peak hour

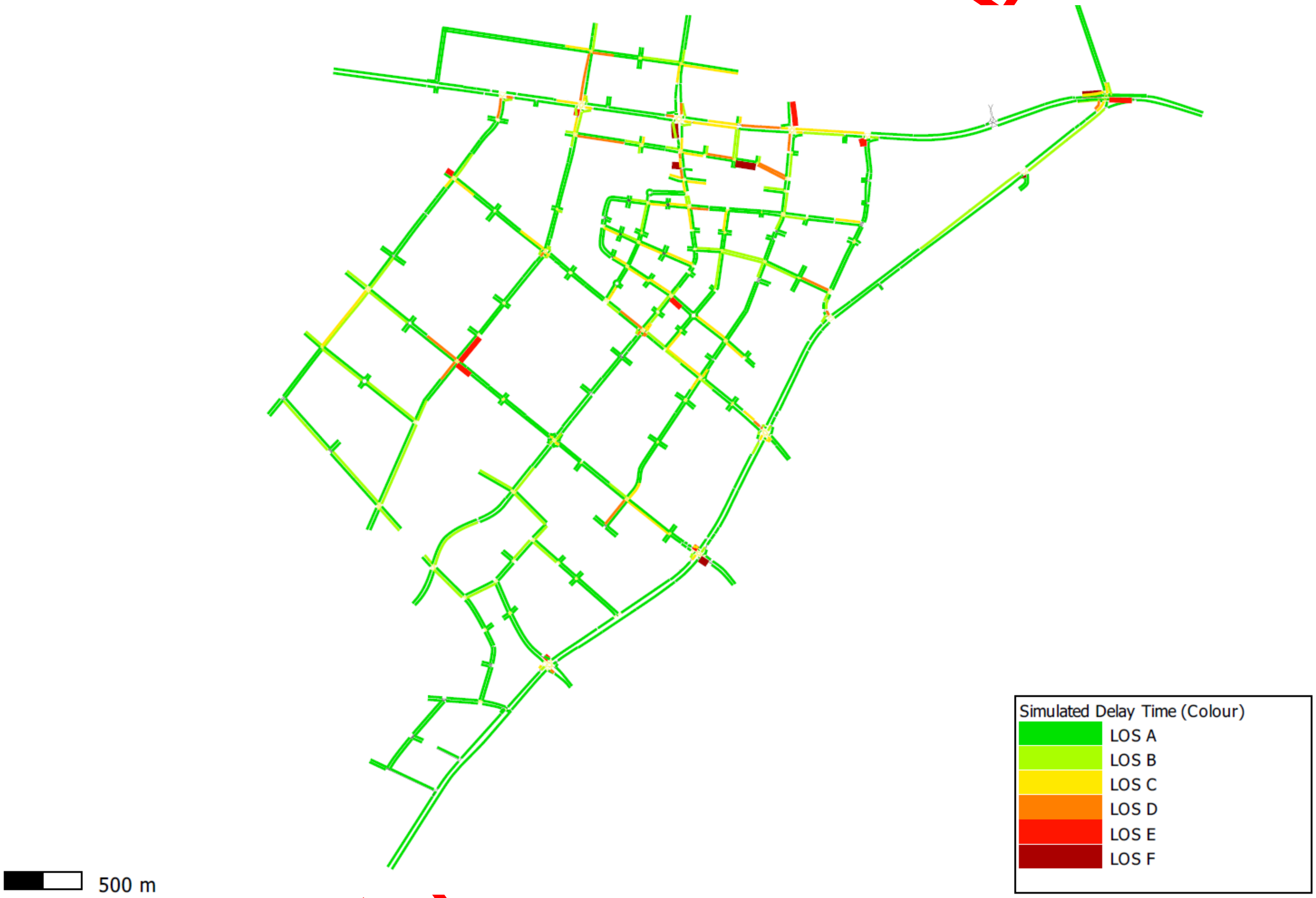


Figure 25: Modelled peak hour delay for the final land use scenario: 2041 PM peak hour

8.3.1 Detailed intersection assessment using SIDRA

The detailed intersection assessment provides an understanding of intersection operations across the road network at key intersections throughout LTCP. The assessment was undertaken using the SIDRA Intersection 9.0 traffic modelling software package, which is a microanalytical tool for evaluation of intersection performance in terms of capacity, delay, level of service and queue lengths for various modes.

The intersections shown in Figure 26 were analysed using SIDRA, namely:

a – Rickard Road / Ingleburn Road

b – Dickson Road / Heath Road

c – Byron Road / Ingleburn Road (PM only)

d – Local Road

e – Rickard Road / Local Road

f – Dickson Road / Ingleburn Road

g – Rickard Road / Heath Road (AM only)

Figure 26: Intersections analysed using SIDRA

SIDRA models were developed based on the following assumptions and parameters:

- Intersection layouts were based on their equivalents in the final Aimsun model.
- 140-second cycle times were assumed along Ingleburn Road, given its vision as a high-volume arterial road.
- 90-140 second cycle times were considered along north-south sub-arterials where they intersect with lower-order roads.
- Intersection optimisation was based on the method of minimum intersection delay with a desired performance target LOS D in 2041 peak periods and an absolute minimum performance targe of LOS E.
- Nominal pedestrian start delays were assumed at all sites in the network.
- Template signal phasing plans were developed in SIDRA, with the software tasked with determining the most optimum phase arrangement for each intersection based on a double diamond overlap operational template.

Based on these inputs and assumptions, the intersection results from the SIDRA analysis are shown in Table 24.

Table 24: Intersection LOS results for layouts as per the Aimsun model

Intersection	**AM**		**PM**	
	Delay	**LOS**	**Delay**	**LOS**
a – Rickard / Ingleburn Road	69	E	92	F
b – Dickson / Heath Road	160	F	53	D
c – Byron / Ingleburn Road	55	D	52	D
d – Local Road	13	A	15	B
e – Rickard / Local Road	Council required no analysis		50	D
f – Dickson / Ingleburn Road	35	C	41	C
g – Rickard / Heath Road	To be confirmed		Council required no analysis	

Detailed results sheets are included in Appendix Q, showing key metrics such as average delays per vehicle, levels of service, degrees of saturation and the 95th percentile queue lengths.

8.3.2 Additional intersection improvements

The results in Based on these inputs and assumptions, the intersection results from the SIDRA analysis are shown in Table 24.

Table 24 suggest the following intersections may still experience suboptimal operations with the assumed layouts:

a – Rickard Road / Ingleburn Road

b – Dickson Road / Heath Road

These intersections were further assessed to determine suitable upgrades that may result in acceptable levels of service by 2041. Following optimisation, the layouts indicated in Figure 27 and Figure 28 yielded the most optimal level of service results.

Based on these upgraded layouts, the intersection results from the SIDRA analysis are shown in Table 25.

Table 25: Intersection LOS results for upgraded layouts

Intersection	AM		PM	
	Delay	LOS	Delay	LOS
a – Rickard / Ingleburn Road	48	D	54	D
b – Dickson / Heath Road	56	D	44	D

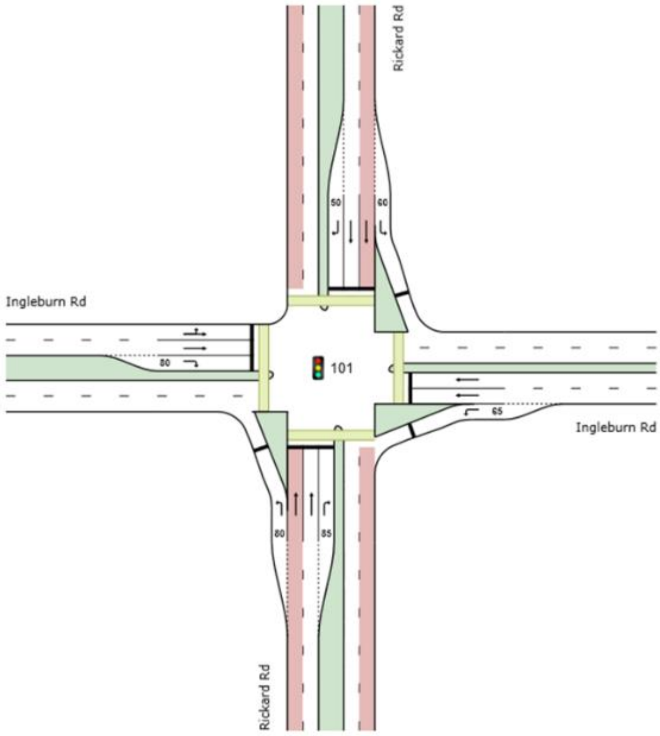
Detailed results sheets are included in Appendix R, showing key metrics such as average delays per vehicle, levels of service, degrees of saturation and the 95th percentile queue lengths.

8.3.3 Final intersection layouts

Following the mesoscopic modelling and subsequent enhanced intersection analysis, scaled versions of the concept intersection layouts are summarised in Appendix S.

It is noted that these layouts are schematic functional drawings reflecting input data. They are not design drawings.

Layout based on mesoscopic modelling



Upgraded layout based on SIDRA analyses

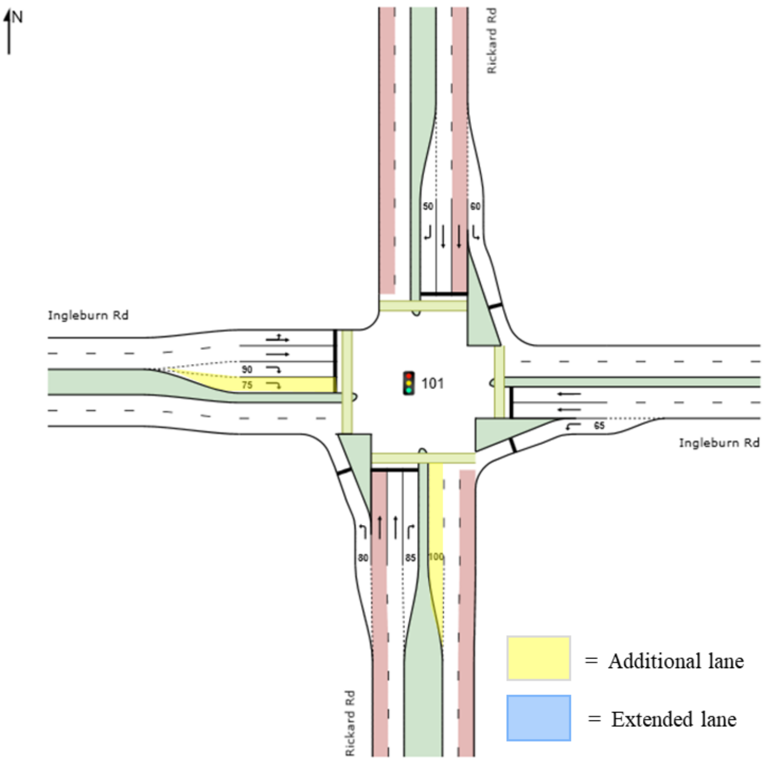
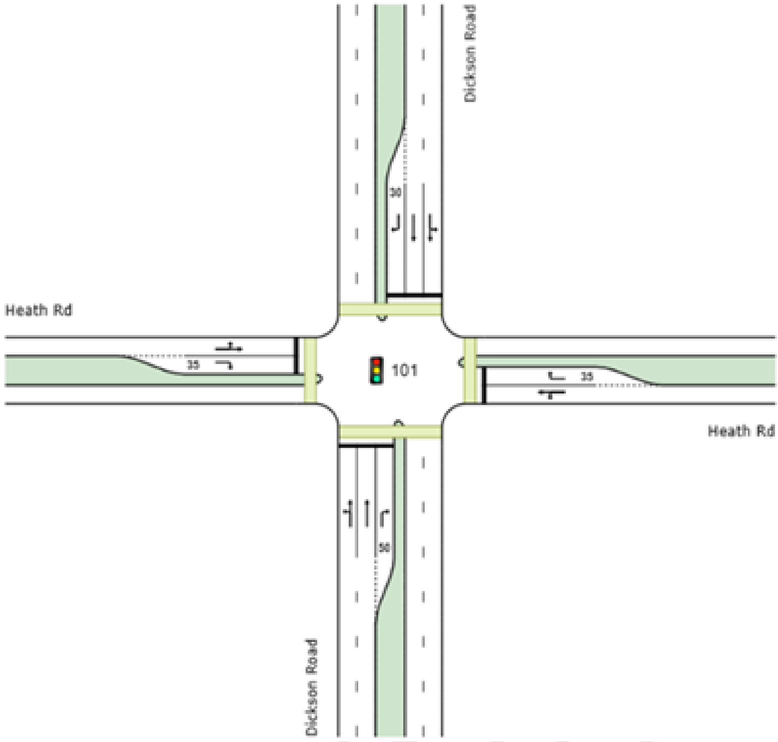


Figure 27: Upgraded layout at Rickard Road / Ingleburn Road intersection

Layout based on mesoscopic modelling



Upgraded layout based on SIDRA analyses

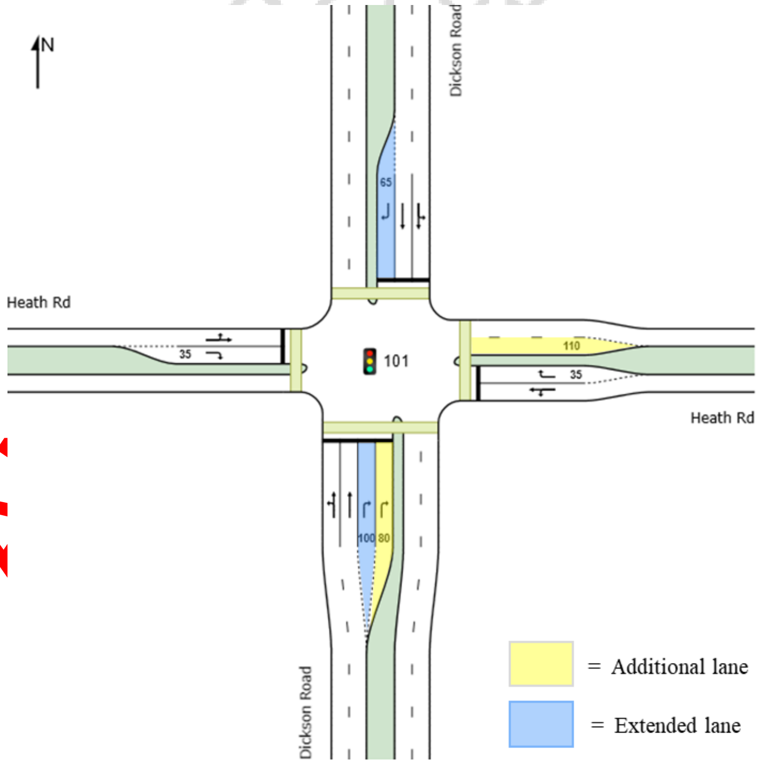


Figure 28: Upgraded layout at Dickson Road / Heath Road intersection

9 Summary

The purpose of this report is multi-fold:

- to assess and test the transport impacts of the preferred development scenario, through modelling, as reflected in the draft Indicative Layout Plan (ILP) for future horizon years, taking into consideration potential development staging.
- to assess, confirm and recommend infrastructure upgrades and other measures to address identified impacts within the vicinity of the LTCP.

A comprehensive two-tiered traffic modelling process, including strategic and mesoscopic modelling, has been used to develop and assess the road network required to support the future Leppington Town Centre and Precincts. The two-tiered approach was supplemented with intersection-level analyses at individual locations.

The base year model:

- was developed for traffic conditions during the morning and afternoon peak hours as observed in late 2019 and has been calibrated and validated to meet the Transport for NSW modelling guidelines.
- provides stable results that enable a degree of confidence to be placed in its ability to serve as a basis for future year road network development and assessment.
- has been accepted and endorsed by Transport for NSW's modelling specialist as suitable for the future year (2041) modelling of the LTCP.

The future year modelling:

- employed a first principles approach to translate land use data into travel demand, in combination with strategic modelling outputs that informed distribution patterns.
- utilised a robust and iterative approach that made use of milestone checks along the way to agree assumptions for various crucial inputs with key stakeholders in local and state government, such as trip generation rates, network layouts and access management principles, intersection controls, roadway hierarchy and capacities.

Summary of 2041 mesoscopic results:

- the modelling suggests that the Council's intended road network and its envisaged hierarchy may be adequate for the LTCP and its associated travel demands, based on hierarchy/capacities shown in Section 5.3 and the layouts and access management principles shown in Appendix I.
- detailed intersection analysis results suggest that most of the intersections will operate at LOS D or better in 2041, based on the layouts presented in Appendix S.

9.1 Next steps

(*Note: this section will be removed from the Final Report*)

This final draft modelling report is to be reviewed by Camden Council. Council has circulated all modelling files to Transport for NSW's modelling specialists for final review and approval.

Appendix A

Leppington Draft Traffic Model Workshop (26 November 2020)

ARUP

WE SHAPE A BETTER WORLD

Leppington Town Centre & Precinct

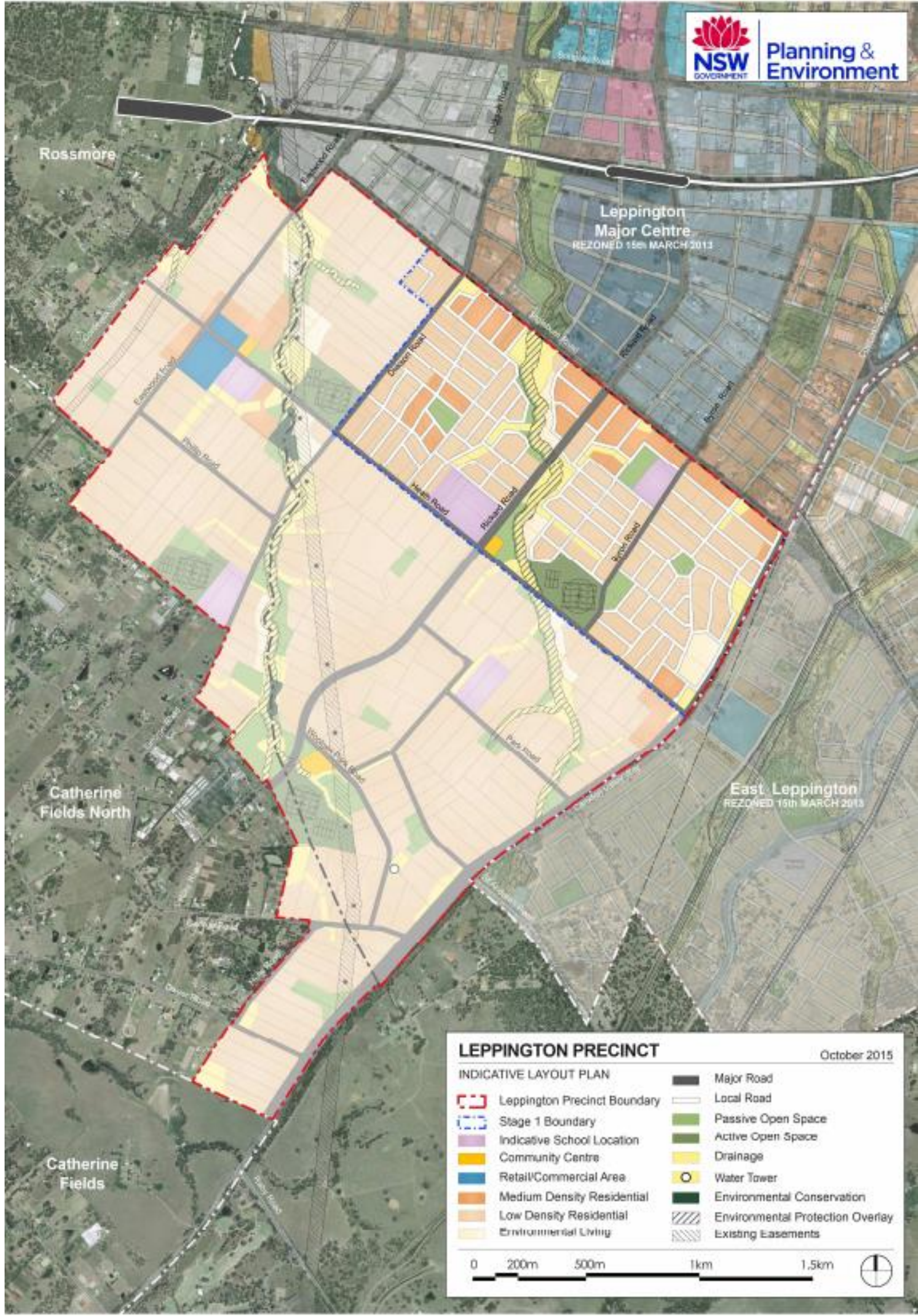
Road network modelling update

Leppington Town Centre & Precinct

Road network modelling update

Agenda

- Introductions
- Context
  - Leppington Town Centre & Precinct status (Council)
  - Previous work key points (Arup)
- Modelling approach
  - Overall process (Arup)
  - Network (Arup)
  - Demand (Arup)
- Initial results
  - Flows & movement patterns (Arup)
  - Performance (Arup)
- Key discussion points



Introductions

Context

Leppington Town Centre & Precinct

Context

2018

Arup engaged by DPIE to undertake a ***Transport Impact Assessment***

2019

Approach and draft road network modelling results & report presented to stakeholders & feedback received

2020

Arup novated to Council and engaged to:
- Expand road network model to include Leppington Precinct
- Consider stakeholder comments on Leppington TC

Model update inputs received
- GIC LUs
- PTPM
- Updated ILP

Stakeholder engagement to
- Present approach & initial findings
- Discuss points of interest
- Direction for adjustment to finalisation

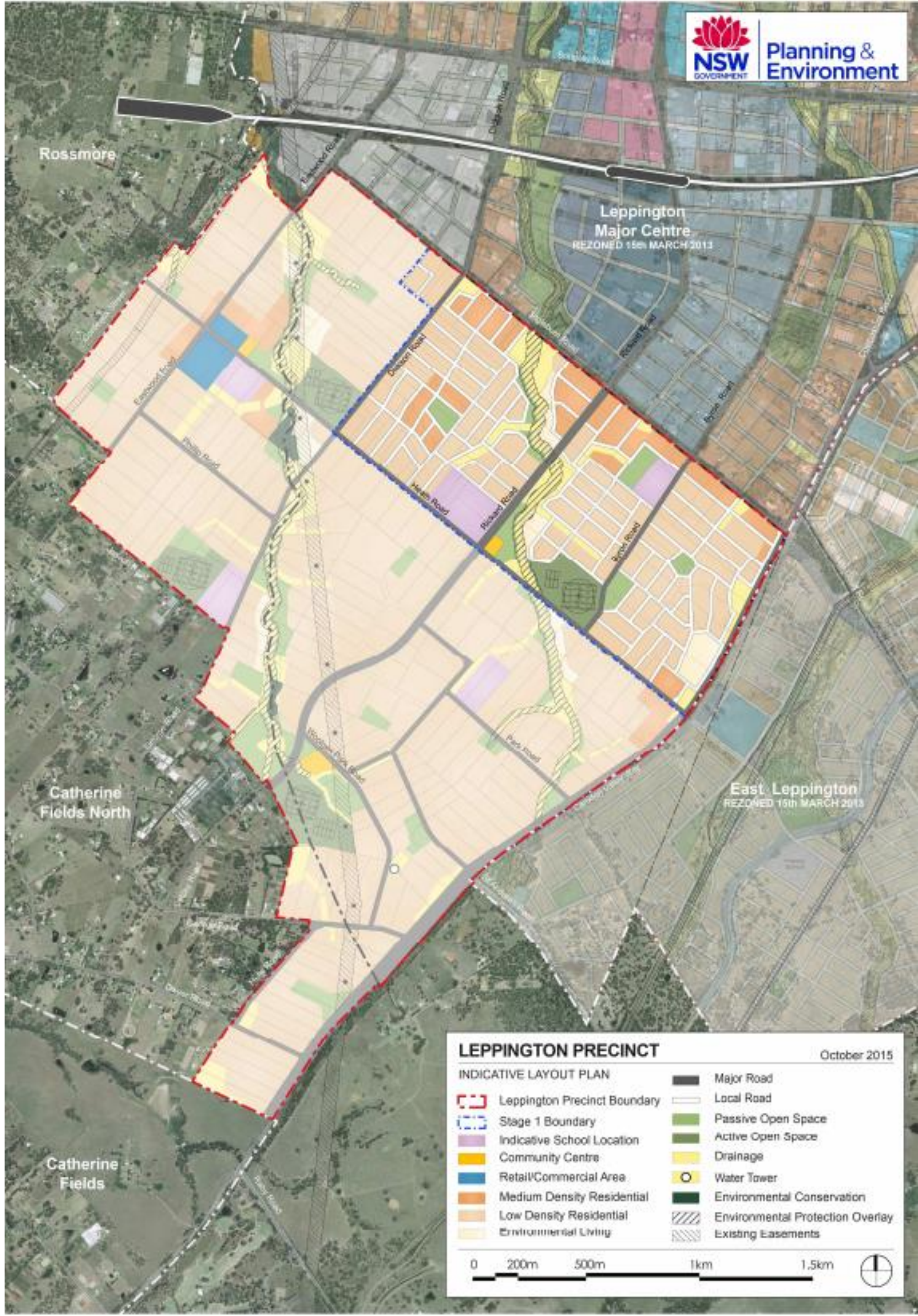
2021

Leppington Town Centre & Precinct

Context

Leppington Town Centre & Precinct

- Overall planning process update (Council)



Context

Council's vision for the model

To have an up to date and accurate road precinct network model and report that provides the required information to confidently move forward with the design and construction of the roads and intersections within the Leppington Town Centre & Precinct

Council's objectives for the model*

Be consistent with latest transport and land use information & investigations information

Provide advice / recommendations / justification regarding the overall road network including hierarchy, function, configuration and intersections

Allow feedback with the draft South West Growth Area Structure Plan (2016) and the Indicative Layout Plan

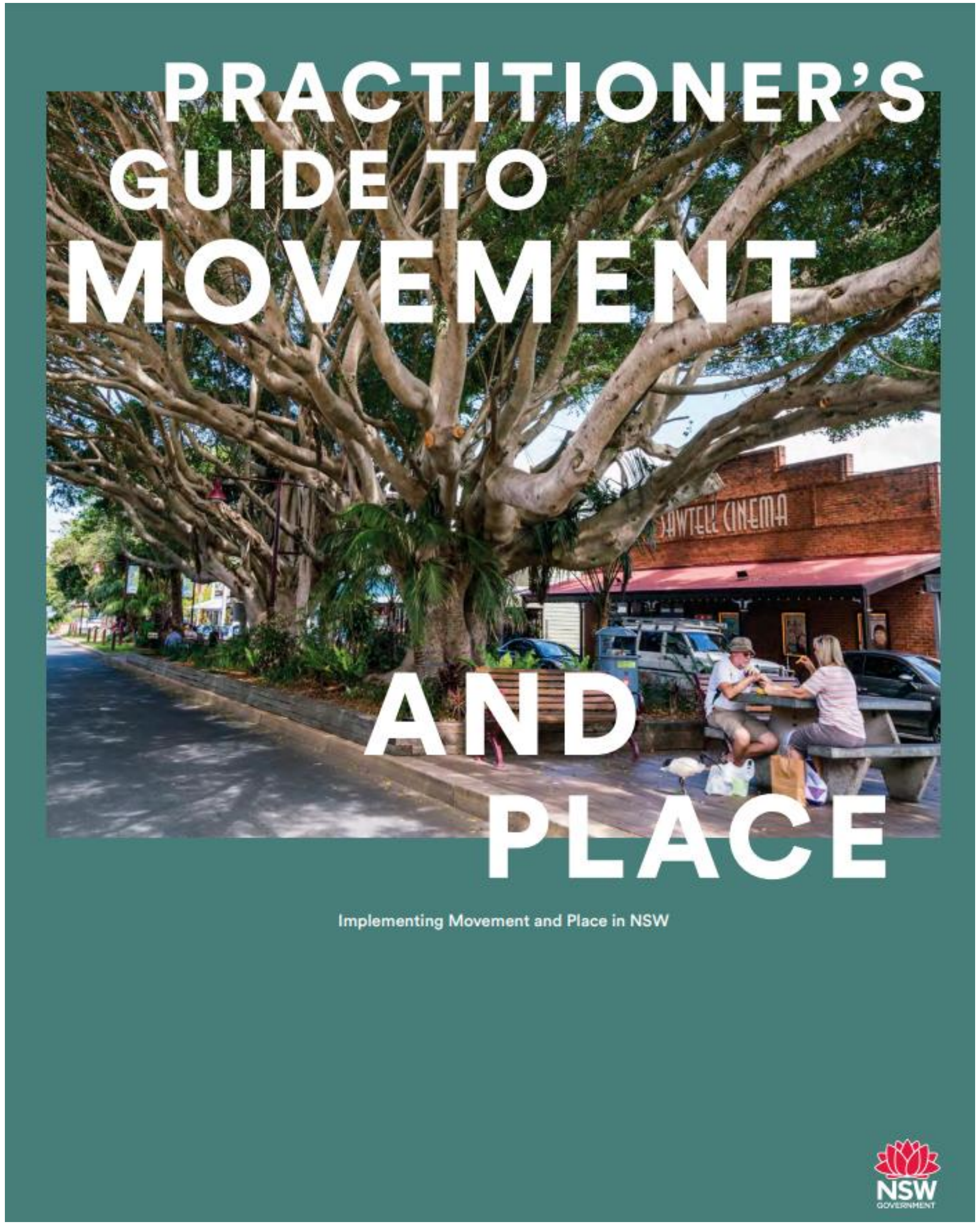
Collaborate with Transport for NSW, particularly regarding integration of Rickard Road projects

* Shortened version

Context

Key contextual points

- **Not** engaged to undertake *Movement & Place* process, rather seeking to align with key M&P principles as possible within remit, particularly:
    - A planning-led road network function & draft definition, validated and refined by modelling

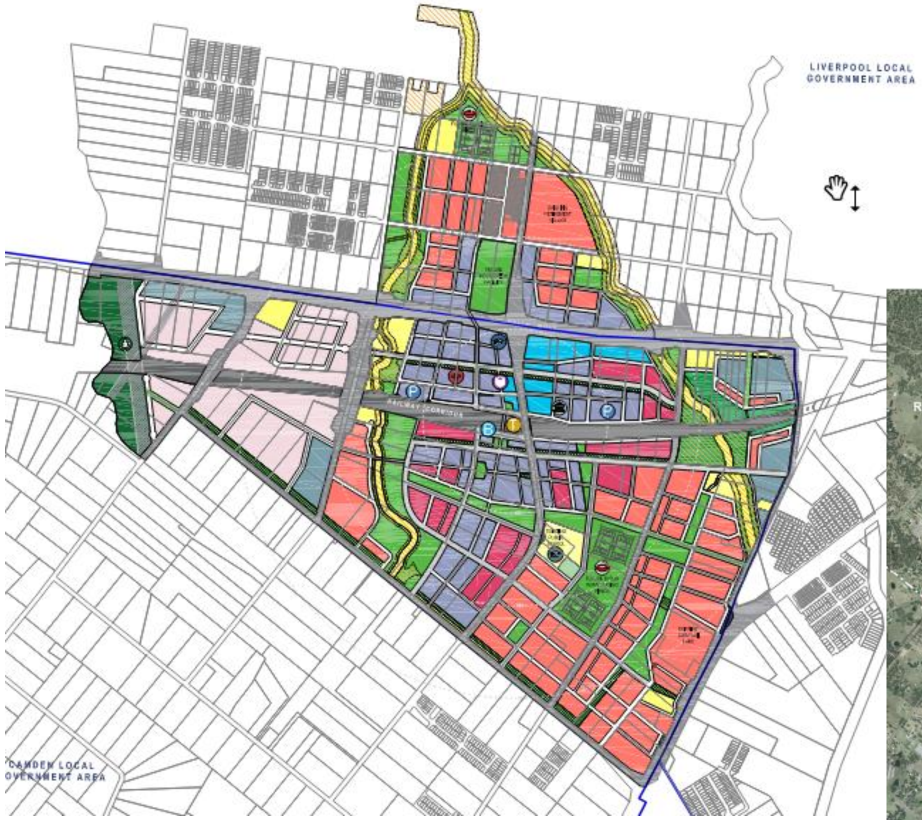


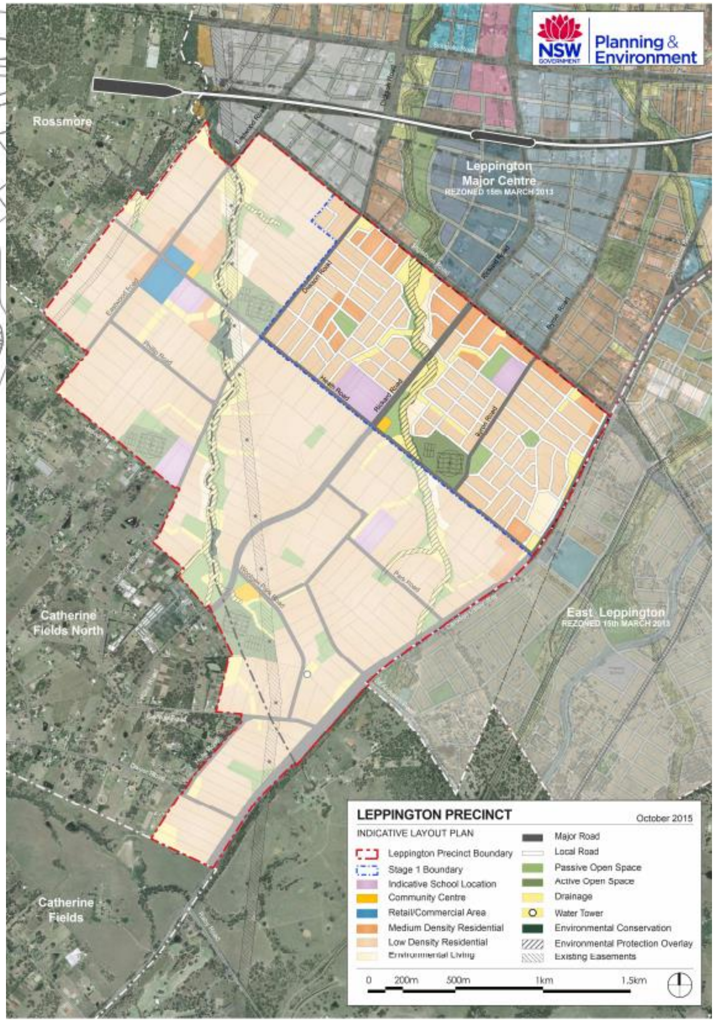
Leppington Town Centre & Precinct

Context

Key points covered

- Place context
  - Natural
    - Blue & green grids
  - Urban
    - Centre function
    - Land use
    - Activity & activation



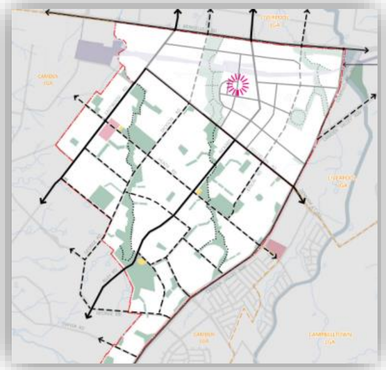


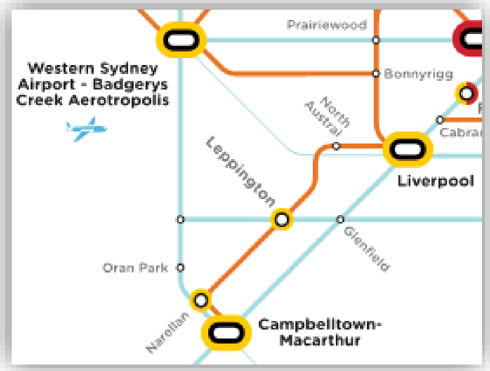
Leppington Town Centre & Precinct

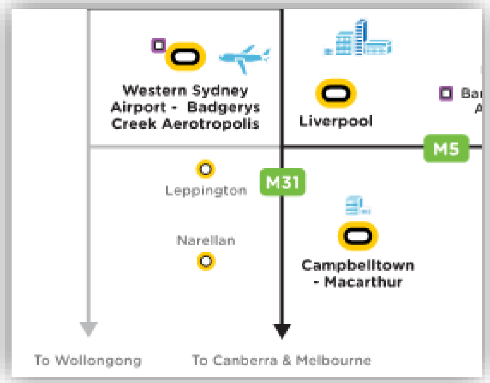
Context

Key points covered

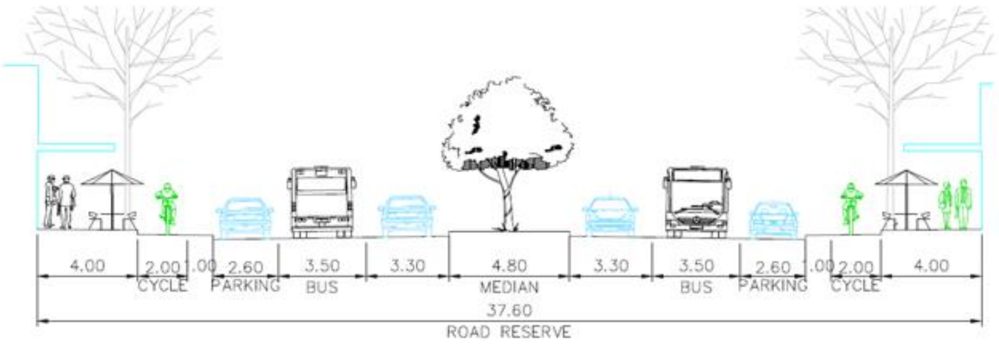
- Movement context
  - Patterns
  - Networks across scales
    - Walking
    - Cycling
    - Bus
    - Rail
    - Freight
    - Private vehicle







Key points covered

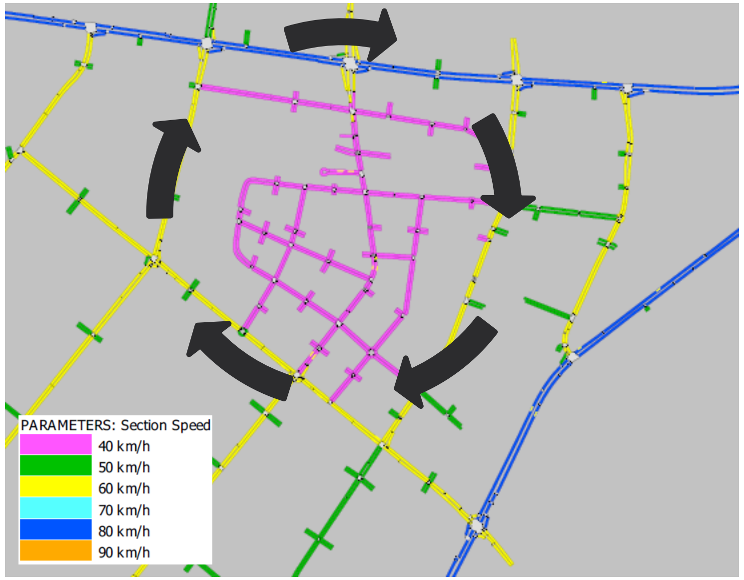


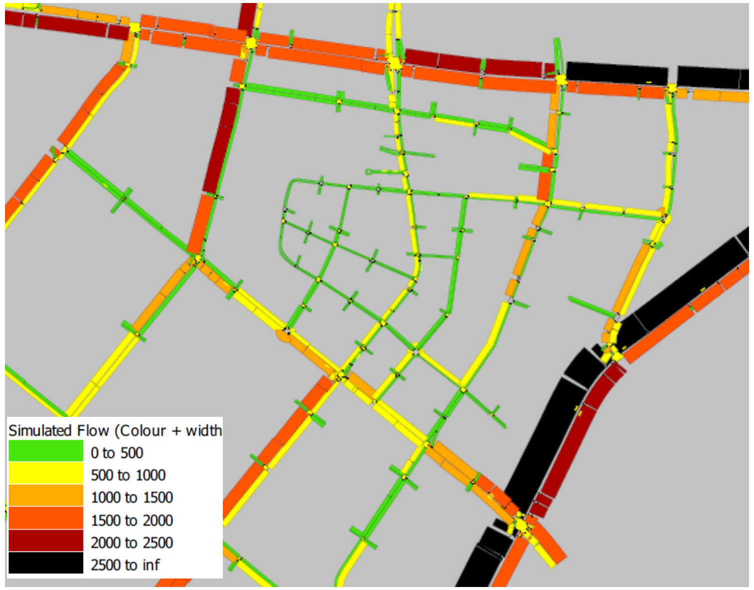
- Consider form in Place with weight when planning functions

- Reinforcing desired functions and patterns with ‘smart’ management

    - Protect place from through movement by reinforcing the ring road system

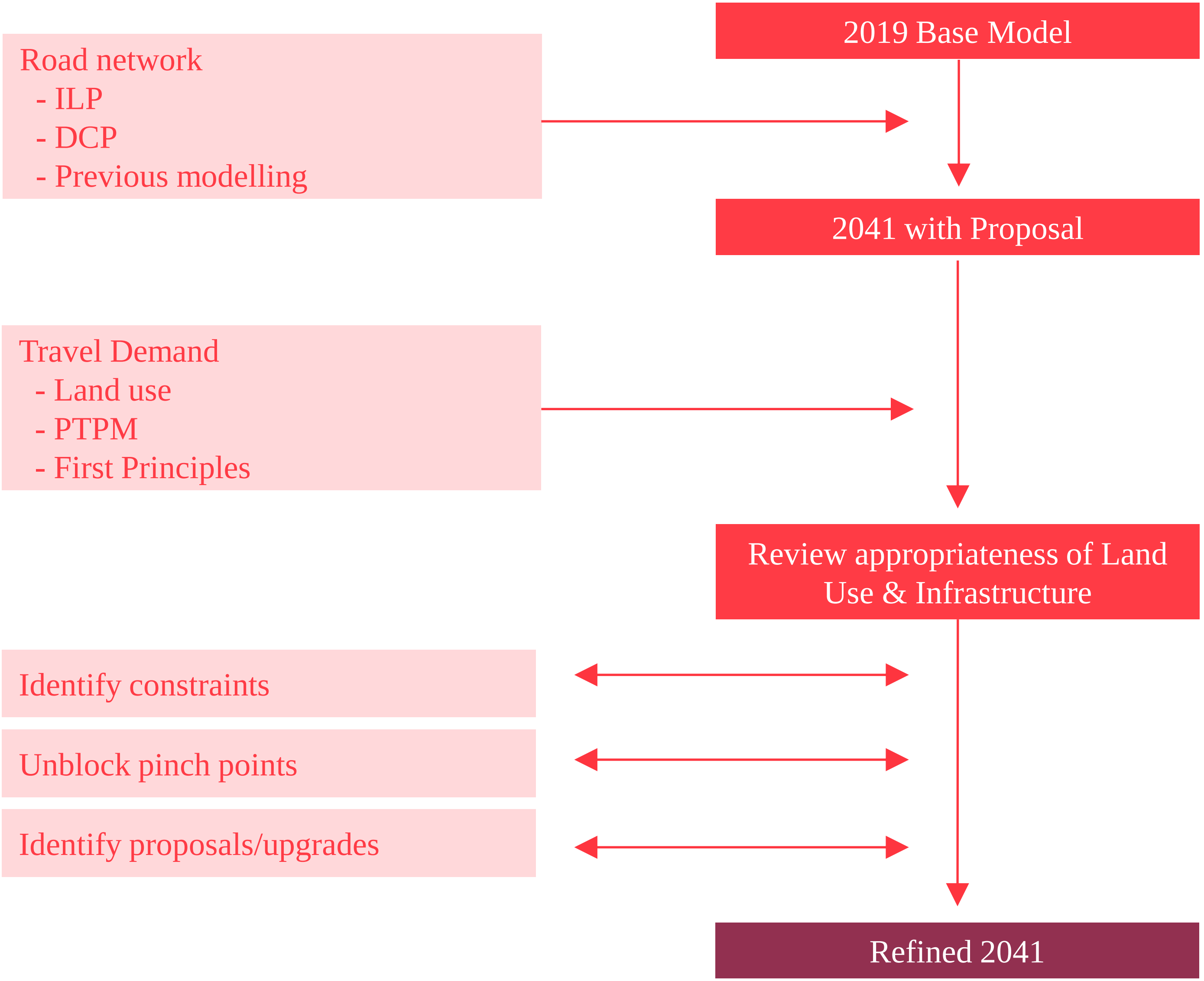
    - Low & slow





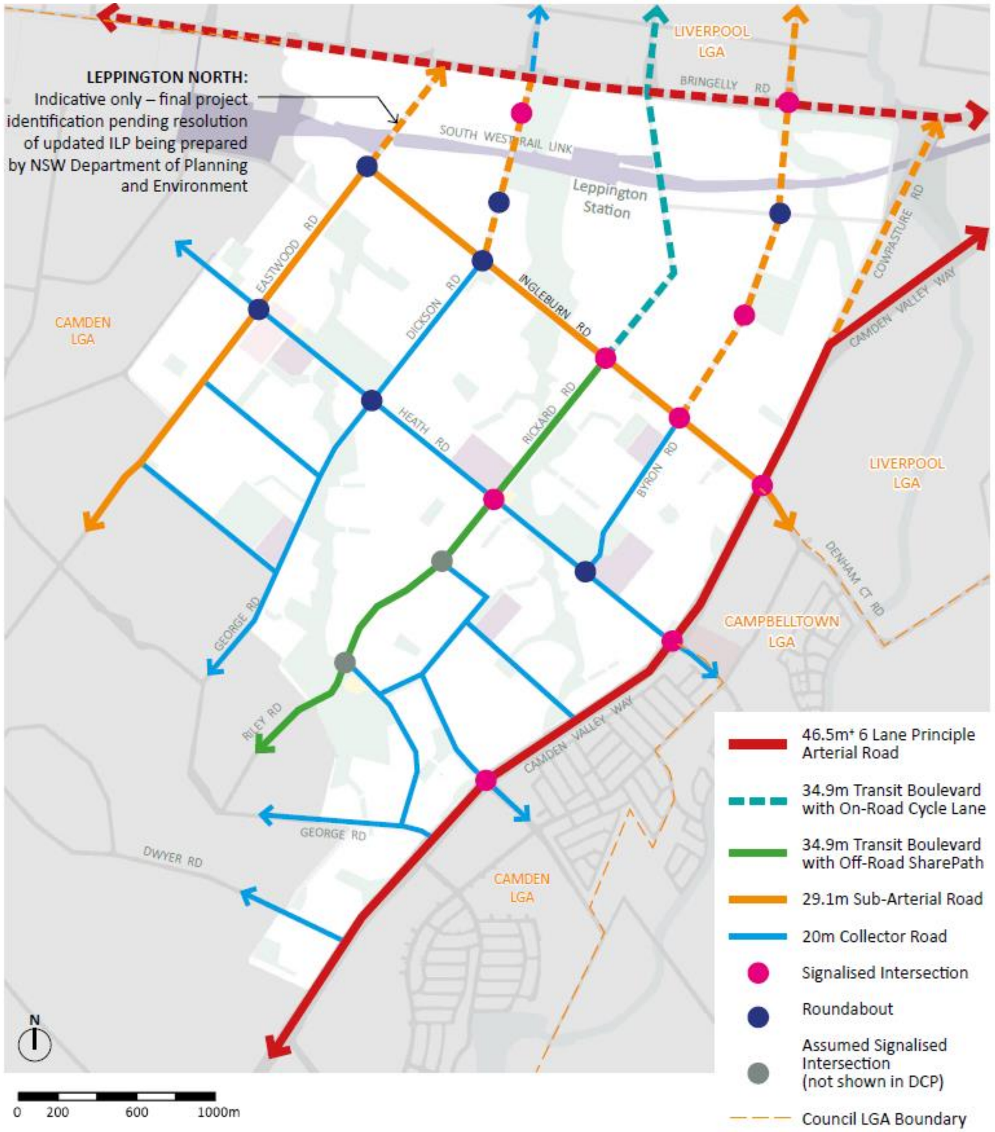
Modelling approach

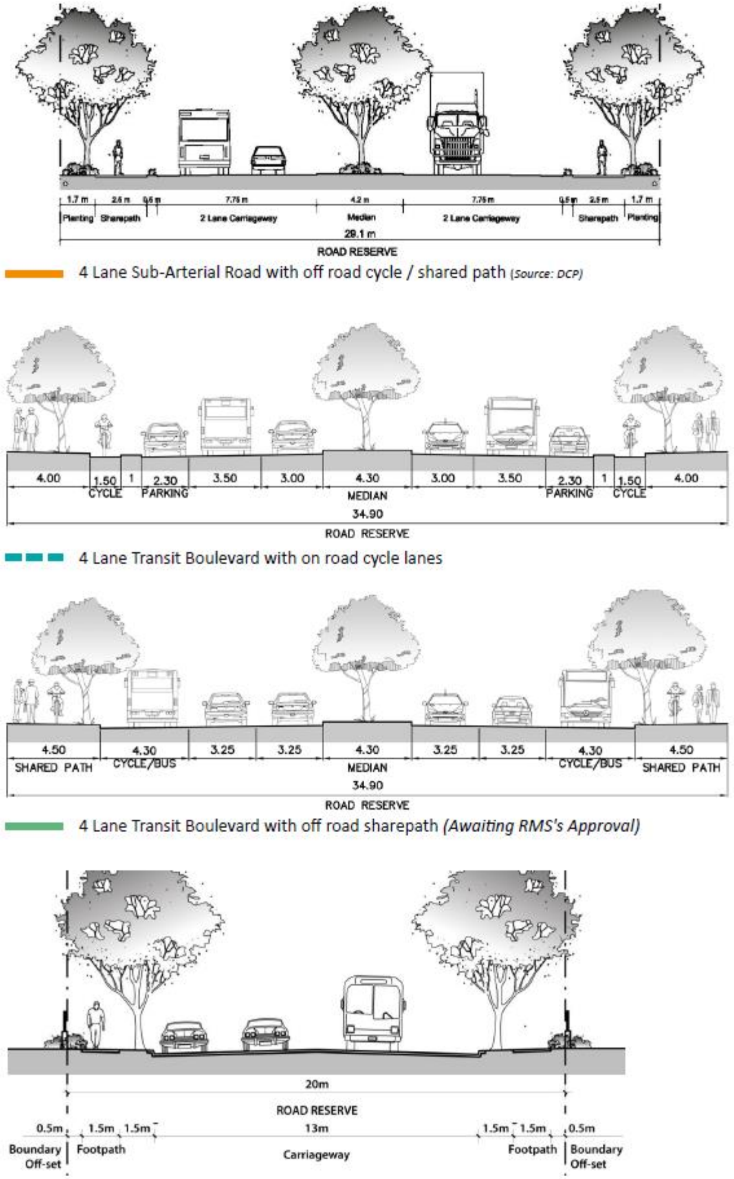
Modelling approach



Modelling approach

- Road network principles
- Initial network

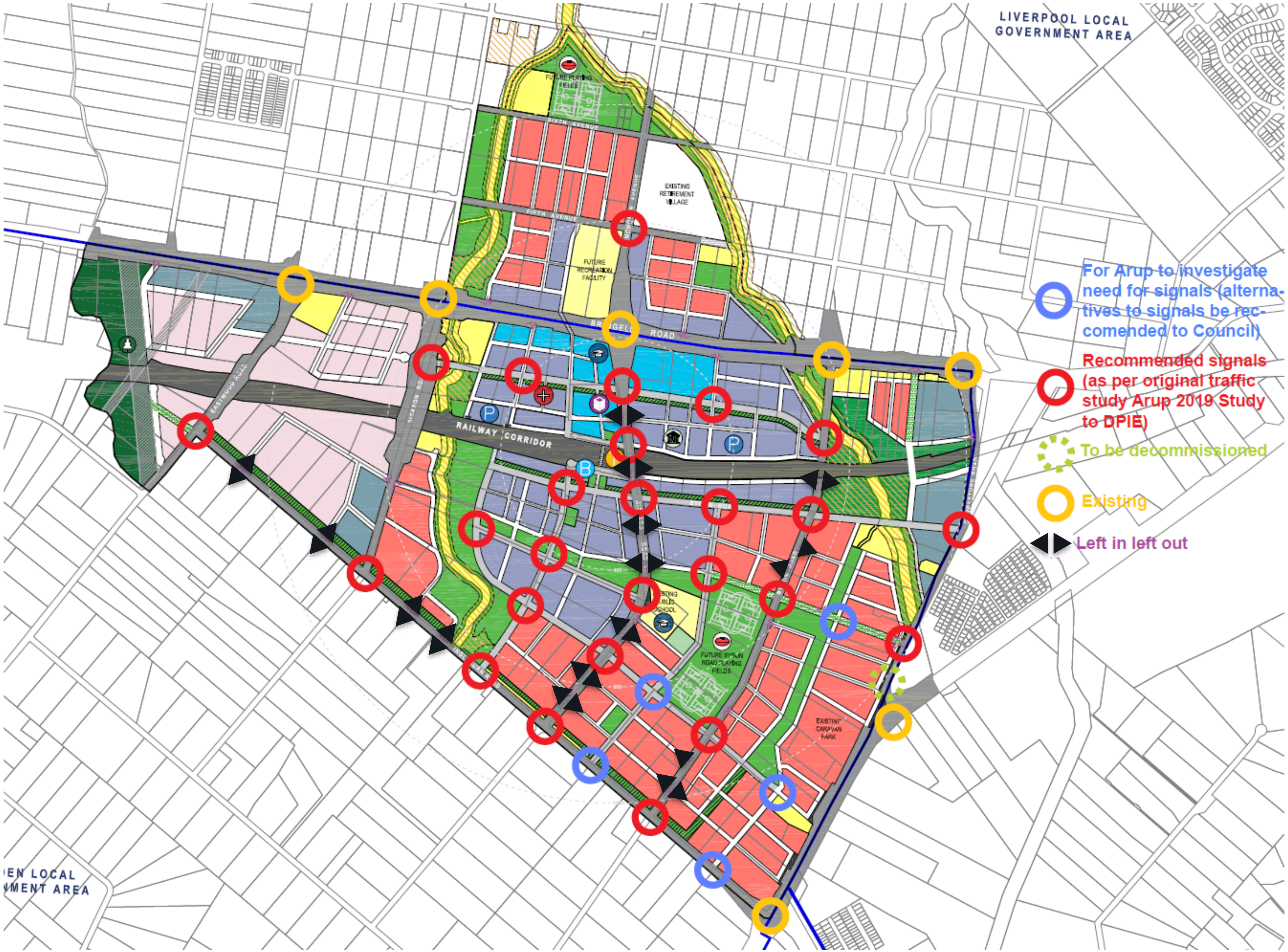




Leppington Town Centre & Precinct

Modelling approach

- Intersection treatment
- Access management



Modelling approach

Forecast demand

	Internal	*External*
Internal	First Principles	First Principles
External	First Principles	PTPM

Distribution

	Internal	*External*
Internal	PTPM	PTPM
External	PTPM	STM

Modelling approach

- Trip generation

Land use	AM		PM	
	In	Out	In	Out
Low Density Residential [1]	2,386	9,543	9,944	2,486
Med Density Residential	499	1,995	2,102	526
High Density Residential	79	315	248	62
Commercial Core	960	417	671	1,109
Mixed Use [2]	1,167	1,172	1,413	1,417
Retail [3]	921	921	1,995	1,995
Industrial	712	178	192	767
Business Development	-	-	630	630
School	250	250	250	250
TOTAL	**6,973**	**14,790**	**17,446**	**9,242**

(1) Include environmental living

(2) 50% office, 50% commercial

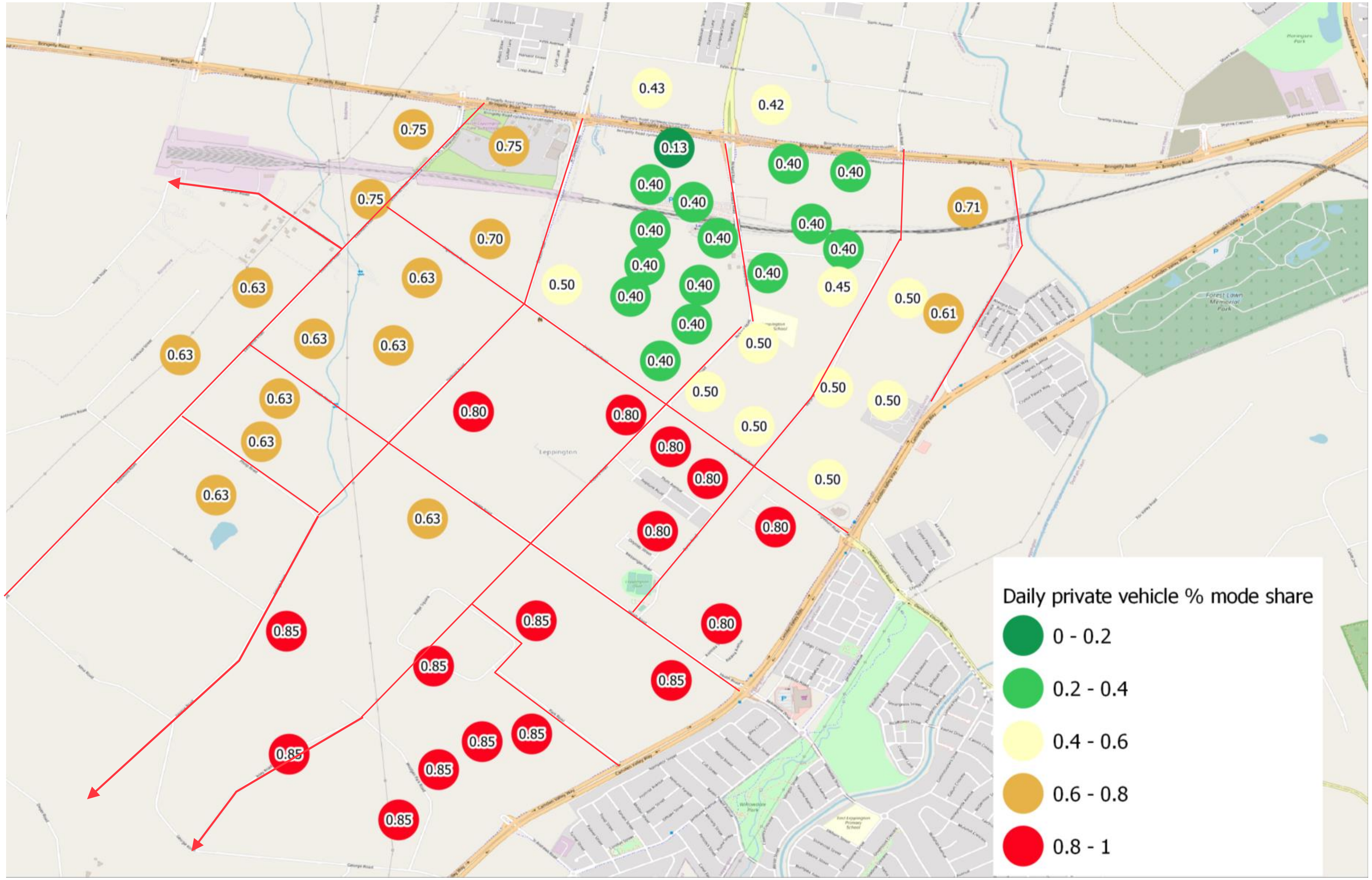
(3) All retail categories as per Technical Direction (2013)

- Implied mode share

Private care mode share (from TfNSW Technical Direction, 2013)
86%
50%
40%
40%
40% (commercial), 60% (office)
60%
75%
75%
(100%)

Modelling approach

- Car mode share

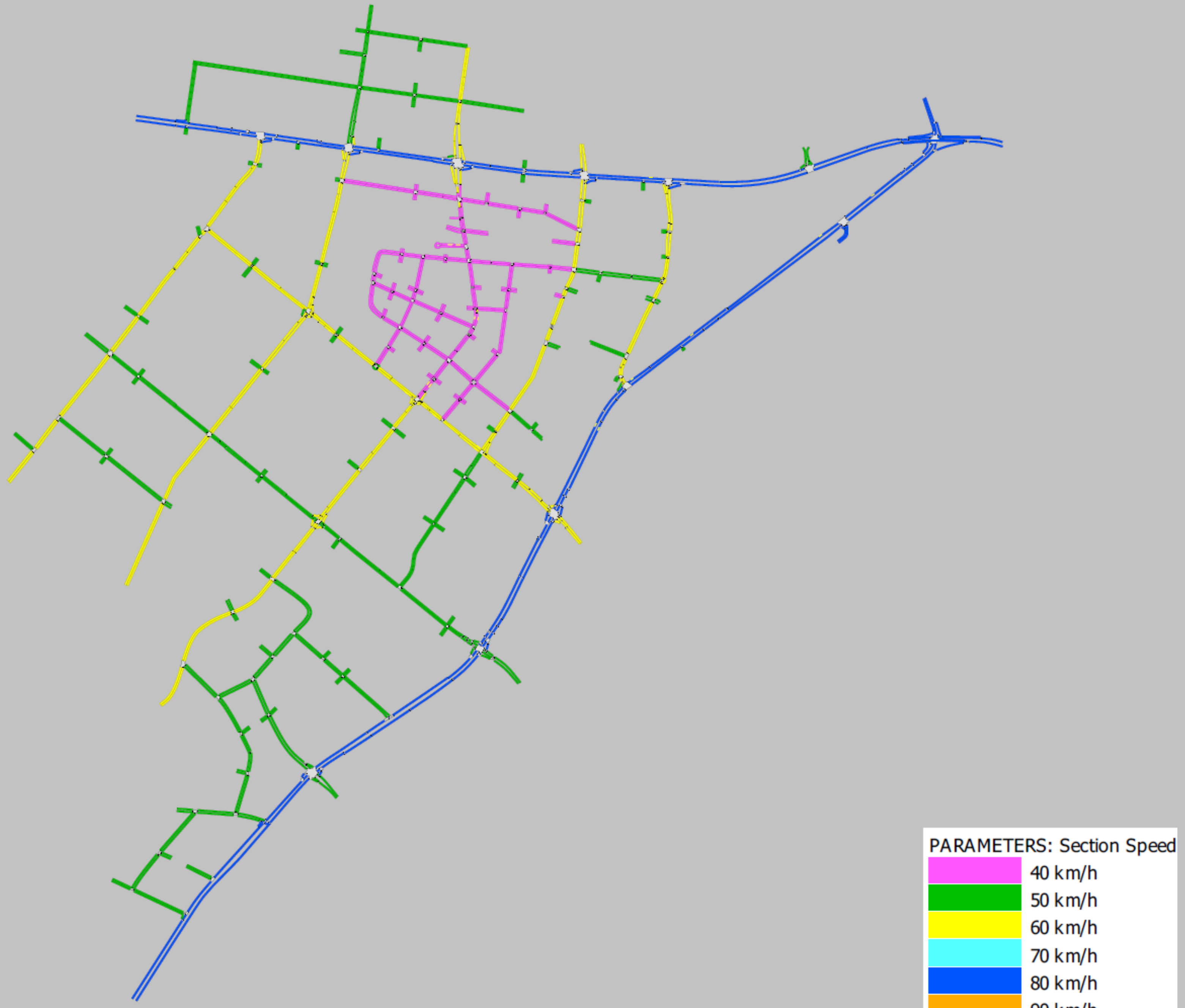


Initial results

Leppington Town Centre & Precinct

Initial results

Speed limit



Leppington Town Centre & Precinct

Initial results

Number of lanes

(shown for final model)

Leppington Town Centre & Precinct

Initial results

Average approach delay - AM

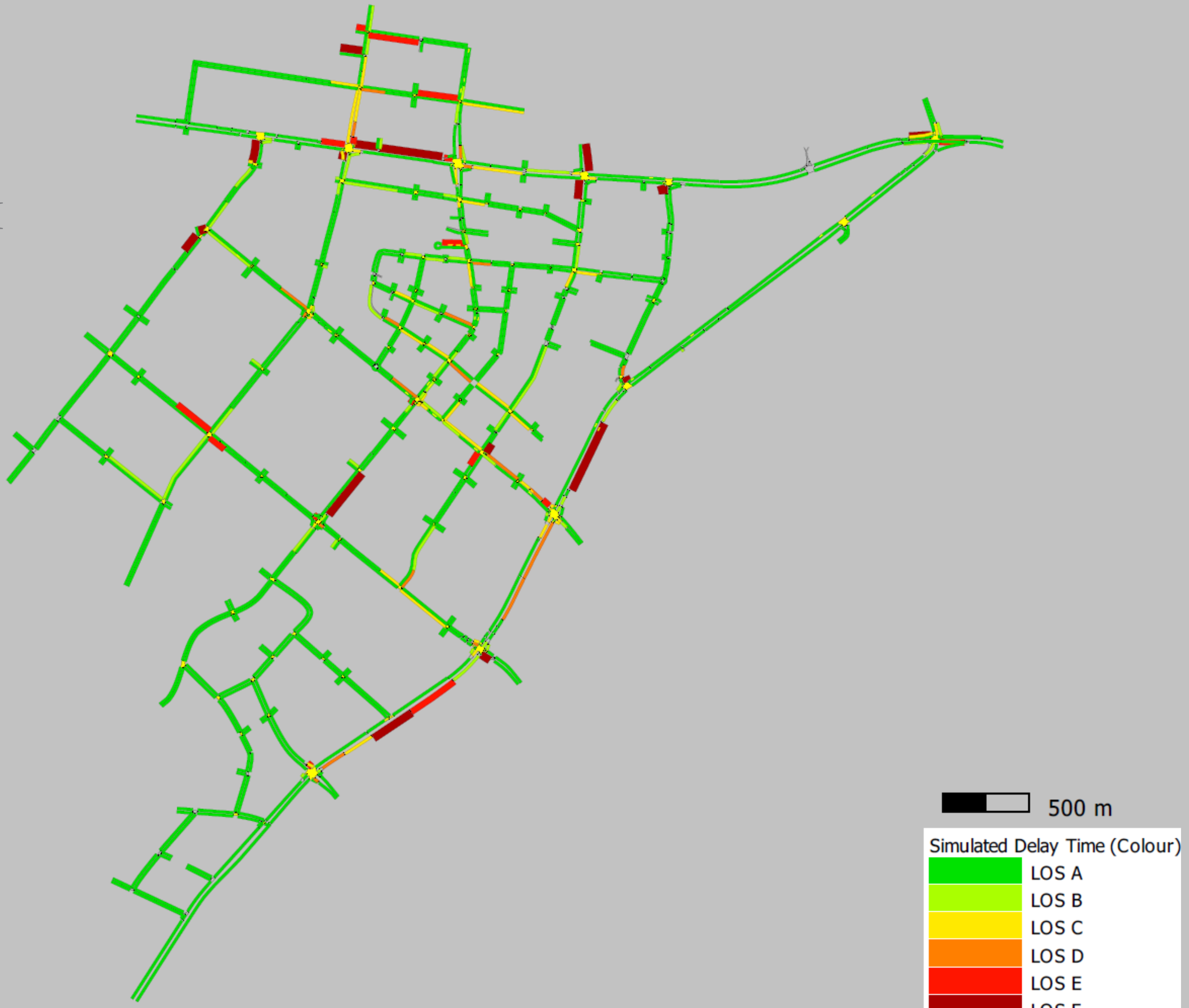
Version 23

Seed nr. 560

Leppington Town Centre & Precinct

Initial results

Average approach delay - PM



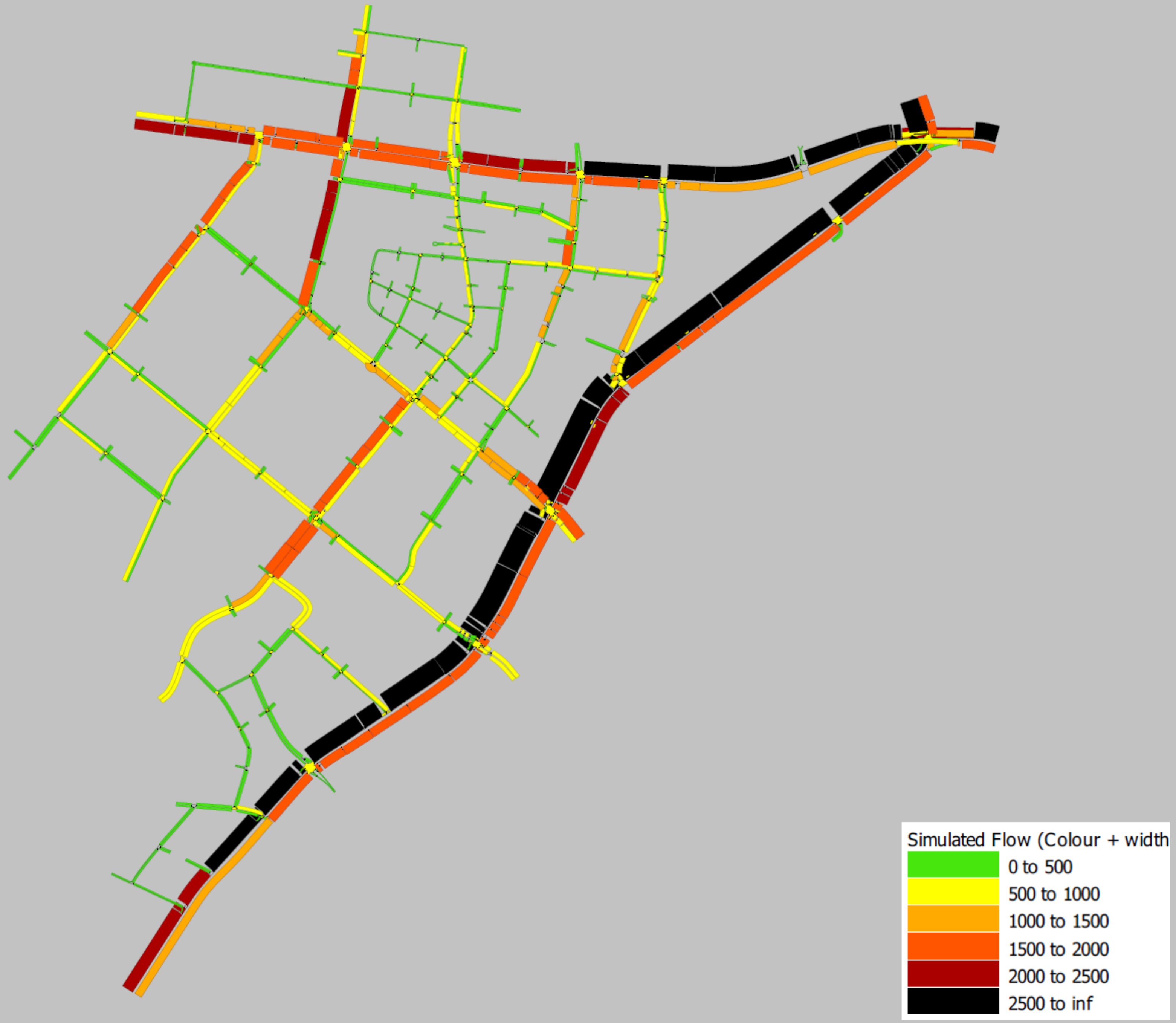
Version 23

Seed nr. 2849

Leppington Town Centre & Precinct

Initial results

Hourly volumes - AM



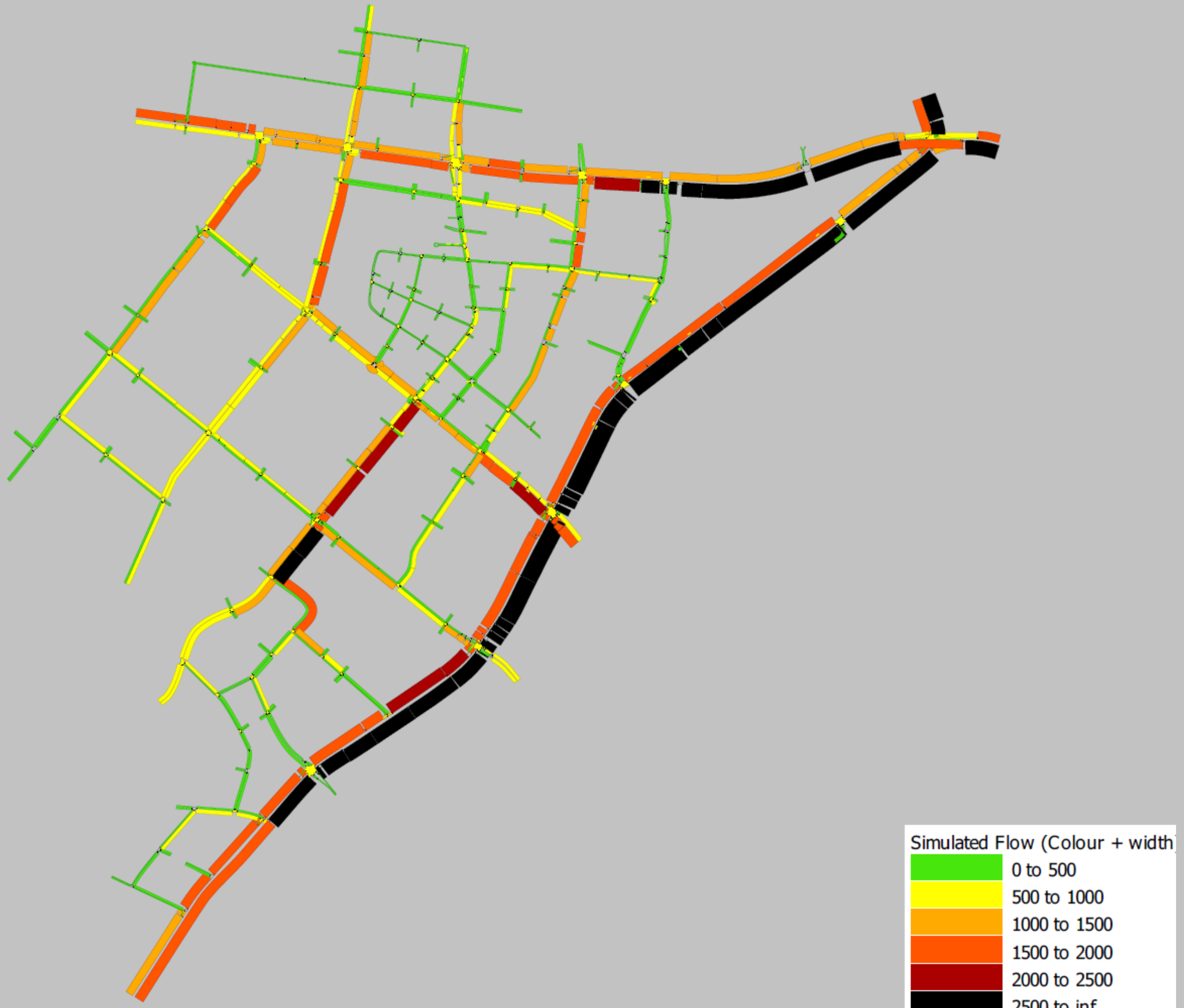
Version 23

Seed nr. 560

Leppington Town Centre & Precinct

Initial results

Hourly volumes - PM



Version 23

Seed nr. 2849

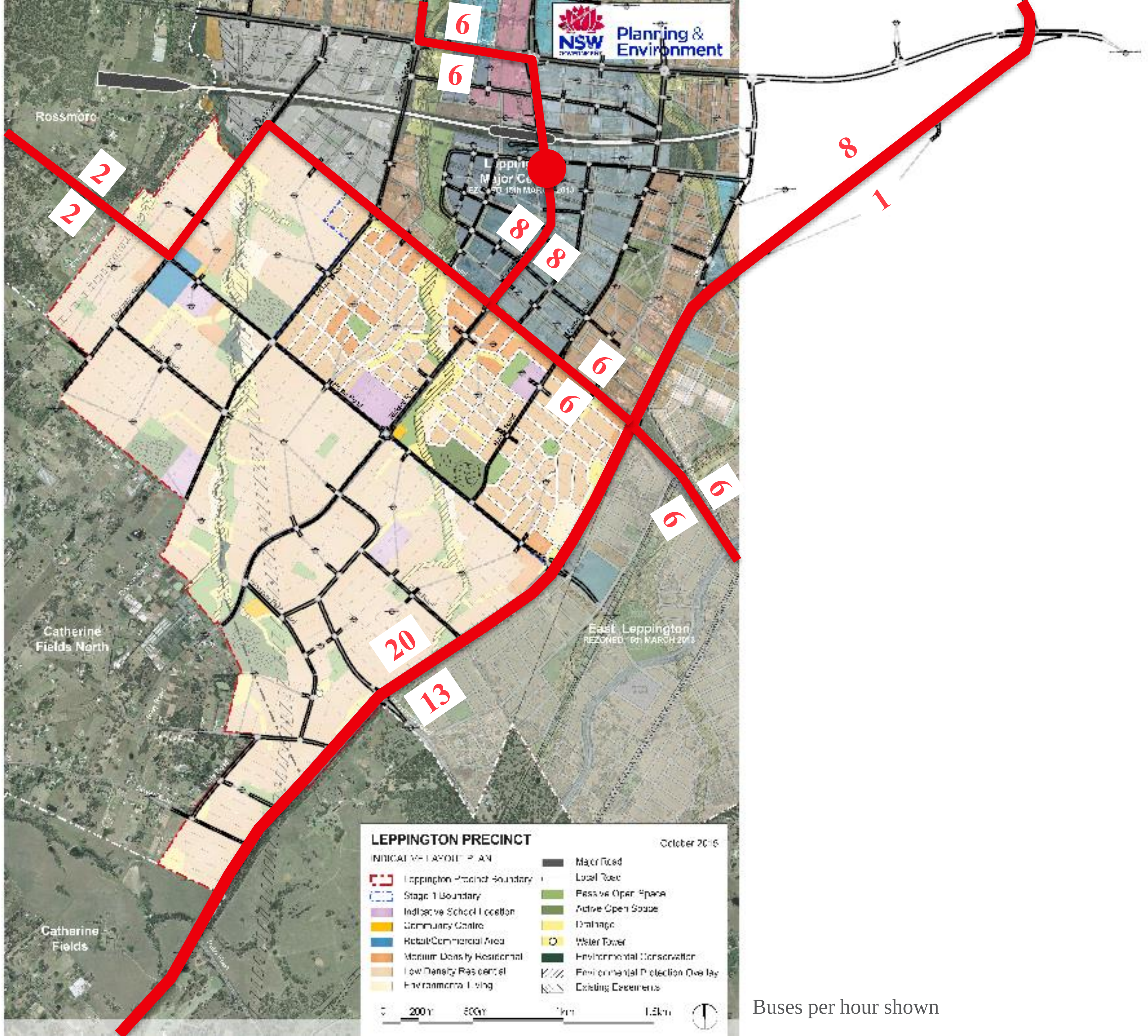
Key discussion points

Alternative result: Impact of Rickard Road bus corridor

Leppington Town Centre & Precinct

Key discussion points

- Future public transport vision
  (currently PTPM)

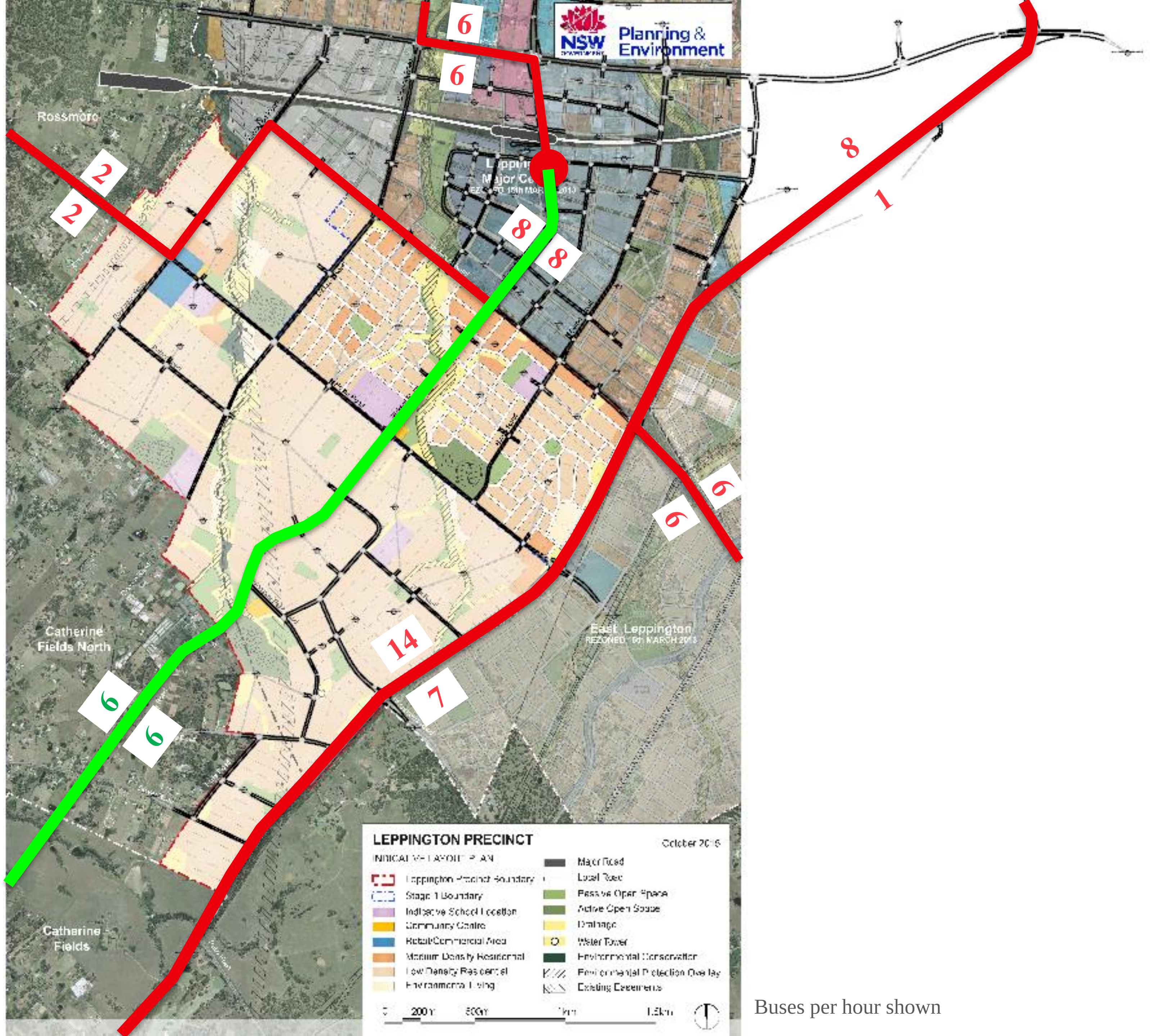


Buses per hour shown

Leppington Town Centre & Precinct

Key discussion points

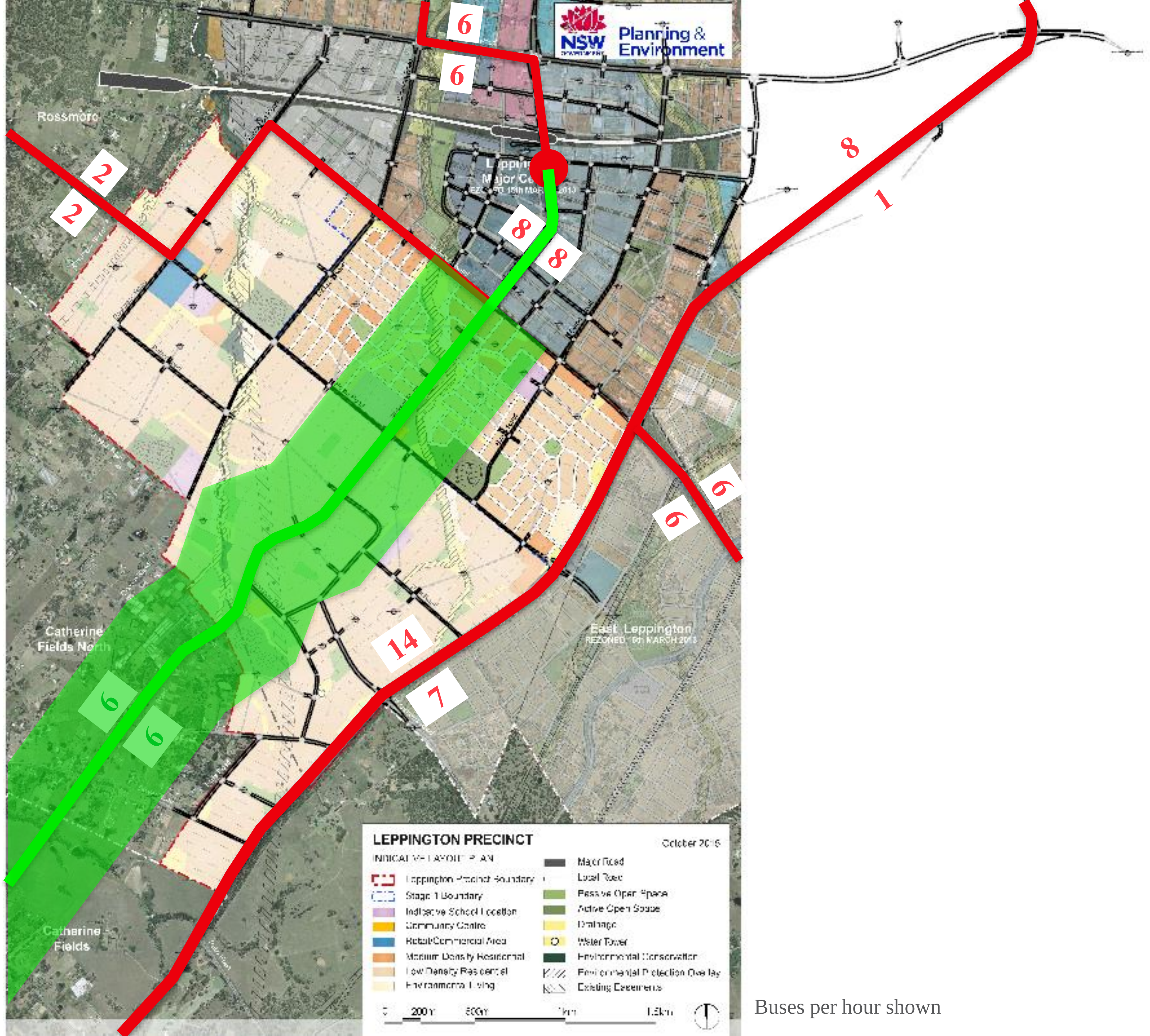
- Future public transport vision
  (currently PTPM)
- Rickard Road public transport corridor



Buses per hour shown

Key discussion points

- Future public transport vision
  (currently PTPM)
- Rickard Road public transport corridor
- Catchment areas
  - 400m either side

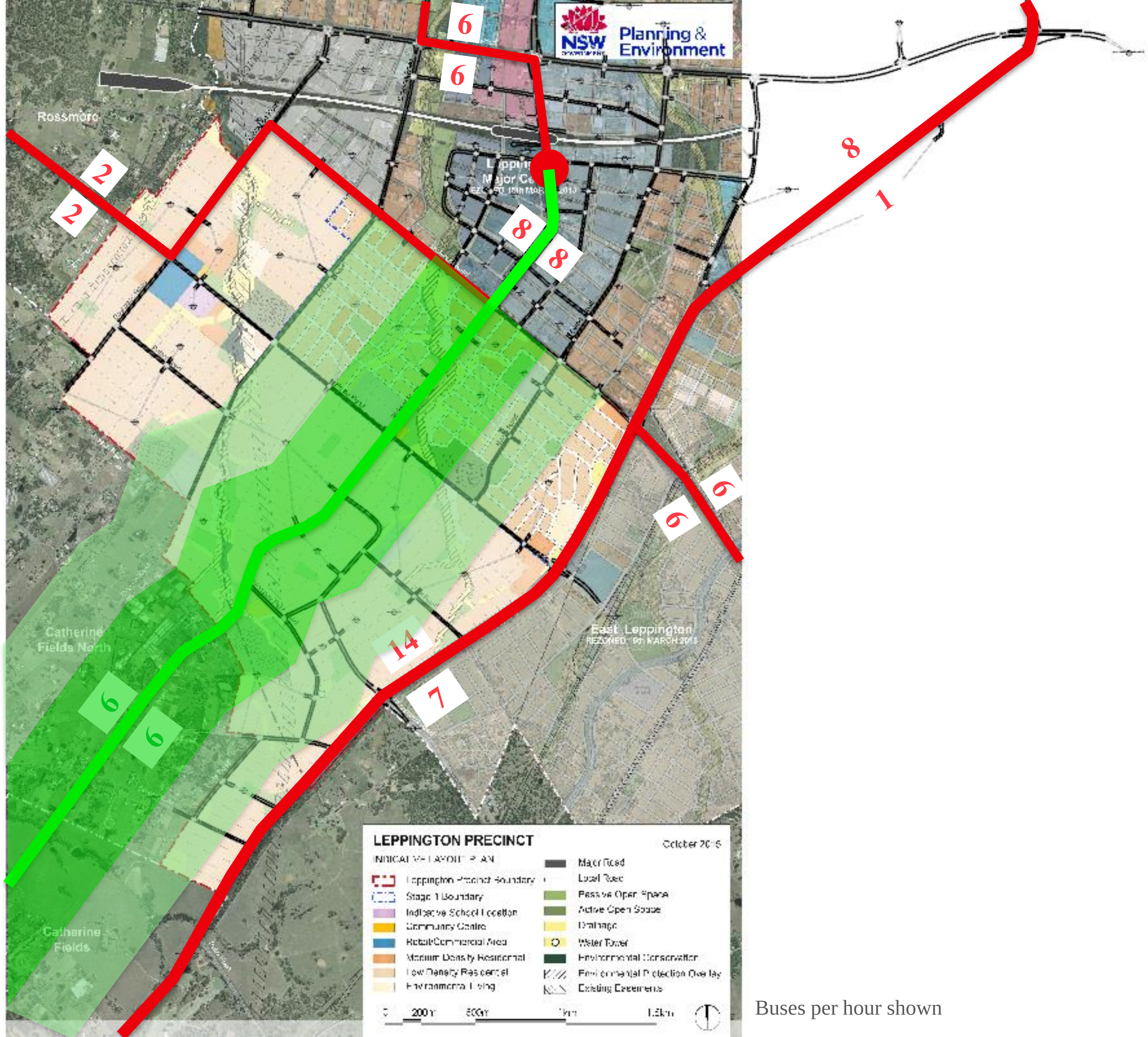


Buses per hour shown

Leppington Town Centre & Precinct

Key discussion points

- Future public transport vision
  (currently PTPM)
- Rickard Road public transport corridor
- Catchment areas
  - 400m either side
  - 400 – 800 m either side



Buses per hour shown

Leppington Town Centre & Precinct

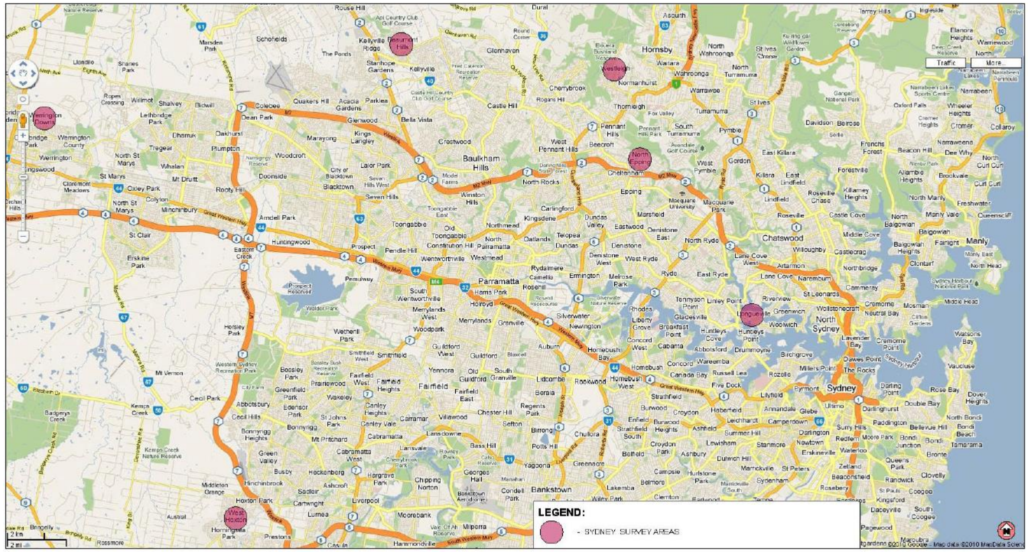
Key discussion points

- Trip rates overview

  Low density residential (2013):

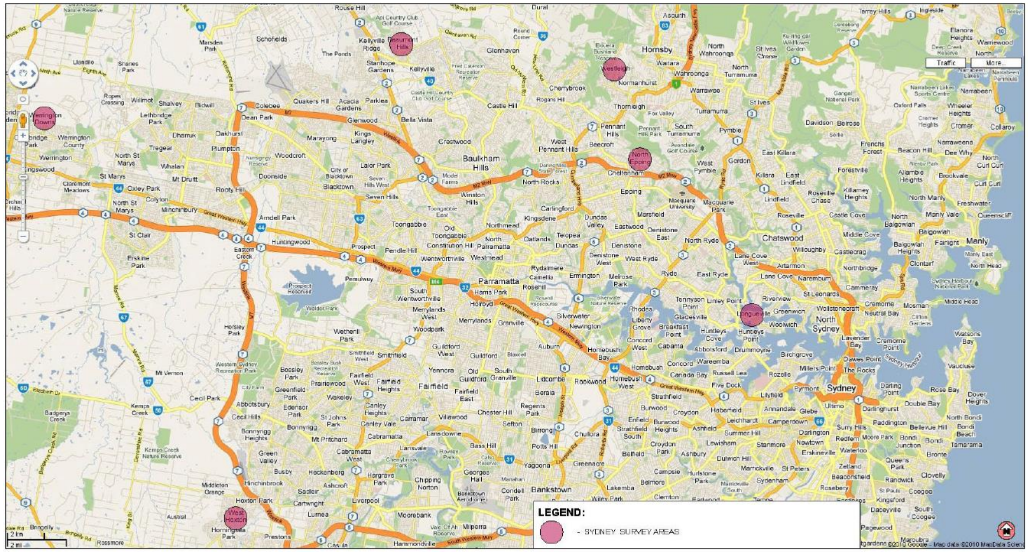
  - AM = 0.95 trips/dwelling
  - PM = 0.99 trips/dwelling

- Most comprehensive



Source: Trip Generation Surveys: Low Density Residential Dwelling, TEP Consulting, 2010

Key discussion points



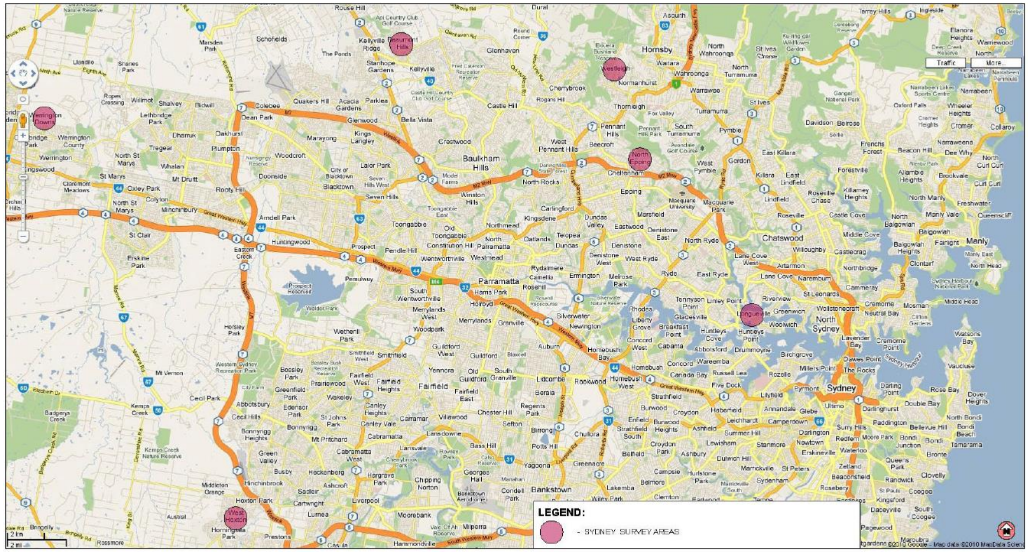
- Trip rates overview
  Low density residential (2013):
  - AM = 0.95 trips/dwelling
  - PM = 0.99 trips/dwelling
- Most comprehensive
- Range
  - AM = 0.56 – 1.00 trips/dwelling
  - PM = 0.54 – 1.05 trips/dwelling

Survey area	Pop.	Dwelling	Trips per dwelling				Similarity with Leppington	Closest station (c. 2010)
			AM	% car	PM	% car		
Beaumont Hills	3,346	956	1.22	72%	1.12	85%	Bisected by continuous routes (610x,617x,610,T64)	Schofields ≈ 5+ km
Longueville	2,084	676	1.00	80%	1.05	92%	Circular bus route (261)	Wollstonecraft ≈ 2.6 km
North Epping	4,295	1,495	0.59	87%	0.54	87%	Circular bus route (295)	North Epping ≈ 2 km
Werrington Downs	2,095	669	0.97	81%	1.39	92%	Bisected by continuous bus route (782).	Kingswood ≈ 1.6 km
West Hoxton	4,552	1,235	1.32	89%	1.14	92%	Bisected by continuous bus route (852, 853, 854, 864)	Leppington ≈ 4.7 km
Westleigh	4,024	1,335	0.56	83%	0.71	94%	Circular bus route (586, 587)	Thornleigh ≈ 2.7 km
Average	**-**	**-**	**0.95**	**82%**	**0.99**	**90%**		**Leppington ≈ 2.6 km**

Source: Trip Generation Surveys: Low Density Residential Dwelling, TEP Consulting, 2010

Leppington Town Centre & Precinct

Key discussion points



- Trip rates overview
  Low density residential (2013):
  - AM = 0.95 trips/dwelling
  - PM = 0.99 trips/dwelling
- Most comprehensive
- Range
  - AM = 0.56 – 1.00 trips/dwelling
  - PM = 0.54 – 1.05 trips/dwelling
- Other sources

  ITE (10th Edition)
  - AM = 0.74 trips/dwelling
  - PM = 0.99 trips/dwelling

  RTA (2002)
  - AM = 0.85 trips/dwelling
  - PM = 0.85 trips/dwelling

Survey area	Pop.	Dwelling	Trips per dwelling				Similarity with Leppington	Closest station (c. 2010)
			AM	% car	PM	% car		
Beaumont Hills	3,346	956	1.22	72%	1.12	85%	Bisected by continuous routes (610x,617x,610,T64)	Schofields ≈ 5+ km
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Source: Trip Generation Surveys: Low Density Residential Dwelling, TEP Consulting, 2010

Outcomes and way forward

Outcomes and way forward

- Finalise travel demand (i.e. trip generation)
- Network hierarchy (order, lanes, connectivity, access)
- Vision
- Intersection arrangements

Key discussion points

Appendix B

Minutes of Leppington Draft Traffic Model Workshop (26 November 2020)

Meeting Minutes – Draft Traffic Modelling Workshop for Leppington Town Centre & Leppington Precincts 1 to 5

Date	26 November 2020	Location: Microsoft Teams
Time:	2pm	4:00 pm
Attendees		
Camden Council Staff		
Suhail Quadri	SQ	Acting Team Leader Major Projects
David Atkin	DA	Leppington Program Manager
Paul Fairweather	PF	Acting Manager Major Projects
Tom Allen	TA	Team Leader Traffic and Road Safety
Jana Jegathesan	JJ	Senior Transport Planning Engineer
Josh Pownell	JP	Team Leader Growth Areas
Bradley Colling	BC	Strategic Planner Growth Areas
Bruce Dunlop	BD	Infrastructure Coordinator
Dick Webb	DW	Manager Assets and Design Services
Faraj Gibbs	FG	Infrastructure Planning Engineer
Brendan Stokes	BS	Infrastructure Planning Engineer
Deaelle Kandasamy	DK	Strategic Planner Growth Areas
Liverpool Council Staff		
Charles Wiafe Stella Qu	CW SQu	Manager Traffic and Transport Transport Planner
Department of Planning, Industry and Environment Staff		
TfNSW Staff		
Benny Horn	BH	Senior Transport Planner – Active Transports Strategy
David Gray	DG	Associate Director Transit Network Planning
Noah Vanraaphorst-King	NV	Senior Transport Planner, Transit Network Planning
Louise Moran	LM	Network Development Leader

John Broady Murray Jay Nhu Doan	JB MJ ND	Unknown Unknown Unknown
ARUP Staff		
Stefan Ellis	SE	Senior Transport Planner
Brett Linnane	BL	Associate Transport Planner
Non-Attendance		
Camden Council Staff		
Adrian Ellis	AE	Strategic Planner Land Use Planning
Patrick Mulqueeney	PM	Acting Director Community Assets
Martin Cooper	MC	Manager Strategic Planning
Liverpool Council Staff		
Adam McInnes	AM	Manager Assets and Design Services
Department of Planning, Industry and Environment Staff		
Frankie Liang Jennifer Yan	FL JY	Manager Place and Infrastructure, Western District, Greater Sydney, Place and Infrastructure Infrastructure Coordinator
TfNSW Staff		
Maria Swallow	MS	Senior Manger Network Development
Sara Stace	SS	Associate Director Walking and Cycling Strategy
Wade Mitford	WM	Program Manager, Bus and Ferry
Jennifer Attard	JA	A/Director Western City Transport Planning
ARUP Staff		

Item	Minutes	Action By
1.0 Introductions		
	SQ would like to begin by **acknowledging** the Dharawal people, **Traditional Custodians of the land**, and pay respects to their Elders past and present. Purpose of the meeting is to bring together relevant stakeholder from across the board. Invitation has been extended to representative from	Camden Council

	Department of Planning, Industry and Environment (DPIE), Transport for New South Wales (TfNSW), Camden Council and Liverpool Council.	

2.0 Background		
2.1	**Leppington Town Centre & Precinct Status** SQ mentioned that ARUP was engaged by Camden Council to undertake traffic modelling for proposed Leppington Town Centre (LTC) and Leppington Precinct (LP) 1 to 5. ARUP had previously undertaken traffic modelling for Leppington Town Centre in 2019 on behalf of DPIE, however Council wanted to expand this model to include all precincts within Leppington and factor in the growth occurring across Western Sydney including the Western Sydney Airport. As part of the modelling exercise, ARUP has used the latest Strategic Travel Model (STM) data produced by Transport Performance and Analytics (TPA) in 2020. The new STM data has been updated with a focus on Western Sydney and has Incorporated the most up-to-date view on land use – developed in conjunction with DPIE, TfNSW and the Greater Sydney Commission. STM used also reflects the latest thinking concerning the Western Parkland City and Future Transport SQ provided a brief introduction on LTC and LP 1 to 5. Leppington is located within the South West Growth Area and is part of the Western Parkland City. **Leppington Town Centre** In 2013 the town centre was rezoned and released under *State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP). In 2017 DPIE commenced a review of the Town Centre by undertaking a number of draft specialist studies, including a design led masterplan. In November 2019, DPIE announced a new approach to precinct planning which included handing control of the rezoning of the town centre to Council. The rezoning is currently underway, which is scheduled to presented to Council - for public exhibition in 2021. **Leppington Precinct 1** Rezoned in 2015, Council is seeing a lot of development activity in stage one and seeing an increase in density. **Leppington Precinct 2 & 5** Council is undertaken an open space review for this area, which is to be completed in February 2021. Rezoning has not taken place due to open space review.	Camden – Suhail Quadri

	Leppington Precinct 3 & 4 The open space review will determine the planning pathway for these precincts. Currently there is no commitment from utilities on servicing these precincts. SQ commented that traffic modelling is a key specialist study which will help us plan the town centre and Leppington precincts 1 – 5	
2.2	**Planning Context** BL mentioned that ARUP were initially engaged by DPIE to undertake a Transport Impact Assessment for LTC in 2018. Mid -2019 ARUP presented draft modelling result as part of stakeholder engagement. Encountered some delays in early 2020 to receive the updated STM model. ARUP did not undertake a full Movement & Place process, however movement & place principles and functions have been considered. ARUP tried to get a full understanding of the movement place context of the road network that we are trying to develop. Reviewed blue & green grids, locate active transport network, obtain understanding of the centre function and land use activities & activation areas. ARUP tried to consider public transport and active transport networks. Tried to be cognisant of the broader movement patterns occurring in the area, identify function and forms of the road, integrate various layers of movement networks and planning scales. Rickard road is identified as a city serving corridor between Leppington and Narellan/Oran Park and north into Liverpool. Rickard Road has also been identified by TfNSW (active transport) as part of the Principal Bicycle Network (PBN) Tier 1 which has influenced Councils pedestrian and cycling network. Leppington intersects with the existing and future rail network. LSPS work has occurred since the SWGASP work. LSPS reinforces the previous work done as part of SWGASP. ARUP are trying to reinforce the traffic patterns by using the ring road system to protect the core for pedestrians, cyclist and public transport. Ring road system to be implemented by using access control and speed. Functional hierarchies as noted in the LSPS and the SWGASP work have been carried down to the precincts south of the town centre.	ARUP - Brett Linnane

3.0 Modelling Approach		
3.1	Overview of Modelling	ARUP - Stefan

	SE advised whilst developing a model they used the road networks from the Indicative Layout Plans (ILPs) and Development Control Plans (DCPs) along with comments that TfNSW provided for the previous model (referring to the 2019 LTC model). Future travel demand and travel patterns from the PTPM have been overlaid, which have been enhanced using first principles trip generation rates against the latest land use data set. This was fed into the AIMSUN model at a mesoscopic level (a level more detailed than a strategic level) applying capacity constraints to intersections and roadways. It considers the time dynamics of demand, meaning if the vehicles cannot clear a route within their designated travel time, they will be pushed into the next available time. It will show bottlenecks forming at intersections where pinch points occur. Modelling tries to unblock pinch points as best as possible using intersection upgrades, turn lanes, etc. Rickard road was initially shown with a six-lane cross section in the Leppington Identification document, consisting of two lanes for general traffic and one for public transport each way up until Ingleburn road. Representation of the internal road network within the town centre has been slightly increased as part of this modelling. Distribution patterns for trips to Leppington, from Leppington, and generated and completed with Leppington have been taken from the forecast demand from the PTPM. High trip generation from the southern lower density precincts. Public transport mode share in the southern precincts is about 14%. Most PT favourable mode split close to Leppington station.	Ellis
4.0 Initial Results		
4.1	<u>Speed</u> Camden Valley Way and Bringelly Road are higher order roads and have been coded in at 80 km/h. Tried to shut down movements within LTC by making it 40 Km/h. Ring roads adjacent to the LTC are of a higher order road to imbed the circular movement, coded at 60 km/h. Local roads are 50 km/h. 3 primary North – South movement corridors. Mesoscopic models are sensitive to speed, there is higher movement on the higher speed road network. <u>Lanes</u> Number of lanes have increased on Heath Road and some section of Dickson Road. Rickard Road south of Ingleburn Road is shown as 6 lane road which includes 2 lanes for buses. North of Ingleburn Road, Rickard Road has 4 lanes which includes 2 lanes for buses. <u>Alternative Vision</u> 2013 technical direction trip generation rate has been used, which is the usual approach for studies when using first principles approach.	ARUP - Stefan Ellis

	However, if we look at the future vision for Rickard Road being a high quality, high frequency, high use public transport corridor with active transport being encouraged and potentially lower car usage along Rickard Road, then the starting foundation for the modelling is slightly flawed in the sense that as we are using the PTPM model as the basis for developing demand and to an extent the wider road network and we are using that to validate what the overall public transport mode share in our model are might be. The result is about 15% public transport mode share which is consistent with the PTPM outputs. We don't have a clear indication on what the future public transport provision for the area might be other than what the Future Transport Strategic Model includes. What it includes is buses coming from the South towards the LTC area using Camden Valley Way, nothing is shown as using Rickard Road corridor. At Ingleburn Road, the buses split into different direction and 8 buses per hour arrive into the town centre. In our discussion with Camden, we are working towards developing an alternative approach for developing the travel demand for the southern areas. If we look at the origin – destination of the public transport lines that go into the town centre and we move them to the Rickard Road corridor which is more in line with what the vision for the corridor is, and if we then assume that the Rickard Road corridor is high quality and high frequency, then that exerts it's own catchment area on the adjacent land use, which is shown as a 400m area and it can extend that to a wider 800m area. We want to be developing a model that is useful for making informed decisions. Trip generation rate of 0.95 in the am and 1.0 in the pm per dwelling have been assumed. 14,500 low density residential in the southern precinct. If we are to investigate based on an alternative trip generation rate, we would have to compare based on trip generation from similar suburbs. 6 similar suburbs across Sydney metropolitan area were identified. ARUP has tried to compare the similarity of these suburbs with Leppington, the suburb of Longueville has the highest similarity with Leppington amongst the 6 suburbs.	
5.0 General Discussion		
5.1	ND - Questioned if there is any vision for 2041 to change the mode share targets and whether any of that vision has been taken in account in terms of network consideration. BL - Currently there isn't an agreed transport vision that has been bought into by all the agencies. Movement and Place principles have been blended in. Strategic walkability assessment will be undertaken as part of this engagement to future proof walking network. ARUP was aware that TfNSW is developing their walking assessment guideline which hasn't been released. ARUP wants to engage their pedestrian planning team to undertake a principle led approach to providing some advice on all of the street typologies that Council have already	Open to the floor

developed along with some of the principles that ARUP is taking towards intersection design and permeability of the road network for pedestrian movement. In terms of estimating mode share for active modes, and modelling those, that is not part of our agreement.

ND – In terms of modelling for active transport, I have to admit, that even TfNSW is struggling. In terms of planning for a centre like this, we may not have the exact science in terms of modelling. But in terms of future proofing for a network, I think we do have various principles that we used earlier for walking and cycling strategic business case considering how people would take up walking and cycling.

BL – Tired to ensure that we are providing the right environment of roads and streets in our planning from a principle's perspective. Keen to hear additional thoughts.

DG – In terms of the network hierarchy, what we also need to include is the bus network hierarchy. Road and bus network don't necessarily align together, so you don't have the top tier of the road network on the top tier of the bus network and vice versa. Rickard Road is planned to become "The" rapid bus corridor through this area and so a lot of the buses on Camden Valley Way will move across. What we (TfNSW) haven't worked out (perhaps John Broady's team can assit on this) is what is the rest of the bus network in terms on local connectivity going to look like. Very difficult to plan the bus corridor without considering the wider bus network.

LM advised there won't be any additional approached lanes on any of the intersection on Bringelly Road and Camden Valley Way.

LM has concerns regarding the access to Leppington station carpark. SQ advised there will be side streets from Dickson to access the carpark.

SQ advised when Council is doing the design for Rickard Road, we are considering the pedestrian and cycle movement.

Key Points

- David Gray
  - Work with Adrian and John and team to identify lower order routes and PT priority needs
  - Need use trips for the mode split that aligns with the planning vision otherwise planning becomes car orientated development precincts.
  - Rickard Rd becomes the main bus corridor once the corridor is complete with buses every 5 mins or less
  - Bus stopping distances - rapid 1-3km and local every 400m. Rickard Rd is planned to become the rapid route corridor. The local bus network has not yet been developed.
- Louise
  - Constraints around intersections – keep to existing kerb to kerb,
  - Ensure car park access pattern

- SQ to talk to network and safety team regarding configuration at Byron Road under rail line

- Charles
  - Reinforcing need for some right turn from Bringelly onto Rickard
  - Active transport link across Bringelly Road
  - Get details from Camden regarding active transport link
  - Liverpool Council is planning Edmondson Ave to accommodate bus movements.
  - Would the road network require any changes to the road network in the adjoining Liverpool LGA?
- Rickard Road
  - Not changing density
  - Should be considered as a 4-lane option
- Orbital link to south
  - Check capacity of it to ensure available
- Tom Allen
  - Envisages Rickard Road being used for Rapid and local bus services
- John Brody
  - It is very unlikely that Camden Valley Way will have the number of bus services indicated (4 per hour in each direction max)
- General
  - Station car park intended to get main access from Dixon Rd
  - Possibility of preventing car through movements at Rickard Rd/Bringelly intersections (north-south)
  - Planning should consider bus hierarchy, not only roadway hierarchy
  - Devonshire link does not seem to be included in the strategic sense based on a possible current vision for it (seem to be lower order in the model).

Appendix C

Literature review of alternative vehicle trip generation rates for low density residential land uses

Your ref
Our ref 264460-02
File ref

ARUP

Barack Place
151 Clarence Street
Sydney 2000
Australia
t +61 2 9320 9320
d +61 2 9320 9263
f +61 2 9320 9321
Stefan.Ellis@arup.com

Suhail Quadri
Acting Team Leader Major Projects
Camden Council
70 Central Avenue, Oran Park NSW 2570
PO Box 183, Camden NSW 2570

8 December 2020

Dear Suhail

Leppington Town Centre and Leppington Precinct – Technical Note: Literature review of alternative vehicle trip generation rates for low density residential land uses as part of Variation 1

On 18 November 2020 Arup submitted a proposal to Camden Council to undertake a desktop review of low density residential trip generation rates complementary to those published by Transport for NSW (TfNSW, 2013). Council's vision is for Rickard Road to function as a high-quality future transport corridor, which has the potential to impact the trip-making characteristics of residential land uses along and adjacent to it in future. Council accepted the proposal on 23 November 2020, with the qualification that only Tasks 1 and 2 be undertaken, at which point Council will assess the outcomes and indicate whether additional work should be undertaken.

This Technical Note is in response to Tasks 1 and 2 of Arup's proposal for the desktop review.

Figure 1 indicated the public transport catchment area that were included in the desktop review.

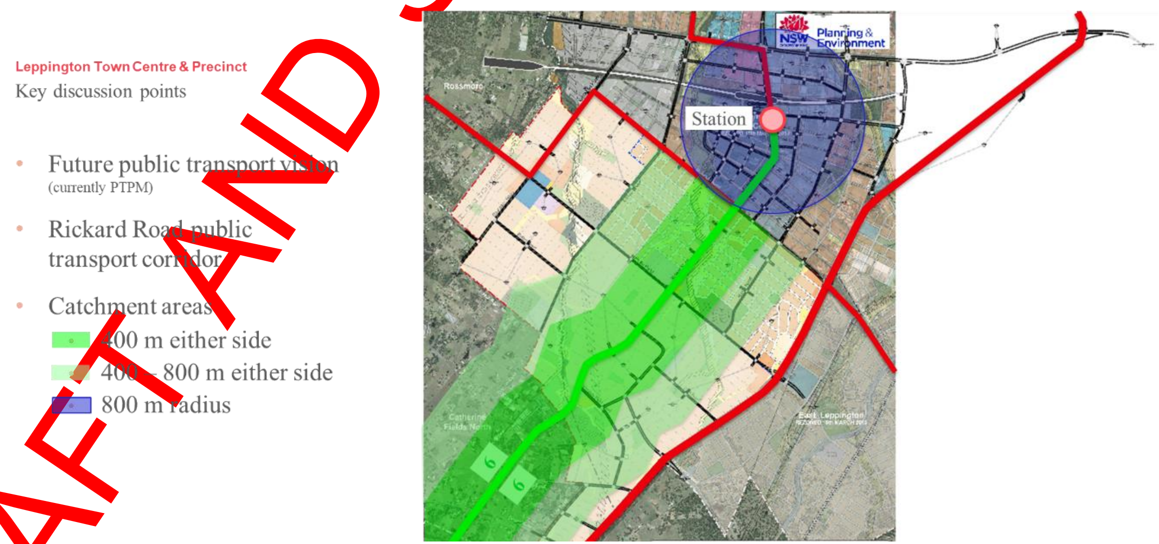

Figure 1: Proposed public transport catchment areas

1 Literature review

Our desktop review considered the following sources:

- Currently available Transport for NSW guideline documents[1], those of other Australian States and the Institute of Transportation Engineers (2018, 10th Edition).
- Recent precinct studies similar in nature to Leppington and situated in Sydney Growth Areas from the NSW Planning Portal completed by various consultants.
- Other traffic impact assessments Arup has recently been involved in with similar land use mixes and transport provision to Leppington.
- The underlying detailed trip generation survey dataset that informed the current TfNSW Technical Direction (2013) guidelines, namely:
    - Trip Generation Surveys – Low Density Residential Dwellings: Data Report (2010) by TEF Consulting;
    - Trip Generation Surveys – Low Density Residential Dwellings: Analysis Report (2010) by TEF Consulting.

2 Summary of literature review rates

Table 1 summarises the recommended trip generation rates for low density residential developments from the literature review.

Table 1 Impact of alternative rates along Rickard Road on trip generation totals

Dataset	Literature		AM vehicle trips per dwelling	PM vehicle trips per dwelling
1	Published guidelines	RTA (2002)	0.85	0.85
		TtNSW (2013)	0.95	0.99
		Western Australia	0.8	0.8
		Queensland	0.8 – 1.0	0.8 – 1.0
		ITE (10th Edition)	0.74	0.99
		New Zealand Trips Database Bureau	0.67 – 0.92	0.80 – 1.29
2	Precinct Studies and other similar developments undertaken by various consultants		0.57 – 0.99	0.57 – 0.99
3	Trip generation surveys at six Sydney sites (2013)		0.59 – 1.32 (mean: 0.95) Recommended: 0.95	0.54 – 1.39 (mean: 0.99) Recommended: 0.99

The datasets are discussed in more details in the following sections.

[1] *RTA Guide to Traffic Generating Developments (2002)* and the *Guide to Traffic Generating Developments: Updated traffic surveys - Technical Direction (2013)*

Dataset 1: Published guidelines

The TfNSW guidelines (2013) are the most comprehensive of any state in Australia. Various other states publish their own rates, but frequently refer to the NSW guidelines to complement their own.

Australian rates typically range from 0.8 to 1.0 vehicle trips per dwelling, while New Zealand rates have a slightly wider range from 0.67 to 1.29. The recommended trip rates for NSW were 0.85 vehicle trips per dwelling (AM and PM) up until 2013, when it was updated to 0.95 (AM) and 0.99 (PM) based on a series of trip generation surveys that informed the TfNSW Technical Direction (2013) are discussed under Dataset 3 in this Technical Note. We note that the updated rates are simply the mean of the surveys that informed the 2013 rates.

Dataset 2: Precinct studies and other recent studies for similar developments

The NSW Planning Portal is home to a wealth of published information and studies for various Planned Precincts in Sydney Growth Areas that share similarities with Leppington Precinct in both land use and scale. Table 2 summarises the vehicle trip generation rates adopted for the low density residential components of these Planned Precincts. Studies conducted after 2013 generally use the latest TfNSW (2013) recommended rates of 0.95 (AM) and 0.99 (PM) vehicle trips per dwelling. The exception was Menangle Park, where regional rates were adopted based on its location. We note that these studies were conducted by various consultants.

The Marsden Park North Draft Masterplan study specifically mentioned that the Consultant, TfNSW and DPIE met in 2018 to discuss ways of reducing the development's total future traffic demand. Reductions of up to 35% in the future would be required in future to achieve acceptable network performance. The impacts were never quantified, but conceptual measures were discussed, namely:

- Improved bus provision in the Growth Area
- Improved rail network
- Future bypasses/motorways in the Growth Area may change traffic flows and distributions.
- Peak spreading

Table 2 Summary of vehicle trip generation rates used for low density residential dwelling units for Planned Precinct studies and other developments in/near Sydney Growth Areas

Proposed Precinct	Submitted	Development details	Vehicle trips rate AM	Vehicle trips rate, PM
Lowes Creek Maryland	September 2018	Residential development (7,060 dwellings): 65% low, 22% medium & 13% high density. Includes town centre with supermarket, commercial and retail (combined 38,000 m^2 GFA), 2 x primary schools, 1 x high school. Future public transport: No direct rail. Only bus.	0.95	0.99
Marsden Park North Draft Masterplan	August 2018	Low density residential (6,300 dwellings on 311 ha). 76,000 m^2 GFA commercial and retail. Future public transport: North-West Rail Link (direct access); 1 x rapid bus and 2 x suburban bus routes.	0.95	0.99
West Schofields Precinct	May 2018	Residential development (4,560 dwellings): 89% low, 9% medium & 2% high density. Future public transport: Rail station (direct access); bisected by 2 x bus rotues; 5 x bus routes adjcent to the development; Walking and Cycling network.	0.99	0.95
Riverstone East Precinct Transport Study	April 2018	Residential development (5,790 dwellings): 73% low, 16% medium & 11% high density. Neighbourhood centre (combined retail & non-retail 5,000 m^2), light industrial (11,000 m^2) Future public transport: North-West rail link (direct access); 1 x regional & 2 x district bus routes to run through the precinct; Walking and Cycling network.	0.99	0.95
East Leppington Precinct Traffic Assessment	June 2013	Residential development (4,384 dwellings): 88% low & 12% medium density. Future public transport: Proposed internal district and local routes; Walking and Cycling network.	0.9(1)	0.9(1)
North Richmond 'Redbank' Transport Management and Accessibility Plan (TMAP)	March 2013	Low and medium density residential (1,399 dwellings). Small local centre (1.2 ha). Future public transport: No direct access to rail; Feeder bus service to Richmond Station; Walking and cycling network.	0.85	0.85
Jacaranda Ponds Glossodia	March 2013	Low density residential (580 lots on 185 ha). Relatively limited PT accessibility. Future public transport: Only bus	0.85	0.85
Menangle Park Residential Subdivision	November 2017	Low density residential (255 dwellings @ 420-970 m^2 plots) Future public transport: Rail (Southern Highlands route); Bus route 889 (incl. stops at station); No walking and cycling provisions.	0.85	0.9
Riverstone and Alex Avenue ILPs	July 2009	Mixed use. Residential (64,605 dwellings, primarily low density) Commercial: 39,835 jobs	0.57(2)	0.57(2)

Note 1: Used daily rates from Guidelines (2002)

Note 2: A mean rate of 0.57 vehicle trips was applied to all dwellings to account for the combination of different residential densities.

Dataset 3: Trip generation surveys at six Sydney low residential developments

In 2010, TfNSW commissioned trip generation surveys targeting six low density residential areas across Sydney, namely Beaumont Hills, Longueville, North Epping, Werrington Downs, West Hoxton and Westleigh. These surveys formed the basis for the currently recommended low density residential trip generation rates that are published in the *Guide to Traffic Generating Developments: Updated traffic surveys - Technical Direction (2013)*.

Table 3 summarises the observed peak hour vehicle trip generations rates from the 2010 surveys. We note that the currently recommended rates of 0.95 (AM) and 0.99 (PM) are the averages of the six survey sites.

We have benchmarked each site against future Leppington across the following criteria:

- How public transport provisions (in 2010) compare to what is expected for future Leppington;
- Shortest drive and walk distance between each site's centroid and the closest railway stations;
- Similarities each site shares with future Leppington;
- Differences between each site and future Leppington;

All survey sites were served by bus routes in 2010, though some were served by direct albeit circuitous routes to nearby economic centres and others by feeder routes to the nearest train station. Once developed, Leppington Precinct's centre of development will be approximately 2.6 km from the Leppington station, measured along the shortest route of the future road network. We understand that Rickard Road will cater to buses that service both Leppington Station and other destinations beyond, including Western Sydney Aerotropolis. In the Leppington workshop held on 26 November 2020, it was mentioned that Rickard Road has a vision for buses every 5 minutes, or 12 buses per hour per direction. We anticipate that a high-frequency, high-quality public transport corridor may play a pronounced role to viably improve public transport and active modes accessibility to the station; this would be expected to reduce car-reliant trip making along the corridor.

Accordingly, we have excluded the survey results from sites that were much further away from their closest train station than the Leppington Precinct would be, namely Beaumont Hills (8+ km, Longueville (3.4 km), and West Hoxton (8+ km); where bus routes were circuitous and indirect or where active transport modes to the station are unappealing due to the topography (Longueville (3.2 km).

The average vehicle trip generation rates based on the remaining three sites (i.e. North Epping, Werrington Downs and Westleigh) are:

- 0.72 trips per dwelling in the AM peak hour
- 0.88 trips per dwelling in the PM peak hour

We note that these reduced trip rates imply an 85% (AM) and 91% (PM) public transport mode share, which is largely consistent with the recommended rates. However, the reduced rates do capture the implied trip-making characteristics of a similar land uses.

Table 3 Summary of observed trip generation rates (2010) at low density residential areas

Survey site	Pop (2010)	Dwellings (2010)	Ave. age (2006)	Surveyed vehicle trips pe dwelling				Public transport directly serving the development (2010)	Distance to closest railway station (in 2010)		Similarities between site (in 2010) and future Leppington	Difference between site (in 2010) and from future Leppington
				AM	% car	PM	% car		Car	Walk/Cycle		
Beaumont Hills	3,346	956	30 - 39 yrs	1.22	72%	1.12	85%	Bisected by continuous bus routes (610x, 617x, 610, T64). Frequent stops	Schofields ≈ 8+ km Quakers Hill ≈ 8+ km	Schofields ≈ 8+ km Quakers Hill ≈ 8+ km	- 100% low density residential with separate dwellings. - Bisecting bus route probably similar in nature to future Leppington.	- Not close to Station (in 2010) - No dedicated bus lane (i.e. possibly less attractive services)
Longueville	2,084	676	40 - 49 yrs	1.00	80%	1.05	92%	Circular bus route (261)	St Leonards ≈ 3.4 km Wollstonecraft ≈ 4.2 km	St Leonards ≈ 3.4 km Wollstonecraft ≈ 3.1 km	- 100% low density residential with separate dwellings. - Centroid is similar distance to Station than Leppington in future. - Commuter car park at Wollstonecraft Station.	- Feeder bus network collects people and transports them to the Station. Leppington may have more direct routes to other destinations. - No dedicated bus lane (i.e. possibly less attractive services) - No commuter car park at St Leonards Station.
North Epping	4,295	1,495	40 - 49 yrs	0.59	87%	0.54	87%	Circular bus route (295)	Epping ≈ 2.4 km	Epping ≈ 2.4 km	- 93% low density residential with separate dwellings. - Centroid is similar distance to Station than Leppington in future.	- Feeder bus network collects people and transports them to the Station. Leppington may have more direct routes to other destinations. - No dedicated bus lane (i.e. possibly less attractive services) - No Commuter car park at Epping Station.
Werrington Downs	2,095	669	±30 yrs	0.97	81%	1.39	92%	Bisected by continuous bus route (782). Frequent stops.	Kingswood ≈ 3.1 km Werrington ≈ 4.0 km	Kingswood ≈ 2.7 km Werrington ≈ 4.0 km	- 100% low density residential with separate dwellings. - Centroid is similar distance to Station than future Leppington. - Bisecting bus route probably similar in nature to future Leppington. - Commuter car parks at Kingswood and Werrington Stations.	- Bus uses circuitous route to Station (possibly unattractive) - No dedicated bus lane (i.e. possibly less attractive services) - Large difference between AM and PM rates (0.97 vs. 1.39). Not clear why, although the PM rate is consistently high for multiple 15-minute sections around the peak hour
West Hoxton	4,552	1,235	20 - 29 yrs	1.32	89%	1.14	92%	Bisected by continuous bus route (852, 853, 854, 864). Frequent stops.	Glenfield ≈ 8+ km	Glenfield ≈ 8+ km	- 99% low density residential with separate dwellings. - Frequented by multiple services. - Located in South West, possibly exhibits similar trip-making characteristics to Leppington. - Route 864 goes directly to Glenfield Station (8km)	- Not close to any Station (in 2010) - Buses do not connect to the closest station (Leppington, 4.7 km). Connects to Liverpool (10+ km) and Glenfield (8 km). Impact likely underplayed. - Circuitous route in areas to increase pickup points. - No dedicated bus lane (i.e. possibly less attractive services)
Westleigh	4,024	1,335	40 - 49 yrs	0.60	87%	0.71	94%	Circular bus route (586, 587)	Thornleigh ≈ 2.6 km	Thornleigh ≈ 2.6 km	- 93% low density residential with separate dwellings. - Centroid is similar distance to Station than Leppington in future. - Commuter car park at Thornleigh Station.	- Feeder bus network collects people and ferries them to the Station. Leppington may have more direct routes to other destinations. - No dedicated bus lane (i.e. possibly less attractive services)
Leppington Precinct (future)	42,000	14,380	30 - 49 yrs	TBD	± 85%	TBD	± 85%					
Average of the surveys				**0.95**	**83%**	**0.99**	**90%**					
Reduced rate (Average of North Epping, Werrington Downs Westleigh)				**0.72**	**85%**	**0.88**	**91%**					

We have assessed the impact that these reduced rates may have on the low density residential land uses along and adjacent to Rickard Road in the future using three scenarios:

- **Base Case**: TfNSW (2013) recommended rates of 0.95 (AM) and 0.99 (PM) apply to low density residential areas across the whole the study area (i.e. no reductions).
- **Scenario 1**: reduced rates of 0.72 (AM) and 0.88 (PM) apply to low density residential dwellings within 400m of Rickard Road.
- **Scenario 2**: the rates of 0.72 (AM) and 0.88 (PM) apply to low density residential dwellings within 800m of Rickard Road.

Table 4 summarises the impacts of applying the reduced trip generation rates to these scenarios.

Table 4 Impact of reduced rates for low density residential land uses along Rickard Road on trip generation totals

Impact scenario	Area	AM		PM	
		Total trips	Change from Base Case	Total trips	Change from Base Case
Base Case	Town Centre + Precinct trips	20,841	-	24,387	-
	Precinct trips only	14,022	-	15,330	-
Scenario 1: Impact within 400m of Rickard Road only	Town Centre + Precinct trips	19,992	(-4%)	23,981	(-2%)
	Precinct trips only	13,174	(-6%)	14,924	(-3%)
Scenario 2: Impact within 800m of Rickard Road only	Town Centre + Precinct trips	19,196	(-8%)	23,600	(-3%)
	Precinct trips only	12,378	(-12%)	14,543	(-5%)

3 Conclusion

Based on our literature review, it may be suitable to employ reduced vehicle trip generation rates for the low density residential areas adjacent to and along Rickard Road to approximate the impacts of high-frequency, high-quality public transport on the trip-making characteristics of the adjacent land uses in future.

In our assessment of the 2010 surveys, we deemed the mature Leppington Precinct to be most similar in nature to the low density residential areas of North Epping, Werrington Downs and Westleigh for reasons discussed under Dataset 3. Observed vehicle trip generation rates in those areas have an average of 0.72 (AM) and 0.88 (PM) per dwelling. Assuming these rates within a 400m catchment area either side of Rickard Road could reduce the total Precinct private vehicle trip generation by 6% (AM) and 3% (PM). By adopting an 800m catchment area, the reduction could be 12% (AM) and 5% (PM).

We acknowledge Council's response via e-mail on 23 November 2020 that they would consider overall reductions of less than 10% to be insignificant and not worth taking forward to the modelling stage as an alternative scenario. In this investigation, a reduction exceeding 10% was only achieved with a catchment area extending 800m either side of Rickard Road during the AM peak hour. We look forward to hearing Council's view on next steps.

We note that final approval of these reduced rates will lie with TfNSW's Development Planning Department and that there is a risk to the project in proceeding with these rates without TfNSW's support. We reached out to TfNSW representatives to discuss the reduced rates proposed in this Technical Note and their response, in principle, is summarised below:

- TfNSW is amenable to trip generation rates outside of those published in NSW if motivated by evidence;
- TfNSW is moving move away from the "off the shelf" rates published in current guidelines as they are increasingly embracing a vision setting approach to planning;
- It may be realistic to expect Rickard Road will have a pronounced impact on adjacent land uses up to 400m away when it matures to a high-quality, high-frequency future bus corridor; and
- The best evidence for alternative trip generation rates will be new surveys commissioned in areas along and adjacent to a bus corridor that currently operates in a similar environment to, and with a similar service frequency than, future Rickard Road.

4 Recommendation

We recommend that Council review this Technical Note and the impacts that reduced vehicle trip generation rates may have on the trip-making characteristics of low density residential land uses along Rickard Road. We look forward to Council's confirmation whether Arup should proceed with updating the modelling based on this review.

Adopting evidence-based reduced trips rates is a viable approach to validating Council's vision for Rickard Road as a high-quality, high-frequency future public transport corridor, its impacts on the trip-making characteristics of adjacent land uses and facilitating a shift toward more sustainable transport modes in Leppington. Other viable interventions include establishing a denser grid of public transport corridors with a similar nature throughout the Precinct, or considering alternative land use distributions with higher densities along the higher order public transport corridors. Arup would be happy to provide additional comment in this regard.

If you need any additional information or have any further queries, please do not hesitate to contact me directly.

Yours sincerely,

Stefan Ellis

Senior Transport Planner | Transport Planning

Appendix D

South West Growth Areas: wider area road network information

Your ref
Our ref 264460-02
File ref

ARUP

Barack Place
151 Clarence Street
Sydney 2000
Australia
t +61 2 9320 9320
d +61 2 9320 9263
f +61 2 9320 9321
Stefan.Ellis@arup.com

Suhail Quadri
Acting Team Leader Major Projects
Camden Council
70 Central Avenue, Oran Park NSW 2570
PO Box 183, Camden NSW 2570

28 January 2021

Dear Suhail

[redacted]

On 26 November 2020 Camden Council facilitated a Leppington Town Centre and Leppington Precinct 1 to 5 workshop with a range of government and agency stakeholders where Arup presented the draft outcomes of the modelling phase. While generally well received, there were some concerns raised by stakeholders during the workshop and in subsequent e-mail communications with Council. These included:

- That the version of the strategic Public Transport Projects Model's Growth Infrastructure Compacts (PTPM5 WSGIC, dated July 2020) which underpinned the original demand forecasts that fed into the Leppington mesoscopic modelling is no longer reflective of the latest thinking regarding the strategic network. It was recommended that various strategic road linkages should now be considered, that may impact the travel demand in, around and through the Leppington study boundary in the future.
- Arup represented Heath Road as having a four-lane cross-section instead of the two-lane cross-section than Council envisages. We highlighted that a four-lane cross-section was required to unblock the network for the given set of assumptions/inputs at the time.
- Rickard Road should be a four-lane Transit Boulevard in its entirety south of Bringelly Road, with only two lanes open to general traffic.
- On 24 November 2020, while reviewing the draft outcomes of the Leppington modelling to be presented at the 26 November 2020 workshop, Council noted in an e-mail to Arup that:
    - The South West Growth Centre Structure Plan prepared by Jacobs, is a draft plan to support the draft South West Growth Area Land Use & Infrastructure Implementation Plan (SWLUIIP). Council notes the plan was not adopted.
    - Better transport planning outcomes for Rickard Road and the broader road network may be achieved if south of Ingleburn Road, some of the North-South traffic volumes can be carried by Eastwood Road / Dickson Road (to be determined through Arup's modelling). Eastwood Road or Dickson Road could be the bypass around the town centre connecting Oran Park and Leppington carrying larger volumes of motor

vehicles. This approach would be consistent with the South West Growth Centre Structure Plan (SWGCSP) prepared by Jacobs shown in **Figure 1**, and could be explored post-workshop.

  - Council's Local Strategic Planning Statement (LSPS), dated March 2020, shows Dickson Road connecting Leppington and Oran Park, whilst Eastwood Road is indicated as an important connection corridor between Bringelly Road (Primary Arterial) and The Northern Road (Primary Arterial). The LSPS is shown in **Figure 2**.

- Via e-mail on 3 December 2020, Council highlighted that:
  - Council feels that the Leppington model is based heavily on the PTPM only and does not fully capture predicted traffic movements from Oran Park, Catherine Fields, Marylands, etc. as have been represented by road linkages in the SWGCSP and Council's LSPS. We note that some of linkages are not represented in the PTPM.
  - North-South movements for general traffic between Aerotropolis / Leppington and Oran Park / Catherine Field need to occur predominantly via Dickson Road (four-lane), then via Eastwood Road (four-lane) and finally some on Rickard Road (listed in order of priority), which was not reflected by the strategic model due to the missing linkages mentioned above.
  - The South West Growth Centre Road Network Strategy (Transport for NSW, June 2011) shows Rickard Road as a Transit Boulevard and Dickson and Eastwood as a Sub Arterial. This is presented in **Figure 3**.
- And on 21 December 2020 Council enquired via e-mail:
  - What might the impacts of various road access management measures along Rickard Road and Heath Road be?
  - How would reducing Heath Road to a two-lane cross-section influence traffic distributions throughout the rest of the network?
  - Would future roads like Raby Road extension, Dwyer Road and George Road be able to reduce the traffic loads on Heath Road?

Figure 1: South West Growth Centre Structure Plan (Jacobs)

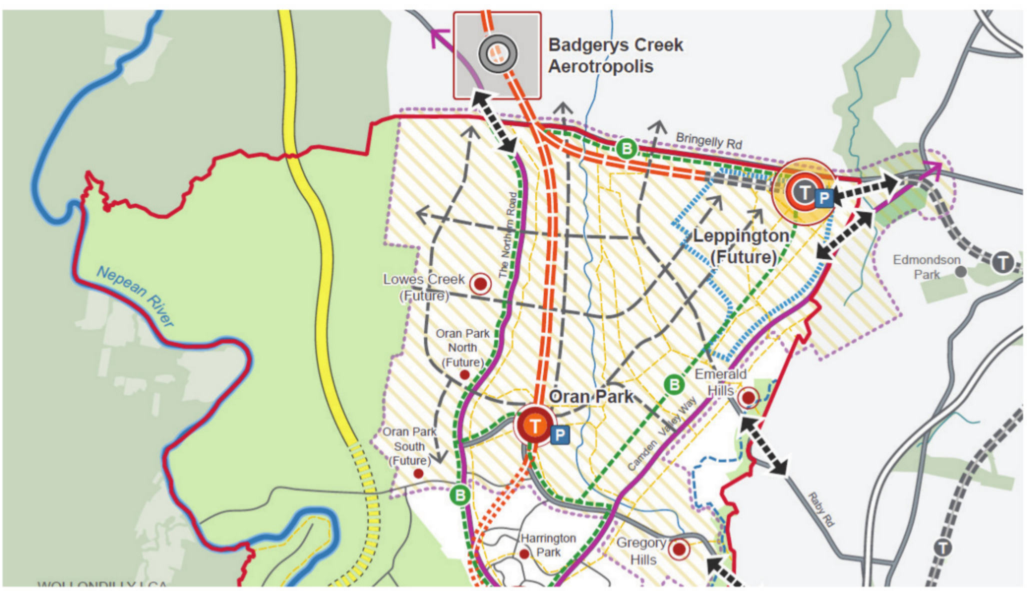

Figure 2 Camden Council's Local Strategic Planning Statement (March 2020)

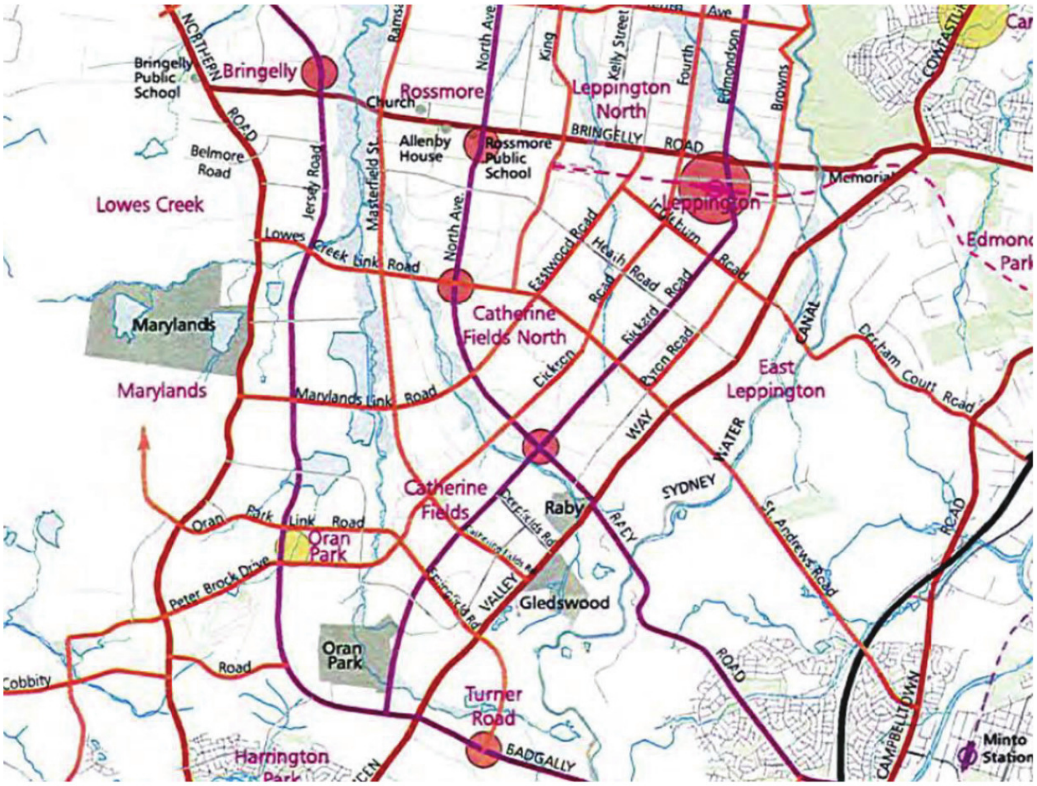

Figure 3: South West Growth Centre Road Network Strategy (TfNSW, June 2011)

Based on the above, we conclude that the changes requested by Council and stakeholders relate both to road network assumptions (strategic and local), and assumptions that relate to travel demand within the study area. **Table 1** summarises our understanding of the representation of the strategic road network in and around Leppington in the PTPM. Please note that we have been instructed by Transport for NSW Advanced Analytics and Insights not to share any visual media provided by them for this study.

Table 1 Representation of highlighted road linkages in the models

Road	Representation in the PTPM (compared to the 2011 SWGC)	Potential impact on modelling result
George Road	Not included in PTPM, but the St Andrews Road extension up to Eastwood Road appears to replace it. St Andrews Road does not continue beyond Eastwood Road and therefore the PTPM does not fully represent the South West Centre Growth Centre Road Network Strategy (2011). A short section of George Road is present in the Leppington model, but it is not significant enough to allow re-routing of east-west traffic.	Minor
Dwyer Road	Does not appear to be included in the PTPM. A short section of Dwyer Road is present in the Leppington model, but it is not significant enough to allow re-routing of east-west traffic.	Minor
Raby Road extension	Included in the PTPM as an extension up to Eastwood Road. It does not continue beyond Eastwood Road and therefore the	Major

	PTPM does not appear to fully represent the South West Centre Growth Centre Road Network Strategy (2011). This road is outside the boundary of the Leppington model.	
Devonshire Road/King Street extension from Bringelly to St Andrews Road	Not included in PTPM. The closest alternative to pick up potential north-south traffic is potentially Dickson Road.	Intermediate to major
Eastwood Road extension to Catherine Fields	Not included in the PTPM.	Major
Rickard Road	Included as a higher order road with at least two traffic lanes per direction, which contradicts its intended function as a Transit Boulevard with one trafficable lane.	Major

Based on the consolidated comments and figures summarised in this letter, it is apparent that there are some inconsistencies in road network assumptions in the available information presented by the 2011 South West Growth Centre Road Network Strategy, the SWGCSP, the 2020 PTPM model and the 2020 LSPS.

To address the recommended changes to the assumptions outlined above, we have developed two proposed approaches to incorporate the network and demand updates into the final modelling deliverable as follows:

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Next steps

We look forward to receiving Council's response. If you require any additional information or have any further queries, please do not hesitate to contact me directly.

Yours sincerely,

Stefan Ellis

Senior Transport Planner | Transport Planning

Appendix E

Desktop study of bus mode shares along a high frequency bus corridor in Sydney, Brisbane, Melbourne and Adelaide

Your ref
Our ref 264460-01
File ref

ARUP

Barack Place
151 Clarence Street
Sydney 2000
Australia
t +61 2 9320 9320
d +61 2 9320 9263
f +61 2 9320 9321
Stefan.Ellis@arup.com

Suhail Quadri
Acting Team Leader Major Projects
Camden Council
70 Central Avenue, Oran Park NSW 2570
PO Box 183, Camden NSW 2570

8 April 2021

Dear Suhail

Leppington Town Centre and Leppington Precinct – Variation 2: Desktop Study of Bus Mode Shares Along a High Frequency Bus Corridor

In March 2021, Transport for NSW released an updated vision for a future bus network throughout the Leppington Town Centre and wider Precinct area. The network is characterised by high-frequency north-south services along Rickard Road, connecting Oran Park in the south to the Leppington Station and Austral to the north.

While this latest vision is significantly different from previous iterations in terms of service provisions, it aligns well with Camden Council's vision for the functioning of the corridor in future. Camden Council appointed Arup under a variation to the existing contract to undertake a desktop study to explore potential impacts that a high frequency bus services may have on the take up of bus ridership in adjacent land uses.

This technical note was prepared and is submitted in response to Council's request.

1 Background

Transport for NSW's current 2041 planning suggests up to 34 buses per direction per hour (±2-minute headways) may traverse the Precinct along Rickard Road, while up to 52 per direction per hour (±1-minute headways) may enter the Town Centre along the same road. This presents a significantly different transport vision than what came before where 12 buses per hour were assumed and upon which all prior modelling was based.

Transport for NSW indicate that the bus network was developed with a pronounced north-south focus. Buses are intended to fill the gap left by the low density of the rail network. The routes and frequencies were designed to serve trip origins/destinations within an 800m catchment area of the corridor in support of Transport for NSW mode share targets in Western Sydney. According to current plans the network will be able to support ±9,000 trips per hour into the Leppington interchange.

Figure 1 presents the latest Transport for NSW vision for the bus network and shows the number of planned buses per hour.

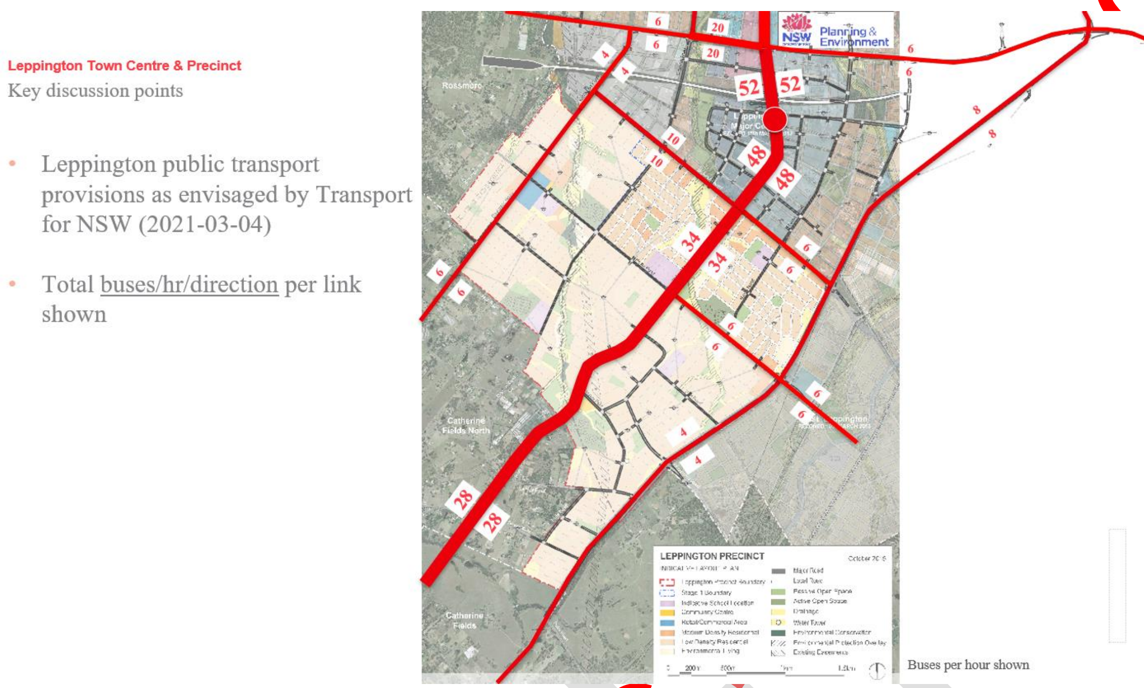


Figure 1: Leppington bus network provisions as envisaged by Transport for NSW (March 2021)

While Transport for NSW is not necessarily committing to put in place all, or any, of the routes, the plan is their latest iteration of the future strategic bus network for Leppington. We note that the network is strategic. As land use and the precinct planning becomes more refined bus routes may have interface through Leppington which is less focussed on the Rickard Road Corridor; however the north-south movement will be critical for any Rapid Bus Services and will be the main point of focus into the train interchanges. There are many different scenarios which could take place; the scenario in Figure 1 is focused on reducing the total amount of bus routes but focusing on high levels of frequency across the network.

We anticipate that high-quality, high frequency and dependable bus services may increase bus attractiveness while reducing car-reliance along the corridor for commuter trips.

2 Summary of Journey to Work data review

Arup's desktop review considered the 2016 Journey to Work (JTW) data derived from the 5-year Census of Population and Housing conducted by the Australian Bureau of Statistics. It includes data on employment by industry and occupation, and method of travel to work at a fine geographical level.

The results reported here were captured at the most granular level of detail, namely the Statistical Areas Level 1 (SA1). SA1-level units generally have a population of between 200 and 800, with an average of around 400.

We note that the JTW data is collected with an emphasis on commuting trips. It may therefore underrepresent the overall number of trips (which may include other purposes such as school, shopping, etc.) or the mode of travel by which those additional trips are taken. While we are confident that our assessment provides reasonable indications of the overall mode shares per SA1, we note that the values shown for trips per dwelling in the subsequent sections are estimates only and need to be interpreted accordingly.

Table 1: High frequency bus corridors analysed at the SA1-level

City	Area / Corridor	Motivation
Sydney	Baulkham Hills area	In 2016 the area was well served by buses, prior to the construction of the Metro. We anticipate that more recent results would show an uptake in train ridership after the Metro was opened.
	Parramatta Road Corridor (Five Dock to Glebe)	High frequency bus corridor with dedicate bus lanes in the morning and afternoon peaks.
	ANZAC Parade (Moore Park to Malabar)	High frequency bus corridor in 2016 using shares traffic lanes. Since 2020, the South East Light Rail has operated along a part of the route, replacing the buses between the CBD and Kingsford Interchange.
	Military Parade (Neutral Bay to Manly Vale)	High frequency bus corridor with dedicate bus lanes in the morning and afternoon peaks.
	Six RMS (2010) trip generation study sites (1)	To provide a point of comparison with the 2010 trip generation survey results
Brisbane	South East Busway	13 km dedicated, grade separated busway offering high frequency services. Limited stopping/interchange opportunities at 13 interchanges.
Adelaide	O-Bahn Busway (i.e. North East Busway)	12 km dedicated, grade separated busway offering high frequency services. Limited stopping/interchange opportunities at three interchanges.
Melbourne	Manningham West area	This is the only area in Melbourne where bus holds a meaningful bus mode share. It is the only significant area not served by train and/or tram.

Notes:
(1) Beaumont Hills, Longueville, North Epping, Werrington Downs, West Hoxton and Westleigh

2.1 Parramatta Road

Parramatta Road between Five Dock and Glebe was deemed to be most appropriate for this review. The T1 train line runs generally parallel to Parramatta Road, between 300m and 700m to its south. We deemed this proximity may dilute the impact of bus ridership in favour of train. Consequently, we only considered SA1s north of Parramatta Road and within 800m of it. Figure 2(a) shows the study area.

Table 2 summarises the JTW mode shares along the Parramatta Road corridor. We note that travel by rail and other modes (including active modes) still represent a significant component of the trips.

Table 2: Parramatta Road study areas (Five Dock to Glebe): JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Parramatta Road	6,327	0.98	23%	12%	47%	19%

Table 3 summarises the distribution of dwelling types along the Parramatta Road corridor. Housing along the corridor is mostly comprised of high density apartments (46%) and medium density, semi-detached type units (33%).

Table 3: Parramatta Road study areas (Five Dock to Glebe): Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
Parramatta Road	19%	33%	18%	28%	0%	2%

2.2 Military Parade

Rail does not service Sydney's north-eastern suburbs or northern beaches. Buses operating in dedicated lanes during the peak transport commuter peaks to/from the North Sydney area. Figure 2 (b) shows the study area, which comprised all SA1 zones within 800m either side of the corridor.

Table 4 summarises the JTW mode shares along the Military Parade corridor.

Table 4: Military Parade study areas (Manly Vale to Neutral Bay): JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Military Parade	4,551	0.97	31%	6%	53%	10%

Table 5 summarises the distribution of dwelling types along the Military Parade corridor. Housing along the corridor is a generally good mixture of freestanding dwellings (31%) closer to the eastern end of the corridor and apartments (56%) toward its western end, with a few others mixed in-between.

Table 5: Military Parade study areas (Manly Vale to Neutral Bay): Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
Military Parade	31%	13%	36%	20%	0%	0%

2.3 Anzac Parade

Prior to the opening of the South East Light Rail (L2 and L3) lines along Anzac Parade between the CBD and Kingsford in 2020, frequent buses served commuters between the south-eastern suburbs and the CBD. Currently, buses interchange at Kingsford. Figure 2(c) shows the study area, which comprised all SA1 zones within 800m either side of the corridor.

Table 6 summarises the JTW mode shares along Anzac Parade corridor.

Table 6: Eastern Suburbs study areas (Anzac Parade between Moore Park and Malabar): JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Anzac Parade	5,036	0.92	30%	5%	53%	11%

Table 7 summarises the distribution of dwelling types along the Anzac Parade corridor. Housing is mostly comprised of apartment units (57%) and freestanding dwellings (25%).

Table 7: Eastern Suburbs study areas (Anzac Parade between Moore Park and Malabar): Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
Anzac Parade	25%	18%	30%	26%	0%	1%

2.4 Baulkham Hills

Prior to the opening of the Metro Northwest in 2019, commuters in the north western Hills suburbs were served by a network of local and rapid buses that fed them to the economic hubs and train stations. Figure 2(d) shows the study area, which comprised all SA1s within the footprint area shown.

Table 8 summarises the JTW mode shares in the northwest Hills suburbs. Prior to the opening of the Metro travel was dominated by private car.

Table 8: The Hills study suburbs: JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
The Hills East (1)	2,306	1.25	19%	6%	73%	1%
The Hills West (2)	2,358	1.40	15%	6%	78%	2%
Average	**2,336**	**1.33**	**17%**	**6%**	**76%**	**2%**

Notes:
(1) Area includes Cherrybrook, West Pennant Hills, Baulkham Hills and Castle Hill.
(2) Area includes Bella Vista and Kellyville..

Table 9 summarises the distribution of dwelling types in the Hills suburbs. The area is overwhelmingly comprised of freestanding houses (81%).

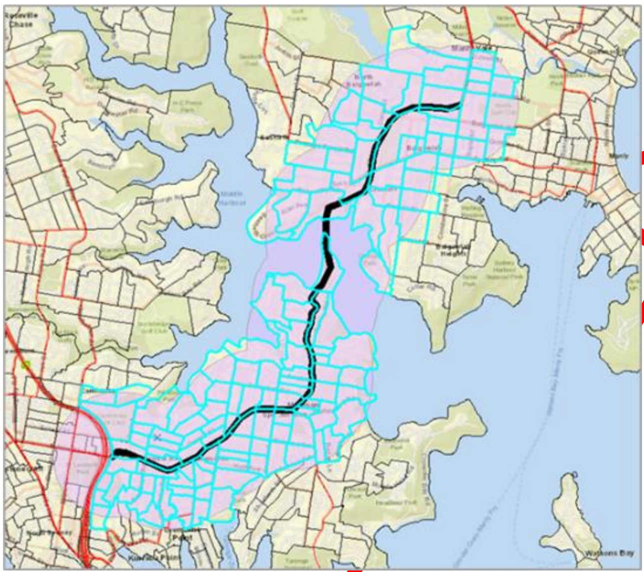
Table 9: The Hills study suburbs: Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
The Hills East (1)	76%	14%	6%	4%	0%	0%
The Hills West (2)	85%	11%	2%	1%	0%	0%
Average	81%	12%	4%	2%	0%	0%

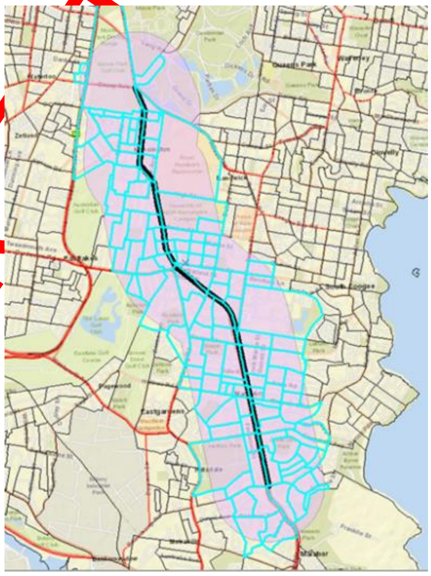
2.5 Brisbane South East Busway

The South East Busway is a 13 km grade separated, dedicated bus-only road running alongside the M3 highway between the Brisbane CBD and Eight Mile Plains and features 13 stations. Figure 3(a) shows the study area, which comprised all SA1 zones within 800m either side of the corridor.

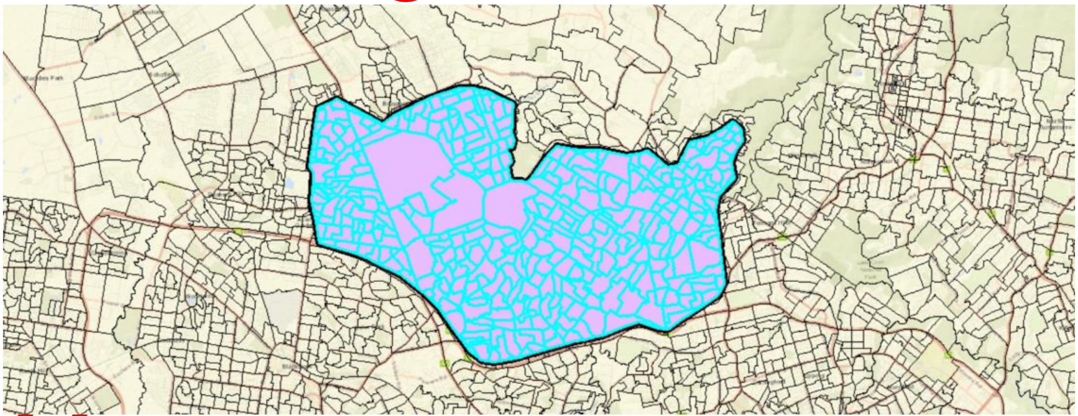
(a) Parramatta Road



(b) Military Parade



(c) ANZAC Parade



(d) Baulkham Hills

Figure 2: Sydney SA1 analysis in corridors serviced heavily by bus

Table 10 summarises the JTW mode shares along the busway.

Table 10: The South East Busway study area (Brisbane): JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
South East Busway	1,541	1.04	20%	2%	69%	8%

Table 11 summarises the distribution of dwelling types along the busway. Housing is mostly comprised of freestanding houses (59%) and apartments (26%).

Table 11: The South East Busway study area (Brisbane): Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
South East Busway	59%	11%	22%	4%	0%	4%

2.7 Adelaide O-Bahn Busway

The O-Bahn is a 12 km rapid bus system that runs on a segregated and dedicated bus-only track between Adelaide's Modbury neighbourhood and the CBD and features three interchanges along the way and a speed limit of 85 km/h. The O-Bahn is said to have ignited a cluster of commercial and community development around its northern end due to its easy accessibility to other public transport services and the direct linkage to the CBD. Figure 3(b) shows the study area, which comprised all SA1 zones within 800m either side of the corridor.

Table 12 summarises the JTW mode shares along the O-Bahn. The results show that travel to/from the SA1s adjacent to the corridor is still dominated by private car, which may be attributed, in part, to the corridor having infrequent access points.

Table 12: The Adelaide O-Bahn study area: JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
O-Bahn	1,685	0.81	14%	0%	77%	9%

Table 13 summarises the distribution of dwelling types along the busway. Housing is mostly comprised of freestanding houses (60%) and a generally equal mix between the other types.

Table 13: The Adelaide O-Bahn study area: Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
O-Bahn	60%	19%	13%	8%	0%	1%

2.8 Melbourne (Manningham West)

Melbourne has an extensive train and tram network. A review of the SA1 data showed that the Manningham West area north east of the CBD is the only area with a noticeable bus mode share, and the reason for this seems to be due to the absence of train or tram infrastructure. Figure 3(c) shows the study area, which comprised all SA1s within the footprint area shown.

Table 14 summarises the JTW mode shares along the busway.

Table 14: Manningham West study area (Melbourne): JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Manningham West	1,886	0.96	12%	4%	81%	4%

Table 15 summarises the distribution of dwelling types along the busway. Housing is overwhelmingly comprised of freestanding houses (73%) and townhouse-type dwellings (18%).

Table 15: Manningham West study area (Melbourne): Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
Manningham West	73%	18%	5%	3%	0%	0%

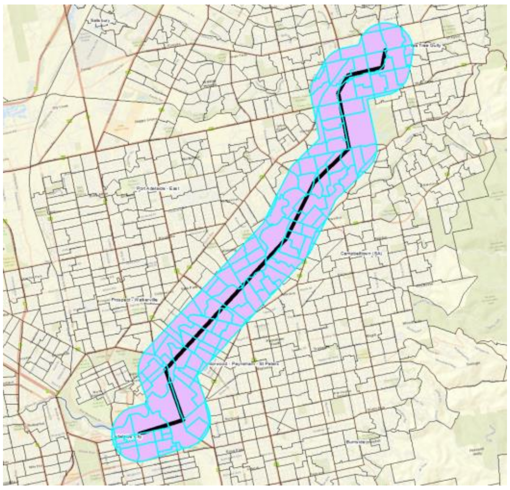
2.9 Six RMS (2012) trip generation survey sites in Sydney

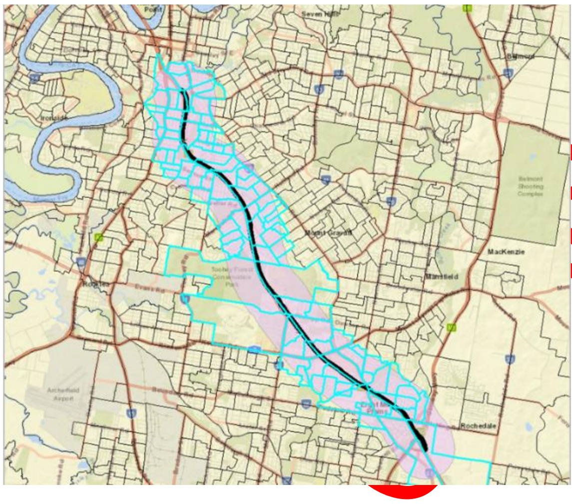
In 2010, Transport for NSW commissioned six trip generation surveys at low density residential areas across Sydney, namely Beaumont Hills, Longueville, North Epping, Werrington Downs, West Hoxton and Westleigh. These surveys informed the currently recommended low density residential trip generation rates published in the *Guide to Traffic Generating Developments: Updated traffic surveys - Technical Direction (2013)*. Arup's Variation 1 study, submitted to Council on 8 December 2020, contained in-depth analysis of the 2010 survey data and the mode share results can be viewed there. Figure 3(d) shows the study areas, which comprised all SA1s within the footprint area shown.

Table 16 summarises the JTW mode shares along the busway.

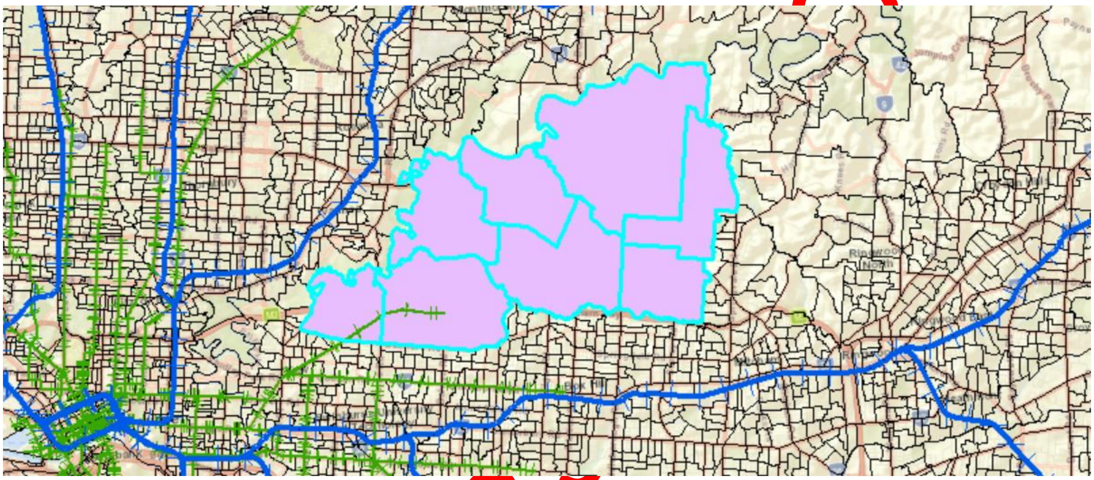
Table 16: Six sites that were the subject of the 2010 RMS trip generation study: JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Beaumont Hills	3,958	1.59	13%	5%	82%	0%
Longueville	2,072	1.15	12%	7%	72%	10%
North Epping	1,941	1.25	2%	25%	68%	4%
Werrington Downs	3,019	1.35	0%	12%	87%	1%
West Hoxton	3,939	1.60	2%	10%	89%	0%
Westleigh	1,416	1.20	1%	27%	71%	1%
Average	**2,308**	**1.35**	**4%**	**16%**	**78%**	**2%**

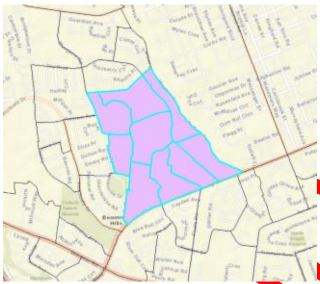




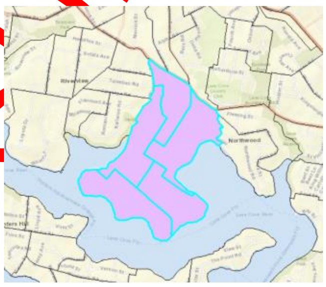
(a) Adelaide O-Bahn (b) Brisbane South East Busway



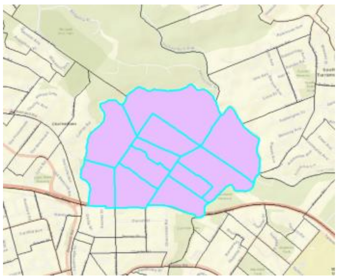
(c) Manningham West (Melbourne)



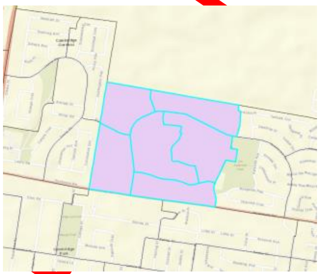
Baulkham Hills



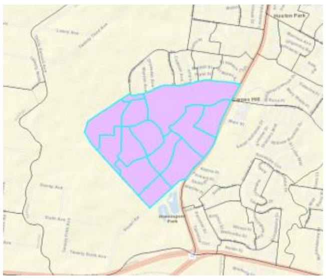
Longueville



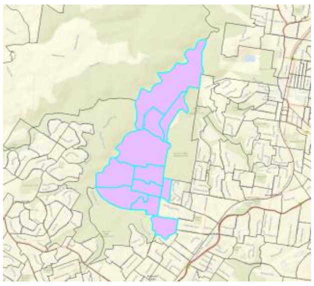
Epping North



Werrington Downs



West Hoxton



Westleigh

(d) Six sites that were the subject of the 2010 RMS trip generation study

Figure 3: SA1 analysis areas

2.10 Summary

An overarching summary of the results of the JTW data is presented in Table 17 for ease of comparison between all areas/corridors.

Table 17: Summary of the mode shares from the SA1 analysis: JTW mode shares

	Density (persons/km2)	Person trips/dwelling	% bus	% train	% private vehicle	% other
Parramatta Road	6,327	0.98	23%	12%	47%	19%
Military Parade	4,551	0.97	31%	6%	53%	10%
Anzac Parade	5,036	0.92	30%	5%	53%	11%
The Hills suburbs	2,336	1.33	17%	6%	76%	2%
South East Busway	1,541	1.04	20%	2%	69%	8%
O-Bahn	1,685	0.81	14%	0%	77%	9%
Manningham West	1,886	0.96	12%	4%	81%	4%

We conclude that dedicated bus lanes in shared traffic in Sydney (Parramatta Road, Military Parade and Anzac Parade) generally show a higher public transport mode share than was observed for dedicated bus ways (Brisbane and Adelaide). A possible reason for this might be that the two busways have a fixed number of stops with extended distances between them, while the Sydney buses may stop more frequent and the bus stops are therefore more accessible.

Dwelling type distributions for the area/corridors are summarised comparatively in Table 18.

Table 18: Summary of the mode shares from the SA1 analysis: Dwelling types

	Separate house	Semi-detached, townhouse etc.	Apartment (<3 storeys block)	Apartment (4+ storeys block)	Apartment attached to a house	Other
Parramatta Road	19%	33%	18%	28%	0%	2%
Military Parade	31%	13%	36%	20%	0%	0%
Anzac Parade	25%	18%	30%	26%	0%	1%
The Hills suburbs	81%	12%	4%	2%	0%	0%
South East Busway	59%	11%	22%	4%	0%	4%
O-Bahn	60%	19%	13%	8%	0%	1%
Manningham West	73%	18%	5%	3%	0%	0%

Figure 4 presents a plot of the relationship between public transport mode share and proportion of freestanding houses from the JTW data. It is clear from the figure that for areas with a high proportion of freestanding houses, the public transport mode share is relatively low. As the proportion of freestanding houses decreases (and density increases), the public transport mode share increases. This result is consistent with expectations and with public transport usage trends in general.

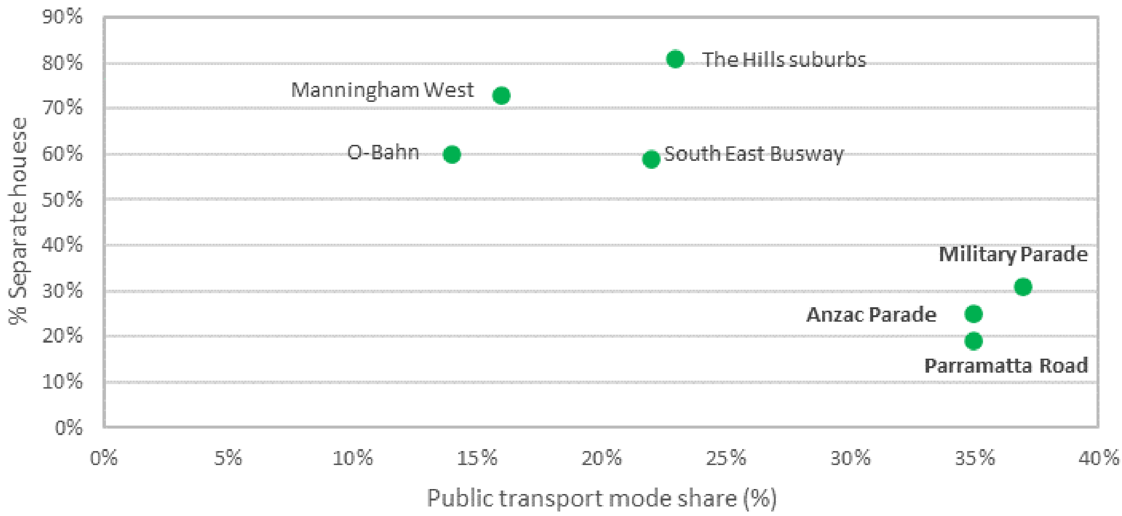


Figure 4: Relationship between public transport mode share and proportion of freestanding houses: JTW data

3 Interaction between land use and transportation

There exists a well-established interaction between land use and transportation systems. Many socio-economic and demographic factors affect trip generation, but the main ones are income, vehicle ownership, household structure and family size.

Traditional four-step travel demand models account for this interaction by basing trip generation on a multi-variable approach that consider many of these factors simultaneously, and each specific combination of factors is called a demand segment. For example, if a model considers three categories for income, two for vehicle ownership, two for household structure and three for family size, there would be 36 unique demand segments for residential trips. Each segment could have its own trip generation rate. The advantage is that, should some of the data change in future, the model can adapt to reflect the impact of that change rather more or less dynamically.

In contrast, the first principles approach that is often applied to studies such as Leppington, uses a simplified trip generation procedure using averages rather than a detailed assessment of the underlying socio-demographics, quite simply because the latter is often not available in early planning stages. In Leppington's case, we are using the *RMS Guide to Traffic Generating Developments* (2002) and its 2012 *Technical Direction (04a)* which contains physical survey evidence. Both documents categorise residential dwellings into three demand segments, namely low, medium and high density dwellings. Each has its own trip generation rate. The Guide (2002) notes that the analyst has some leeway in adapting the rates based on their assessment of factors like public transport availability, noting that:

> *"The above rates are based on surveys conducted in areas where new residential subdivisions are being built. Public transport accessibility in such areas is often limited. Traffic generation rates in inner metropolitan areas where public transport is more accessible could be lower. However in inner metropolitan areas that are more affluent, higher car ownership rates often counter-balance better public transport accessibility"*

The default RMS trip generation rates for low, medium and high density residential dwellings are expressed as vehicle trips per dwelling and are shown in Table 19.

Table 19: RMS residential trip generation rates (2012)

Peak	Low density residential	Medium density residential	High density residential
AM	0.95	0.37	0.15
PM	0.99	0.39	0.19

As can be seen from Table 20, Leppington Precinct will overwhelmingly comprise low density dwellings. These land uses also carry the highest trip generation rates, prior to accounting for good public transport provisions and because of likely higher car ownership.

Table 20: Leppington Precinct distribution of low, medium and high density dwellings

Peak	Low density residential (1)	Medium density residential (2)	High density residential (3)
Dwellings	12,557	1,823	172
% of dwellings	86%	13%	1%

Notes:
(1) Freestanding houses (land use R2 and E4)
(2) Semi-detached, row or terrace house, townhouse, etc (land use R3)
(3) Apartments (land use B2)

We note that Leppington Precinct has a theoretical maxim planning capacity of in 2041 of 47,744 people over 455.25 hectare, which equates to an average population density of ±10,500 persons/km^2. While the Precinct area is anecdotally regarded to be low density in future, we note than a density in this range is relatively high when compared to the other SA1 population densities from Table 17.

This duality between low density dwellings (in dwellings/km^2) and high density population (in persons/km^2) provides an ideal opportunity for a vision-led plan that pro-actively seeks to provide a high quality, high frequency bus network to facilitate a significant shift from car-based trip making towards public transport use. Transport for NSW is clearly pursuing this vision with the proposed bus network and Council has a unique opportunity to explore, through this modelling stage, the future network impacts that could be expected if a major shift from cars to buses is promoted and achieved.

Based on the results reported in this technical note, the transport vision expressed by Transport for NSW and the indicated future service frequencies, we recommend that a public transport mode share of at least 30% should be considered for Leppington. We believe a mode share of 30% is reasonable and in line with public transport commuter mode shares observed along high-frequency bus corridors on Parramatta Road (35%), Military Parade (37%) and Anzac Parade (35%) in the Sydney context.

Arup's recommendation (see Section 2.10) of using a public transport mode share of at least 30% for future trip generation will reduce the low density residential rates from Table 19 substantially. As low density dwellings comprise 86% of the Precinct area, we anticipate a reduced rate to have a far reaching impact.

4 Impact on trip generation rates

This section motivates an appropriate trip generation rate to be used for low density residential zones in Leppington within 800m of Rickard Road.

Figure 5 indicated the public transport catchment area that were included in the desktop review.

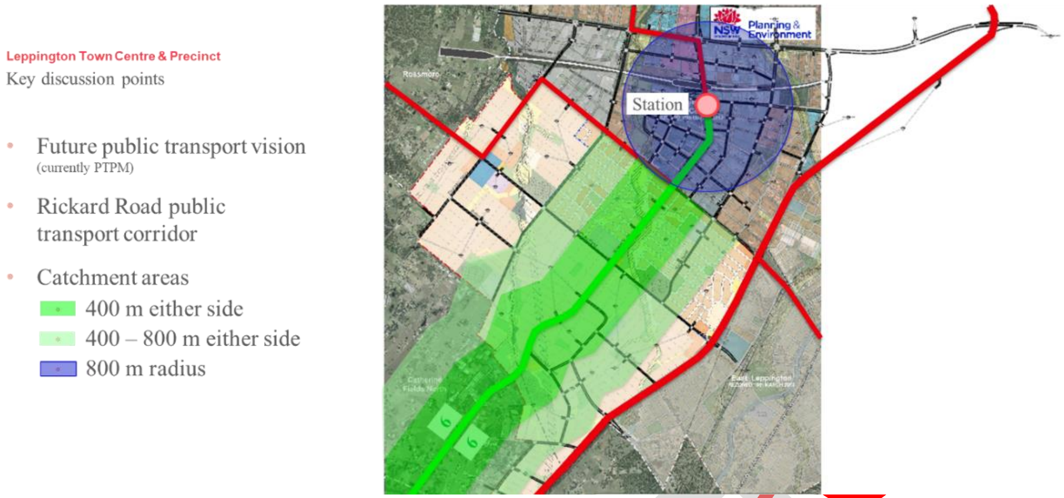


Figure 5: Proposed public transport catchment areas

As discussed, Arup's Variation 1 review, submitted to Council on 8 December 2020, summarised survey results of six low density residential trip generation sites from 2010. These results are summarised in Table 21 (AM) and

Table 22 (PM) for easy reference.

Table 21: Summary of observed AM trip generation results (2010) at low density residential areas in Sydney

Area	Car trips per dwelling	Mode share based on person trips			Average vehicle occupancy
		% car	% bus	% other	
Beaumont Hills	1.22	72%	20%	8%	1.15
Longueville	1.00	80%	11%	9%	1.29
North Epping	0.59	87%	9%	4%	1.39
Werrington Downs	0.97	81%	11%	8%	1.31
West Hoxton	1.32	89%	6%	5%	1.54
Westleigh	0.60	83%	11%	2%	1.26
Average per dwelling	**0.95**	**82%**	**11%**	**7%**	**1.33**

Table 22: Summary of observed PM trip generation rates (2010) at low density residential areas in Sydney

Area	Car trips per dwelling	Mode share based on person trips			Average vehicle occupancy
		% car	% bus	% other	
Beaumont Hills	1.12	85%	8%	7%	1.20
Longueville	1.05	92%	3%	5%	1.15
North Epping	0.54	87%	4%	9%	1.18
Werrington Downs	1.39	92%	2%	4%	1.25
West Hoxton	1.14	86%	6%	8%	1.64
Westleigh	0.71	94%	1%	5%	1.20

Average per dwelling	**0.99**	**89%**	4%	**7%**	**1.27**

Using the 30% bus mode shares in Section 2.9, we have adapted the 2010 survey results by recalculating the number of car trips per dwelling for each of the six sites by assuming each site obtains the recommended 30% bus mode share. For the calculation we assumed that all additional bus trips shifted from private car only. The recalculated private car trips per dwelling are shown in Table 23.

Table 23: Recalculated car trips per dwelling based on a 30% bus mode share

Area	AM	PM
Beaumont Hills	1.05	0.83
Longueville	0.76	0.74
North Epping	0.45	0.38
Werrington Downs	0.75	0.97
West Hoxton	0.97	0.81
Westleigh	0.44	0.49
Average per dwelling	**0.73**	**0.70**

We have assessed the impact that these reduced rates may have on the low density residential land uses along and adjacent to Rickard Road in the future using four scenarios:

- **Base Case**: Transport for NSW (2013) recommended rates of 0.95 (AM) and 0.99 (PM) apply to low density residential areas across the whole the study area (i.e. no reductions).
- **Scenario 1**: reduced rates of 0.73 (AM) and 0.70 (PM) apply to low density residential dwellings within 400m of Rickard Road.
- **Scenario 2**: reduced rates of 0.73 (AM) and 0.70 (PM) apply to low density residential dwellings within 800m of Rickard Road.
- **Scenario 3**: reduced rates of 0.73 (AM) and 0.70 (PM) apply to all low density residential dwellings in the Precinct.

Table 24 summarises the impacts of applying the reduced trip generation rates to these scenarios. We note that Scenario 3 is not currently our recommendation; however, it is included for comparative purposes and for a sense of scale of the impact area of the Rickard Bus Road corridor.

Table 24: Impact of reduced rates for low density residential land uses along Rickard Road on trip generation totals

Impact scenario	Area	AM		PM	
		Total trips	Change from Base Case	Total trips	Change from Base Case
Base Case (i.e. using published rates)	Town Centre + Precinct trips	20,841	-	24,387	-
	Precinct trips only	14,022	-	15,330	-
	Town Centre + Precinct trips	20,029	(-4%)	23,317	(-4%)

Scenario 1: Reduced rate within 400m of Rickard Road only	Precinct trips only	13,211	(-6%)	14,260	(-7%)
Scenario 2: Reduced rate within 800m of Rickard Road only	Town Centre + Precinct trips	19,267	(-8%)	22,313	(-9%)
	Precinct trips only	12,449	(-11%)	13,256	(-14%)
Scenario 3: Reduced rates throughout the Precinct (for comparison only)	Town Centre + Precinct trips	17,965	(-14%)	20,596	(-16%)
	Precinct trips only	11,147	(-21%)	11,540	(-25%)

While developing the Variation 1 study in December 2020 we reached out to a number of Transport for NSW representatives to discuss the concept of using reduced rates and their response, in principle, is summarised below:

- Transport for NSW is amenable to exploring trip generation rates outside of those published in NSW if motivated by evidence. Such an approach supports their adopted Vision and Validate methodology. Transport for NSW desires to shift away from simply using "off the shelf" rates published in current guidelines which are representative of an outdated way of planning;
- It may be realistic to expect Rickard Road will have a pronounced impact on adjacent land uses up to 800m away when it matures to a high-quality, high-frequency future bus corridor; and
- The best evidence for alternative trip generation rates will be new surveys commissioned in areas along and adjacent to a bus corridor that currently operates in a similar environment to, and with a similar service frequency than, future Rickard Road. Such an exercise may be costly and provide only marginally different result over the JTW data.

5 Conclusion

Based on the results reported in this technical note, the transport vision expressed by Transport for NSW and the indicated future service frequencies, we recommend that a public transport mode share of at least 30% should be considered for Leppington. We believe a mode share of 30% is reasonable and in line with public transport commuter mode shares observed along high-frequency bus corridors on Parramatta Road (35%), Military Parade (37%) and Anzac Parade (35%) in the Sydney context.

Adopting an 800m catchment area around Rickard Road would result in reductions of 11% (AM) and 14% (PM) in the traffic demand currently being modelled from published first principles' rates.

We note that final approval of these reduced rates will lie with Transport for NSW's Development Planning Department and that there is a risk to the project in proceeding with these rates without Transport for NSW's support. While developing the Variation 1 study in December 2020 we reached out to a number of Transport for NSW representatives to discuss the concept of using reduced rates and their response, in principle, is summarised below:

- Transport for NSW is amenable to exploring trip generation rates outside of the published NSW ones if motivated by evidence. This approach supports their adopted Vision and Validate methodology. Transport for NSW desires to shift away from simply using "off the shelf" rates from current guidelines which may represent outdated planning methodologies;

- It may be realistic to expect Rickard Road will have a pronounced impact on adjacent land uses up to 800m away when it matures to a high-quality, high-frequency future bus corridor; and
- The best evidence for alternative trip generation rates will be new surveys commissioned in areas along and adjacent to a bus corridor that currently operates in a similar environment to what is being planned for future Rickard Road. Such an exercise may be costly and provide only marginally different result over the JTW data.

6 Recommendation

We recommend that Council review this Technical Note and the impacts that reduced vehicle trip generation rates may have on the trip-making characteristics of low density residential land uses along Rickard Road. We look forward to Council's confirmation on whether Arup should proceed with updating the modelling based on this review.

Adopting evidence-based reduced trips rates is a viable approach to validating Council's vision for Rickard Road as a high-quality, high-frequency future public transport corridor, its impacts on the trip-making characteristics of adjacent land uses and facilitating a shift toward more sustainable transport modes in Leppington. Other viable interventions include establishing a denser grid of public transport corridors with a similar nature throughout the Precinct, or considering alternative land use distributions with higher densities along the higher order public transport corridors. Arup would be happy to provide additional comment in this regard.

If you need any additional information or have any further queries, please do not hesitate to contact me directly.

Yours sincerely,

Stefan Ellis

Senior Transport Planner | Transport Planning

Appendix F

Updated Aimsun Base Model Development Report, submitted to Camden Council on 17 December 2021

Camden Council

Leppington Town Centre and Precincts Traffic Modelling

Base Model Development Report

REP001

Final Report | 17 Dec 2021

Job number 273247

Arup Pty Ltd ABN 18 000 966 165

Arup
Level 5
151 Clarence Street
Sydney NSW 2000
Australia
www.arup.com

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Document verification

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Job title	Leppington Town Centre and Precincts Traffic Modelling	**Job number**	273247
Document title	Base Model Development Report	**File reference**	
Document ref	REP001		

Revision	**Date**	**Filename**	REP001.docx		
Draft 1	07 May 2020	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Nigel Chan, Leila Kazemnezhad	Stefan Ellis	Brett Linnane
		Signature			
Final Report	17 Dec 2021	**Filename**			
		Description	Updated report in response to TfNSW review of draft model/report.		
			Prepared by	Checked by	Approved by
		Name	Elliot Roberts	Stefan Ellis	Andrew Weir
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document verification with document ✓

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1 Introduction

1.1 Background

The Leppington Town Centre (LTC) has been identified with the aim to encourage a sustainable and liveable town centre based on the principles of transit-oriented development. The Department of Planning, Industry and Environment (DPIE) commissioned Arup in 2018 to develop the Leppington Town Centre Transport Plan, a holistic transportation and land use integration plan to support the principles of sustainable development for the centre. This work included the development of operational road network models of the LTC study area.

In 2019, DPIE released '<u>A new approach to precincts</u>' summarising the outcomes of a review of roles and responsibilities in the undertaking of precinct planning, undertaken in partnership with the Greater Sydney Commission (GSC) and Government Architect NSW (GANSW). A key outcome of which being that local councils would be empowered to plan for their local areas because they know their people and communities best, with DPIE continuing to support and collaborate with each council to deliver great places while remaining focused on strategic issues and getting a coordinated approach from State agencies. As such, in November 2019, Arup's role and responsibilities in supporting the investigation into LTC were novated to Camden Council (Council), whilst DPIE also provided Council appropriate permissions to use the operational road network models already developed by Arup.

As part of this novation, Arup were requested by Council to expand the previously developed traffic model to include Leppington Precinct – a planned staged residential community immediately to the south of LTC.

To facilitate above, Arup have developed an operational transport model which covers both Leppington Town Centre and Leppington Precinct (LTCP) with a view to developing two outputs, namely:

- Future Year Operational Modelling Report: including an assessment of the full build-out of both areas by ±2041; and
- Leppington Town Centre Transport Plan: providing a more precinct-type multi-modal transport plan, with the above report as an attachment.

To enable an appropriate assessment of the development proposals, the traffic and transport assessment adopted a two-tiered modelling approach, namely:

- **Strategic modelling**, using outputs from the PTPM model provided by Transport for NSW to inform wider future year land use and travel demand forecasts.
- **Operational modelling**, using Aimsun to consider the time dynamics of traffic demand and network performance to ensure that the Precinct's road network is commensurate with the expected level of traffic forecasts.

1.2 Study area

The LTCP modelled area, including existing road links only, is shown in Figure 1.The study area is bound by Camden Valley Way to the East, Bringelly Road to the North, Heath Road to the South and Eastwood Road to the West.

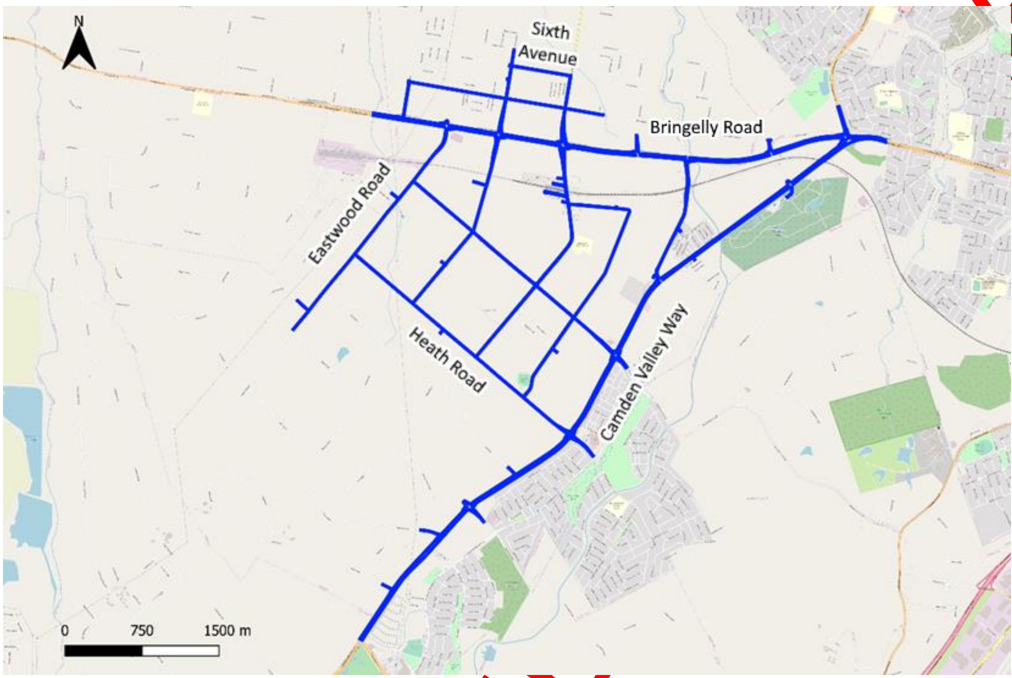


Figure 1 LTCP study area existing road links

1.3 Purpose

The purpose of this Base Model Development Report is to detail the methodology undertaken to develop, calibrate and validate the LTC base model, and to list all assumptions made during this process. The report concludes with the calibration and validation performance of the model against the *Traffic Modelling Guidelines* (Roads and Maritime, 2013)('the Guidelines').

This document will form an appendix to the Traffic Modelling Report.

1.4 Report structure

The remainder of this report is structured as follows:

- Section 2: Data collection
- Section 3: Model assumptions
- Section 4: Calibration and validation
- Section 5: Summary

2 Data collection

2.1 Intersection counts

Arup engaged TTM to undertake classified intersection counts and travel time surveys on Wednesday 11 December 2019 from 5:30am to 9:15am, and from 2:30pm to 6:15pm.

The location of every intersection surveyed is displayed in Figure 2. The surveyed intersections are listed in Table 1 along with intersection type.

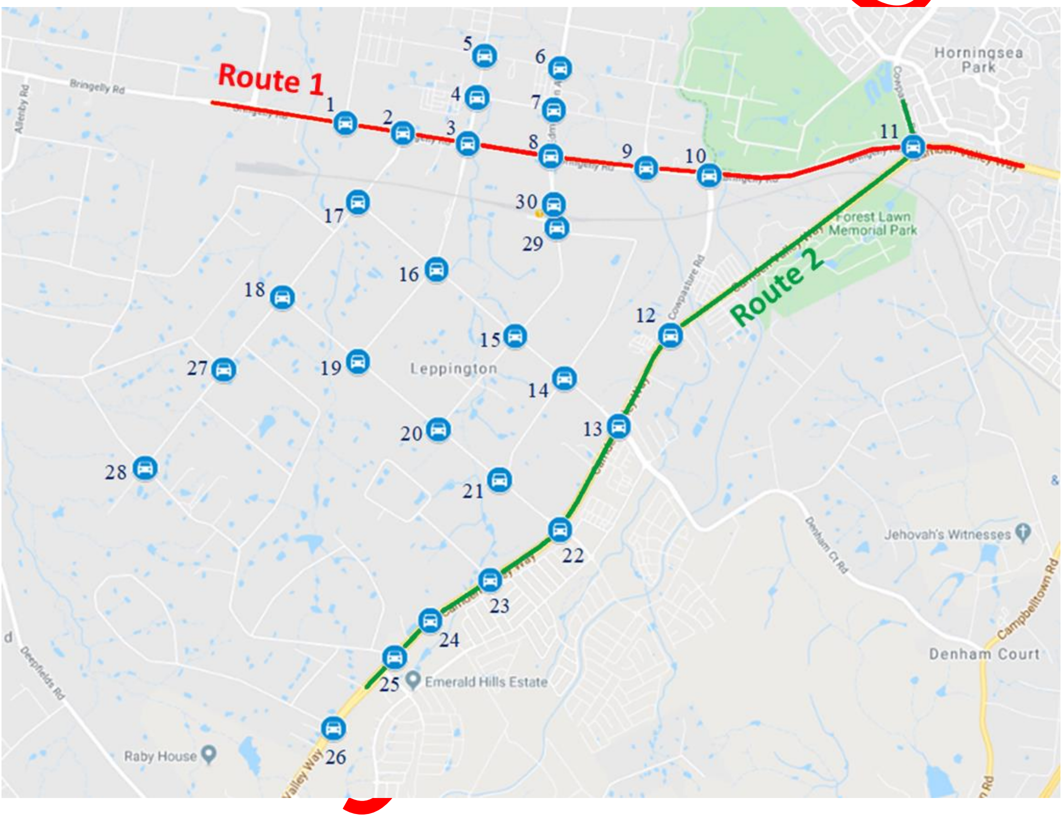


Figure 2 Location of intersection counts and travel time surveys

Table 1 Surveyed intersections and control type

Int.	Description	Control type	Int.	Description	Control type
1	Bringelly Road / Kelly Street	Unsignalised	16	Ingleburn Road / Dickson Road	Unsignalised
2	Bringelly Road / Eastwood Road	Signalised	17	Ingleburn Road / Eastwood Road	Unsignalised
3	Bringelly Road / Dickson Road	Signalised	18	Eastwood Road / Heath Road	Unsignalised
4	Fourth Avenue / Fifth Avenue	Unsignalised	19	Heath Road / Dickson Road	Unsignalised
5	Fourth Avenue / Sixth Avenue	Unsignalised	20	Heath Road / Rickard Road	Unsignalised
6	Edmondson Avenue / Sixth Avenue	Unsignalised	21	Heath Road / Byron Road	Unsignalised
7	Edmondson Avenue / Fifth Avenue	Unsignalised	22	Camden Valley Way / Heath Road	Signalised
8	Bringelly Road / Edmondson Avenue	Signalised	23	Camden Valley Way / Park Road	Unsignalised
9	Bringelly Road / Browns Road	Signalised	24	Camden Valley Way / St Andrews Road	Signalised
10	Bringelly Road / Cowpasture Road	Signalised	25	Camden Valley Way / George Road	Unsignalised
11	Bringelly Road / Camden Valley Way	Signalised	26	Camden Valley Way / Dwyer Road	Unsignalised
12	Camden Valley Way / Cowpasture Road	Signalised	27	Eastwood Road / Anthony Road	Unsignalised
13	Camden Valley Way / Ingleburn Road	Signalised	28	Eastwood Road / Alma Road	Unsignalised
14	Ingleburn Road / Byron Road	Unsignalised	29	Rickard Road / Leppington Station South Carpark Entry/Exit	Unsignalised
15	Ingleburn Road / Rickard Road	Unsignalised	30	Rickard Road / Leppington Station North Carpark Entry/Exit	Unsignalised

2.2 Travel time surveys

Arup engaged TTM to undertake travel time surveys on Wednesday 11 December 2019 from 5:30am to 9:30am, and from 2:30pm to 6:30pm.

Travel time data was collected in each direction along two routes:

- Bringelly Road between Glen Allen Road and Ryan Avenue; and
- Cowpasture Road, between Dwyer Road and Greenway Drive.

The extent of each travel time route is highlighted in Figure 2 above. The route distance, observed average travel time and calculated average speed for each direction and peak are shown in Table 2. Detailed plots showing individual surveyed travel time measurements are shown in Appendix A.

Table 2 Distance, travel time and speed

Peak period	Route/Direction	Distance (km)	Observed travel time (s)	Average Speed (km/h)
AM - (6:30 am – 8:30 am)	Route 1 / EB	5.1	334	55
	Route 1 / WB	5.7	397	52
	Route 2 / NB	5.7	510	40
	Route 2 / SB	7.0	524	48
PM - (4:00 pm – 6:00 pm)	Route 1 / EB	5.1	354	52
	Route 1 / WB	5.7	372	55
	Route 2 / NB	5.7	404	50
	Route 2 / SB	7.0	478	53

2.3 Signal data

SCATS history files, Traffic Control Signals (TCS) plans and LX files were provided by TfNSW for all of the signalised intersections (in 15-minute slices) within the Leppington study area for Wednesday, 11 December 2019.

SCATS history files and TCS plans have been received for the intersections listed in Table 3. The provided data specified that signals along Bringelly Road were not synchronised with other singalsed intersections. Signal offsets along Camden Valley Road were assumed based on the provided LX files.

Table 3 Signal offset values

ID	Location	TCS
13	**Ingleburn Road / Denham Court Road / Camden Valley**	2939
11	**Bringelly Road / Camden Valley Way / Cowpasture Road**	3553
22	**Heath Road / Camden Valley**	4452
24	**St Andrews Road / Camden Valley Way**	4453
12	**Cowpasture Road Sth / Camden Valley Way**	4460
8	**Rickard Road / Bringelly Road / Edmondson Avenue**	4540
3	**Bringelly Road / Dickson Road / Fourth Avenue**	4541
2	**Bringelly Road / Eastwood Road**	4549
9	**Bringelly Road / Browns Road**	4551
10	**Bringelly Road / Cowpasture Road**	4552

2.4 Public transport

Bus routes, stopping patterns and frequencies have been coded based on the most recent data available from Transport NSW.

3 Model assumptions

3.1 Software

The traffic model was developed in Aimsun Next (version 20.0.2), chosen for its ease of use and navigability.

Mesoscopic simulation was chosen for this project as it was deemed sufficiently detailed for the objectives of this study, while still being finer grained than strategic modelling in its ability to spatially model the many route choices available and also temporally, to model traffic profiles across multiple time intervals.

Mesoscopic modelling offers the following perceived advantages:

- It considers the relationship between road network demand, supply and route choice in greater detail than strategic modelling.
- It considers the time dynamics of traffic when finding routes between origins and destinations, thereby identifying parallel routes.
- It allows for identification and testing of strategies of how to best allocate road network capacity against demand for each freight, private vehicles and public transport.
- In conjunction with the intersection modelling (which will be relevant to future year modelling of this study), mesoscopic modelling allows the identification of road network pinch points ("bottlenecks") and the development of a series of solutions and upgrades to optimise the infrastructure and unlock additional capacity.

3.2 Road network

The study area was undergoing major infrastructure changes at the time of the data collection; therefore, several spatial data sets were used to construct and verify the network, including Google Maps and Nearmaps.

The base year model network's functional hierarchy consists of the following pre-defined Aimsun link types:

- Primary (80km/h)
- Secondary (70-80km/h)
- Tertiary (70km/h)
- Residential (50km/h)

Refining the detail of the road network was then undertaken based on the aerial imagery, as well as the publicly available Google. These sources were used to determine the following key network attributes, including certain time dependent traffic measures:

- Number of lanes
- Construction changes
- Turn restrictions
- Intersection layouts and lane arrangements
- Stop lines at intersections
- Speed limits
- Parking restrictions.

3.3 Posted speed limits

The speed limits were coded based on Nearmap and Google Streetview. Up to date aerial imagery was first used to ascertain speed limits and at locations where this was unclear, Google Streetview was used. The modelled speed limits are shown in Figure 3.

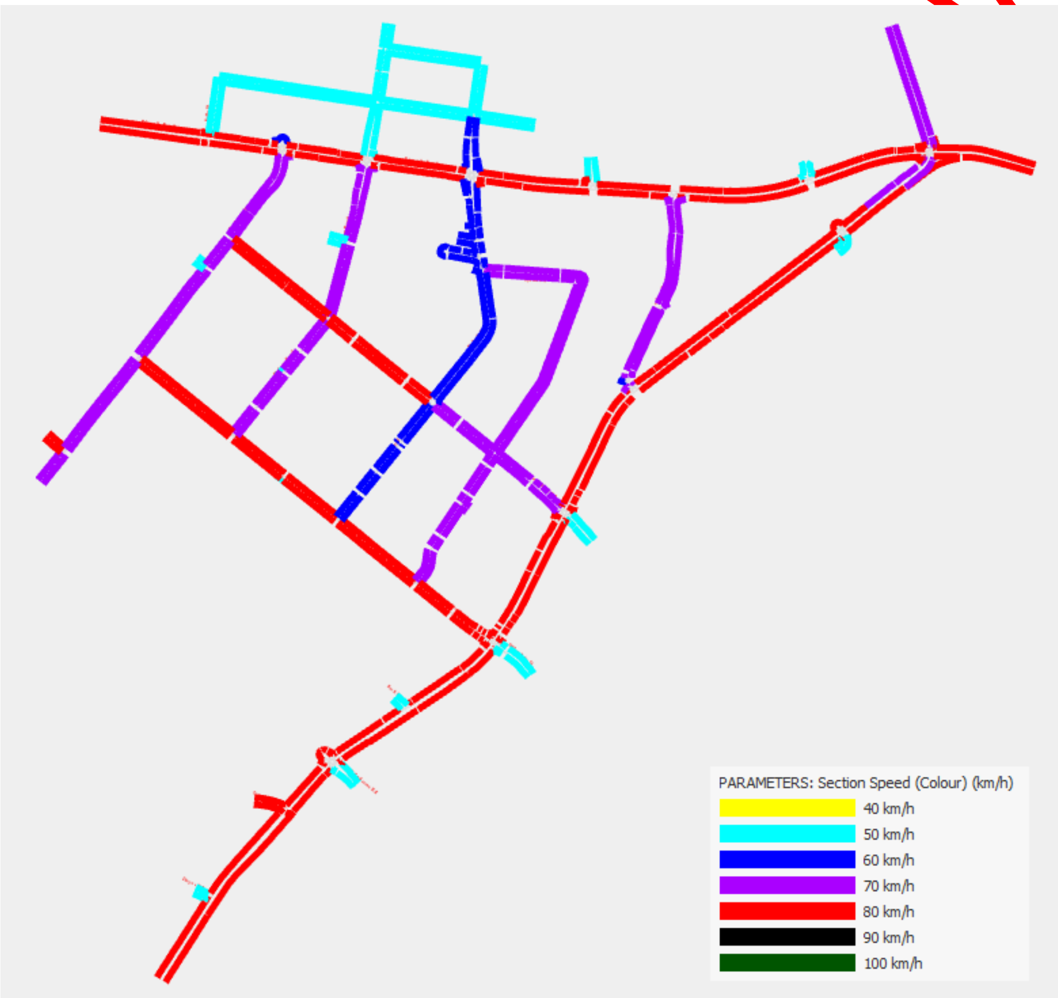


Figure 3 Posted speed limits

3.4 School zones

There exists one school zone within the model boundary, namely Unity Grammar located on Fourth Avenue, North of Bringelly Road.

As shown in Figure 4, the 40km/h school zone is active during school days from 8:00am to 9:30am and 2:30pm to 4:00pm.

Figure 4 School zone sign

The school zone was only applied during the AM peak period. It was modelled using a speed change traffic condition that is only active from 8:00am to 9:30am (when the AM peak model ends).

3.5 Modelled period

The combined traffic volume profile, derived by summing the observed movement volumes of multiple key intersections in the study area, are presented in Figure 5 and Figure 6 for both AM and PM peak periods.

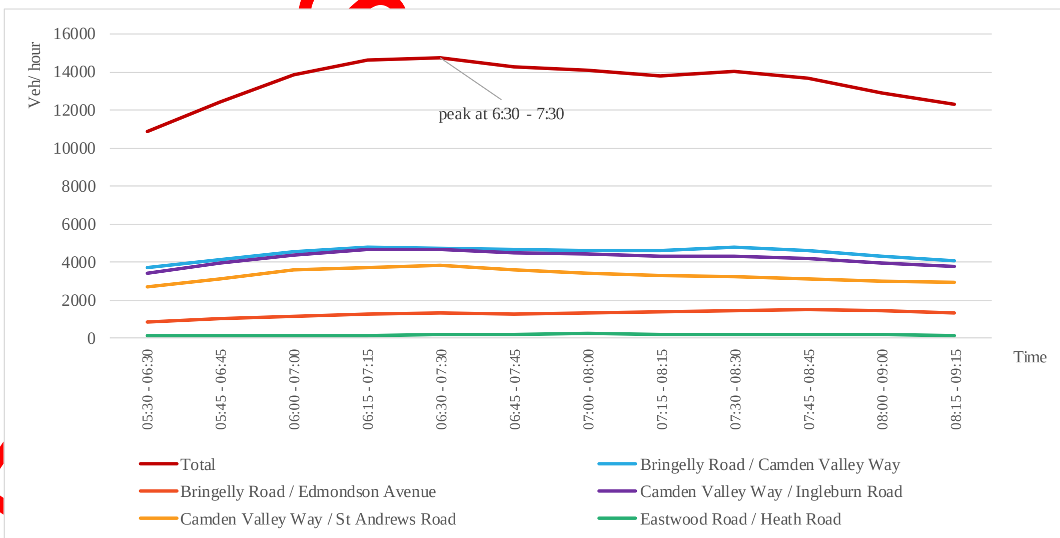


Figure 5 AM traffic profile (05:30am to 09:15am)

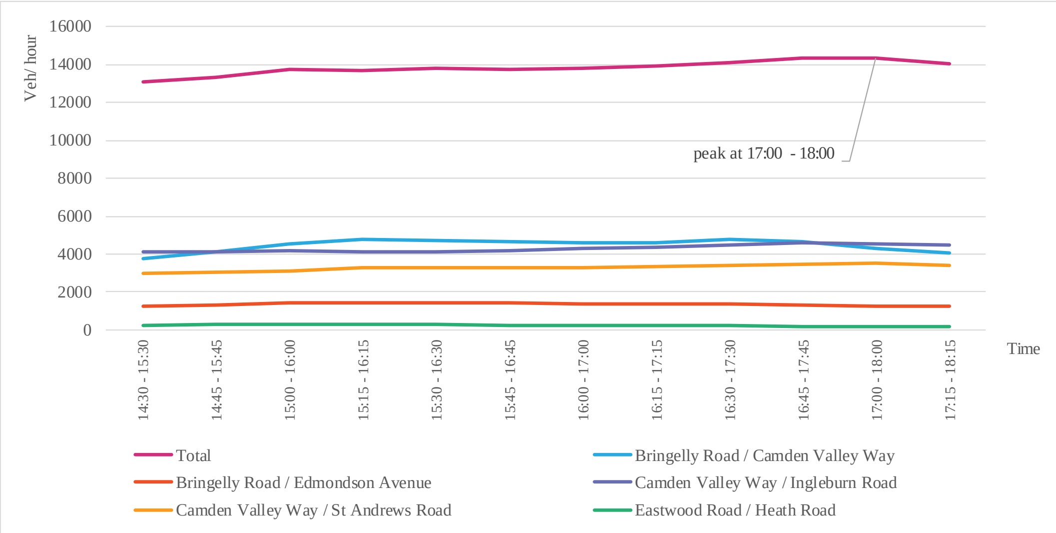


Figure 6 PM traffic profile (14:30pm to 18:15pm)

In summary, the peak periods are as follows:

1-hour peak:

- AM peak hour from 6:30am to 7:30am; and
- PM peak hour from 5.00pm to 6.00pm

2-hour peak:

- AM peak period from 6:30am to 8:30am
- PM peak period from 4:00pm to 6:00pm

A 2-hour model was chosen to be modelled for both peak periods due to the relative flatness of the traffic profiles.

3.6 Vehicle types

The following four vehicle types were used within the Aimsun model:

- Cars and light commercial vehicles (LVs)
- Rigid Heavy vehicles
- Articulated Heavy vehicles
- Buses

3.7 Signal plans

Using the provided SCATS history files and TCS plans, an hourly signal plan was coded for each signalised intersection as fixed time. Some of the lesser used phases were double cycled (i.e. a minor phase occurs once every two cycles) or ignored all together if they did not have a turning movement exclusive to that phase.

Signal actuation was not modelled; rather, signals were coded as fixed time using the average cycles observed from the SCATS history files.

Signal data was not provided for the following three signalised intersections within the modelled area:

- Bringelly Road / Skyline Crescent
- Camden Valley Way / Forest Lawn Cemetery Access
- Cowpasture Road / Four Lanterns Estate Access

Signal phasing and timings at these intersections have been assumed for calibration purposes.

Modelled phasing has been compared with the raw data in Appendix D to confirm that the total green time allocated to each phase is within 10% of the data recorded on site, as per Table 11.3 of the Guidelines.

3.8 Public transport

The following bus routes have been included in this model:

- 841: Narellan – Leppington
- 855: Rutleigh Park - Liverpool
- 856: Liverpool – Bringelly
- 857: Liverpool – Narellan
- 858: Oran Park – Leppington

The bus routes, frequencies, stops and stopping patterns have been coded in the Aimsun model based on the published bus routes and timetables from TfNSW. Modelled dwell times were assumed to be 30 seconds.

3.9 STM outputs

Ccordon matrices were extracted from the Sydney Strategic Travel Model (STM) standard model version and provided by TfNSW TPA Branch for 2016 AM and PM peaks. The AM model was 2 hours while the PM model was 3 hours. However, this was normalised during the demand development process. The STM zones and layout are shown in Figure 7.

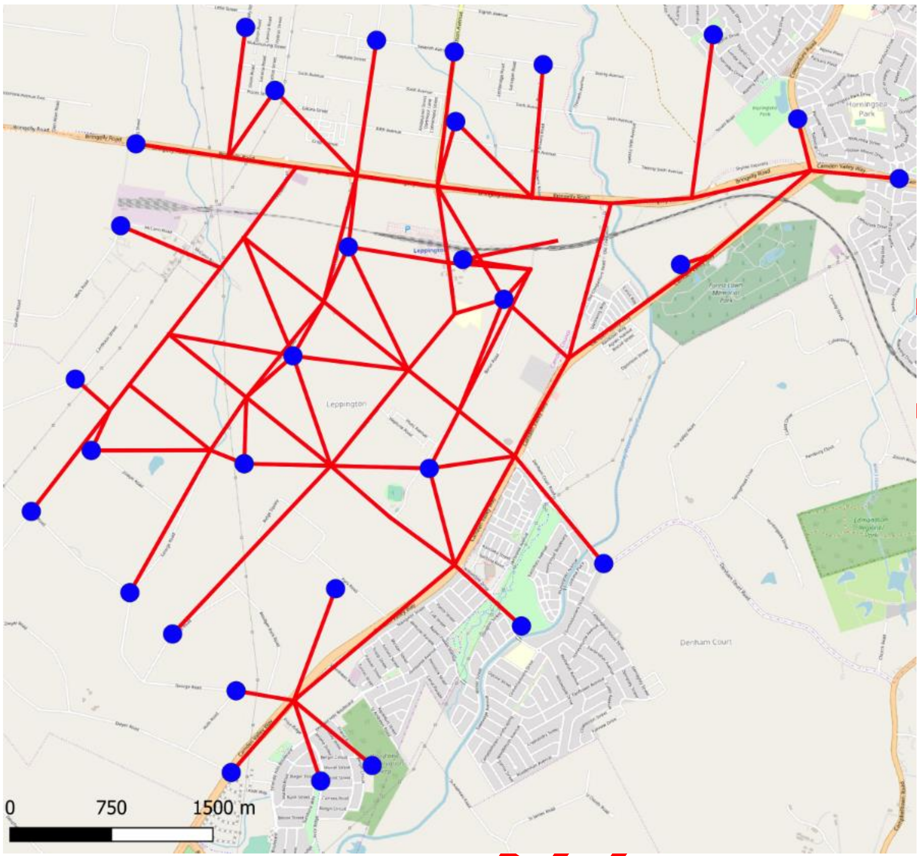


Figure 7 STM cordon model layout

3.10 Aimsun zoning system

The zoning system used for the Aimsun base model has a total of 30 zones and is shown in Figure 8. The location of these zones and their connections to the network considered physical road boundaries surrounding the study area, homogenous land uses (based on current and future planning), as well as the future indicative layout plan (ILP) for the LTC.

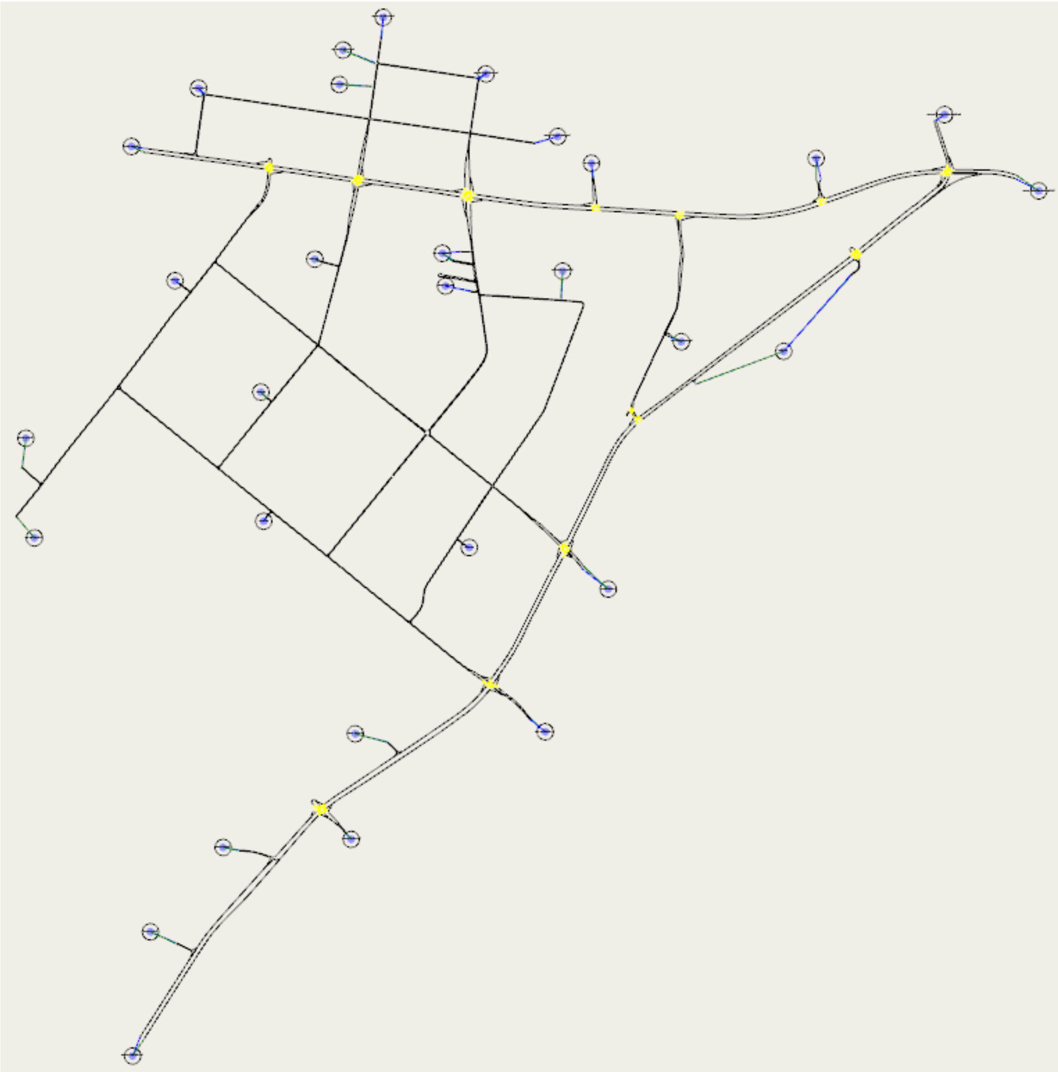


Figure 8 Aimsun zoning system

3.11 Demand matrix development

Traffic demand is one of the major inputs to a traffic model. Traffic demand directly impacts the accuracy of the model so it is imperative that they are developed using the best available data and appropriate methodology. The process below describes the methodology undertaken to develop the initial demand matrices prior to model calibration and validation for both the 2 hour AM peak (6:30 – 8:30 AM) and the 2 hour PM peak (4:00 – 6:00 PM).

The base year (2019) initial Aimsun demand matrices were developed through the steps described below.

1. The STM (2016) traversal matrices were adapted to the Aimsun zone system by overlaying the two sets of zones and converted into Aimsun by overlaying the STM zones with the Aimsun zones:
    a. Where STM zones matched exactly with the Aimsun zones, their demands were left unchanged

b. Where multiple STM zones matched to one Aimsun zone, the STM zone demands were summed up

c. Where one STM zone matched to multiple Aimsun zones, the STM zone demand was distributed to the multiple Aimsun zones using proportions derived from nearby intersection counts

This process was undertaken for both peak periods for LV and HV. It resulted in four matrices, namely:

- AM, LV (2 hours)
- AM, HV (2 hours)
- PM, LV (3 hours)
- PM, HV (3 hours).

These matrices represented the 2016 STM demand translated into a zoning structure that is commensurate with the 2019 Aimsun model. At this stage they were called the 2016 seed matrices.

2. The 2016 seed matrices were scaled to 2019 estimates, which could then be used as the basis from which to calibrate the 2019 Aimsun model. The following steps were then undertaken:

   a. The observed (2019) turning movement counts were summed up at all the entrances and the exits of the model for the 2 hour period for each peak.

   b. These values became the row and column sums of the 2016 matrices.

   c. Each cell of the 2016 matrix were then multiplied with the sum of the traffic counts then dividing by the sum of the entire matrix in order to scale the 2016 matrix to 2019 values.

   Although previously the PM matrices were 3 hours, after having scaled them to 2019, this no longer mattered. This resulted in four estimated 2019 seed matrices, namely:

   - AM, LV (2 hours)
   - AM, HV (2 hours)
   - PM, LV (2 hours)
   - PM, HV (2 hours)

3. The seed matrices were furnessed in Aimsun using the row sums and column sums as the targets.

4. Hourly observed turning movement counts were entered into Aimsun through Real Data Set (RDS). These served as the targets for matrix estimation.

5. A static origin-desitination (OD) adjustment was run which uses both the turning counts and the furnessed matrix to give an initial demand matrix.

6. This resulting initial 2020 demand matrix was then split into 15 minute intervals based on the profile observed from the intersection counts.

As shown below in Figure 9, Bringelly Road and Camden Valley Way are classified as B-Double Routes. It was deemed important to represent this vehicle type in more detail in the model due to their length and subsequent impact on network performance.

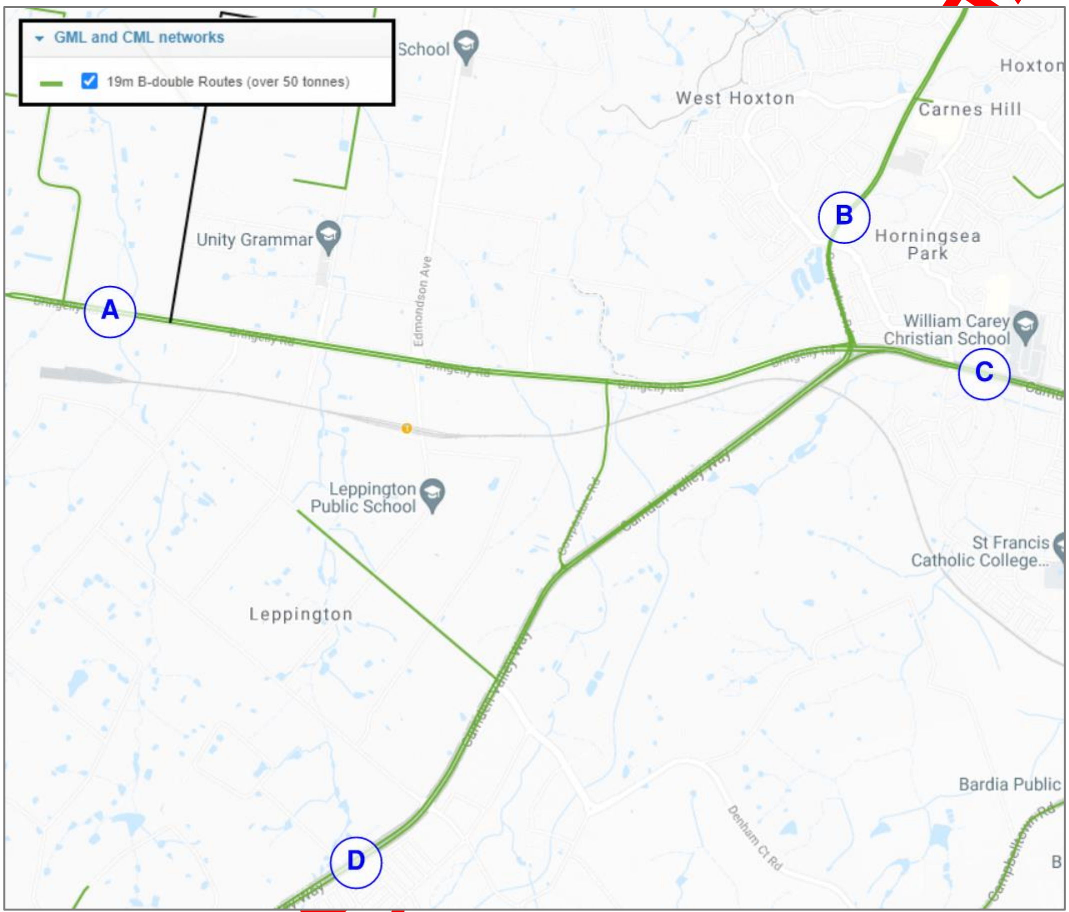


Figure 9: B-Double route map (Source: TfNSW restricted access vehicles map)

Survey video data was reviewed to identify proportions of heavy vehicles along key routes that were either rigid or articulated. Origin-destination proportions of articulated heavy vehicles, corresponding to the location shown above in Figure 9, are summarised in Table 4.

Table 4: Proportion of artciulated HVs on key routes

From	To	% Articulated HVs	
		AM Peak	PM Peak
A	B	0%	3%
	C	23%	7%
	D	8%	3%
B	A	1%	0%
	C	4%	8%
	D	12%	23%
C	A	5%	7%

	B	3%	4%
	D	9%	4%
D	A	1%	6%
	B	8%	6%
	C	7%	6%

These proportions were used to split the HV demands into two separate sets of matrices based on the following vehicle type specifications:

Heavy vehicle type	Min length (m)	Mean length (m)	Max length (m)	Proportion of HV demand (AM / PM)
Rigid	6	8	10	94.2% / 94.6%
Articulated	12	18.5	25	5.8% / 5.4%

3.12 Assignment types

A macroscopic static assignment was used for this model followed by a Dynamic User Equilibrium (DUE) assignment and then a Stochastic Route Choice (SRC) both at the mesoscopic level. Both the DUE and the SRC included a 30 minute warmup period. The parameters used for the DUE assignment are shown in Table 5.

Table 5 DUE assignment parameters

Category	Parameter	Adopted value	Default value
Stopping criteria	Maximum iterations	50	20
	Relative gap	0.5%	0.5%
Reaction time	Reaction time (global)	1.2	1.2
	Reaction time at traffic lights	1.6	1.6
Dynamic assignment	Feedback cycle	15 min	15 min
	Number of intervals	1	1
	Attractiveness weight	3	0
	User-defined cost weight	1	0
	Assignment model	Gradient-based	Gradient-based
	Path cost	Instantaneous	Instantaneous
	Maximum paths per interval	3	3

Note that the assignment parameters changed from the default values were required due to the high number of available route choices through side roads. As such, costs were required to attract vehicles back onto main roads and better represent reality. By running a static assignment before the DUE assignment, a significant portion of time can be saved as well as ensuring convergence can be reached.

4 Calibration and validation

4.1 Traffic assignment

Traffic was assigned to the network using a combination of dynamic user equilibrium assignment (DUE) and stochastic assignment. The DUE assignment involves running a series of iterations to calculate the optimum solution in which all route choices within each OD pair experiences the same travel time/cost.

The paths from this DUE were then input into five stochastic assignment runs, each with a different seed number (560, 28, 7771, 2849, 86524, as per the Guidelines).

The DUE convergence plots for the AM and PM are shown below. All models reached the 0.5% relative gap threshold and converged in less than 20 iterations.

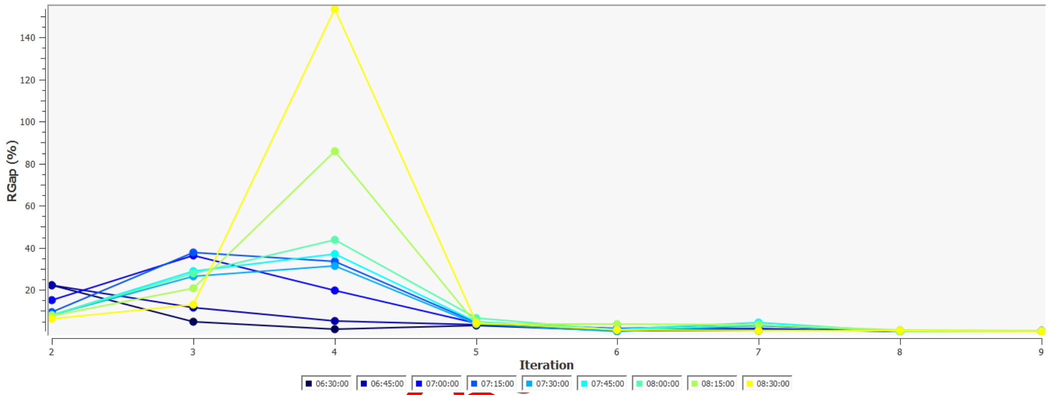


Figure 10 AM DUE Convergence

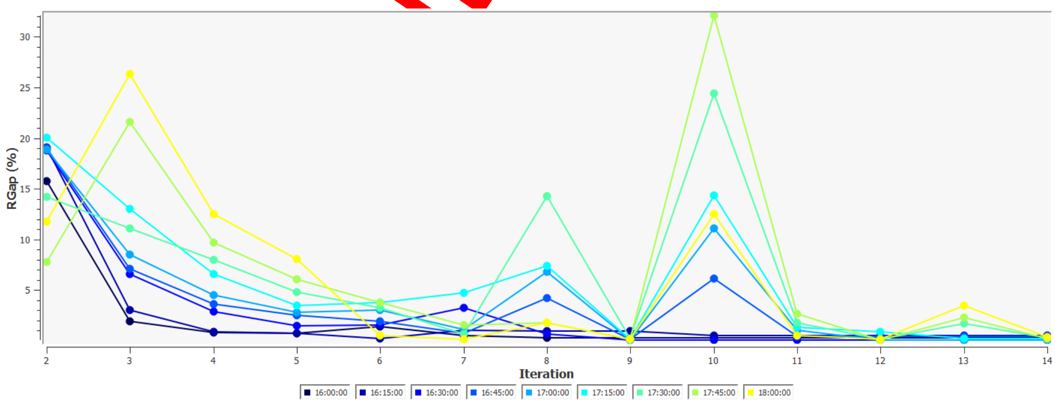


Figure 11 PM DUE Convergence

4.2 Stability

Model stability is an important measure that should be evaluated before the model can be deemed to be fit for purpose. Stability improves the ability of the simulation model to give similar results every run despite using different pseudorandom seed values. High stability is vital in encouraging confidence in a simulation model.

Both peak models were run for the five seeds (as recommended by the Guidelines) in mesoscopic SRC in order to determine stability. The Vehicle Hours Travelled (VHT) results for each 1 hour model are shown in Table 6 and Table 7. Seeds 86524 and 560 were identified as the median seed for the AM and PM peaks respectively.

Table 6 AM Peak VHT stability - Total travelled time (in hours) for each seed number

Seed value	AM VHT (Hour 1)	AM (Hour 1) Difference vs. Average	AM VHT (Hour 2)	AM (Hour 2) Difference vs. Average	AM VHT (Total)	AM (Total) Difference vs. Average
28	796	-3.0%	743	-0.9%	1539	-0.9%
560	825	0.5%	761	1.6%	1586	1.6%
2849	827	0.8%	762	1.6%	1589	1.6%
7771	818	-0.3%	734	-2.1%	1552	-2.1%
86524	837	2.0%	748	-0.2%	**1585**	-0.2%
Average	**821**		**750**		**1570**	

Table 7 PM Peak VHT stability - Total travelled time (in hours) for each seed number

Seed value	PM VHT (Hour 1)	PM (Hour 1) Difference vs. Average	PM VHT (Hour 2)	PM (Hour 2) Difference vs. Average	PM VHT (Total)	PM (Total) Difference vs. Average
28	692	2.8%	678	-1.2%	1370	-0.9%
560	668	-0.7%	692	0.8%	**1360**	1.6%
2849	672	-0.2%	683	-0.5%	1355	1.6%
7771	671	-0.4%	694	1.1%	1364	-2.1%
86524	664	-1.4%	685	-0.2%	1349	-0.2%
Average	**673**		**686**		**1360**	

The same data is shown graphically below in Figure 12 and Figure 13 for both AM and PM peak respectively. As shown, the variation in VHT is 5% or less for each seed compared to the average. Therefore the model is deemed to be stable.

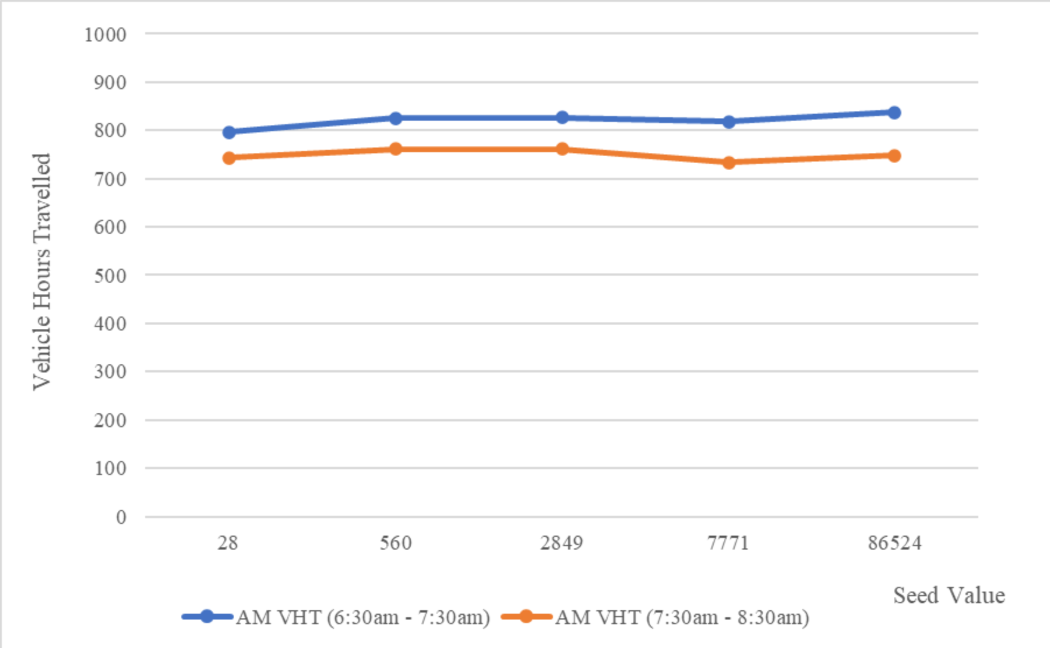


Figure 12 VHT stability graph - AM models

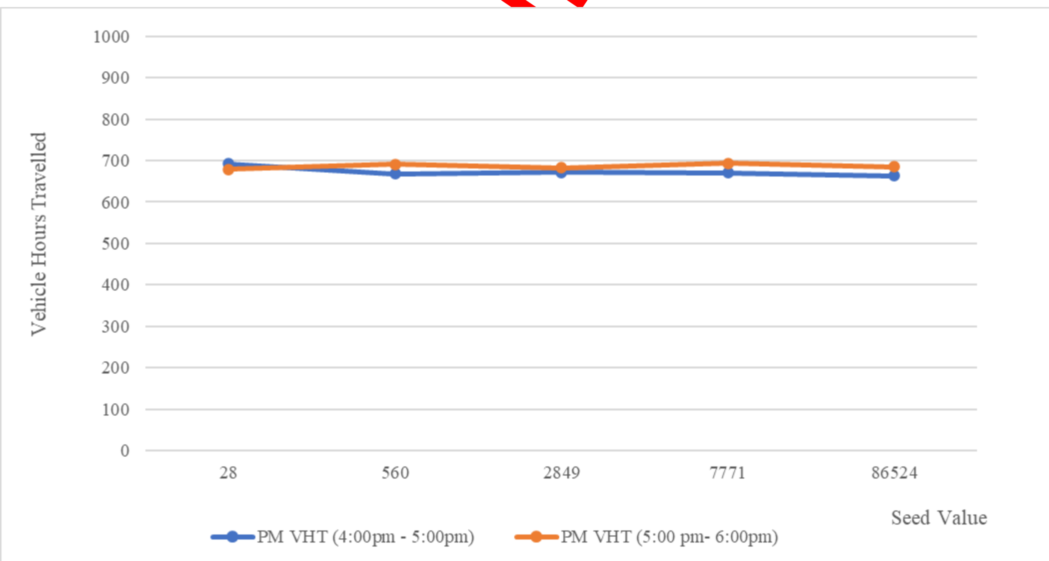


Figure 13 VHT stability graph - PM models

4.3 Calibration

The Guidelines recommend the following target calibration criteria for mesoscopic models:

- 100% hourly turn volumes with a GEH<=10
- 85% of hourly turn volumes with a GEH<=5
- $R^2 > 0.9$
- RMSE <= 30

The calibration process typically involves determining whether the observed and modelled traffic volumes are closely matched using the GEH statistic and if not, modifying the model parameters until it is. The formulation is as follows:

$$GEH = \sqrt{\frac{(V_o - V_m)^2}{0.5\,(V_o + V_m)}}$$

Where:

V_o is the observed flow in vehicles per hour

V_m is the modelled flow in vehicles per hour

Root Mean Square Error (RMSE) also measures the degree of error between two data sets. The smaller an RMSE value, the closer predicted and observed values are. The formulation is as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (P_i - O_i)^2}{n}}$$

Where:

P_i is Predicted value

O_i is Observed value

n is number of observations

The following key modifications were made for calibration purposes:

- At certain intersections, slight changes were made to the signal timings but the modelled timings were all within 10% difference of the SCATS data, which still meets the Guidelines.
- Cost functions on turns were utilised to reduce the number of vehicles rat running through side roads
- Minor manual adjustments were made to the matrices to match the observed traffic counts. This was required as the STM model from which the seed matrices were derived was not calibrated in this area and to this detail. Additionally, the STM had zones significantly larger than the Aimsun model.

4.3.1 Total traffic calibration

Table 8 summarises the averaged calibration results for AM and PM peak periods. The cumulative percent distribution GEH plots are shown in Figure 14 to Figure 17 for AM and PM traffic respectively.

As shown, all turning movements had a GEH less than 10 and 92% of turns had a GEH of less than 5 in the AM and 90% in the PM.

Table 8 GEH summary table

Peak period	% of turns with GEH<5	% of turns with GEH<10
AM Peak (6:30am - 7:30am)	92%	100%
AM Peak (7:30am - 8:30am)	89%	100%
PM Peak (4:00pm - 5:00pm)	87%	100%
PM Peak (5:00pm - 6:00pm)	93%	100%

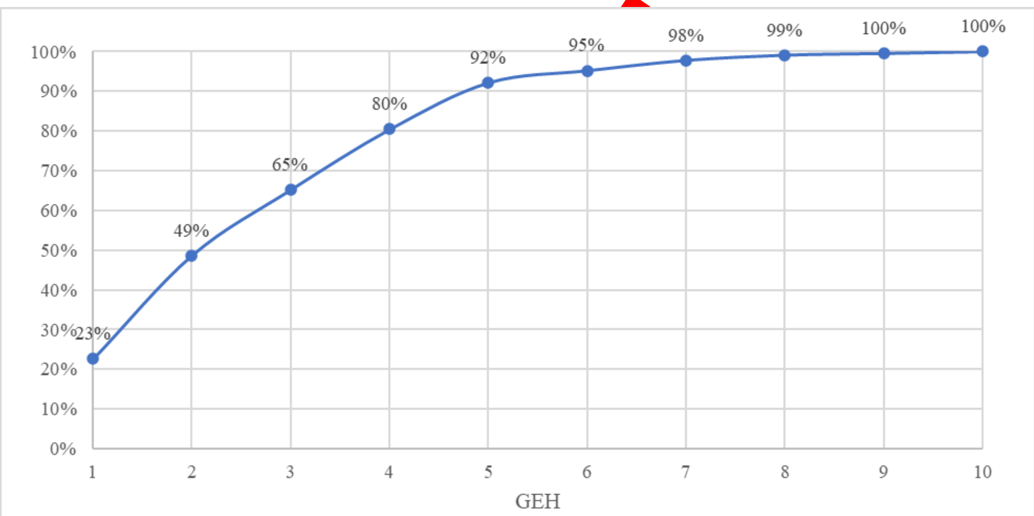


Figure 14 GEH summary graph - GEH distribution plot for 6:30am – 7:30am

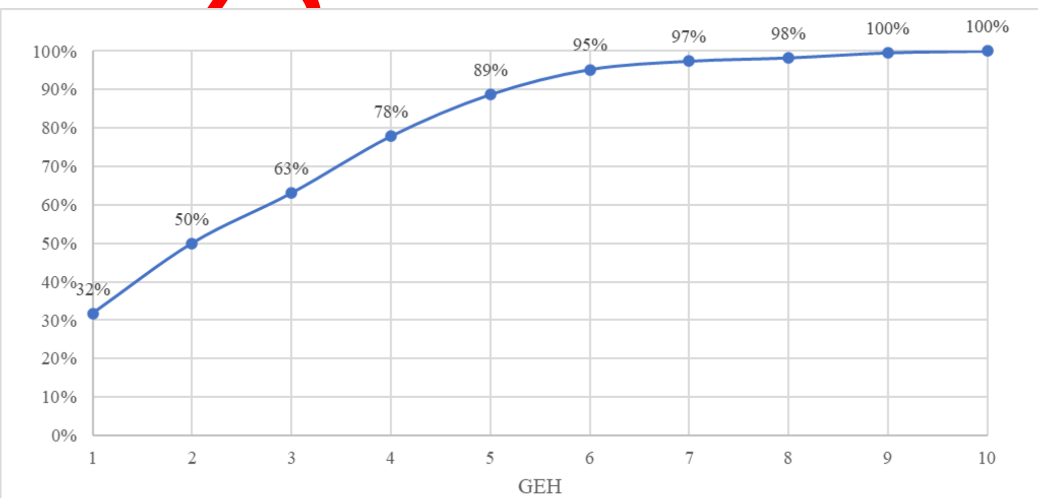


Figure 15 GEH summary graph - GEH distribution plot for 7:30am – 8:30am

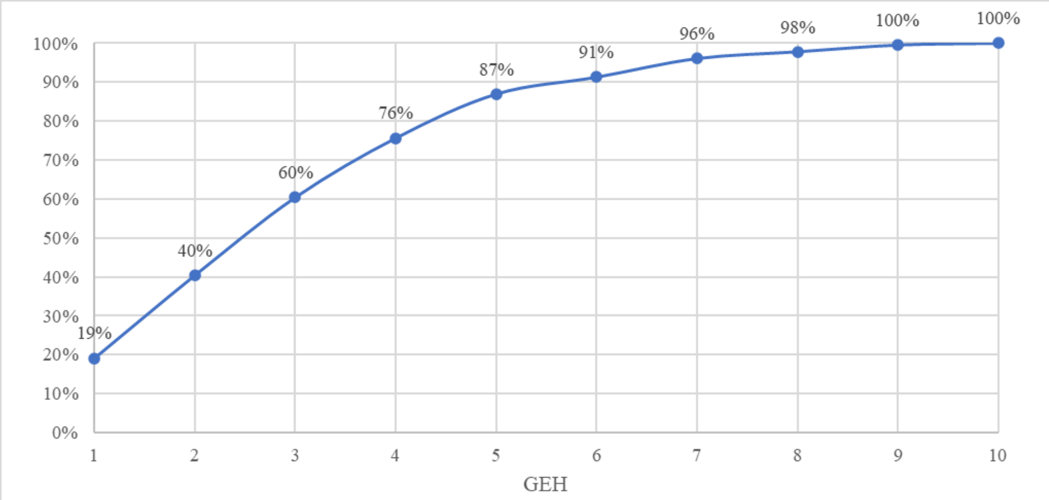


Figure 16 GEH summary graph - GEH distribution plot for 4:00pm – 5:00pm

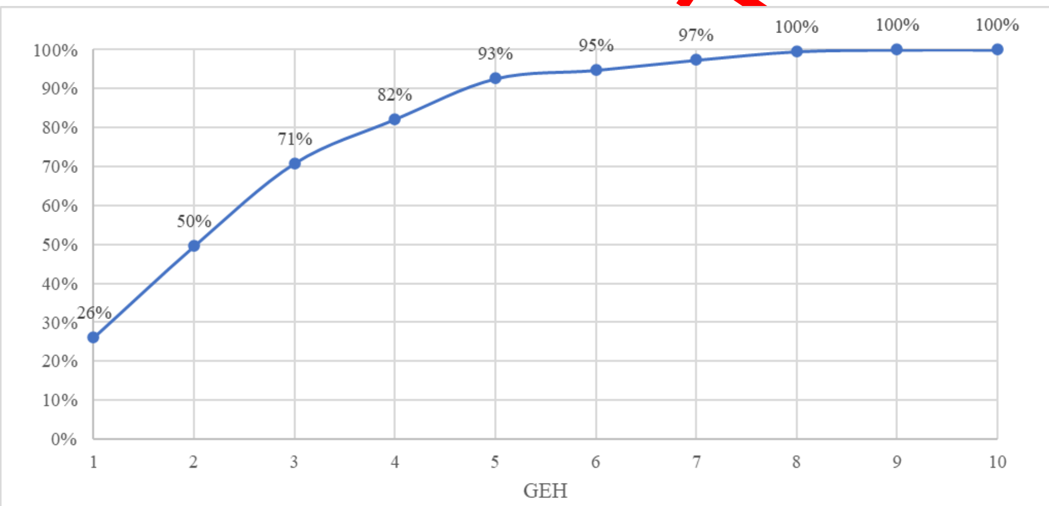


Figure 17 GEH summary graph - GEH distribution plot for 5:00pm – 6:00pm

Plots showing the observed volumes compared to modelled volumes using the corresponding median seed simulations are shown in Figure 18 to Figure 21 for AM and PM traffic respectively.

The R^2 values are shown to exceed 0.9 in all time periods. Similarly the RMSE was significantly lower than 30.0 in all scenarios, indicating very good fits between the observed and modelled volumes.

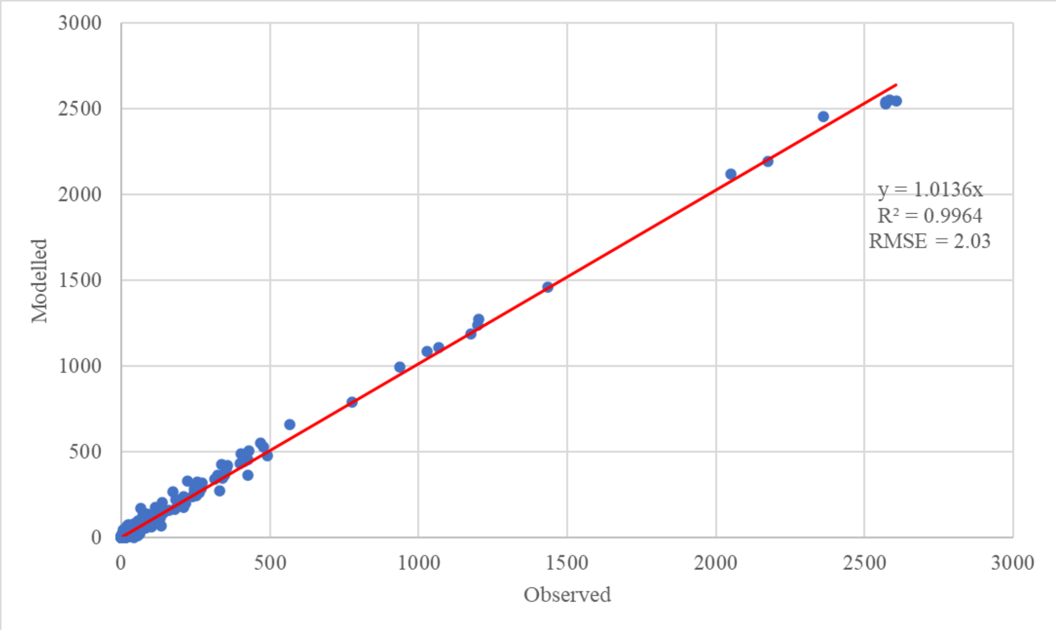


Figure 18 Observed vs modelled plot for AM peak traffic (6:30am – 7:30am)

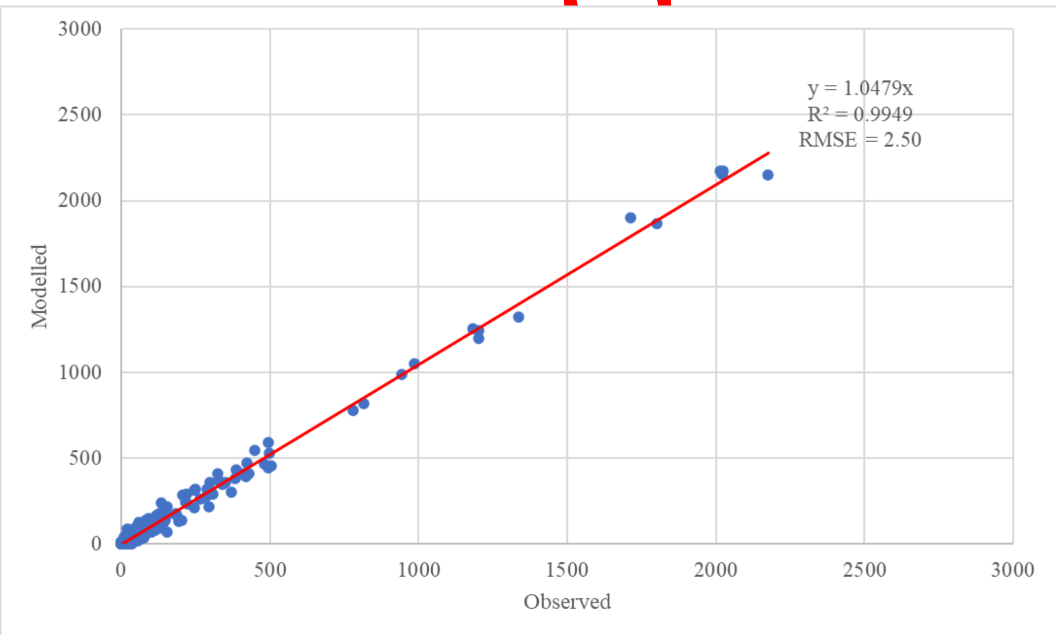


Figure 19 Observed vs modelled plot for AM peak traffic (7:30am – 8:30am)

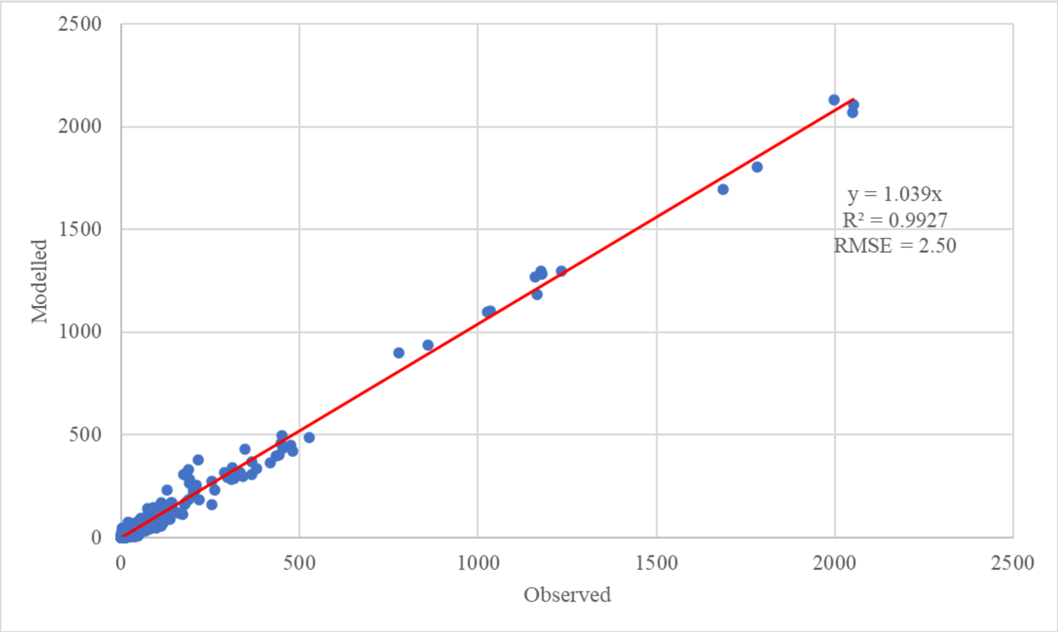


Figure 20 Observed vs modelled plot for PM peak traffic (4:00pm – 5:00pm)

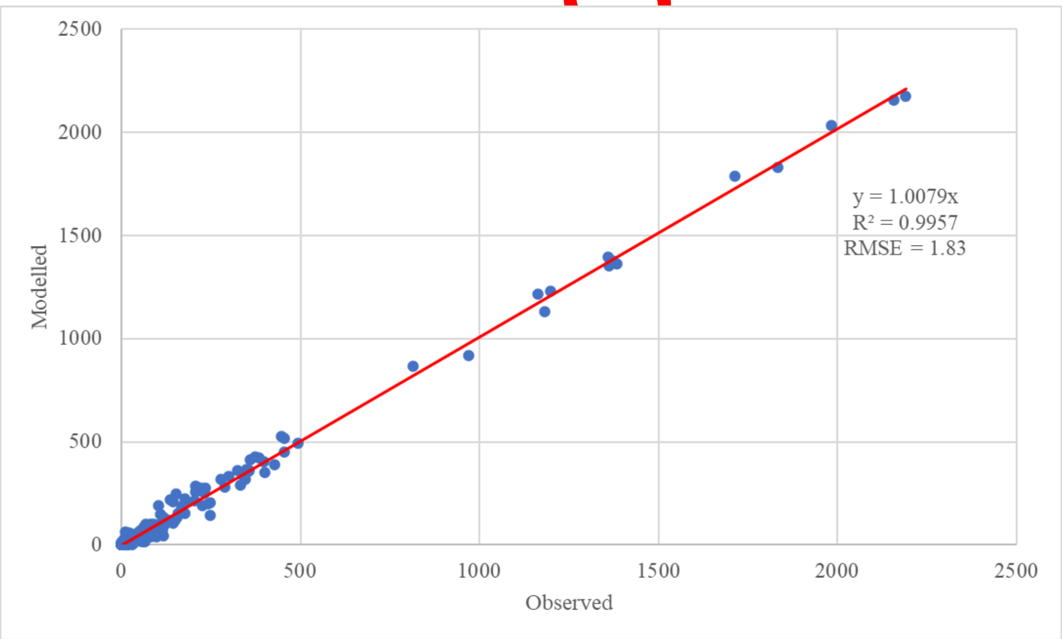


Figure 21 Observed vs modelled plot for PM peak traffic (5:00pm – 6:00pm)

4.3.2 Heavy vehicle calibration

Heavy vehicles represent approximately 11% of total traffic in the AM peak models, compared to approximately 4% in the PM peak models. Due to the relatively high proportion of heavy vehicles in the AM peak, detailed calibration has also been undertaken separately for this vehicle class for this time period.

Table 10 summarises the calibration results for heavy vehicles in the AM peak period. The cumulative percent distribution GEH plots are shown in Figure 22 and Figure 23.

As shown, all turning movements had a GEH less than 10, while 96% and 97% of turns had a GEH of less than 5 in the AM and PM peaks respectively.

Table 9 GEH summary table – heavy vehicles

Peak period	% of turns with GEH<5	% of turns with GEH<10
AM Peak (6:30am - 7:30am)	96%	100%
AM Peak (7:30am - 8:30am)	97%	100%

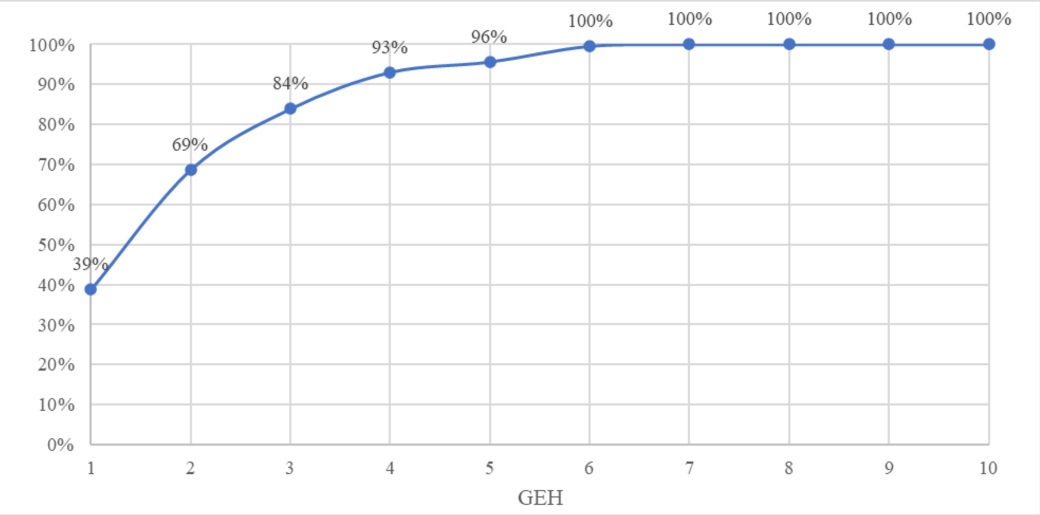


Figure 22: GEH distribution plot for 6:30am – 7:30am

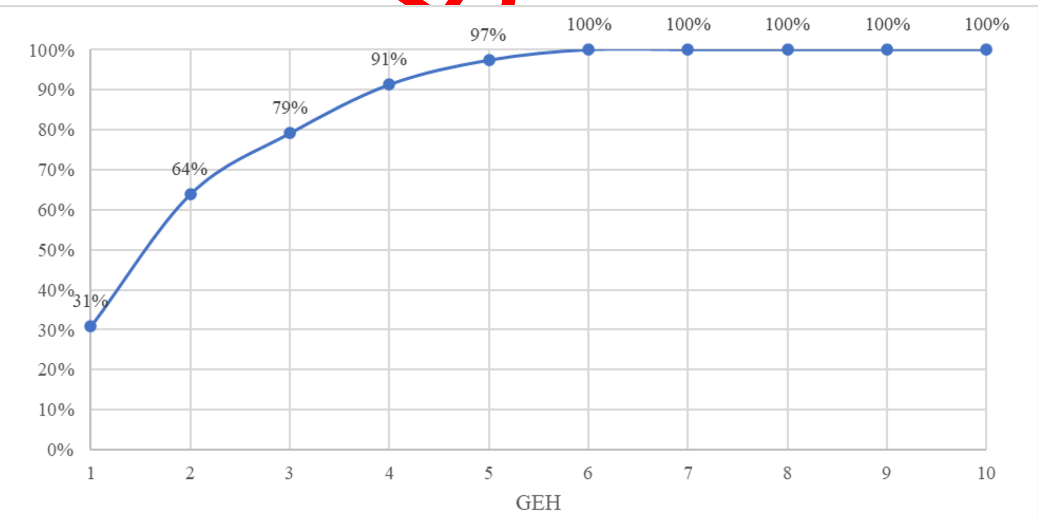


Figure 23: GEH distribution plot for 7:30am – 8:30am

Plots showing the observed vs. modelled heavy vehicle volumes using the median seed simulations are shown in Figure 24 and Figure 25. The R^2 values are shown to exceed 0.9 in both time periods.

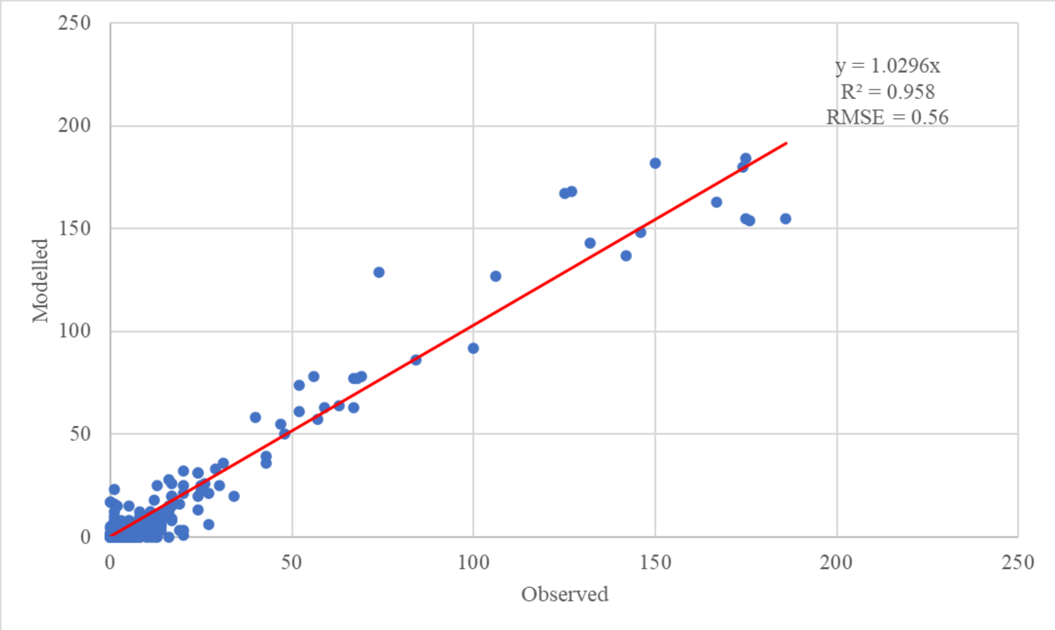


Figure 24: Observed vs modelled heavy vehicles for AM peak traffic (6:30am – 7:30am)

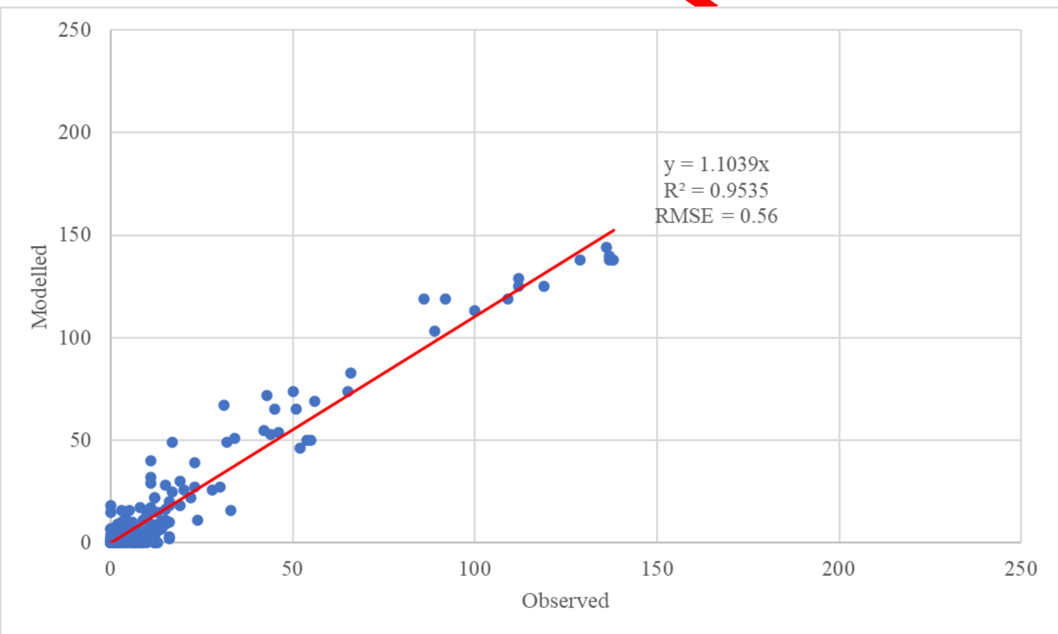


Figure 25: Observed vs modelled heavy vehicles for AM peak traffic (7:30am – 8:30am)

4.4 Validation

Model validation is another important step of the model development process required for verifying that a model has been calibrated sufficiently. Model validation uses a source of traffic data additional to that used for calibration, usually travel time or queue lengths.

The Guidelines recommend a validation criterion of modelled travel times to be within 1 minute or 15% (whichever is greater) of the observed value for the full travel time route for 95% of observed routes. The Guidelines also specifiy an additional validation target for individual sections of each route to be within 15% of the average observed time.

The travel time validation results are summarised in Table 10 and illustrated in Figure 26 to Figure 33. Detailed data for individual sections is provided in Appendix C.

As shown in Table 10, the modelled travel times for both peak periods meet the Guidelines criterion for both directions along all the overall routes.

Table 10 Travel time validation table

Peak period	Route/Direction	Observed (s)	Modelled (s)	Absolute Difference	% Difference	Within 15%
AM	Route 1 / EB	334	328	6	2%	✓
	Route 1 / WB	397	376	21	5%	✓
	Route 2 / NB	510	473	37	7%	✓
	Route 2 / SB	524	479	45	9%	✓
PM	Route 1 / EB	354	355	-2	-1%	✓
	Route 1 / WB	372	356	16	4%	✓
	Route 2 / NB	404	391	13	3%	✓
	Route 2 / SB	478	462	16	3%	✓

Referring to the plots of cumulative travel time vs. distance in Figure 26 to Figure 33, it can be seen that the modelled travel times closely match the observed data across all routes. As shown in the detailed data in Appendix C, 37 out of 40 sections successfully meet the detailed Guideline target of being within 15% of the observed data.

Where sections did not meet this criteria, it was important to consider that the survey data, captured by a typical 'floating car' methodology, is based on a sample of data across the peak period. While this is meant to represent overall traffic performance, it may be slightly lower or higher depending on, for example, how often the survey vehicle was stopped at a red light. Additionally, highly localised or abnormal traffic behaviour on site, leading to short-term queue and travel time impacts, is difficult to replicate in models. Excessive attempts to meet all criteria may risk 'over-fitting' the model to a specific dataset, which can impact the models ability to respond realistically to new scenarios, including the future year modelling assessment. With this in mind, the three sections during the AM peak where the 15% target was exceeded are described below.

- Route 2 NB – St Andrews to Willowdale: Compared to the observed average of 140.8 seconds, the modelled average was 102.9 seconds (-27%). However, it is noted that there is significant variation in the data, ranging from a minimum of 88 seconds up to a maximum of 228 seconds, as illustrated in Figure 38 in Appendix A. The modelled travel time was deemed to be reasonable for this section given the high level of variability in the observed data, and because the modelled average is well within the observed min/max range.

- Route 2 SB – Greenway to Camden Valley: Compared to the observed average of 104.9 seconds, the modelled average was 80.9 seconds (-23%). However, similar to the item above, it is noted that there is significant variation in the data, ranging from a minimum of 64 seconds up to a maximum of 135 seconds in Figure 40 of Appendix A. The modelled travel time was therefore deemed to be reasonable for this section given the high level of variability in the observed data, and because the modelled average was well within the oserved min/max range.
- Route 2 SB – Willowdale to St Andrews: Compared to the observed average of 78.9 seconds, the modelled average fell just outside of the 15% criteria at 65.5 seconds (-17%). Additionally, the modelled average was within the observed min/max range.

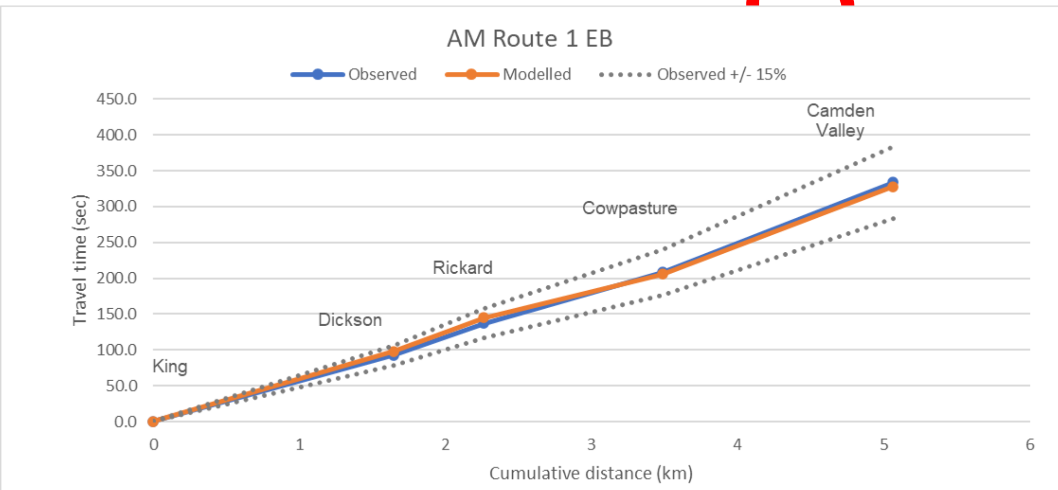


Figure 26 Travel time validation graph – AM1 Eastbound

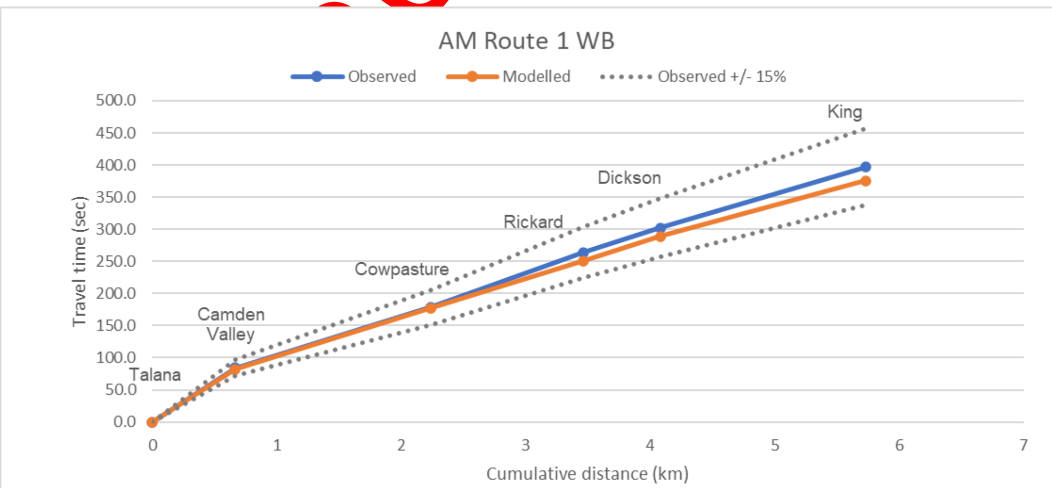


Figure 27 Travel time validation graph – AM1 Westbound

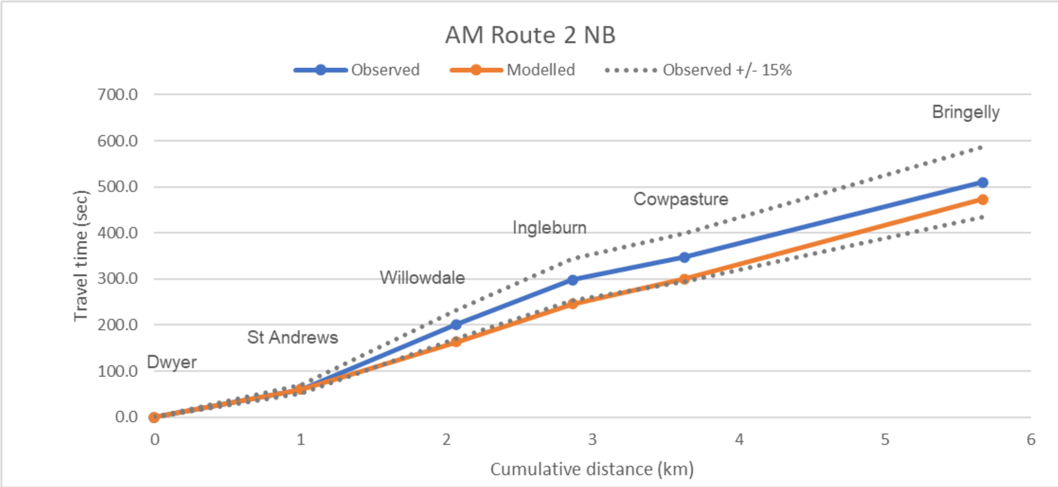


Figure 28 Travel time validation graph – AM2 Northbound

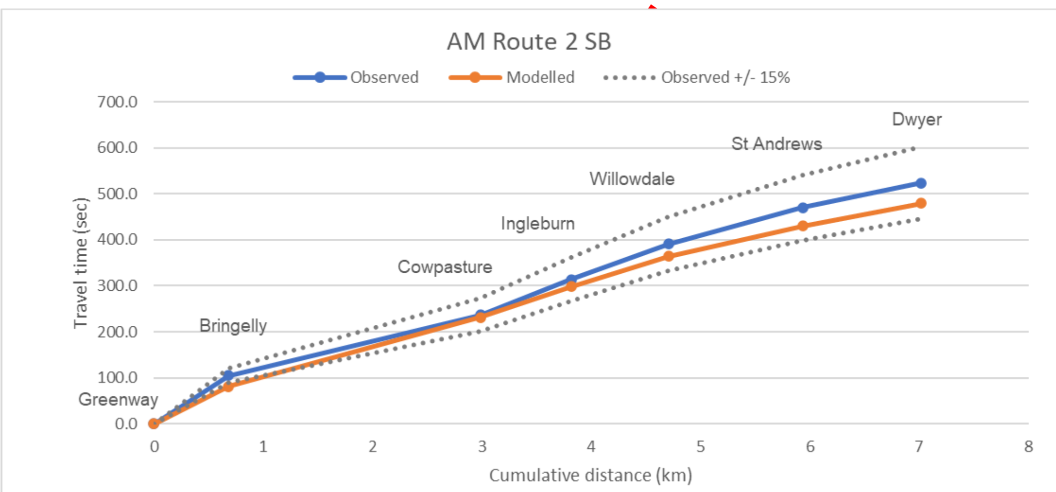


Figure 29 Travel time validation graph – AM2 Southbound

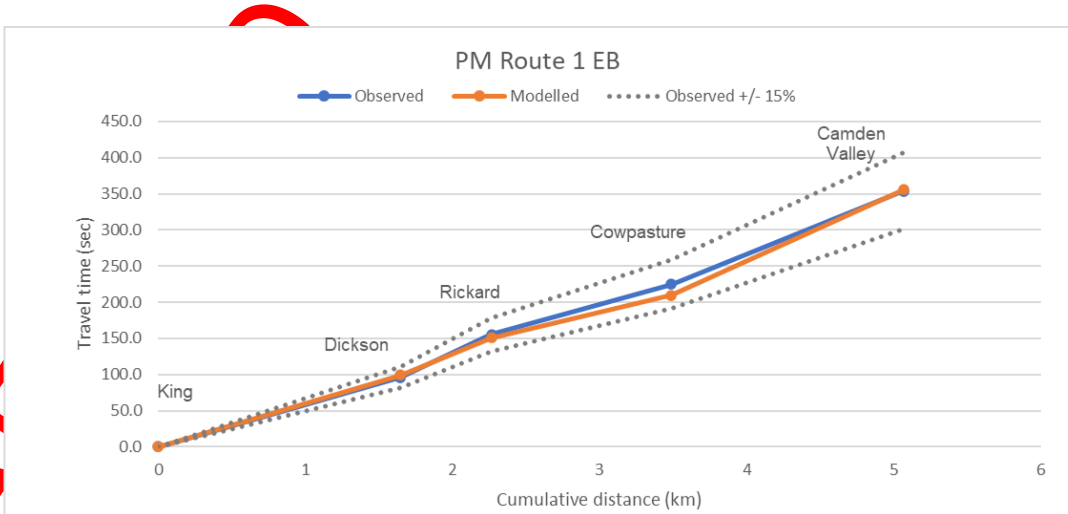


Figure 30 Travel time validation graph – PM1 Eastbound

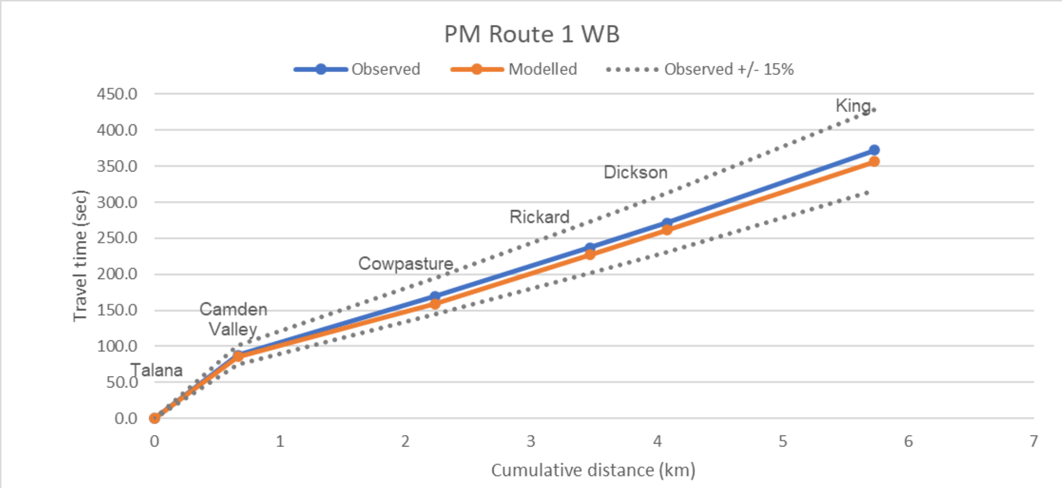


Figure 31 Travel time validation graph – PM1 Westbound

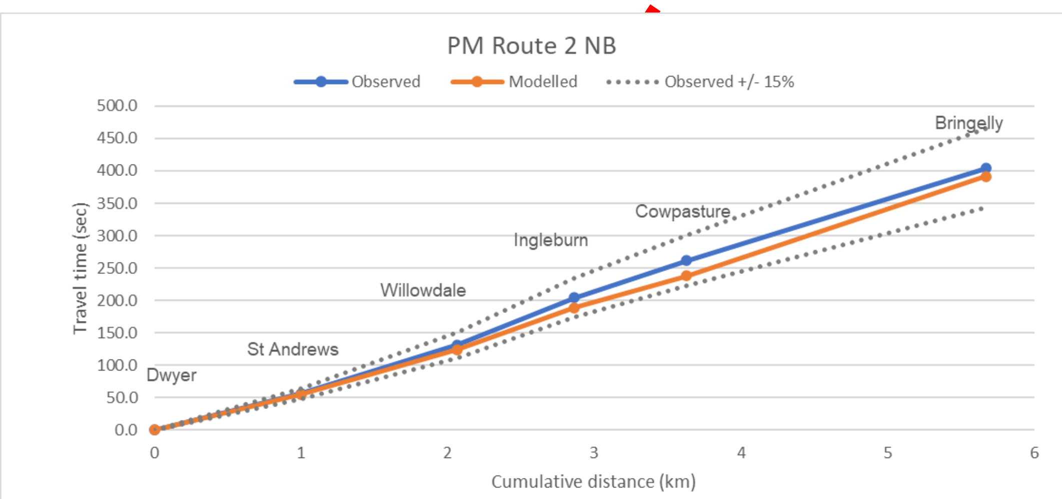


Figure 32 Travel time validation graph – PM2 Northbound

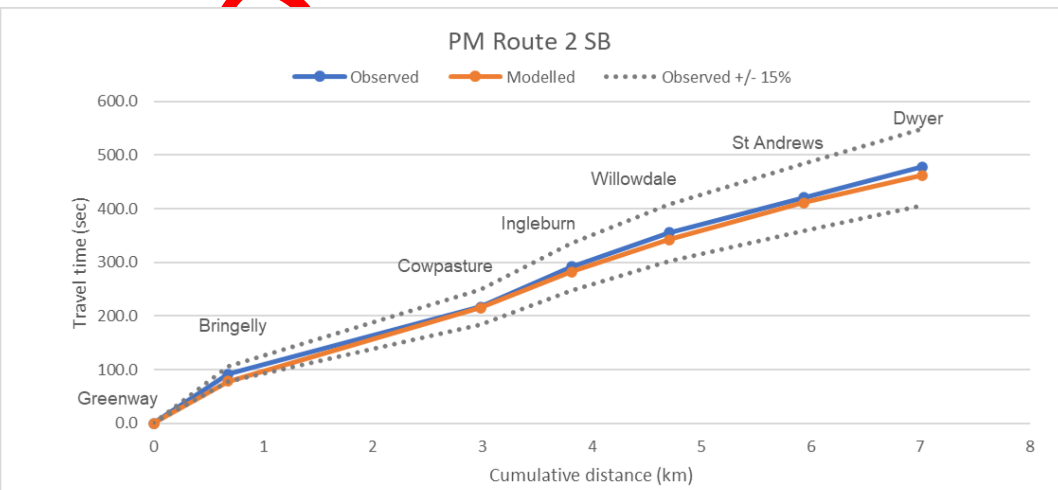


Figure 33 Travel time validation graph – PM2 Southbound

5 Summary

Arup has produced this Base Model Development Report to detail the processes undertaken in developing an operational Aimsun model for the Leppington Town Centre and Precicnts. A summary of the calibration and validation performance of the models against the Guidelines is presented in Table 11.

Both peak period models met the criteria of having 100% of turns with a GEH less than 10, and having >85% of turns with a GEH of less than 5. The R^2 value for each hour all exceeded 0.9. Similarly, RMSE were well within the limit of <30.0. The modelled travel time for both routes in each direction were within 15% of the observed travel time for the AM and PM peak periods.

In conclusion, the model meets the key calibration and validation criteria outlined in the Guidelines. Based on the analysis presented in this report, the Aimsun model is considered suitable for the purpose of investigating future development scenarios.

Table 11 Calibration and validation summary table

Peak period	% of turns with GEH<5 (Target>85%)	% of turns with GEH<10 (Target: 100%)	R^2 (Target>0.9)	RMSE (Target<30)	Travel time (Target<15% or 1 min)
AM (6:30-7:30)	92%	100%	0.996	2.03	R1 EB: 6s / 2% R1 WB: 21s / 5%
AM (7:30-8:30)	89%	100%	0.995	2.50	R2 NB: 37s / 7% R2 SB: 45s / 9%
PM (4:00-5:00)	87%	100%	0.993	2.50	R1 EB: 2s / 1% R1 WB: 16s / 4%
PM (5:00-6:00)	93%	100%	0.996	1.83	R2 NB: 13s / 3% R2 SB: 16s / 3%

Note: results repoted for all vehicle classes combined.

Appendix A

Travel time survey data

A1

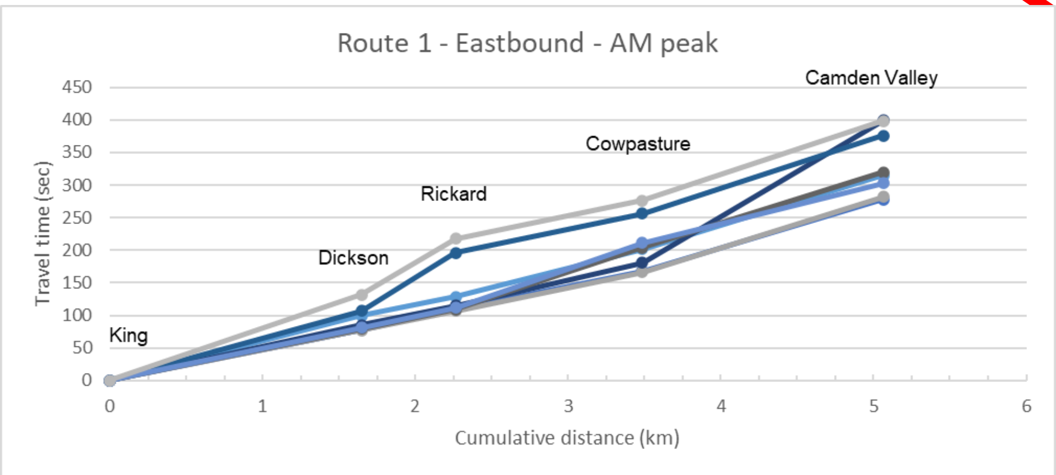


Figure 34: Surveyed travel time - Route 1 Eastbound AM Peak

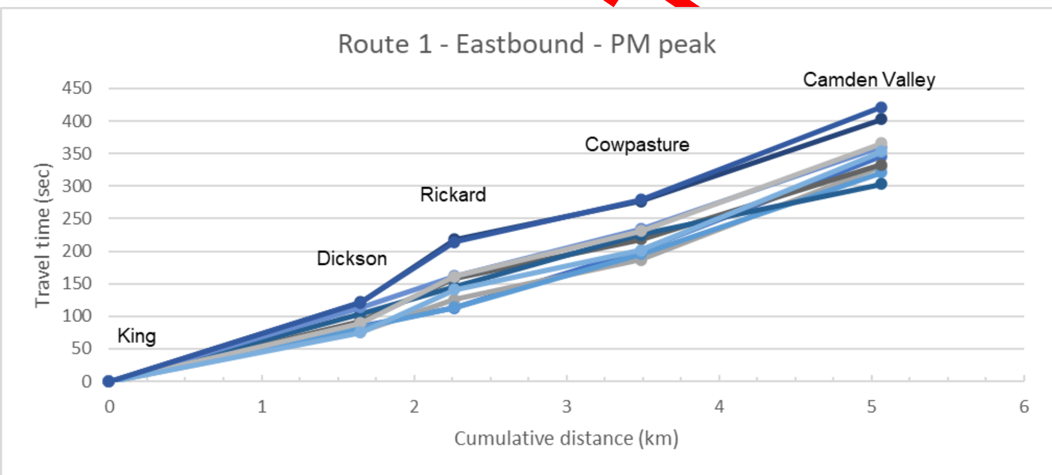


Figure 35: Surveyed travel time - Route 1 Eastbound PM Peak

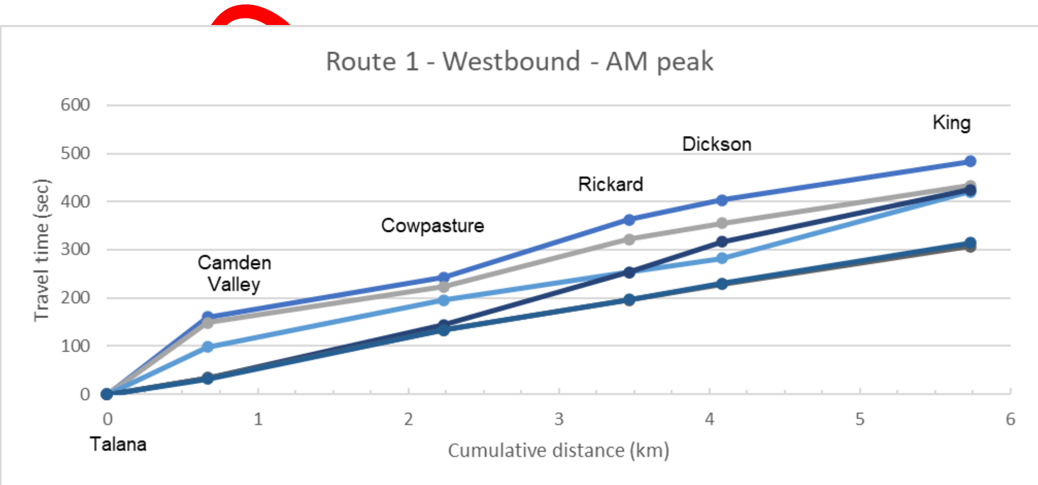


Figure 36: Surveyed travel time - Route 1 Westbound AM Peak

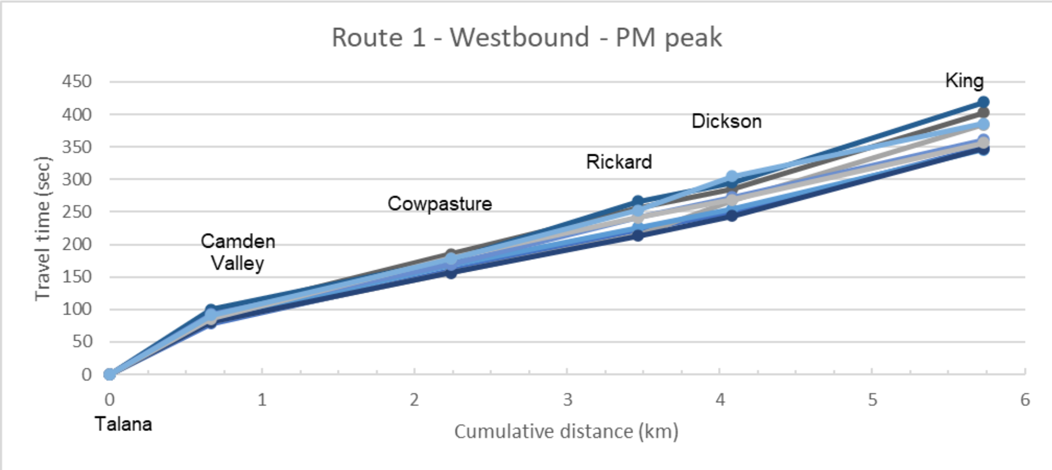


Figure 37: Surveyed travel time - Route 1 Westbound PM Peak

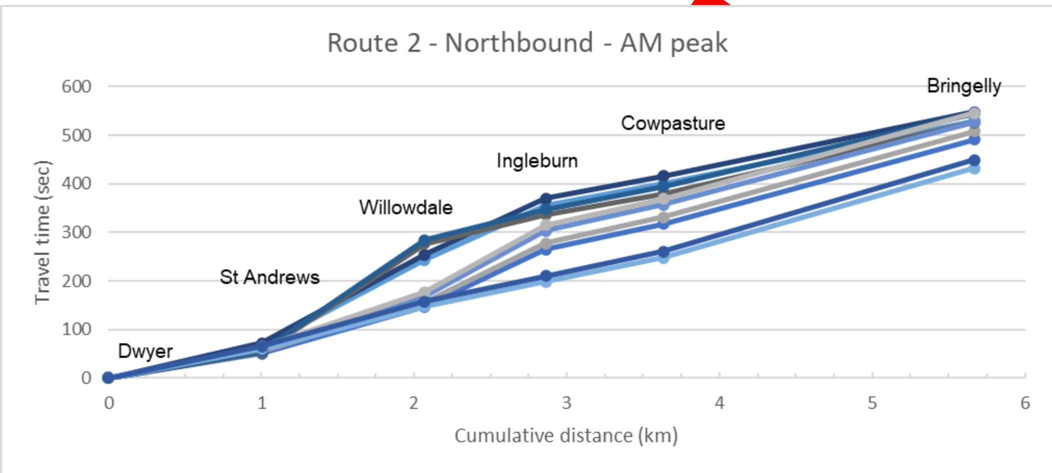


Figure 38: Surveyed travel time - Route 2 Northbound AM Peak

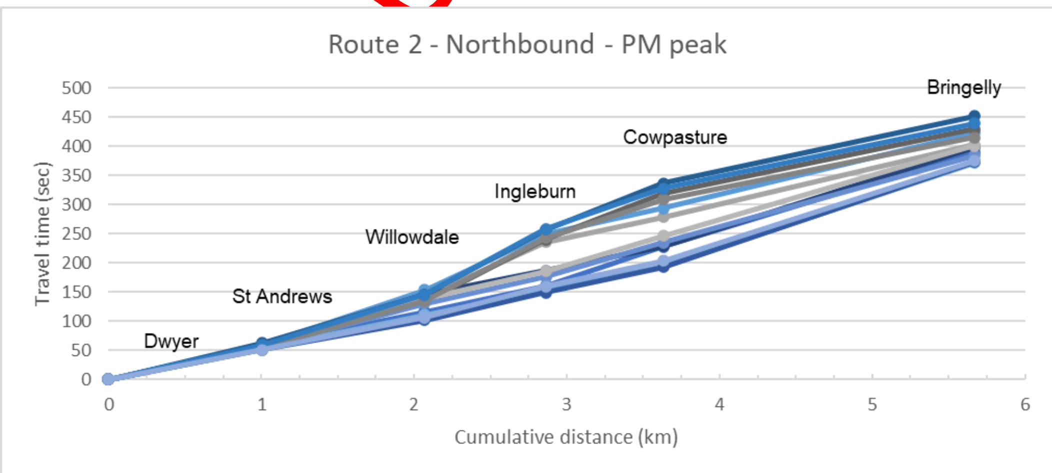


Figure 39: Surveyed travel time - Route 2 Northbound PM Peak

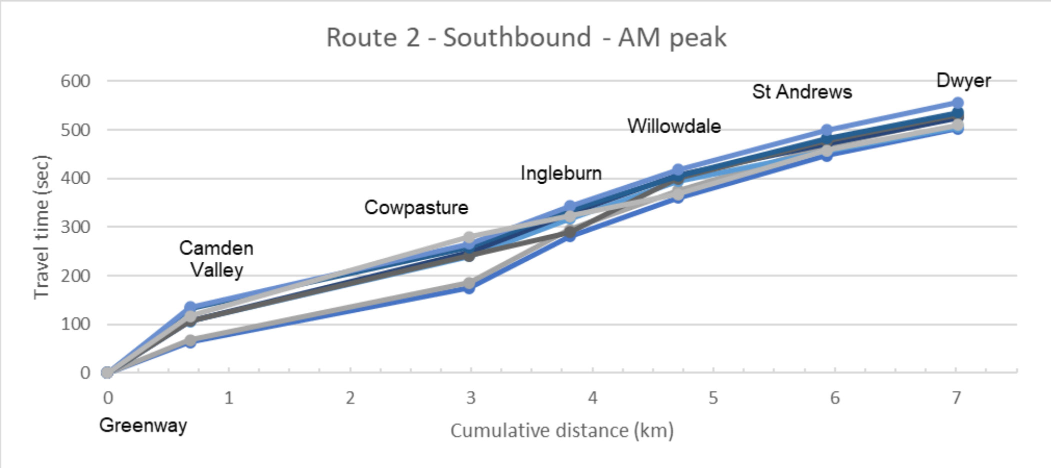


Figure 40: Surveyed travel time - Route 2 Southbound AM Peak

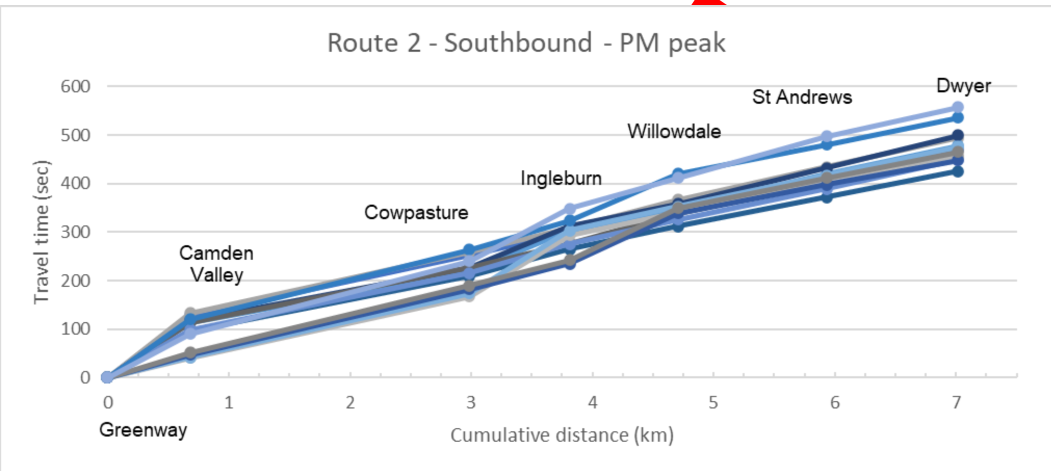


Figure 41: Surveyed travel time - Route 2 Southbound PM Peak

Appendix B

Turning Movement Summary

B1 Turning movement

Table 12: AM turn count calibration results (6:30am – 7:30am)

Intersection	Turning Movement	Observed volume	Modelled volume	GEH
Bringelly Road / Kelly Street	EBLT	8	13	1.5
	EBT	566	657	3.7
	WBT	409	485	3.6
	SBLT	13	20	1.7
Bringelly Road / Eastwood Road	NBLT	89	136	4.4
	NBT	3	0	2.4
	NBRT	40	52	1.8
	SBLT	7	0	3.7
	SBT	1	0	1.4
	SBRT	6	11	1.7
	EBLT	10	11	0.3
	EBT	468	552	3.7
	EBRT	101	106	0.5
	WBLT	38	23	2.7
	WBT	314	338	1.3
	WBRT	3	0	2.4
Bringelly Road / Dickson Road	NBLT	47	17	5.3
	NBT	105	125	1.9
	NBRT	0	2	2.0
	SBLT	77	127	5.0
	SBT	60	93	3.8
	SBRT	40	59	2.7
	EBLT	73	106	3.5
	EBT	403	490	4.1
	EBRT	39	15	4.6
	WBLT	12	31	4.1
	WBT	268	281	0.8
	WBRT	71	122	5.2
Fourth Avenue / Fifth Avenue	NBLT	24	22	0.4
	NBT	222	326	6.3
	NBRT	3	6	1.4
	SBLT	7	0	3.7
	SBT	174	266	6.2
	SBRT	22	5	4.6
	EBLT	6	0	3.5
	EBT	5	0	3.2
	EBRT	2	7	2.4
	WBLT	1	1	0.0
	WBT	22	5	4.6
	WBRT	3	0	2.4
Fourth Avenue / Sixth Avenue	NBLT	22	36	2.6
	NBT	209	236	1.8
	NBRT	0	2	2.0
	SBLT	8	0	4.0
	SBT	179	164	1.1
	SBRT	15	13	0.5
	EBLT	20	23	0.6
	EBT	4	0	2.8
	EBRT	22	34	2.3

	WBLT	2	5	1.6
	WBT	0	0	0.0
	WBRT	9	0	4.2
Edmondson Avenue / Fifth Avenue	NBLT	18	3	4.6
	NBT	184	222	2.7
	NBRT	2	0	2.0
	SBLT	0	0	0.0
	SBT	159	158	0.1
	SBRT	8	3	2.1
	EBLT	3	6	1.4
	EBT	0	0	0.0
	EBRT	12	0	4.9
	WBLT	7	0	3.7
	WBT	0	0	0.0
	WBRT	2	0	2.0
Bringelly Road / Edmondson Avenue	NBLT	65	78	1.5
	NBT	122	151	2.5
	NBRT	83	56	3.2
	SBLT	31	14	3.6
	SBT	131	114	1.5
	SBRT	16	31	3.1
	EBLT	30	14	3.4
	EBT	337	426	4.6
	EBRT	114	173	4.9
	WBLT	109	115	0.6
	WBT	271	320	2.9
	WBRT	52	59	0.9
Bringelly Road / Browns Road	SBLT	26	15	2.4
	SBRT	33	58	3.7
	EBLT	26	42	2.7
	EBT	425	455	1.4
	WBT	399	430	1.5
	WBRT	14	43	5.4
Bringelly Road / Cowpasture Road	NBLT	68	102	3.7
	NBRT	61	38	3.3
	EBT	412	443	1.5
	EBRT	39	27	2.1
	WBLT	34	23	2.1
	WBT	345	371	1.4
Bringelly Road / Camden Valley Way	NBLT	10	8	0.7
	NBT	1434	1460	0.7
	NBRT	935	992	1.8
	SBLT	245	282	2.3
	SBT	775	790	0.5
	SBRT	119	120	0.1
	EBLT	118	116	0.2
	EBT	323	365	2.3
	EBRT	32	17	3.0
	WBLT	429	506	3.6
Camden Valley Way / Cowpasture Road	NBLT	101	128	2.5
	NBT	2361	2452	1.9
	SBT	1202	1272	2.0
	SBRT	28	41	2.2
	EBLT	12	7	1.6
	EBRT	61	20	6.4
Camden Valley Way / Ingleburn Road	NBLT	211	175	2.6
	NBT	2049	2117	1.5
	NBRT	125	117	0.7

	SBLT	197	214	1.2
	SBT	1027	1083	1.7
	SBRT	37	24	2.4
	EBLT	54	11	7.5
	EBT	197	210	0.9
	EBRT	101	59	4.7
	WBLT	82	55	3.3
	WBRT	357	420	3.2
Ingleburn Road / Byron Road	NBLT	5	0	3.2
	NBT	24	52	4.5
	NBRT	13	1	4.5
	SBLT	9	10	0.3
	SBT	2	20	5.4
	SBRT	4	0	2.8
	EBT	330	273	3.3
	EBRT	6	45	7.7
	WBLT	14	0	5.3
	WBT	424	362	3.1
	WBRT	55	96	4.7
Ingleburn Road / Dickson Road	NBLT	3	9	2.4
	NBT	45	42	0.5
	NBRT	3	0	2.4
	SBLT	78	64	1.7
	SBT	24	72	6.9
	SBRT	9	2	3.0
	EBLT	5	0	3.2
	EBT	98	112	1.4
	EBRT	1	1	0.0
	WBLT	5	0	3.2
	WBT	58	45	1.8
	WBRT	102	92	1.0
Ingleburn Road / Eastwood Road	NBT	86	133	4.5
	NBRT	31	22	1.7
	SBLT	73	91	2.0
	SBT	67	40	3.7
	WBLT	24	4	5.3
	WBRT	46	54	1.1
Eastwood Road / Heath Road	NBT	64	95	3.5
	NBRT	18	24	1.3
	SBLT	42	1	8.8
	SBT	49	43	0.9
	WBLT	8	3	2.1
	WBRT	53	64	1.4
Heath Road / Dickson Road	SBLT	27	72	6.4
	SBRT	2	1	0.8
	EBLT	6	0	3.5
	EBT	54	26	4.4
	WBT	59	66	0.9
	WBRT	44	38	0.9
Heath Road / Rickard Road	SBLT	63	72	1.1
	SBRT	12	0	4.9
	EBLT	15	0	5.5
	EBT	66	95	3.2
	WBT	91	104	1.3
	WBRT	252	241	0.7
Heath Road / Byron Road	SBLT	18	65	7.3
	SBRT	4	0	2.8
	EBLT	4	7	1.3

	EBT	125	159	2.9
	WBT	339	343	0.2
	WBRT	38	46	1.2
Camden Valley Way / Heath Road	NBLT	263	263	0.0
	NBT	2175	2195	0.4
	NBRT	141	142	0.1
	SBLT	135	65	7.0
	SBT	1066	1107	1.2
	SBRT	8	6	0.8
	EBLT	14	9	1.5
	EBT	64	169	9.7
	EBRT	65	47	2.4
	WBLT	78	87	1.0
	WBT	106	119	1.2
	WBRT	195	195	0.0
Camden Valley Way / St Andrews Road	NBLT	18	25	1.5
	NBT	2585	2553	0.6
	NBRT	4	0	2.8
	SBLT	10	0	4.5
	SBT	1200	1236	1.0
	SBRT	0	9	4.2
	EBLT	0	9	4.2
	EBT	0	0	0.0
	EBRT	17	23	1.3
	WBLT	0	5	3.2
	WBT	0	0	0.0
	WBRT	3	1	1.4
Camden Valley Way / George Road	NBLT	60	37	3.3
	NBT	2572	2530	0.8
	SBT	1174	1188	0.4
	SBRT	44	81	4.7
	EBLT	36	46	1.6
Camden Valley Way / Dwyer Road	NBLT	7	12	1.6
	NBT	2606	2548	1.1
	EBLT	26	19	1.5
Eastwood Road / Anthony Road	NBLT	0	0	0.0
	NBT	36	37	0.2
	SBT	27	22	1.0
	SBRT	30	24	1.2
	EBLT	46	79	4.2
	EBRT	0	0	0.0
Rickard Road / Leppington Station South Carpark Entry/Exit (North)	NBLT	22	5	4.6
	NBT	478	527	2.2
	SBT	254	325	4.2
	SBRT	1	1	0.0
	EBLT	5	1	2.3
	EBRT	5	7	0.8
	NBT	238	238	0.0
	SBT	355	400	2.3
	EBLT	33	45	1.9
	NBLT	348	363	0.8
	NBT	135	165	2.4
	SBT	137	202	5.0
	SBRT	216	199	1.2
	EBLT	103	71	3.4
	EBRT	118	124	0.5

Table 13: AM turn count calibration results (7:30am – 8:30am)

Intersection	Turning Movement	Observed volume	Modelled volume	GEH
Bringelly Road / Kelly Street	EBLT	25	12	3.0
	EBT	495	590	4.1
	WBT	449	547	4.4
	SBLT	32	21	2.1
Bringelly Road / Eastwood Road	NBLT	119	164	3.8
	NBT	0	0	0.0
	NBRT	83	98	1.6
	SBLT	4	1	1.9
	SBT	0	0	0.0
	SBRT	1	14	4.7
	EBLT	3	15	4.0
	EBT	423	473	2.4
	EBRT	100	127	2.5
	WBLT	32	17	3.0
	WBT	328	369	2.2
	WBRT	4	0	2.8
Bringelly Road / Dickson Road	NBLT	67	73	0.7
	NBT	150	160	0.8
	NBRT	14	11	0.8
	SBLT	122	131	0.8
	SBT	73	109	3.8
	SBRT	32	44	1.9
	EBLT	82	139	5.4
	EBT	408	409	0.0
	EBRT	20	12	2.0
	WBLT	12	35	4.7
	WBT	265	263	0.1
	WBRT	187	168	1.4
Fourth Avenue / Fifth Avenue	NBLT	29	31	0.4
	NBT	386	431	2.2
	NBRT	4	2	1.2
	SBLT	16	0	5.7
	SBT	205	288	5.3
	SBRT	20	0	6.3
	EBLT	9	0	4.2
	EBT	1	0	1.4
	EBRT	22	2	5.8
	WBLT	0	0	0.0
	WBT	7	6	0.4
	WBRT	18	1	5.5
Fourth Avenue / Sixth Avenue	NBLT	86	89	0.3
	NBT	298	289	0.5
	NBRT	29	4	6.2
	SBLT	2	0	2.0
	SBT	184	179	0.4
	SBRT	31	14	3.6
	EBLT	29	31	0.4
	EBT	2	0	2.0
	EBRT	55	65	1.3
	WBLT	2	0	2.0
	WBT	3	0	2.4
	WBRT	0	0	0.0
Edmondson Avenue / Fifth Avenue	NBLT	16	6	3.0

	NBT	223	235	0.8
	NBRT	2	0	2.0
	SBLT	21	17	0.9
	SBT	146	185	3.0
	SBRT	9	1	3.6
	EBLT	3	2	0.6
	EBT	1	0	1.4
	EBRT	17	0	5.8
	WBLT	5	0	3.2
	WBT	0	0	0.0
	WBRT	3	0	2.4
Bringelly Road / Edmondson Avenue	NBLT	64	59	0.6
	NBT	131	110	1.9
	NBRT	71	89	2.0
	SBLT	56	17	6.5
	SBT	92	140	4.5
	SBRT	20	26	1.3
	EBLT	36	18	3.5
	EBT	420	392	1.4
	EBRT	90	149	5.4
	WBLT	67	30	5.3
	WBT	382	382	0.0
	WBRT	74	118	4.5
Bringelly Road / Browns Road	SBLT	24	24	0.0
	SBRT	25	12	3.0
	EBLT	42	41	0.2
	EBT	504	457	2.1
	WBT	497	529	1.4
	WBRT	45	43	0.3
Bringelly Road / Cowpasture Road	NBLT	60	106	5.0
	NBRT	56	33	3.4
	EBT	496	444	2.4
	EBRT	32	30	0.4
	WBLT	48	33	2.4
	WBT	482	468	0.6
Bringelly Road / Camden Valley Way	NBLT	36	1	8.1
	NBT	1336	1321	0.4
	NBRT	816	816	0.0
	SBLT	215	248	2.2
	SBT	779	778	0.0
	SBRT	145	151	0.5
	EBLT	192	134	4.5
	EBT	340	349	0.5
	EBRT	20	2	5.4
	WBLT	428	412	0.8
Camden Valley Way / Cowpasture Road	NBLT	73	86	1.5
	NBT	2175	2148	0.6
	SBT	1181	1255	2.1
	SBRT	44	48	0.6
	EBLT	11	2	3.5
	EBRT	70	45	3.3
Camden Valley Way / Ingleburn Road	NBLT	114	156	3.6
	NBT	1801	1868	1.6
	NBRT	126	176	4.1
	SBLT	283	270	0.8
	SBT	942	989	1.5
	SBRT	24	17	1.5
	EBLT	76	43	4.3

	EBT	135	238	7.5
	EBRT	97	93	0.4
	WBLT	78	50	3.5
	WBRT	369	301	3.7
Ingleburn Road / Byron Road	NBLT	0	0	0.0
	NBT	28	27	0.2
	NBRT	9	6	1.1
	SBLT	11	41	5.9
	SBT	2	1	0.8
	SBRT	0	0	0.0
	EBT	288	321	1.9
	EBRT	3	16	4.2
	WBLT	10	5	1.8
	WBT	324	411	4.5
	WBRT	50	69	2.5
Ingleburn Road / Dickson Road	NBLT	5	5	0.0
	NBT	86	100	1.5
	NBRT	2	5	1.6
	SBLT	81	64	2.0
	SBT	21	89	9.2
	SBRT	3	1	1.4
	EBLT	12	4	2.8
	EBT	95	112	1.7
	EBRT	1	0	1.4
	WBLT	3	0	2.4
	WBT	66	94	3.1
	WBRT	133	125	0.7
Ingleburn Road / Eastwood Road	NBT	142	168	2.1
	NBRT	32	11	4.5
	SBLT	76	105	3.0
	SBT	56	37	2.8
	WBLT	14	4	3.3
	WBRT	60	96	4.1
Eastwood Road / Heath Road	NBT	127	91	3.4
	NBRT	16	39	4.4
	SBLT	33	0	8.1
	SBT	37	41	0.6
	WBLT	14	25	2.5
	WBRT	47	42	0.7
Heath Road / Dickson Road	SBLT	24	87	8.5
	SBRT	1	1	0.0
	EBLT	7	0	3.7
	EBT	42	39	0.5
	WBT	60	66	0.8
	WBRT	86	95	0.9
Heath Road / Rickard Road	SBLT	74	37	5.0
	SBRT	3	0	2.4
	EBLT	6	0	3.5
	EBT	60	125	6.8
	WBT	143	150	0.6
	WBRT	153	70	7.9
Heath Road / Byron Road	SBLT	14	16	0.5
	SBRT	1	5	2.3
	EBLT	4	1	1.9
	EBT	130	159	2.4
	WBT	295	215	5.0
	WBRT	33	34	0.2
Camden Valley Way / Heath Road	NBLT	203	139	4.9

	NBT	1712	1900	4.4
	NBRT	125	128	0.3
	SBLT	116	79	3.7
	SBT	984	1051	2.1
	SBRT	17	16	0.2
	EBLT	20	6	3.9
	EBT	49	101	6.0
	EBRT	75	68	0.8
	WBLT	142	123	1.7
	WBT	108	100	0.8
	WBRT	309	294	0.9
Camden Valley Way / St Andrews Road	NBLT	34	28	1.1
	NBT	2021	2158	3.0
	NBRT	6	0	3.5
	SBLT	0	0	0.0
	SBT	1201	1243	1.2
	SBRT	1	14	4.7
	EBLT	0	15	5.5
	EBT	0	0	0.0
	EBRT	32	29	0.5
	WBLT	1	6	2.7
	WBT	0	0	0.0
	WBRT	2	1	0.8
Camden Valley Way / George Road	NBLT	40	42	0.3
	NBT	2019	2157	3.0
	SBT	1202	1198	0.1
	SBRT	37	78	5.4
	EBLT	47	37	1.5
Camden Valley Way / Dwyer Road	NBLT	9	8	0.3
	NBT	2025	2175	3.3
	EBLT	34	19	2.9
Eastwood Road / Anthony Road	NBLT	0	0	0.0
	NBT	72	71	0.1
	SBT	17	41	4.5
	SBRT	34	24	1.9
	EBLT	71	59	1.5
	EBRT	1	0	1.4
Rickard Road / Leppington Station South Carpark Entry/Exit (North)	NBLT	4	4	0.0
	NBT	299	358	3.3
	SBT	219	292	4.6
	SBRT	9	0	4.2
	EBLT	0	0	0.0
	EBRT	4	6	0.9
	NBT	247	210	2.4
	SBT	250	322	4.3
	EBLT	20	50	5.1
	NBLT	153	217	4.7
	NBT	146	141	0.4
	SBT	138	181	3.4
	SBRT	111	141	2.7
	EBLT	100	69	3.4
	EBRT	90	110	2.0

Table 14: PM turn count calibration results (4:00pm – 5:00pm)

Intersection	Turning Movement	Observed volume	Modelled volume	GEH
Bringelly Road / Kelly Street	EBLT	16	7	2.7
	EBT	451	496	2.1
	WBT	527	486	1.8
	SBLT	17	12	1.3
Bringelly Road / Eastwood Road	NBLT	83	90	0.8
	NBT	0	0	0.0
	NBRT	45	8	7.2
	SBLT	4	0	2.8
	SBT	0	0	0.0
	SBRT	5	0	3.2
	EBLT	11	3	3.0
	EBT	311	341	1.7
	EBRT	141	151	0.8
	WBLT	69	39	4.1
	WBT	434	397	1.8
	WBRT	3	3	0.0
Bringelly Road / Dickson Road	NBLT	77	48	3.7
	NBT	55	76	2.6
	NBRT	3	31	6.8
	SBLT	133	118	1.3
	SBT	130	140	0.9
	SBRT	49	64	2.0
	EBLT	40	47	1.1
	EBT	297	292	0.3
	EBRT	23	7	4.1
	WBLT	43	14	5.4
	WBT	380	334	2.4
	WBRT	61	79	2.2
Fourth Avenue / Fifth Avenue	NBLT	7	13	1.9
	NBT	141	172	2.5
	NBRT	7	17	2.9
	SBLT	5	9	1.5
	SBT	289	316	1.6
	SBRT	2	0	2.0
	EBLT	10	0	4.5
	EBT	4	0	2.8
	EBRT	18	4	4.2
	WBLT	4	0	2.8
	WBT	4	0	2.8
	WBRT	15	8	2.1
Fourth Avenue / Sixth Avenue	NBLT	39	67	3.8
	NBT	127	113	1.3
	NBRT	1	1	0.0
	SBLT	4	0	2.8
	SBT	253	275	1.4
	SBRT	26	6	5.0
	EBLT	19	13	1.5
	EBT	0	0	0.0
	EBRT	38	41	0.5
	WBLT	6	5	0.4
	WBT	1	0	1.4
	WBRT	2	0	2.0
Edmondson Avenue / Fifth Avenue	NBLT	13	0	5.1

	NBT	191	266	5.0
	NBRT	7	6	0.4
	SBLT	3	0	2.4
	SBT	203	209	0.4
	SBRT	7	0	3.7
	EBLT	5	8	1.2
	EBT	2	0	2.0
	EBRT	9	18	2.4
	WBLT	0	0	0.0
	WBT	3	10	2.7
	WBRT	7	0	3.7
Bringelly Road / Edmondson Avenue	NBLT	76	99	2.5
	NBT	106	145	3.5
	NBRT	70	95	2.8
	SBLT	60	31	4.3
	SBT	111	172	5.1
	SBRT	44	21	4.0
	EBLT	24	13	2.6
	EBT	365	370	0.3
	EBRT	45	57	1.7
	WBLT	52	27	4.0
	WBT	365	306	3.2
	WBRT	84	114	3.0
Bringelly Road / Browns Road	SBLT	16	34	3.6
	SBRT	22	29	1.4
	EBLT	21	38	3.1
	EBT	475	450	1.2
	WBT	480	420	2.8
	WBRT	22	26	0.8
Bringelly Road / Cowpasture Road	NBLT	50	14	6.4
	NBRT	36	16	3.9
	EBT	448	457	0.4
	EBRT	43	25	3.1
	WBLT	48	34	2.2
	WBT	452	433	0.9
Bringelly Road / Camden Valley Way	NBLT	23	2	5.9
	NBT	777	901	4.3
	NBRT	442	400	2.0
	SBLT	206	229	1.6
	SBT	1164	1183	0.6
	SBRT	136	152	1.3
	EBLT	140	131	0.8
	EBT	332	317	0.8
	EBRT	12	1	4.3
	WBLT	860	937	2.6
Camden Valley Way / Cowpasture Road	NBLT	51	27	3.8
	NBT	1234	1299	1.8
	SBT	1997	2131	2.9
	SBRT	35	18	3.3
	EBLT	4	0	2.8
	EBRT	87	67	2.3
Camden Valley Way / Ingleburn Road	NBLT	97	46	6.0
	NBT	1033	1102	2.1
	NBRT	87	92	0.5
	SBLT	346	429	4.2
	SBT	1687	1697	0.2
	SBRT	47	10	6.9
	EBLT	68	34	4.8

	EBT	202	228	1.8
	EBRT	176	159	1.3
	WBLT	187	185	0.1
	WBRT	180	169	0.8
Ingleburn Road / Byron Road	NBLT	3	45	8.6
	NBT	0	19	6.2
	NBRT	16	8	2.3
	SBLT	12	39	5.3
	SBT	1	8	3.3
	SBRT	2	0	2.0
	EBT	418	366	2.6
	EBRT	1	0	1.4
	WBLT	8	30	5.0
	WBT	317	287	1.7
	WBRT	9	17	2.2
Ingleburn Road / Dickson Road	NBLT	2	1	0.8
	NBT	20	53	5.5
	NBRT	5	0	3.2
	SBLT	135	127	0.7
	SBT	58	32	3.9
	SBRT	3	7	1.8
	EBLT	2	31	7.1
	EBT	100	94	0.6
	EBRT	0	9	4.2
	WBLT	6	12	2.0
	WBT	84	45	4.9
	WBRT	113	54	6.5
Ingleburn Road / Eastwood Road	NBT	76	48	3.6
	NBRT	24	66	6.3
	SBLT	78	68	1.2
	SBT	132	123	0.8
	WBLT	37	4	7.3
	WBRT	52	51	0.1
Eastwood Road / Heath Road	NBT	55	85	3.6
	NBRT	9	21	3.1
	SBLT	95	66	3.2
	SBT	75	73	0.2
	WBLT	24	68	6.5
	WBRT	46	31	2.4
Heath Road / Dickson Road	SBLT	52	23	4.7
	SBRT	12	12	0.0
	EBLT	4	0	2.8
	EBT	100	86	1.5
	WBT	58	88	3.5
	WBRT	23	54	5.0
Heath Road / Rickard Road	SBLT	118	72	4.7
	SBRT	7	0	3.7
	EBLT	16	10	1.7
	EBT	136	90	4.3
	WBT	74	142	6.5
	WBRT	41	15	4.9
Heath Road / Byron Road	SBLT	8	26	4.4
	SBRT	2	12	3.8
	EBLT	1	0	1.4
	EBT	253	162	6.3
	WBT	113	148	3.1
	WBRT	18	75	8.4
Camden Valley Way / Heath Road	NBLT	55	96	4.7

	NBT	1027	1097	2.1
	NBRT	124	124	0.0
	SBLT	263	230	2.1
	SBT	1782	1806	0.6
	SBRT	6	27	5.2
	EBLT	27	4	5.8
	EBT	83	61	2.6
	EBRT	152	121	2.7
	WBLT	218	184	2.4
	WBT	71	101	3.2
	WBRT	164	116	4.1
Camden Valley Way / St Andrews Road	NBLT	46	37	1.4
	NBT	1180	1285	3.0
	NBRT	1	0	1.4
	SBLT	0	4	2.8
	SBT	2052	2108	1.2
	SBRT	1	0	1.4
	EBLT	2	0	2.0
	EBT	0	0	0.0
	EBRT	39	39	0.0
	WBLT	2	4	1.2
	WBT	0	0	0.0
	WBRT	16	15	0.3
Camden Valley Way / George Road	NBLT	39	39	0.0
	NBT	1160	1268	3.1
	SBT	2050	2070	0.4
	SBRT	43	76	4.3
	EBLT	67	60	0.9
Camden Valley Way / Dwyer Road	NBLT	19	25	1.3
	NBT	1177	1297	3.4
	EBLT	22	16	1.4
Eastwood Road / Anthony Road	NBLT	0	0	0.0
	NBT	19	40	3.9
	SBT	44	59	2.1
	SBRT	55	82	3.3
	EBLT	45	65	2.7
	EBRT	1	0	1.4
Rickard Road / Leppington Station South Carpark Entry/Exit (North)	NBLT	5	10	1.8
	NBT	216	376	9.3
	SBT	309	284	1.5
	SBRT	1	0	1.4
	EBLT	0	0	0.0
	EBRT	1	14	4.7
	NBT	174	305	8.5
	SBT	209	256	3.1
	EBLT	79	41	4.9
	NBLT	89	146	5.3
	NBT	128	230	7.6
	SBT	140	169	2.3
	SBRT	67	87	2.3
	EBLT	46	74	3.6
	EBRT	171	115	4.7

Table 15: PM turn count calibration results (5:00pm – 6:00pm)

Intersection	Turning Movement	Observed volume	Modelled volume	GEH
Bringelly Road / Kelly Street	EBLT	11	5	2.1
	EBT	455	451	0.2
	WBT	494	493	0.0
	SBLT	17	17	0.0
Bringelly Road / Eastwood Road	NBLT	106	68	4.1
	NBT	0	0	0.0
	NBRT	42	27	2.6
	SBLT	6	0	3.5
	SBT	0	0	0.0
	SBRT	3	0	2.4
	EBLT	3	0	2.4
	EBT	355	354	0.1
	EBRT	113	117	0.4
	WBLT	59	23	5.6
	WBT	384	424	2.0
	WBRT	4	0	2.8
Bringelly Road / Dickson Road	NBLT	51	35	2.4
	NBT	62	85	2.7
	NBRT	3	2	0.6
	SBLT	83	102	2.0
	SBT	118	132	1.3
	SBRT	48	47	0.1
	EBLT	30	45	2.4
	EBT	342	332	0.5
	EBRT	31	4	6.5
	WBLT	25	36	2.0
	WBT	348	366	1.0
	WBRT	99	40	7.1
Fourth Avenue / Fifth Avenue	NBLT	5	10	1.8
	NBT	177	151	2.0
	NBRT	9	13	1.2
	SBLT	10	21	2.8
	SBT	235	278	2.7
	SBRT	6	0	3.5
	EBLT	8	0	4.0
	EBT	0	0	0.0
	EBRT	10	4	2.3
	WBLT	4	2	1.2
	WBT	2	3	0.6
	WBRT	9	28	4.4
Fourth Avenue / Sixth Avenue	NBLT	48	63	2.0
	NBT	145	107	3.4
	NBRT	1	9	3.6
	SBLT	8	0	4.0
	SBT	221	269	3.1
	SBRT	35	10	5.3
	EBLT	19	0	6.2
	EBT	0	0	0.0
	EBRT	25	28	0.6
	WBLT	5	0	3.2
	WBT	0	0	0.0

	WBRT	1	0	1.4
Edmondson Avenue / Fifth Avenue	NBLT	8	27	4.5
	NBT	179	212	2.4
	NBRT	2	2	0.0
	SBLT	12	0	4.9
	SBT	152	246	6.7
	SBRT	5	4	0.5
	EBLT	5	5	0.0
	EBT	2	0	2.0
	EBRT	12	29	3.8
	WBLT	4	0	2.8
	WBT	2	0	2.0
	WBRT	8	0	4.0
Bringelly Road / Edmondson Avenue	NBLT	110	91	1.9
	NBT	110	150	3.5
	NBRT	68	99	3.4
	SBLT	44	54	1.4
	SBT	104	193	7.3
	SBRT	21	30	1.8
	EBLT	21	14	1.7
	EBT	356	362	0.3
	EBRT	55	57	0.3
	WBLT	46	34	1.9
	WBT	345	316	1.6
	WBRT	59	77	2.2
Bringelly Road / Browns Road	SBLT	62	40	3.1
	SBRT	25	33	1.5
	EBLT	15	8	2.1
	EBT	455	519	2.9
	WBT	427	390	1.8
	WBRT	38	31	1.2
Bringelly Road / Cowpasture Road	NBLT	66	18	7.4
	NBRT	60	28	4.8
	EBT	448	527	3.6
	EBRT	68	35	4.6
	WBLT	40	33	1.2
	WBT	398	402	0.2
Bringelly Road / Camden Valley Way	NBLT	27	34	1.3
	NBT	969	916	1.7
	NBRT	374	428	2.7
	SBLT	232	254	1.4
	SBT	1182	1131	1.5
	SBRT	111	82	3.0
	EBLT	169	176	0.5
	EBT	325	360	1.9
	EBRT	14	2	4.2
	WBLT	814	865	1.8
Camden Valley Way / Cowpasture Road	NBLT	102	49	6.1
	NBT	1359	1393	0.9
	SBT	1982	2032	1.1
	SBRT	24	6	4.6
	EBLT	7	0	3.7
	EBRT	101	71	3.2
Camden Valley Way / Ingleburn Road	NBLT	116	45	7.9
	NBT	1163	1218	1.6
	NBRT	93	87	0.6
	SBLT	343	328	0.8
	SBT	1713	1787	1.8

	SBRT	27	8	4.5
	EBLT	54	28	4.1
	EBT	177	222	3.2
	EBRT	247	144	7.4
	WBLT	169	184	1.1
	WBRT	243	202	2.7
Ingleburn Road / Byron Road	NBLT	4	18	4.2
	NBT	3	10	2.7
	NBRT	13	3	3.5
	SBLT	64	38	3.6
	SBT	11	35	5.0
	SBRT	3	0	2.4
	EBT	401	353	2.5
	EBRT	4	0	2.8
	WBLT	7	6	0.4
	WBT	332	290	2.4
	WBRT	12	11	0.3
Ingleburn Road / Dickson Road	NBLT	5	4	0.5
	NBT	22	38	2.9
	NBRT	0	0	0.0
	SBLT	134	119	1.3
	SBT	38	49	1.7
	SBRT	1	12	4.3
	EBLT	3	11	3.0
	EBT	70	83	1.5
	EBRT	0	5	3.2
	WBLT	7	6	0.4
	WBT	82	40	5.4
	WBRT	90	80	1.1
Ingleburn Road / Eastwood Road	NBT	77	55	2.7
	NBRT	15	28	2.8
	SBLT	58	71	1.6
	SBT	114	72	4.4
	WBLT	17	15	0.5
	WBRT	71	41	4.0
Eastwood Road / Heath Road	NBT	52	70	2.3
	NBRT	11	9	0.6
	SBLT	64	32	4.6
	SBT	67	75	0.9
	WBLT	14	26	2.7
	WBRT	40	24	2.8
Heath Road / Dickson Road	SBLT	35	35	0.0
	SBRT	10	7	1.0
	EBLT	1	0	1.4
	EBT	74	41	4.4
	WBT	44	42	0.3
	WBRT	26	41	2.6
Heath Road / Rickard Road	SBLT	151	121	2.6
	SBRT	4	0	2.8
	EBLT	3	0	2.4
	EBT	106	84	2.3
	WBT	66	82	1.9
	WBRT	56	16	6.7
Heath Road / Byron Road	SBLT	21	58	5.9
	SBRT	1	0	1.4
	EBLT	10	0	4.5
	EBT	247	204	2.9
	WBT	121	95	2.5

	WBRT	10	28	4.1
Camden Valley Way / Heath Road	NBLT	58	60	0.3
	NBT	1199	1229	0.9
	NBRT	126	113	1.2
	SBLT	289	282	0.4
	SBT	1834	1831	0.1
	SBRT	6	11	1.7
	EBLT	19	5	4.0
	EBT	91	101	1.0
	EBRT	158	154	0.3
	WBLT	203	212	0.6
	WBT	67	51	2.1
	WBRT	154	134	1.7
Camden Valley Way / St Andrews Road	NBLT	43	51	1.2
	NBT	1376	1369	0.2
	NBRT	2	0	2.0
	SBLT	0	6	3.5
	SBT	2191	2175	0.3
	SBRT	4	7	1.3
	EBLT	4	9	2.0
	EBT	0	0	0.0
	EBRT	41	47	0.9
	WBLT	4	6	0.9
	WBT	0	0	0.0
	WBRT	13	1	4.5
Camden Valley Way / George Road	NBLT	38	29	1.6
	NBT	1361	1353	0.2
	SBT	2157	2158	0.0
	SBRT	77	74	0.3
	EBLT	58	64	0.8
Camden Valley Way / Dwyer Road	NBLT	18	26	1.7
	NBT	1384	1361	0.6
	EBLT	15	25	2.2
Eastwood Road / Anthony Road	NBLT	0	0	0.0
	NBT	22	24	0.4
	SBT	37	48	1.7
	SBRT	44	52	1.2
	EBLT	41	55	2.0
	EBRT	0	0	0.0
Rickard Road / Leppington Station South Carpark Entry/Exit (North)	NBLT	3	15	4.0
	NBT	278	320	2.4
	SBT	359	411	2.7
	SBRT	0	2	2.0
	EBLT	0	2	2.0
	EBRT	3	18	4.6
	NBT	211	281	4.5
	SBT	207	284	4.9
	EBLT	79	58	2.5
	NBLT	137	113	2.1
	NBT	143	209	5.0
	SBT	136	220	6.3
	SBRT	69	64	0.6
	EBLT	66	72	0.7
	EBRT	225	193	2.2

Appendix C

Travel time validation

C1

Table 16: Detailed travel time statistics - AM Peak

Details		**Section**								**Cumulative**				
Route	**Section**	Observed (min)	Observed (max)	Observed (average)	Modelled (average)	Difference (s)	Difference (%)	Within 15%	Within Min/ Max	Modelled	Observed	Difference (s)	Difference (%)	Route total within 15%
1_EB	King to Dickson	77.0	132.0	92.5	98.2	5.7	6%	✓	✓	98.2	92.5	5.7	6%	✓
	Dickson to Rickard	29.0	89.0	44.4	46.7	2.3	5%	✓	✓	144.9	136.9	8.0	6%	
	Rickard to Old Cowpasture	58.0	99.0	71.1	61.1	-10.0	-14%	✓	✓	206.0	208.0	-2.0	-1%	
	Old Cowpasture to Camden Valley	92.0	218.0	125.9	121.9	-3.9	-3%	✓	✓	328.0	333.9	-5.9	-2%	
1_WB	Talana to Camden Valley	32.0	160.0	84.3	81.7	-2.6	-3%	✓	✓	81.7	84.3	-2.6	-3%	✓
	Camden Valley to Old Cowpasture	75.0	110.0	94.3	95.3	1.0	1%	✓	✓	177.1	178.7	-1.6	-1%	
	Old Cowpasture to Rickard	57.0	120.0	85.3	73.5	-11.9	-14%	✓	✓	250.5	264.0	-13.5	-5%	
	Rickard to Dickson	29.0	63.0	38.5	38.1	-0.4	-1%	✓	✓	288.6	302.5	-13.9	-5%	
	Dickson to King	78.0	138.0	94.7	87.0	-7.6	-8%	✓	✓	375.7	397.2	-21.5	-5%	
2_NB	Dwyer to St Andrews	51.0	72.0	60.7	60.1	-0.6	-1%	✓	✓	60.1	60.7	-0.6	-1%	✓
	St Andrews to Willowdale	88.0	228.0	140.8	102.9	-37.9	-27%	-	✓	163.0	201.5	-38.5	-19%	
	Willowdale to Ingleburn	51.0	138.0	96.6	82.2	-14.4	-15%	✓	✓	245.2	298.1	-52.9	-18%	
	Ingleburn to Cowpasture	43.0	54.0	49.3	54.5	5.2	11%	✓	-	299.8	347.4	-47.6	-14%	
	Cowpasture to Camden Valley	128.0	188.0	162.5	173.2	10.7	7%	✓	✓	473.0	509.9	-36.9	-7%	
2_SB	Greenway to Camden Valley	64.0	135.0	104.9	80.9	-24.0	-23%	-	✓	80.9	104.9	-24.0	-23%	✓
	Camden Valley to Cowpasture	111.0	163.0	132.0	150.4	18.4	14%	✓	✓	231.3	236.9	-5.5	-2%	
	Cowpasture to Ingleburn	43.0	109.0	76.9	66.9	-10.0	-13%	✓	✓	298.2	313.8	-15.5	-5%	
	Ingleburn to Willowdale	45.0	110.0	77.1	66.0	-11.2	-14%	✓	✓	364.2	390.9	-26.7	-7%	
	Willowdale to St Andrews	62.0	91.0	78.9	65.5	-13.4	-17%	-	✓	429.7	469.8	-40.1	-9%	
	St Andrews to Dwyer	49.0	61.0	54.4	49.3	-5.0	-9%	✓	✓	479.0	524.1	-45.1	-9%	

Table 17: Detailed travel time statistics - PM Peak

Details		Section								Cumulative				
Route	**Section**	Observed (min)	Observed (max)	Observed (average)	Modelled (average)	Difference (s)	Difference (%)	Within 15%	Within Min/ Max	Modelled	Observed	Difference (s)	Difference (%)	Route total within 15%
1_EB	King to Dickson	75.0	122.0	96.1	99.4	3.3	3%	✓	✓	99.4	96.1	3.3	3%	✓
	Dickson to Rickard	29.0	96.0	59.2	51.3	-7.9	-13%	✓	✓	150.7	155.3	-4.6	-3%	
	Rickard to Old Cowpasture	59.0	88.0	69.6	59.2	-10.4	-15%	✓	✓	209.8	224.9	-15.1	-7%	
	Old Cowpasture to Camden Valley	78.0	152.0	128.7	145.7	17.0	13%	✓	✓	355.5	353.6	1.9	1%	
1_WB	Talana to Camden Valley	78.0	100.0	87.6	85.6	-2.0	-2%	✓	✓	85.6	87.6	-2.0	-2%	✓
	Camden Valley to Old Cowpasture	75.0	93.0	82.2	73.7	-8.5	-10%	✓	-	159.3	169.8	-10.5	-6%	
	Old Cowpasture to Rickard	57.0	90.0	67.3	67.5	0.1	0%	✓	✓	226.8	237.1	-10.4	-4%	
	Rickard to Dickson	27.0	53.0	34.2	34.9	0.7	2%	✓	✓	261.7	271.3	-9.6	-4%	
	Dickson to King	81.0	124.0	101.0	94.7	-6.3	-6%	✓	✓	356.4	372.3	-15.9	-4%	
2_NB	Dwyer to St Andrews	51.0	63.0	56.1	54.6	-1.4	-3%	✓	✓	54.6	56.1	-1.4	-3%	✓
	St Andrews to Park Willowdale	51.0	95.0	75.3	69.6	-5.7	-8%	✓	✓	124.2	131.4	-7.2	-5%	
	Willowdale to Ingleburn	41.0	112.0	72.9	64.2	-8.8	-12%	✓	✓	188.4	204.3	-15.9	-8%	
	Ingleburn to Cowpasture	42.0	80.0	57.0	49.3	-7.7	-14%	✓	✓	237.6	261.3	-23.7	-9%	
	Cowpasture to Camden Valley	106.0	180.0	142.9	153.8	10.9	8%	✓	✓	391.4	404.2	-12.8	-3%	
2_SB	Greenway to Camden Valley	41.0	133.0	92.1	78.5	-13.6	-15%	✓	✓	78.5	92.1	-13.6	-15%	✓
	Camden Valley to Cowpasture	105.0	150.0	125.2	136.8	11.6	9%	✓	✓	215.3	217.3	-2.0	-1%	
	Cowpasture to Ingleburn	47.0	129.0	74.2	66.9	-7.3	-10%	✓	✓	282.2	291.5	-9.3	-3%	
	Ingleburn to Willowdale	44.0	107.0	63.8	59.7	-4.1	-6%	✓	✓	341.9	355.3	-13.4	-4%	
	Willowdale to St Andrews	59.0	85.0	65.5	69.4	3.8	6%	✓	✓	411.3	420.8	-9.5	-2%	
	St Andrews to Dwyer	50.0	67.0	56.7	50.6	-6.1	-11%	✓	✓	461.9	477.5	-15.6	-3%	

Appendix D

Signal phasing data

D1

Intersection	AM peak	PM peak

AM peak

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	3069	2867	-7%	✓
D	133	141	6%	✓
E	76	77	2%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2780	2726	-2%	✓
D	244	257	5%	✓
E	93	103	10%	✓

PM peak

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2877	2957	3%	✓
D	232	231	0%	✓
E	46	0	-	-

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2804	2931	5%	✓
D	266	257	-3%	✓
E	41	0	-	-

AM peak

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1698	1581	-7%	✓
B	107	116	8%	✓
D	282	309	10%	✓
E	379	399	5%	✓
G	251	270	8%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1684	1594	-5%	✓
B	123	129	4%	✓
D	363	399	10%	✓
E	256	270	6%	✓
G	274	283	3%	✓

PM peak

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1906	1954	3%	✓
B	0	0	-	-
D	311	334	8%	✓
E	309	334	8%	✓
G	254	257	1%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1760	1903	8%	✓
B	26	0	-	-
D	299	309	3%	✓
E	309	334	8%	✓
G	303	334	10%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1770	1826	3%	√
B	57	0	-	-
D	316	334	6%	√
E	309	334	8%	√
G	223	231	4%	√

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1665	1723	3%	√
B	64	0	-	-
D	335	360	7%	√
E	371	386	4%	√
G	251	257	3%	√

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1874	1877	0%	√
D	271	257	-5%	√
E	370	360	-3%	√
G	213	206	-3%	√

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1766	1723	-2%	√
D	307	309	1%	√
E	467	463	-1%	√
G	201	206	2%	√

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2664	2623	-2%	√
B	160	154	-4%	√
C	225	231	3%	√

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2642	2597	-2%	√
B	197	206	4%	√
C	208	206	-1%	√

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2501	2469	-1%	√
B	254	257	1%	√
C	295	283	-4%	√

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2556	2584	1%	√
B	244	257	5%	√
C	265	270	2%	√

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	477	514	8%	✓
D	832	823	-1%	✓
E	1181	1157	-2%	✓
G	270	283	5%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	496	540	9%	✓
D	860	874	2%	✓
E	1139	1054	-7%	✓
G	280	309	10%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	471	514	9%	✓
D	552	514	-7%	✓
E	1392	1363	-2%	✓
G	352	386	10%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	444	489	10%	✓
D	521	514	-1%	✓
E	1420	1389	-2%	✓
G	368	386	5%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2418	2360	-2%	✓
B	238	260	9%	✓
C	262	280	7%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2353	2240	-5%	✓
B	278	280	1%	✓
C	245	240	-2%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2584	2480	-4%	✓
B	254	260	2%	✓
C	155	160	3%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2488	2440	-2%	✓
B	317	300	-5%	✓
C	149	160	7%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2750	2556	-7%	✓
B	144	144	0%	✓
C	174	180	4%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2603	2358	-9%	✓
B	188	198	5%	✓
C	178	180	1%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	2662	2520	-5%	✓
B	191	198	4%	✓
C	156	162	4%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	2275	2322	2%	✓
B	331	342	3%	✓
C	189	180	-5%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1459	1400	-4%	✓
B	25	-	-	-
D	427	440	3%	✓
E	450	440	-2%	✓
G	493	520	5%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1525	1480	-3%	✓
B	14	-	-	-
D	389	360	-7%	✓
E	459	440	-4%	✓
G	481	480	0%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1471	1440	-2%	✓
C	36	0	-	-
D	413	400	-3%	✓
E	476	480	1%	✓
G	468	480	3%	✓

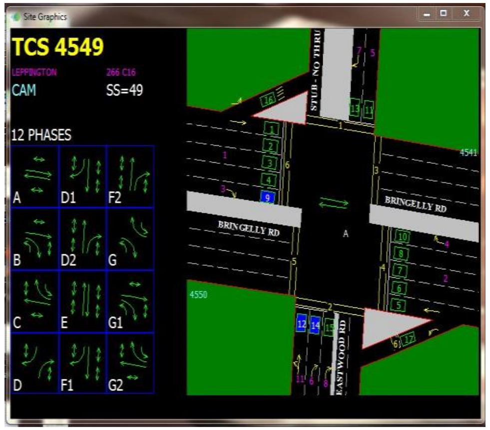
Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1537	1480	-4%	✓
C	12	0	-	-
D	425	400	-6%	✓
E	456	440	-4%	✓
G	442	440	0%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1543	1540	0%	✓
C	53	-	-	-
D	175	180	3%	✓
E	378	400	6%	✓
G	333	360	8%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1209	1160	-4%	✓
C	213	220	3%	✓
D	170	180	6%	✓
E	434	440	1%	✓
G	326	340	4%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1353	1220	-10%	✓
C	149	140	-6%	✓
D	280	260	-7%	✓
E	339	320	-6%	✓
G	250	240	-4%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1356	1400	3%	✓
C	176	180	2%	✓
D	249	260	5%	✓
E	335	360	8%	✓
G	258	280	9%	✓



Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1668	1560	-6%	✓
B	162	160	-1%	✓
D	273	300	10%	✓
E	198	200	1%	✓
G	242	260	8%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1680	1620	-4%	✓
B	128	120	-6%	✓
D	404	400	-1%	✓
E	121	120	-1%	✓
G	239	220	-8%	✓

Total seconds green time per hour – Hour 1				
Phase	SCATS	Model	%Diff	Check
A	1605	1540	-4%	✓
B	316	340	7%	✓
D	235	240	2%	✓
E	167	160	-4%	✓
G	193	200	3%	✓

Total seconds green time per hour – Hour 2				
Phase	SCATS	Model	%Diff	Check
A	1691	1860	10%	✓
B	225	240	7%	✓
D	232	240	3%	✓
E	207	220	6%	✓
G	194	200	3%	✓

Appendix G

Technical note on the development of future year travel demand

Technical Note

ARUP

Level 5
151 Clarence Street
Sydney NSW 2000
Australia
www.arup.com

t +61 2 9320 9320
f +61 2 9320 9321
d +61 2 9320 9051

Project title	Leppington Town Centre and Precinct	Job number	
cc		File reference	
Prepared by	Stefan Ellis, Nigel Chan	Date	2 May 2021
Subject	Future year (2041) demand development		

This section presents an overview of the methodology followed to derive the future year vehicle-based transport demand for the LTCP.

Future traffic demand was developed using a combination of:

- 2019 calibrated base year Aimsun matrices
- 2019-2056 estimated traffic growth matrices from PTPM
- First principles estimation of traffic demand based on data-based traffic generation rates

Different methodologies were followed to populate the different sectors of a traditional travel demand matrix, shown in Figure 1.

	Internal	*External*
Internal	First principles demand PTPM distribution	First principles demand PTPM distribution
External	First principles demand PTPM distribution	PTPM growth PTPM distribution

Figure 1: Future year travel demand matrix development

The following methodologies were used to populate each sector:

- **Internal-internal trips**

Replaced PTPM growth with our own first principle trip generation for the internal zones. Made assumption about split of internal vs external trips based on PTPM. Distribution weighted by trip gen for each origin-destination pair.

- **Internal-external and external-internal trips**

  Replaced PTPM growth with our own first principle trip generation for these internal zones. Made assumption about split of internal vs external trips based on PTPM. Distributed according to future PTPM distribution.

- **External-external trips**

  Adopted the growth between the 2019 and relevant future year scenarios directly from the PTPM matrices.

This method was applied to account for the specific traffic generation patterns particularly of the significant retail presence proposed as part of the LTCP, with steps taken to validate the first principles approached against PTPM outputs on metrics such as mode choice.

The following sections describe the multi-step process to develop the future demand totals.

PTPM traffic forecasts

Transport for NSW provided subarea matrices from the PTPM subarea defined in Figure 2 for 2019, 2026, 2036 and 2056. Arup generated a 2041 equivalent matrix using linear interpolation.

Forecast traffic growth between 2019 and 2041 within the subarea was calculated in both absolute and percentage terms. The values shown in Table 1 reflect the differences between the 2019 PTPM matrices and those of the future horizon years.

Table 1: PTPM traffic growth (AM peak period)

Horizon year	Matrix Total	Growth (vehicles)	Growth (%) from 2019
2019	16,618	-	-
2026	20,658	4,041	24%
2036	27,082	10,464	63%
2041 (interpolated)	29,531	12,913	78%
2056	36,880	20,262	122%

Demand profile

PTPM demands represent two-hour totals during both the AM and PM peak periods.

Traffic profiles observed in December 2019 during traffic data collection suggest that the peak one-hour traffic volumes represent approximately 52% of the two-hour volumes. Accordingly, the two-hour PTPM matrices were factored by 0.52 to determine the peak one-hour demands to be modelled in Aimsun. The resulting matrices represent the same modelled peak hours as the base year Aimsun model.

Technical Note

2 May 2021

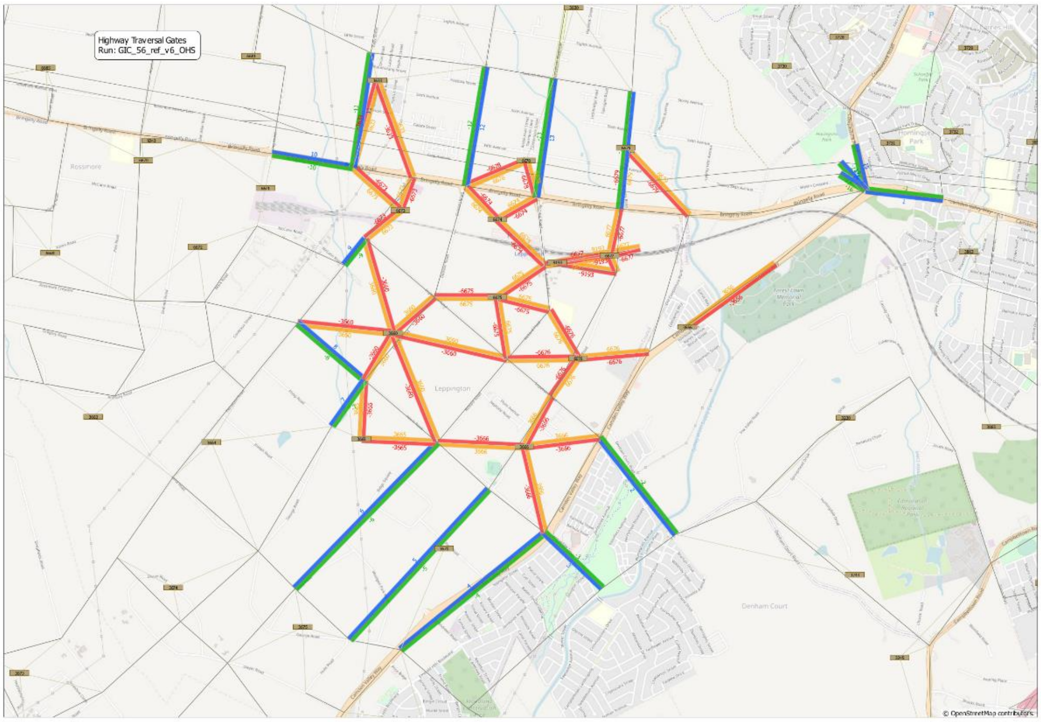


Figure 2: Sub-area definition in PTPM

Future traffic distribution

Traffic distribution was completed in four steps, according to the nature of the trips.

School trips

A car occupancy rate of 2.0 was assumed for trips to and from the school. School trips were distributed according to the following assumptions:

- Catchment extends to all adjacent (shared border) PTPM zones
- Reduced likeliness of attraction from more distant zones is balanced by the increased likelihood of car mode share

Traffic distribution within Leppington

Trips generated by the Precinct was distributed as internal-to-internal in the same proportions as suggested by the PTPM.

Traffic distribution to/from Leppington

The remaining traffic generation was distributed to external centroids, using the internal-to-external and external-to-internal distribution proportions observed in the 2036 PTPM distribution.

The final matrix output from the preceding steps included the internal-internal, internal-external, and external-internal portions of the future traffic demand. This was then furnessed using production/attraction targets obtained from trip generation calculated using first principles.

External-external traffic growth

External-external traffic growth was calculated as the growth between the 2019 PTPM and future PTPM models.

External-to-external growth was capped under the following assumptions:

- The PTPM demand data is for 2019, whereas the traffic surveys on which the Aimsun model was calibrated were carried out in December 2019.
- This presents the possibility that some of the growth (or decline) predicted by the PTPM model may have already occurred by the time that the surveys were completed.

Final future traffic demands

The matrices generated at the end of each of the preceding steps were added together to develop the total future traffic matrices for the LTCP, each representing a one-hour matrix. Each resulting one-hour matrix was broken down into 15-minute assignment matrices according to profiles observed from the traffic surveys.

Traffic assignment

As was the case with the base year, the future year models used the Dynamic User Equilibrium (DUE) assignment method.

Travel zones

The proposed LTCP development broadly aligns with the boundaries of three transport zones in PTPM, namely 3634, 3655, 3658, 3654, 3660, 3664, 3665, 3666, 3670, and 3675 as shown in Figure 3.

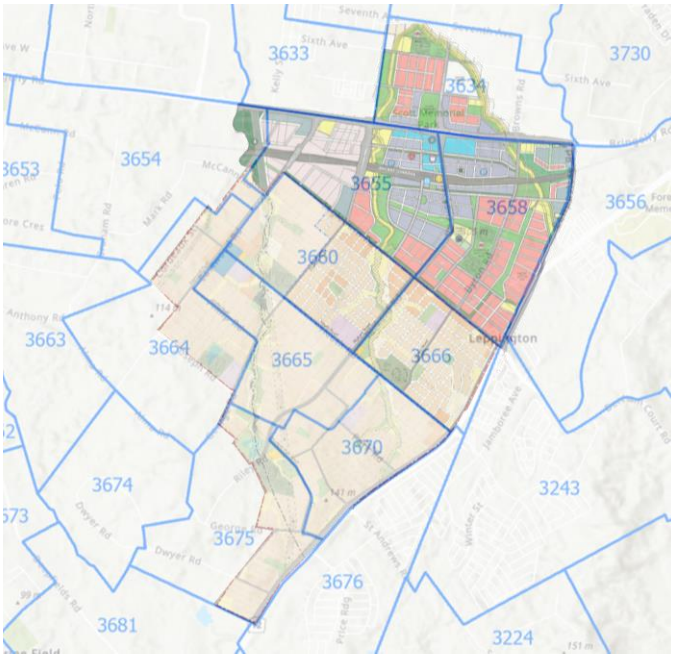


Figure 3: PTPM zone numbers in LTCP

The PTPM subarea matrices provided by Transport for NSW cover a larger area than the modelled network within Aimsun (shown in Figure 2). The PTPM subarea demand along the periphery was rationalised to prevent unwanted trips from being included in future growth calculations.

Furthermore, the Aimsun zonal system was updated in order to appropriately reflect how traffic generated by proposed development would access the road network. Figure 4 presents the future zonal arrangement adopted for the LTCP. It has been developed using the following principles:

- Grouping homogenous land uses as far as practical
- Delineating zonal boundaries based on physical barriers such as roads, creeks and continuous green spaces.

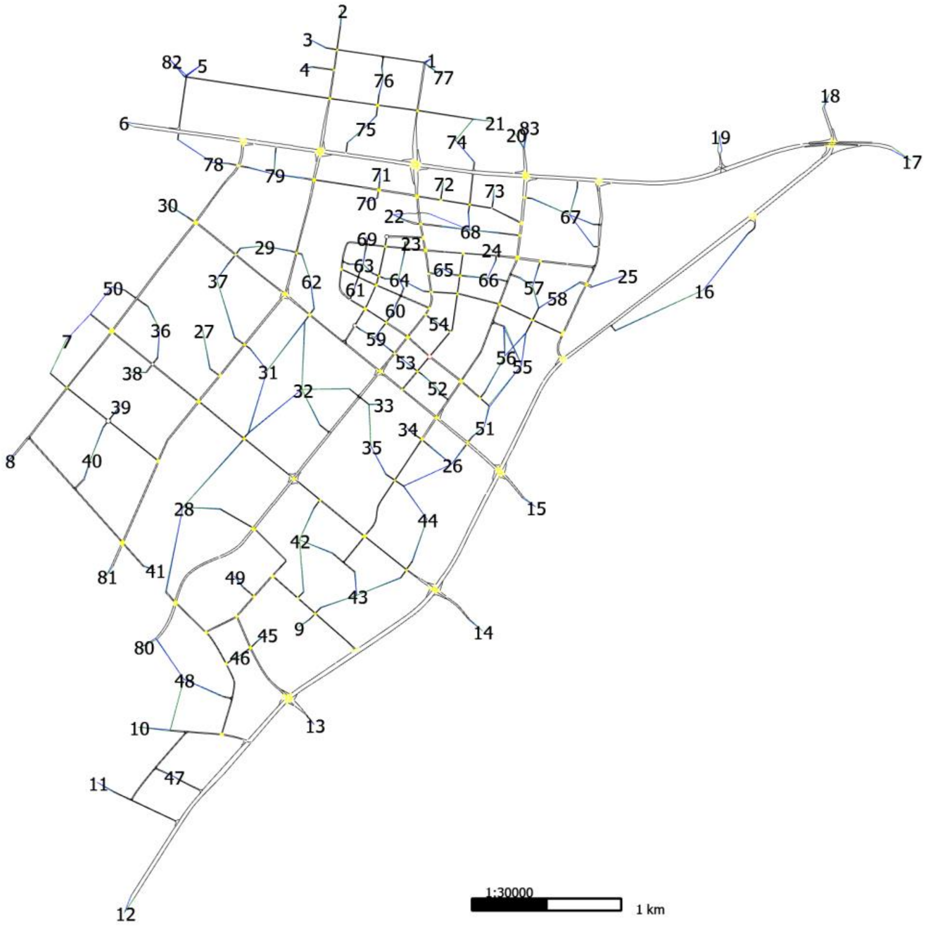


Figure 4: Future mesoscopic model zone structure

Zonal connectivity to the road network considered the following:

- Rationalisation of where traffic could enter the network
- Loading onto stubs so that queue build-up happens on links outside the main right of way.
- Distributions by percentages in cases where the loading point allows all possible turn into and from the connector
- Distribution by "best entrance/exit" in cases where the loading point is a left-in/left-out intersection. This is done to encourage Aimsun to find the most direct route for every vehicle and to prevent unrealistic "rat running" around the block.

Technical Note

2 May 2021

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Stefan Ellis, Nigel Chan	Stefan Ellis	Andrew Weir
Signature			

Appendix H

Consolidated Transport for NSW commentary (dated 22 August 2019) on the LTC study

#	Comment	Response
General		
1	It is noted we have been advised by DPIE that the Leppington town centre is now planned to accommodate 11,000 – 14,000 dwellings and 13,600 jobs. This yield in the area is a considerable increase over and above the original planning work for the precinct and infrastructure designed in 2013/14 for this area. The traffic issues are likely to be significantly exacerbated without substantial travel demand management measures	Noted, the planned change is a trigger for this transport study.
2	Ideally the proposed changes to the Leppington Town Centre should be delayed until the road structure plan for the Aerotropolis/Western Sydney Airport Growth Area has been determined to fully understand the impact on the network of any changes to the existing Leppington road structure plan, and ensure corridors are future-proofed to accommodate demand as the area is developed. This would help to verify that the future road network assumptions are correct and aligned with adjoining precincts. Further, Objective 1 of the Greater Sydney Region Plan states "transport corridors and locations for new centres need to be safeguarded for future infrastructure investments". The Leppington Town centre is being investigated in isolation which may create issues with aligning networks with the adjoining precincts and Aerotropolis and therefore may conflict with transport corridor preservation requirements.	There are several comments around alignment with transport and land use assumptions outside LTC - which have progressed since the beginning of the Leppington investigation. Forecast demand is being informed by STM forecasts extracted mid 2018, underpinned by STM assumptions on transport and land use for Western Sydney at this time. It is understood an updated set of assumptions for Western Sydney were agreed and incorporated into STM in December 2018 – with further changes and planning decisions likely made since, and further more in the near future. We suggest collating, discussing, agreeing way forward among cluster.
3	The overall scope of the transport study should be more focused on multi-modal assessment; considering impacts of growth to buses, trains, pedestrian facilities and cycling facilities – as well as general traffic and local freight tasks (servicing, loading delivery tasks will increase with increased density), balancing residential and non-residential land uses to ensure long term trip containment and walkability. It is noted that the Modelling Methodology Report will form part of an overarching Transport Study and we anticipate that it will address the multi-modal impacts to enable capacity, solutions and costings to be adequately assessed	A draft Transport Plan is also being developed, addressing the strategic needs and provisions for all modes. It is understood these will be expressed spatially via refinement of already proposed typical sections of the variety of street typologies and key specific streets / corridors.
4	Pedestrian Level of Service (Fruin) assessment should be provided for key pedestrian desire lines to ensure that adequate pedestrian facilities are provided to cater for future growth and pedestrian demands, particularly within the commercial core and around train station and bus stops.	Allowance has not been made for Pedestian LoS assessment on streets, though could be easily undertaken for Leppington Station vertical transport and connecting immediate station vicinity desire lines – where pedestrian demand can be identified more easily via STM outputs already at hand. In the core a principles-based approach would likely be more appropriate at this stage due to the complexity of pedestrian demand forecasting at a street level without finer grain modelling.
5	Bus travel time should be reported as a separate performance measure.	Agreed and has been captured, will be provided in final reporting.
6	It is noted that there is a potential proposal to remove the Leppington Rail carpark and bus turn around area. This infrastructure was recently built and proposed removal could be contentious with the community. Careful consideration should be given to the competing needs of customers who use their vehicles to access public transport facilities (which may currently be working to reduce kms travelled by private vehicle for a number of individuals). Alternative solutions should be explored.	Removal of the Commuter Car Park would be supported through the lens of the end-state vision for LTC, and is understood to be aligned with Transport for NSW thinking. Transport cluster to confirm and timing – supply would likely be displaced with planned line extension to Aerotropolis post 2026. Propose to assume occurred by 2036 – which is understood to align with STM assumptions.
Modelling comments		

7	The model area does not seem large enough to accurately capture the impacts of the proposed development, given its scale	Extensions are currently being considered to the south to capture Leppington Precinct. Please confirm if the model requires other extensions in order to address transport cluster concerns, and/or information required to support. It would need to be discussed and agreed among the transport cluster what is considered large enough.
8	The modelled peak durations seem inappropriate based on the surveyed demand profile in the report	Noted.
9	The report does not mention if the forecast traffic generation had been reflected in STM to more accurately assess the development impact at a strategic level, and generate more reasonable cordon demand for operational model.	The operational model demand matrices have been shaped by two LU scenario tests in STM – considered appropriate to reflect any pattern changes for adjustment based modified traffic generation based first principles demand assessment.
10	RMS understands the STM LU16 land use forecasts are currently being revised to incorporate changes associated with the Aerotropolis. The consultant should contact TfNSW's Transport Performance and Analytics team to ensure the latest available forecasts are utilised	Noted. To be considered as part of #2 response.
11	It is noted the report mentions that strategic modelling draws upon the 'S2: "DPIE Medium SWGA Growth" scenario. Can further detail please be provided about this scenario and how it compares to any high growth scenario developed for SWGA?	Noted. To be confirmed with DPIE and considered as part of #2 response.
12	The future demand estimation for the Aimsun model needs to be further justified and verified.	Noted, see below section of comments on trip generation.
13	It seems the SIDRA model was not calibrated and the method of directly using Aimsun turning volumes for the SIDRA models may be problematic.	Sidra's key purpose is to inform traffic signal operational assumptions in Aimsun, and undertake intersection configuration sensitivity tests. All performance will be extracted from Aimsun – in which microsimulation subareas can be set as required to analyse key parts of the network. Sensitivity tests with assignment types have confirmed these do not affect calibration & validation of the base case.
14	SCATS signal phasing time should be used for existing and future conditions rather than using those captured by video footage. Please contact SCATS.Traffic.Signal.Data@rms.nsw.gov.au for data requests. Please note this will incur a fee.	This is proposed as part of re-calibration and re-validation of the proposed extension of the model to include Leppington Precinct to the south. Though future year operational assumptions will be continued to be informed using Sidra due to the significant forecast functional changes in the network – and the assumption that traffic signal operations will need to adjust appropriately in time with significant functional changes.
15	The electronic copies of the base mesoscopic model and accompanying calibration/validation report should be provided for RMS review prior to future scenario modelling being undertaken - base case models should be calibrated/validated and endorsed by RMS as being 'fit for purpose', prior to proceeding with future assessment scenarios.	A report will be provided to the transport cluster for review should the model be extended, re-calibrated, re-validated. Otherwise happy to provide after comments addressed.
16	There should be a hold point after the strategic modelling exercises to ensure that the outputs adequately reflect possible future travel behaviours in terms of anticipated demographics, land uses including major planning proposals and any traffic and transport projects (including both service and capital improvements) currently proposed (whether in planning or under development). This hold point should include consultation with Council, TfNSW and RMS.	Noted. This is also proposed as part of model extension.

17	Will SIDRA modelling be used as a network? This will affect the modelling result reasonableness as some of the junctions are closely-spaced from one another (further comments on this provided in later sections). TCS signal timing and capacity will be affected due to the queue spill back effects	Sidra's key purpose is to inform traffic signal operational assumptions in Aimsun, and undertake intersection configuration sensitivity tests. All performance will be extracted from Aimsun – in which microsimulation subareas can be set as required to analyse key parts of the network. Sensitivity tests with assignment types have confirmed these do not affect calibration & validation of the base case.
Trip generation		
18	**High density residential** Trip generation rates of 0.19 vehicle trips per hour (vtph) per dwelling and 0.15 vtph per dwelling for the morning and afternoon peak periods respectively, are based on Sydney average rates in Roads and Maritime's Technical Direction TDT2013/04a Updated Traffic Surveys. The Sydney average traffic generation rates are not considered appropriate for the subject site as these rates have been derived from the results of surveys undertaken at locations with highly established, high frequency public transport networks, in very close proximity to Sydney's major employment centres with high trip containment and very high mode share to public transport (i.e. St Leonards and Chatswood, which are among centres with the highest public transport mode share in Sydney). Trip generation from these locations may not be representative of the travel behaviour of the subject locality, particularly in the short to medium term. It is also noted that there is no proposed R4 High density zone, which is the land use type that the rates 0.19 and 0.15 vtph are derived from.	**High Density**: No R4 zoning proposed, but a high density residential component of the mixed-use core is assumed. All mixed-use proposed within immediate proximity of planned highly rail and rapid bus network. Rates will be reviewed based on further interrogation of TD data sets. This may include application of higher rates for interim year model.
19	**Medium density residential** Figure 15 - The implied 80-90% private car mode share for medium density residential development may be appropriate for medium density outside of the 800m walking catchment of the train station, however is not appropriate for medium density residential within the 800m walking distance of the station. We advise that more recent surveys undertaken by RMS in 2013 of medium density residential dwellings recorded average of 0.39vtph and 85th percentile of 0.58vtph in AM peak, and average of 0.37vtph and 85th percentile of 0.65vtph in the PM peak, which represents close to 50/50 split of car and non-car mode share when compared to the person trips generated for the corresponding peaks.	**Medium Density**: traffic generation rate of 0.4 vtph per dwelling has been applied for each AM and PM, can adjust to 0.39vtph and 0.37vtph for AM and PM respectively. Almost all captured within 0.6-1.2km of station – seems reasonable to retain above rates given typically high % of pedestrian walk-ups to Sydney stations in this distance range.
20	**Retail** It is noted from Table 12 that it is intended to apply 2.11vtph per 100sqm on the assumption that all retail will be located within a major centre that would result in significant containment/linked trip effect. It is noted that this reduced rate is applied to the total 163,388sqm retail. It is not realistic to assume that all retail in Leppington Town Centre will be contained in one centre. There is likely to be supermarket(s) and plazas in addition to any major centre. Recent surveys undertaken by RMS of smaller retail centres has revealed higher trip generation rates for smaller centres and free-standing supermarkets (see graph below for plot of trip rates per 100sqm compared to centre size). Previous rates for larger centres in the RMS TDT2013/04a represent a best case scenario. Therefore, a large portion of the total retail could be assumed to be within one larger centre and a portion should be assumed to be in smaller standalone stores/centres to give a more realistic understanding of the trip generation.	**Retail**: Proposal to split the retail task in to 'large centre' and 'smaller centres' is generally supported (though would suggest a strong weighting towards 'large centre') as is the AM peak adjustment. It is likely that the significant majority of AM trips would be linked with other land uses.

	From RMS surveys for Sydney metropolitan retail sites in Roads and Maritime's TDT2013/04a, the Thursday AM peak traffic generation as a percentage of PM peak traffic ranges from around 34% - 68%, with an average of around 45%. The AM peak trips assumed are likely to significantly understate this component and should be adjusted.	
21	**Bulky goods and Industrial** Rates of 0vtph and 1.01vtph, and 0.16vtph for AM and PM (respectively) are proposed to be applied. For industrial, the rates proposed are the lowest rates observed in RMS surveys underpinning the TDT2013/04a. Industrial zones allow for a range of uses including Hardware and Building Supplies and Garden Centres which are considered 'retail premises' in the LEP, and as such can generate significantly more traffic than the rates currently assumed. Using the lowest rate observed as proposed may significantly understate the traffic generation potential of the industrial and bulky goods areas. Surveys of business parks and industrial estates undertaken by RMS in 2012 revealed a Sydney average rate of 0.52vtph AM and 85th percentile of 0.91vtph, and 0.56 and 85th percentile of 1.01vtph PM. For bulky goods stores (now specialised retail premises), RMS surveys in 2009 revealed average weekday peak hour vehicle trips of 2.7vtph per 100sqm GFA in PM (higher in weekend peaks). For hardware and building stores, RMS surveys in 2009 revealed average weekday peak hour vehicle trips of 4.2vtph per 100 sqm of GFA in PM. For the AM peak, 2009 surveys revealed an average of 1.68vtph per 100sqm and 85th percentile of 2.16vtph AM. Given this, the proposed rates are not supported by RMS. Use of the higher end of the range of rates surveyed, or a survey of a comparable site is recommended, rather than using Sydney average rates or the lowest rate observed. Recent experience has shown that similar precincts generate significantly more traffic than that predicted, particularly with the emerging of prevalence of higher generating bulky goods stores. such as Marsden Park Industrial where the bulky goods precinct and industrial area have attracted numerous high traffic generators including Ikea, Costco, Bunnings and two large home maker centres which has contributed to significant traffic generation.	**Bulky goods and Industrial:** given the number of potential uses here, it is recommended that any further feedback or insights are sought on the type of bulky goods and industrial intended, or desired to be attracted, before adjusting trip rates. A mix of rates may be required. This would have a reasonable impact on precinct demand though would most likely impact periphery network infrastructure where this LU is proposed.
22	**Office** The most comparable location to Leppington in TDT2013/04a is likely to be the Liverpool site surveyed which generated a rate of 2.02vtph per 100sqm in the AM road peak and 1.63vtph per 100sqm in the PM road peak. It is noted that the report has assumed the Sydney average rate from TDT2013/04a for office component and states that a 10% reduction was applied to the trip generation rates for office developments to account for containment (live and work in same area). The rates from TDT2013/04a were derived from surveys of office uses in locations where there is already significant containment and linked trip effect (e.g. Chatswood, North Sydney, Hurstville, Parramatta). It is not appropriate to assume Leppington will have a higher containment or linked trip factor than these established mixed use centres.	**Office:** Linked-trip affect to be reviewed and a comparison between Sydney average and Liverpool rates to be undertaken. Maximum parking rates should also be discussed with Council, as these will significant influence office-generated traffic.
Detailed comments		
23	The existing traffic volumes on Rickard Road and access to Leppington station already indicate high volumes similar to those movements along Bringelly Road in the peak hours, consistent with a movement corridor. Figure 9 shows there are 580 vehicles in the PM peak southbound on Rickard	Existing and future volumes along Rickard Road should be considered in the context of the transport and land use conditions that drive these volumes.

	Road which is not clearly reflected in the commentary on page 12, which states the local roads carry less than 500 vehicles in the peak hour. The 2036 models appear to show less traffic than is currently using Rickard Road.	
24	A number of signalised intersections were constructed as part of Bringelly Road upgrade with the footprints able to accommodate the future traffic demand and additional approach and departure lanes at the signals.	Noted.
25	It is also noted that the intersection of Browns Road has been constructed as a T-intersection and does not have a connection for Byron Road. The proposal would put more pressure on the intersections of Bringelly Road and Dickson, Byron and Eastwood Roads and on the State road corridors of Bringelly Road and Camden Valley Way. The bridge on Dickson Road over the rail line only allows one traffic lane in each direction so would also need to be duplicated to accommodate the proposed volumes of traffic. The underpass under the rail for the potential extension of Byron Road is only about 20m wide which would limit the potential to upgrade this corridor without significant works being required.	Mid-block traffic volumes and intersection locations/configurations will be reviewed to understand potential for narrowing at rail under/over passes to reduce cost-sensitive infrastructure.
26	The proposal in the Arup report does not align with works that have already been carried out and to upgrade intersections as identified would require additional property acquisition and additional costs. An intersection at Bringelly Road and Rickard Road has been constructed and is future-proofed to accommodate the demand generated by the Leppington Precinct and surrounding areas.	It is likely modelling which informed concept and detailed design development of the Bringelly Road corridor was underpinned by different transport and land use assumptions both locally (Leppington) and strategically (Western Sydney).
27	The proposal (in the report) shows the intersection of Bringelly Road requiring auxiliary lanes on Bringelly Road at each of the intersections and additional approach and departure lanes from the local road network that have not been planned for. RMS has no plans to accommodate 4 through lanes through these intersections on Bringelly Road and Camden Valley Way or 3 through lanes on approach to the signals from the intersecting local roads.	No additional east-west through lanes are proposed along Bringelly Road, only adjustments to right turn configurations and side-road configurations. Issues along Bringelly Road beyond localised management solutions within a six-lane corridor may be an indicator of the need for the planned parallel motorway north of Bringelly Road. The approach has not been to assume that State Road upgrades are in planning or not, but to identify the likely need for upgrades to occur based on the transport and land use assumptions applied – and on the assumption that further investigation may be required to confirm configuration, form, or other response.
28	It appears that the proposal also excludes the road linking the commuter car parks to Rickard Road. The access to these commuter carparks is already highly utilised with the station carparks typically filling up early (i.e. around 7am) on weekdays. The NSW Government has also recently committed funding to increase the number of carparking spaces at Leppington Station.	A few minor changes may be made to the local access network at this location. It is understood the car park would be displaced in the long term when the rail line extends west and as the Leppington centre begins to take its place as a strategic centre - to be confirmed by transport cluster.
29	The right turn from Bringelly Road into Rickard Road is a significant movement and if removed is likely to have a detrimental impact on the road network.	Modelling indicates diverting this demand to Dickson Road is manageable. Banning the right turn is about both reducing demand in the Leppington core where vulnerable road users are likely to be as well as efficiency of road space (avoiding multiple right turns in order to access the town centre from western Bringelly Road)
30	Figure 28 shows almost every intersection will be signalised. In newly developed areas RMS does not support traffic signals being closely spaced. The provision of signals at the intersections proposed would not be supported due to their close proximity to other signalised sites. Any proposed works on, or installation of, traffic signals on any road would require RMS approval under Section 87 of the *Roads Act, 1993*. The installation of new traffic signals will be subject to	All signals are currently approximately separated by a minimum 200m, with the exception of the bus interchange access on Rickard Road - which should require much less green time for side street movements than the neighbouring intersection as only required to move buses accessing station. As such, queueing

	the intersections meeting the warrants as outlined under Section 2 (Warrants) of the RMS Traffic Signal Design manual. A warrant assessment should be provided, broken down to demonstrate that the proposed signals can meet the criteria based on the four one hour periods of an average day. If the site satisfies the warrants, it does not necessarily mean that traffic signals are the best solution. All traffic data should be analysed and alternative treatments considered to determine the optimum treatment. New proposals for closely spaced signalised intersections are not supported due to the following reasons: • The potential see-through safety effect of closely spaced intersections and resultant road safety risks. • Practicalities of providing a single traffic controller for intersections closely spaced. • Insufficient storage capacity between the intersections resulting in queues extending back through the adjacent intersections and across pedestrian crossings, resulting in road safety impacts particularly to pedestrians.	issues are less likely to be significant. The see-through safety effect is certainly understood. An assessment against warrants is not currently proposed to be developed. Need confirmation that this is standard practise in planning stages, before early design development.
31	Appropriate maximum parking controls, along with on-street parking schemes will be essential to achieving mode shift.	Noted and agreed. Most local streets have been assumed to require on-street parking space even during peaks, except on approach to intersections. Off-site parking should be considered in the estimation of traffic generation and position reinforced in the Transport Plan.
32	RMS is generally supportive of a grade separated pedestrian crossing on the key pedestrian desire line. A Fruin level of service assessment should be provided for key pedestrian desire lines and the proposed pedestrian bridge to ensure that adequate footpath widths are safeguarded for future demands, particularly where place making such as footpath dining is proposed on key pedestrian movement corridors.	There is a reasonable principles-based case for a pedestrian overpass of Bringelly Road. No Fruin analysis is currently proposed and would be difficult to undertake without a reasonably rigorous demand assessment – though could be undertaken for key station-based movements or coarsely for desire lines such as across Bringelly Road. Though other approaches may be more appropriate.
33	Existing Roads and Maritime road reservations should be retained and zoned SP2 Infrastructure (Classified Road) in proposed SEPP/LEP maps. A number of preliminary infrastructure items indicatively shown as required to support LTC may require land acquisition from private land owners in order to be delivered. Land components to facilitate the proposed works should be delineated and identified as the study progresses. Roads and Maritime would require strategic concept design sketches overlayed on aerial for any proposed classified road upgrades (once agreed in-principle) in order to confirm proposed road widening reservation boundaries. Please note that Roads and Maritime's concurrence is required under Clause 10 of the Environmental Planning and Assessment Regulation 2000 for any proposed road reservations if DPIE intends to identify Roads and Maritime as the acquiring authority for land acquisition. Funding for land acquisition will need to be identified in the SIC.	Noted. Strategic designs are not currently proposed to be developed, though could be undertaken. It is recommended the end-state and staged infrastructure requirements are better understood upon modelling updates first.
34	Page 17 - STM assumptions may over-estimate traffic demand for "external – external trips".	Noted – please confirm if there is a preferred means of addressing .
35	Figure 13 - The STM plot appears to misrepresent the planned Leppington North road network. The extension of Eastwood Rd to Eight Ave is not illustrated and is therefore missing an additional access to the Leppington Aimsun model area. Figure 17 - Travel zone 3633 distribution to road network is missing the Eastwood Road extension.	Noted, STM is not reflective of current planning here and the northern extension of Eastwood Road was not included. This will be addressed with any opportunity to re-extract updated data from STM – which it seems there will be. Other minor modifications/additions may also be made to town centre and local access roads based on comments from DPIE and transport cluster.

	Figure 19 - Future roadway lanes for Eastwood Road (between Bringelly Road and Fifth Ave) are not illustrated. Why are not all town centre roads included as illustrated in Figure 18?	
36	TfNSW advises that Rickard Road / Edmondson Road only have one general traffic lane and one bus lane (per direction) as indicated in table 17. This layout is also continued south of Ingleburn Road.	Noted, this is consistent with current assumption with the exception of south of Ingleburn Road – this will be updated accordingly.
37	Figure 24 - It is noted that Leppington DCP assumes signalised intersections at Ingleburn Road with Rickard Road and Byron Road.	Signalised intersections are currently proposed in Ingleburn Road’s intersections with Rickard Road and Byron Road.
38	Figure 28 - Actual design of the activated streetscape should consider options other than signals where appropriate to manage traffic / pedestrian movement in the town centre, supporting customer outcomes for Successful Places (Future Transport 2056) and directions for Liveability and Productivity (Western City District Plan).	Noted and agreed. Though the current nature of modelling may not be fine-grained enough to properly address the traffic/ped dynamic at intersections of the more localised network – further investigation may be required as part of more detailed planning studies.
39	Figure 29 - Service planning for Western Sydney has progressed substantially since the development of the bus network illustrated in this figure. The city-serving transport corridor identified in Future Transport will most likely support a combination of services to and from Narellan, Campbelltown-Macarthur, Oran Park, Austral and Liverpool. In addition centre-serving services will provide access to the town centre and transport nodes (e.g. Leppington station). The assumption of two regional services on Rickard Road and one district service on Dickson Road is not aligned with indicative service frequencies for city-serving and centre-serving services, identified in the Greater Sydney Services and Infrastructure Plan (p60).	We are aware of these changes through our roles on bus corridor preservation and planning bus service integration for Metro, though it is understood that service planning hasn’t progressed to detailed stages as of yet. The bus service network shown though outdated was used simply as a means to generate a course estimate of bus service demand, under the assumption that buses will predominantly be using Rickard Road, Edmonson Road, Bringelly Road to access Lepptington Station, or the precinct (via Rickard Road). We’re happy to take any updated direction for the purposes of modelling as well as for incorporating and communicating in the Transport Plan.
40	Section 5 - Transport modelling and network performance evaluation should be focussed on validating the integrated transport vision for the precinct to shape the transport network (all modes) required to support future development.	A Transport Plan is in development, including vision and principles for transport (all modes) in the precinct.
41	Note that walking and cycling has not been assessed (*Customer Outcome 3: Walking or cycling is the most convenient option for short trips around centres and local areas, supported by a safe road environment and suitable pathways*).	Layers for each walking and cycling networks have been identified. This will form part of the Transport Plan.
42	In regards to the intersection for the bus interchange, this is too close to the signalised intersection further south. This is unlikely to be supported by RMS and needs to be reconsidered. The impacts need to be assessed in a microsimulation model that shows the detail of the two linked intersections working together and basically showing a green band which would allow the buses from the interchange to enter Rickard Road without resulting in extensive queues, as with the other legs of the two intersections. The model would have to show scenarios for 2019, 2026 and 2036 with a report showing queue lengths, delay, LOS and Degree of Saturation as a minimum.	Noted, and microsimulation subareas will be set up at key locations such as this - accounting for the effect of queueing on upstream intersections. Current modelling scope does allows 2026 and 2036 peak period modelling for the preferred land use scenario. If the modelling demonstrates the configuration does not work, due to the number of potential solutions and affected parties if bus travel path changes are required to change, this may be best addressed in an integrated stakeholder meeting.
Appendix A		
43	Extension of Eastwood Road between Bringelly Road and Fifth Ave should be included.	See response to #35
44	Rickard Road south of Ingleburn Road has the same layout as northern section: 1 transit lane and 1 traffic lane in each direction.	See response to #36

45	Section 4.1.4 indicates that mesoscopic modelling focussed on the higher order road network including town centre roads; why is the town centre road east of Rickard Road not modelled?	This will be included as one of a few minor changes to the lower order network.
46	How has modelling considered the planned access to Leppington precinct (intersections on Ingleburn Road)?	Discussions are currently taking place around the extension of the model to the south to include Leppington Precinct
47	Road network is not consistent with figure 10 and 18 that propose no road access to Camden Valley Way/Cowpasture Road other than Byron Road (and a local street north of the rail line?)	Figure 10 is superseded – used as a placeholder for the land use proposal only.
48	RMS is responsible for the determination of speed limits on all roads in NSW including local roads. The speed limit of 40km/hr along Rickard Road is unlikely to be supported. Speed limits are determined by a number of factors including the road geometry, surrounding conditions, road usage, adjacent development, vehicle types and volumes, crash history and the number of access points along the route. RMS regularly reviews speed limits and monitors for change in these factors. The needs of all road users must be taken into consideration when determining appropriate speed limits. The use of full-time 40 km/h speed limits is predominantly limited to High Pedestrian Activity areas and Local Traffic areas where there is a need to protect vulnerable road users across a network of streets. A key feature of both of these areas is the provision of physical devices or treatments to create a self-enforcing 40 km/h speed environment For RMS to authorise a 40 km/h speed zone (being either a 40 km/h Local Traffic Area or a 40 km/h High Pedestrian Activity Area), the section of road in question must have sufficient traffic calming devices (existing or installed) to deliver a self-enforcing road environment that 'naturally' restricts the speed of vehicles. Traffic calming treatments may involve either the vertical displacement of vehicles (e.g. raised threshold pedestrian crossings, road humps), or the horizontal displacement of vehicles (e.g. chicanes, road narrowing). RMS considers proposals for the introduction of a new 40 km/h High Pedestrian Activity Area or Local Traffic Area, however 24 hour 7 day speed surveys need to be provided for RMS to assess any proposal. Upon receipt of this survey data, RMS will review the proposal in accordance with the current Speed Zoning Guidelines and the "40 km/h Speed Limits in High Pedestrian Activity Areas" guidelines.	Noted and understood, though further connection is required between the commentary and unlikely support. The proposal has been put forward as an end-state means to improve road safety for what is envisaged to be a High Pedestrian Activity area in the core of the strategic centre, reinforce Rickard Road as a local access corridor at segments within the centre, and improve amenity in the centre. The timing of the proposal to reduce speed from existing would be dependent on many factors identified. Creating a natural sense of slower speed in an end-state could be considered as a layer of part of current design activities - i.e how can design & management of the corridor adapt to required functions through time.
49	It is difficult to distinguish between proposed public plaza and proposed school/expansion colouring shown in the ILP map. We request that no new schools and child care centres are located adjoining major roads. As a general principle, RMS discourages new schools being located with a direct frontage or access (pedestrian or vehicular) to any major arterial roads on road safety and traffic efficiency grounds, as arterial roads tend to have high operating speeds and carry high volumes of traffic, including freight and heavy vehicles. The NSW Auditor-General's 'Performance Audit Report - Improving Road Safety: School Zones' in 2010 made a number of recommendations for improving road safety around schools, including that new schools are built on roads where the risk of conflict with motor vehicles is minimised where possible. The *Development Near Rail Corridors and Busy Roads – Interim Guideline* (NSW Department of Planning, 2008), recommends separation between a busy road and a school site (and other sensitive receivers) to avoid noise and air quality impacts on students who can be more sensitive to the impacts of noise and adverse air quality. It is preferred that the impacts are avoided rather than needing to implement potentially costly measures to reduce or mitigate these impacts at the DA	Agreed, any proposed school or child care facility to be reviewed against their proximity to sub-arterial or greater roads and rail corridor. Upon quick review, the only school seems to be that planned to the east of Rickard Road which is otherwise surrounded by local streets. Rickard Road is not being planned as a major road for traffic, though an option could be explored which places an alternative use along it's frontage in the vicinity of the school – as a barrier.

	stage. Therefore we request that any new school sites are located so that they have frontage and access to local roads only to optimise road safety and amenity outcomes for future students.	
50	RMS supports the creation of places and is of the view that the town centre would be better located between (and set back from) proposed movement corridors, not spread over movement corridors. The proposed spread of the town centre over Bringelly Road means that the centre is severed and contradicts the downgrading of Rickard Road	Agreed and to be discussed with Master Plan team re drivers and options.

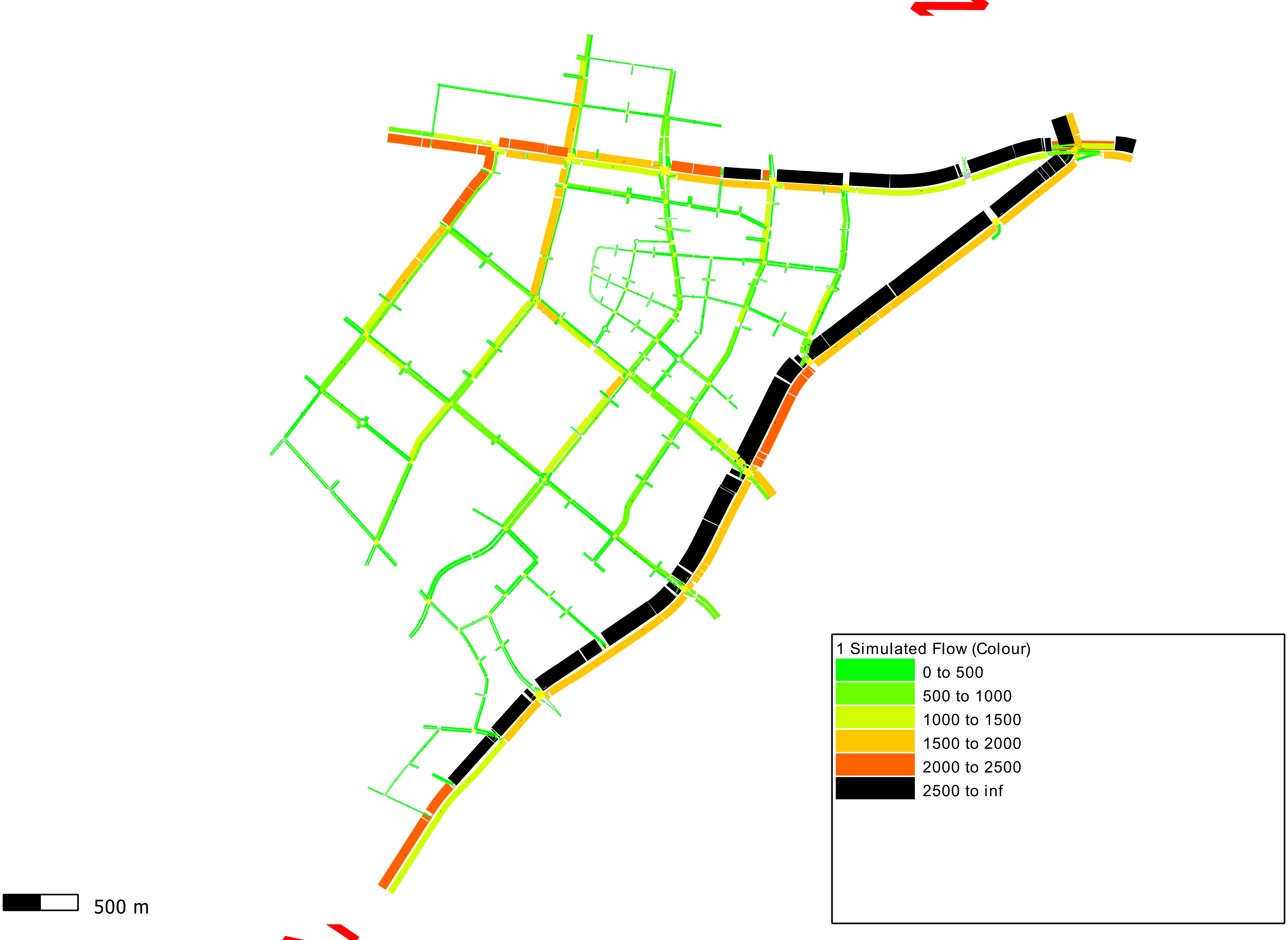
Appendix I

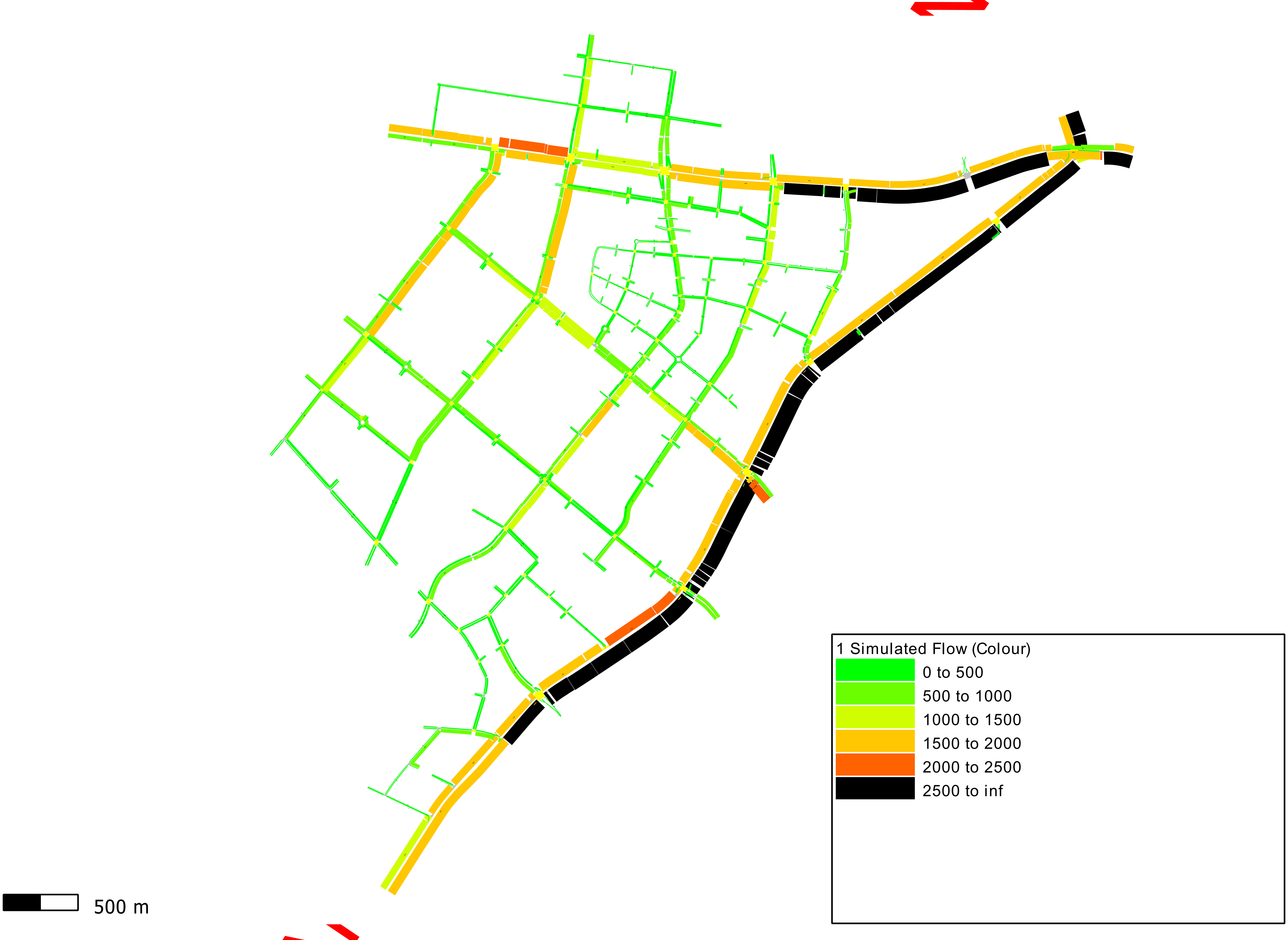
LTCP road network (2041)


500 m

Appendix J

LTCP Modelled peak hour flows (2041) based on initial land use

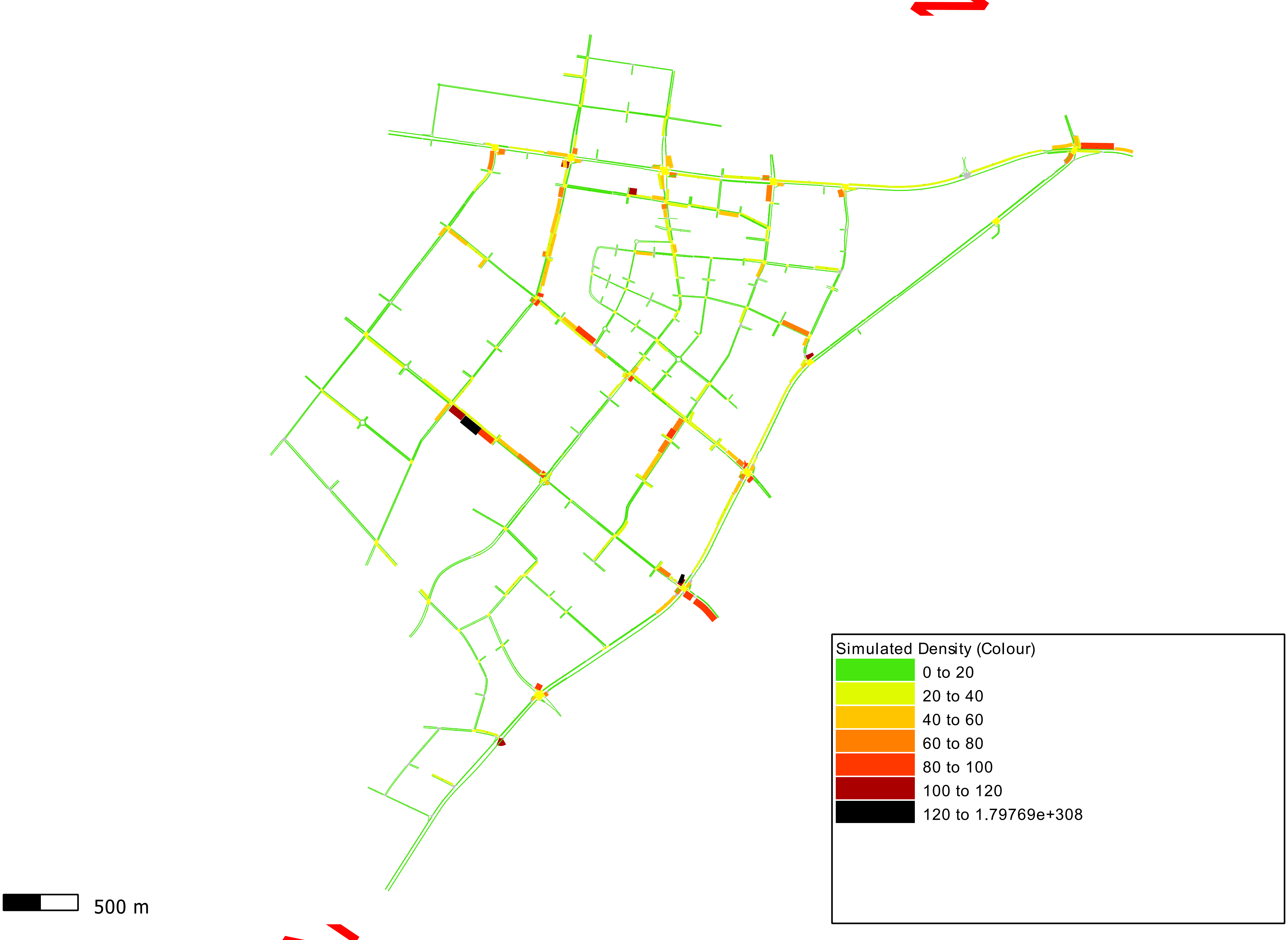

1 Simulated Flow (Colour)
0 to 500
500 to 1000
1000 to 1500
1500 to 2000
2000 to 2500
2500 to inf
500 m

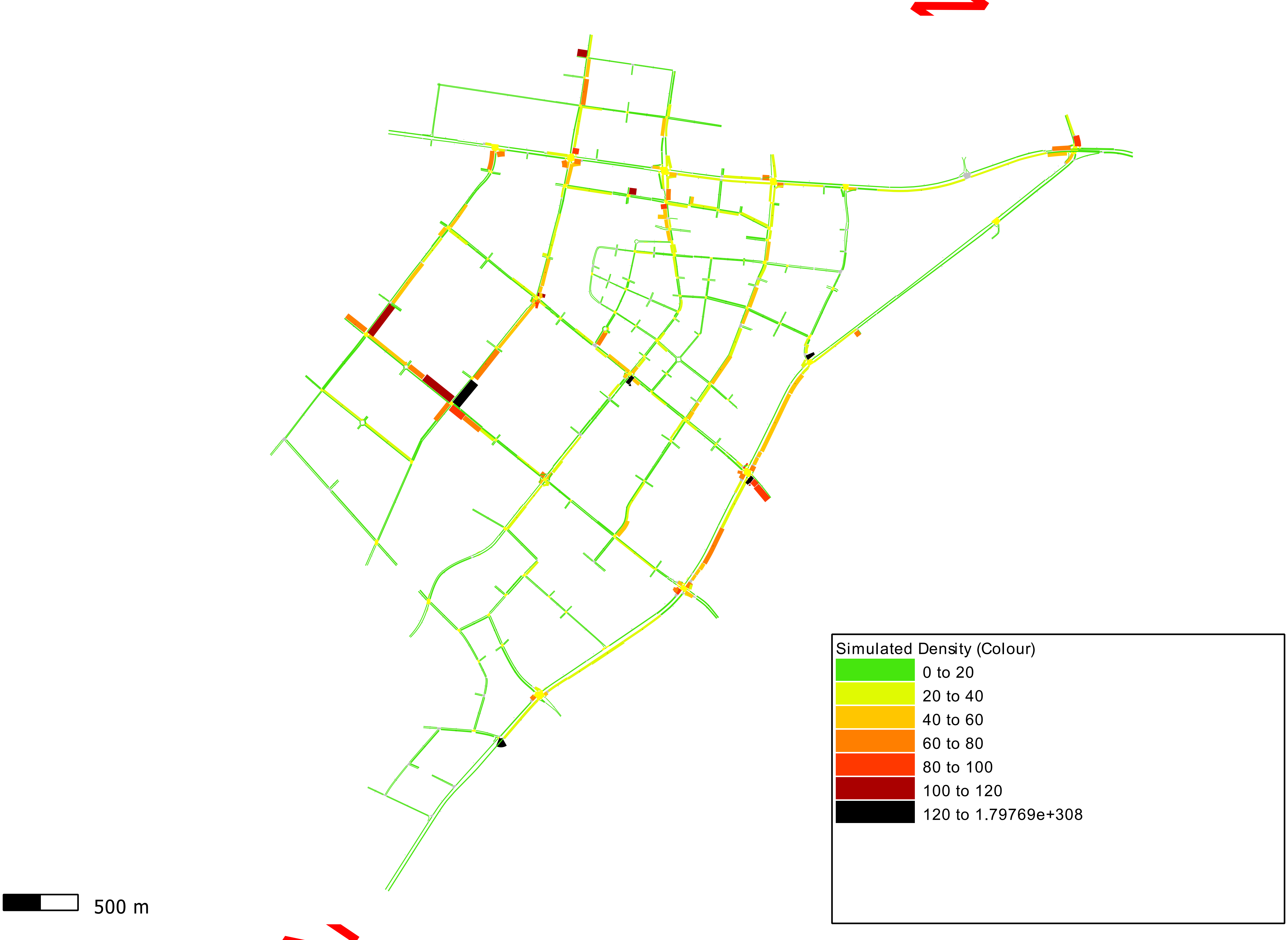


1 Simulated Flow (Colour)
0 to 500
500 to 1000
1000 to 1500
1500 to 2000
2000 to 2500
2500 to inf
500 m

Appendix K

LTCP Modelled peak hour density (2041) based on initial land use


Simulated Density (Colour)
0 to 20
20 to 40
40 to 60
60 to 80
80 to 100
100 to 120
120 to 1.79769e+308
500 m



Simulated Density (Colour)
0 to 20
20 to 40
40 to 60
60 to 80
80 to 100
100 to 120
120 to 1.79769e+308
500 m

Appendix L

LTCP Modelled peak hour delays (2041) based on initial land use


Simulated Delay Time (Colour)
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
500 m


Simulated Delay Time (Colour)
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
500 m

Appendix M

Transport for NSW recommended school trip generation rates summary

School Trip Generation – Assessment/Analysis

TfNSW undertook a trip generation survey for 22 Schools in NSW including Greater Sydney and regional area in 2014. The 2014 survey data consist of 5 primary schools and 9 secondary schools in the ***Greater Sydney Region***. The HTML (attached as part of the email) shows summarised information in a map and detailed survey data can be found in Appendix A of the 2014 survey report.

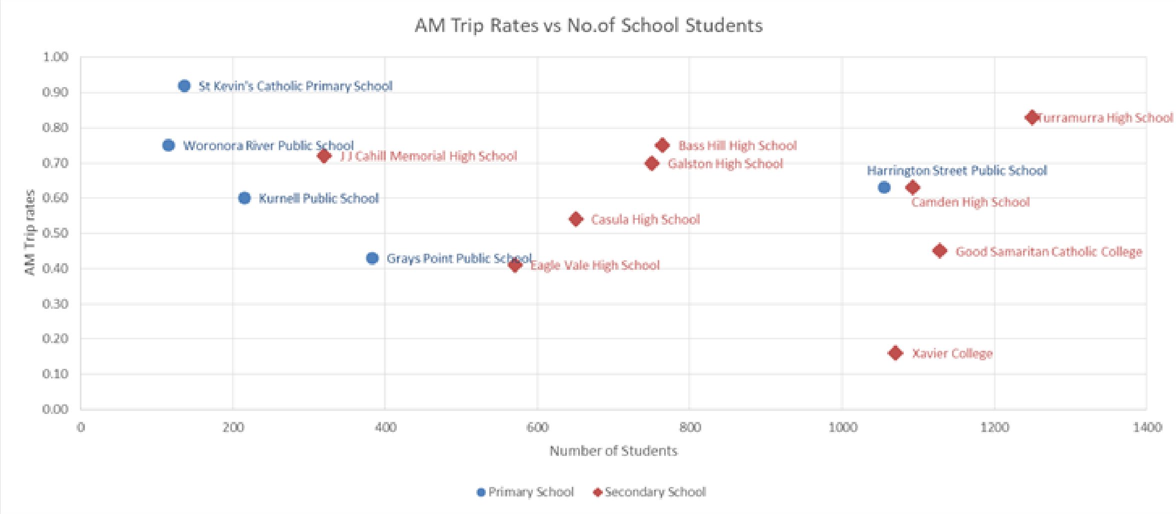
For the analysis, one primary school and four secondary schools in the vicinity of Leppington precinct were selected. The reason is being that the surveyed schools were not located in a Greenfield area and geographic factors may influence the trip rates. A summary of peak hour trip generation and peak hours are provided as below:

School	AM Peak hour	AM trip rate	PM Peak hour	PM trip rate	Type of School
Harrington Street Public School	8:15 - 9:15	0.63	15:00 - 16:00	0.52	Primary School
Good Samaritan Catholic College	7:45 - 8:45	0.72	15:15 - 16:15	0.16	Secondary
Casula High School	7:45 - 8:45	0.41	14:45 - 15:45	0.32	Secondary
Eagle Vale High School	7:45 - 8:45	0.7	14:45 - 15:45	0.51	Secondary
Camden High School	7:45 - 8:45	0.54	15:00 - 16:00	0.23	Secondary

The table below shows the observed mode share during the ***AM peak*** for the selected schools and other primary schools that have included in the original survey. On average, the car mode share for the primary school is 50% and high school is 62%.

	Observed % - Car modeshare	**Observed % - Bus modeshare**	**Observed % - Walk modeshare**
Harrington Street Public School	41%	0%	59%
Grays Point Public School	25%	8%	66%
Kurnell Public School	53%	0%	47%
St Kevin's Catholic Primary School	66%	0%	34%
Woronora River Public School	65%	0%	35%
Camden High School	58%	41%	1%
Casula High School	46%	29%	25%
Eagle Vale High School	58%	15%	27%
Good Samaritan Catholic College	84%	12%	5%

A relationship between the number of schools students and the AM trip rates were also analysed. However, there were no particular trends or patterns identified.



Recommendations

Considering that the model is being developed for the 2041 year, and the precincts will cater all necessary infrastructure to support sustainable transport, **a 25% reduction in trip generation rate is supported for the 2041 Base year model**. TfNSW also recommends Council/Arup to undertake scenario testing for further reductions of 30% and 35%.

The Model's PM peak hour is between 4:00 PM to 6:00PM. The average school trip PM peak hour is 3:00 PM to 4:00 PM. However, the PM trip rates cannot be assumed as none for the following reasons:

For Primary Schools:
- Teachers leaving late
- Schools having after school care

For Secondary Schools:
- Teachers leaving late
- Students having extra-curricular activities
- Students having after school classes

As such, it recommended to adopt 10% - 15% of School PM peak trips rates for the model's PM peak.

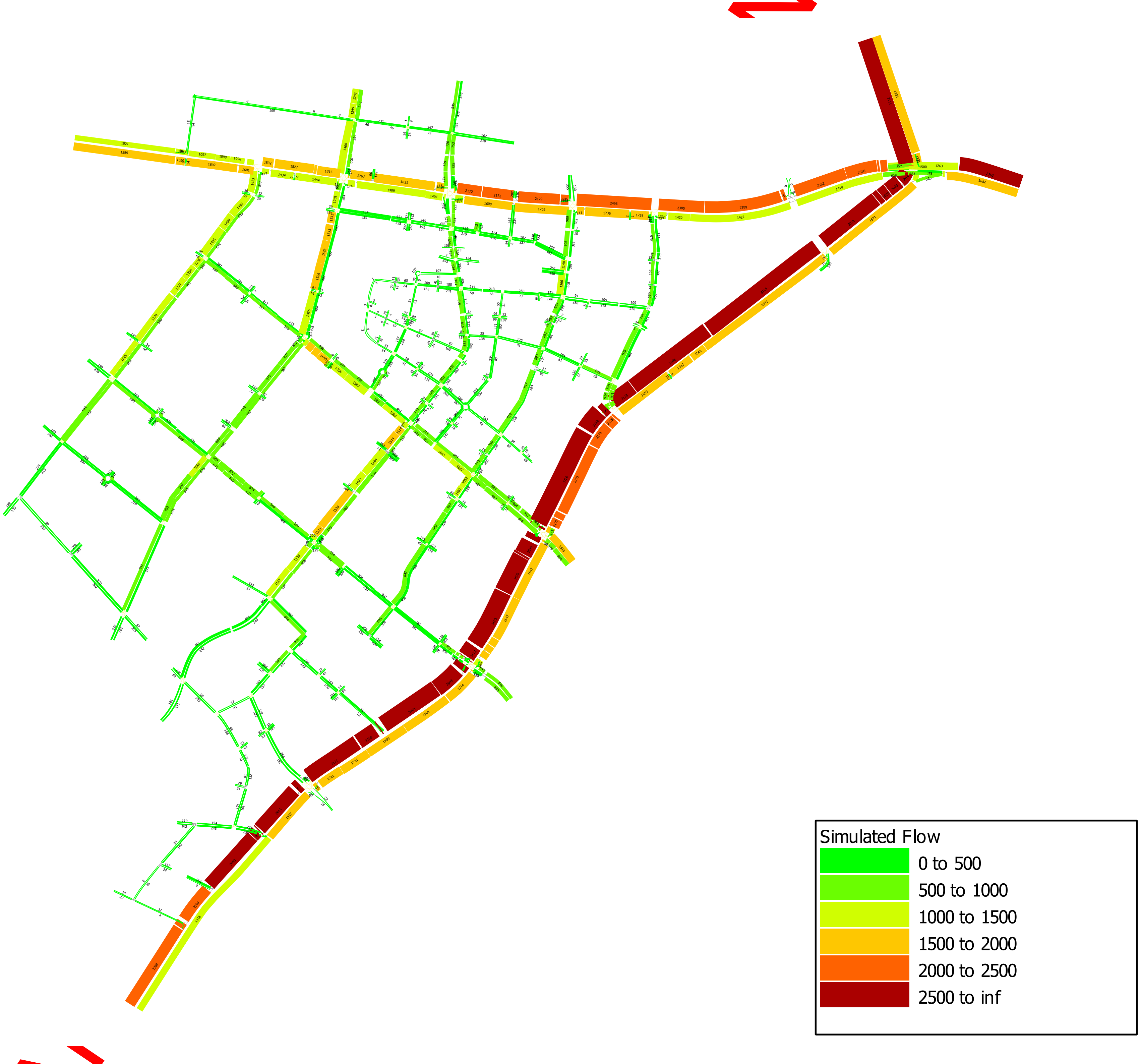
Please note that the trip rates are calculated by averaging the trip rate values for selected schools in the vicinity to Leppington precinct.

			25% reduction		***30% reduction***		***35% reduction***	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Primary School	0.63	0.52	0.47	0.39	0.44	0.36	0.41	0.34
Secondary School	0.59	0.31	0.44	0.23	0.41	0.22	0.38	0.20
Primary and Secondary combined	0.61	0.41	0.46	0.31	0.43	0.29	0.40	0.27

Appendix N

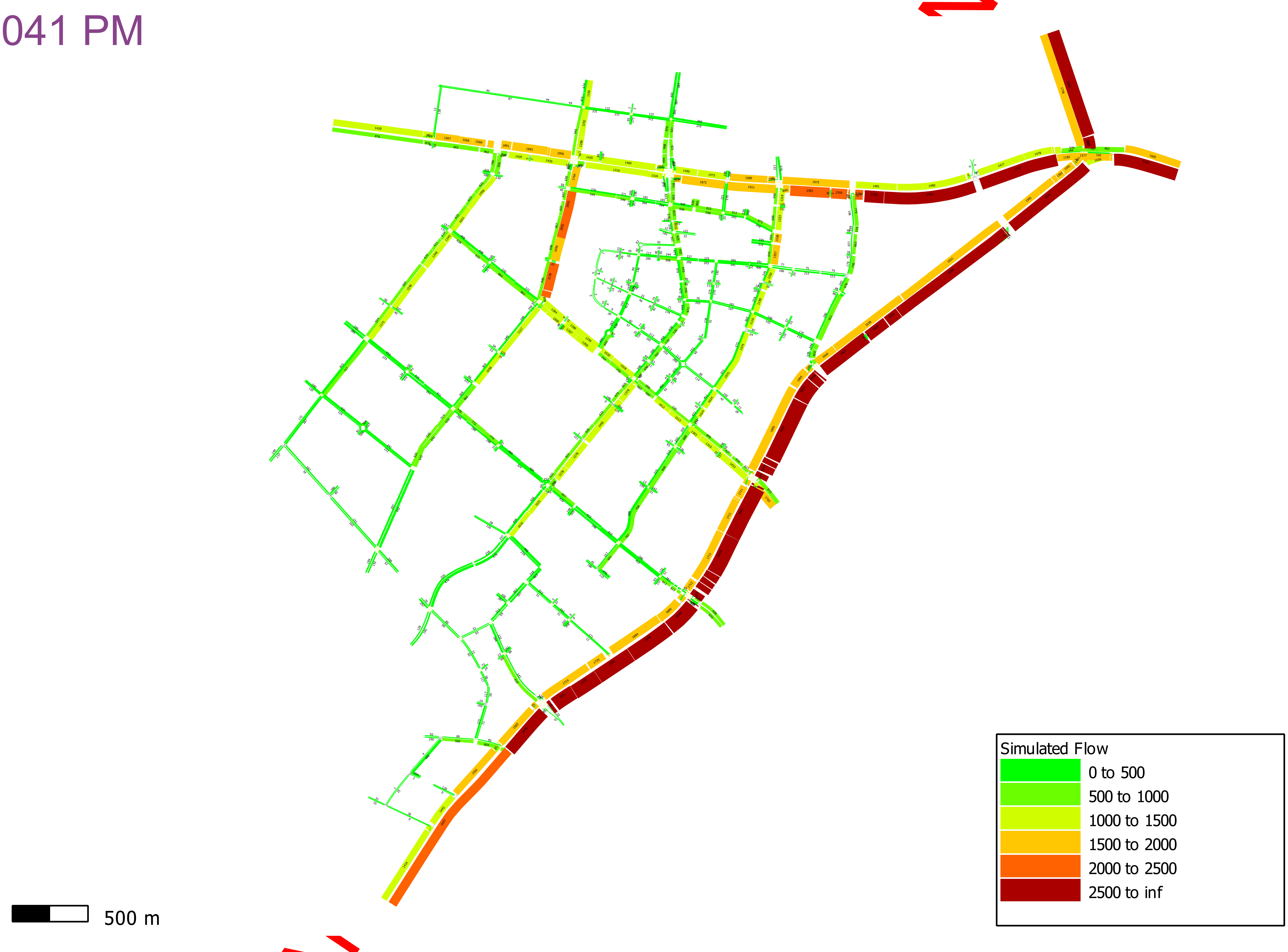
LTCP Modelled peak hour flows (2041) based on final land use

2041 AM



Simulated Flow
0 to 500
500 to 1000
1000 to 1500
1500 to 2000
2000 to 2500
2500 to inf
500 m

2041 PM

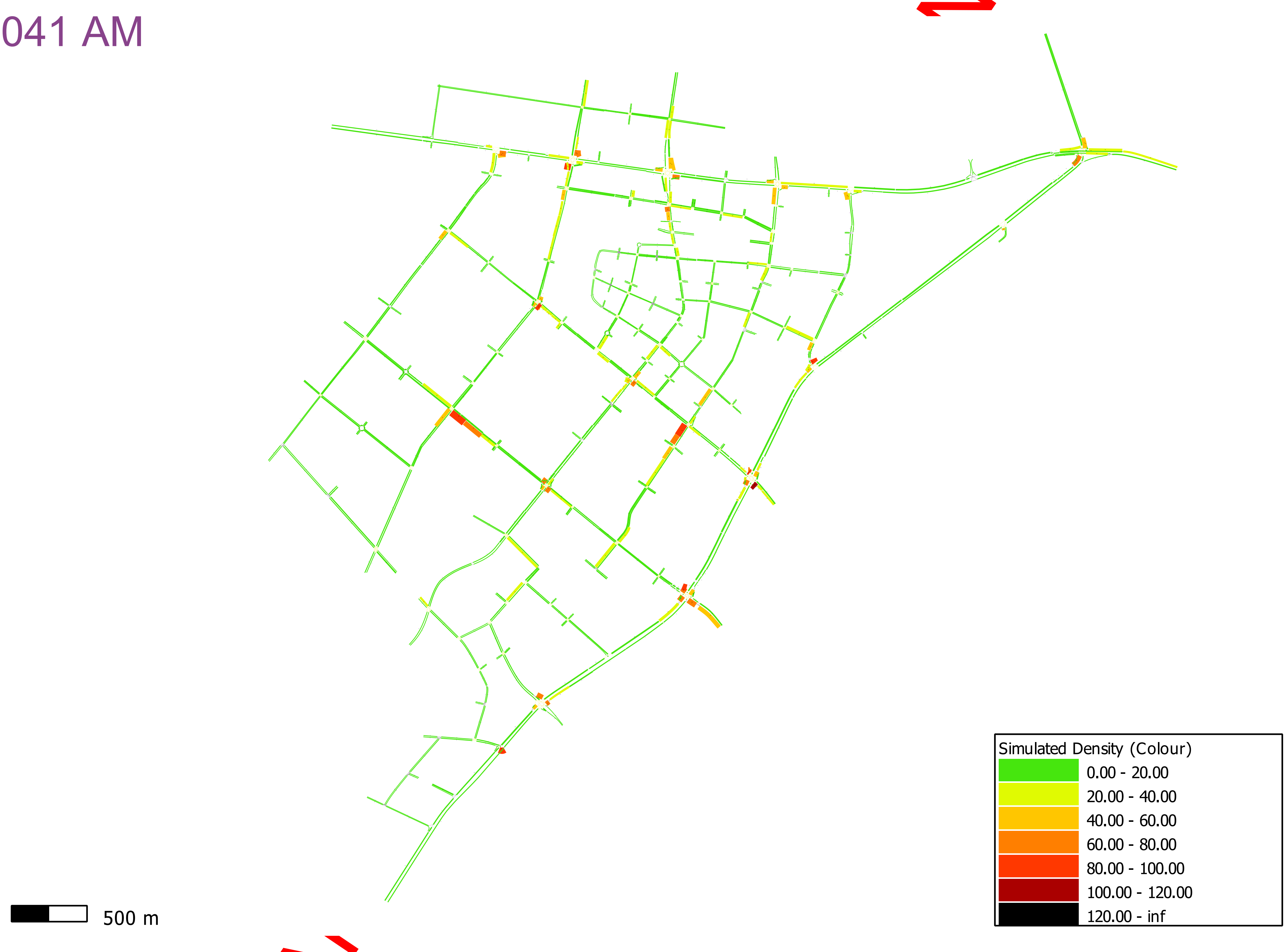


Simulated Flow
0 to 500
500 to 1000
1000 to 1500
1500 to 2000
2000 to 2500
2500 to inf
500 m

Appendix O

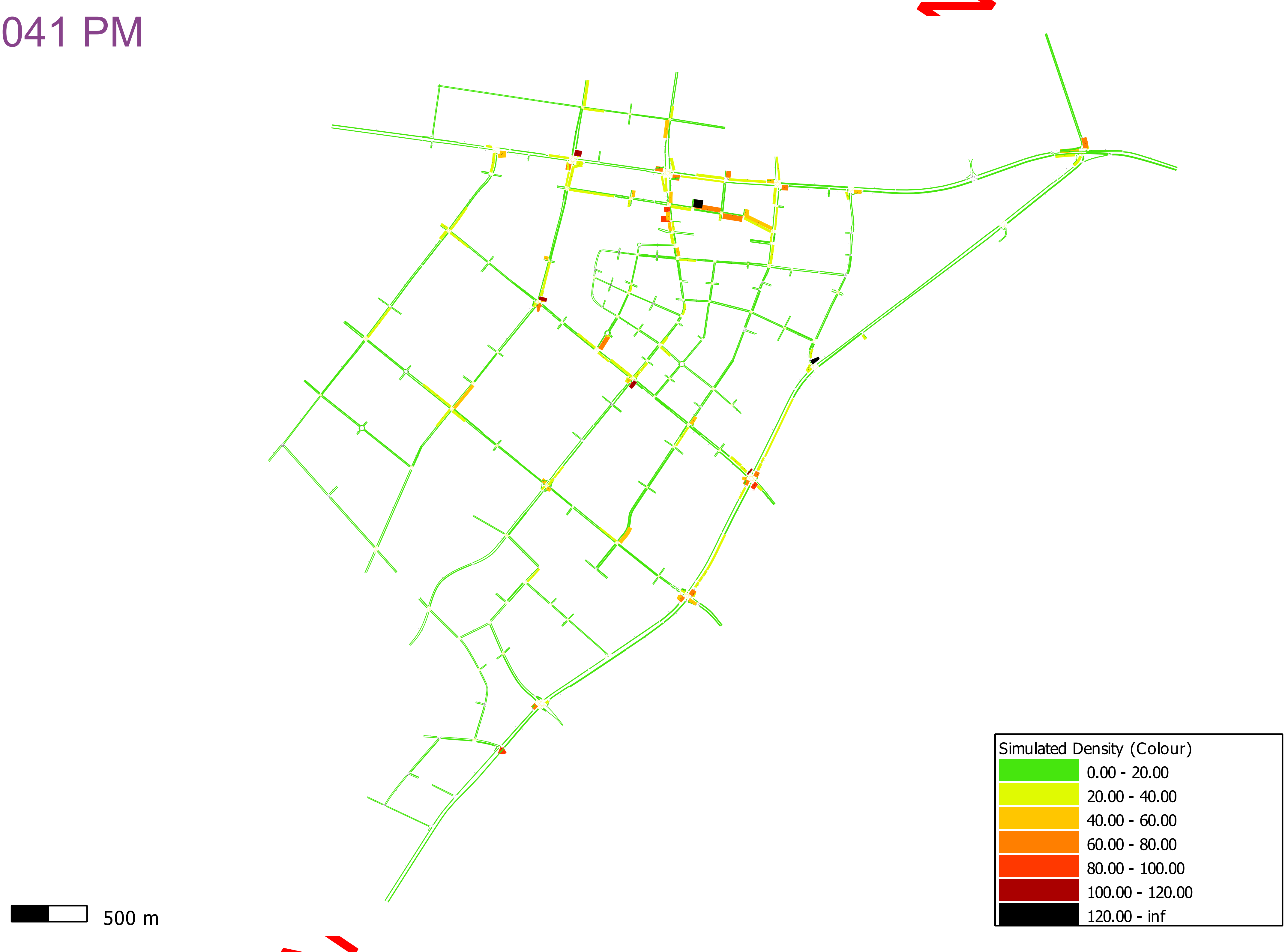
LTCP Modelled peak hour density (2041) based on final land use

2041 AM



Simulated Density (Colour)
0.00 - 20.00
20.00 - 40.00
40.00 - 60.00
60.00 - 80.00
80.00 - 100.00
100.00 - 120.00
120.00 - inf
500 m

2041 PM

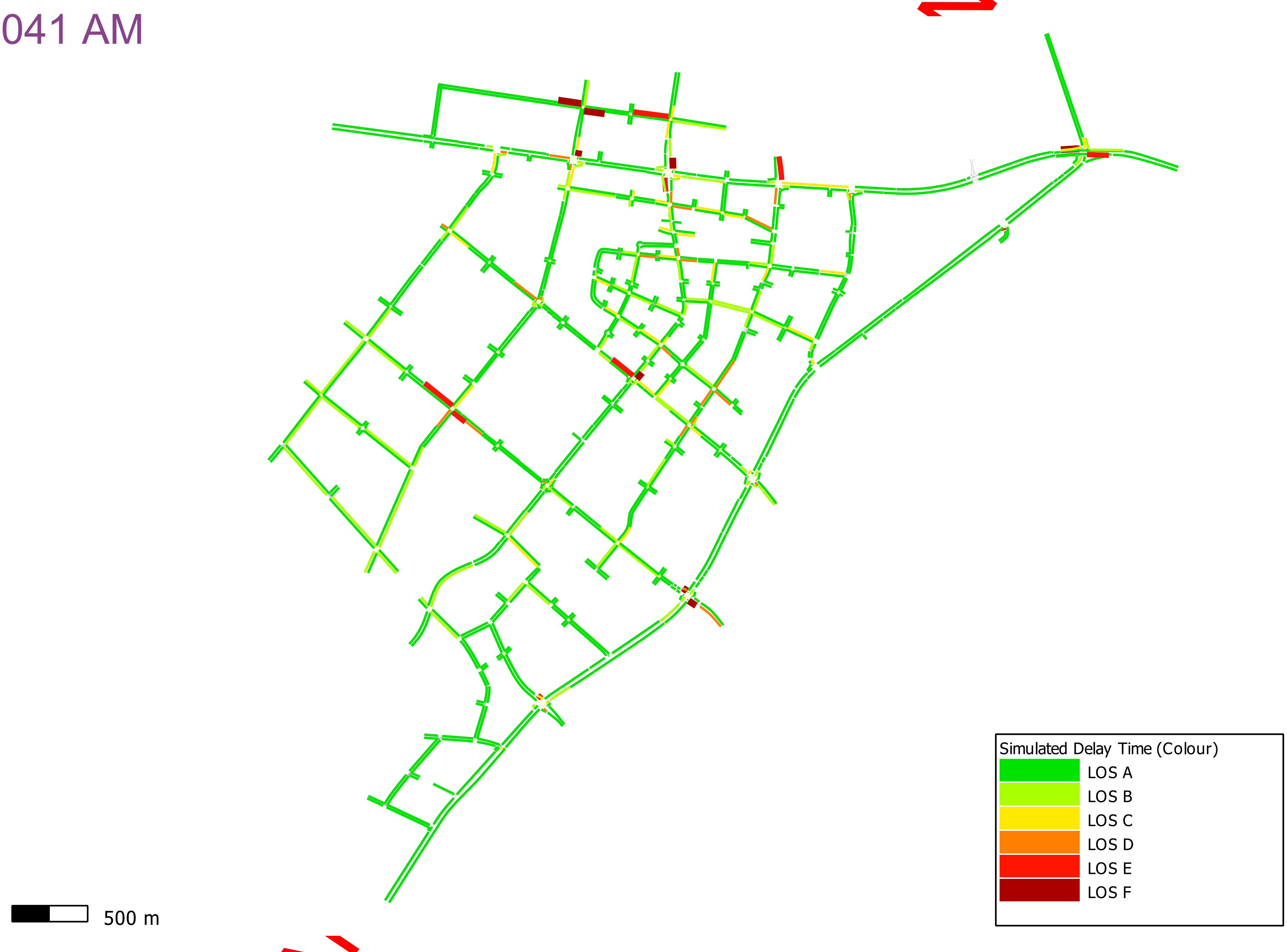


Simulated Density (Colour)
0.00 - 20.00
20.00 - 40.00
40.00 - 60.00
60.00 - 80.00
80.00 - 100.00
100.00 - 120.00
120.00 - inf
500 m

Appendix P

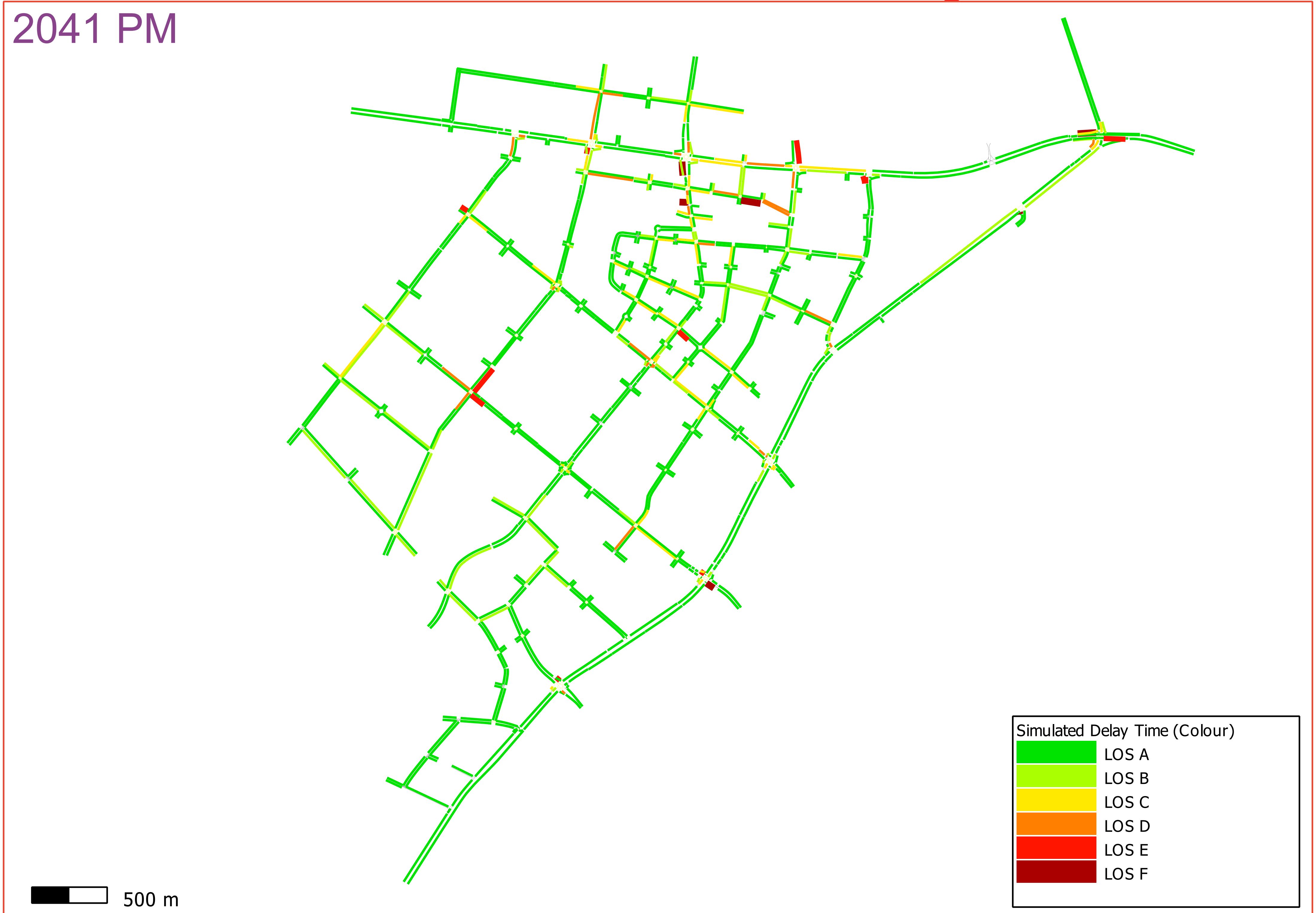
LTCP Modelled peak hour delays (2041) based on final land use

2041 AM



Simulated Delay Time (Colour)
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
500 m

2041 PM


Simulated Delay Time (Colour)
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
500 m

Appendix Q

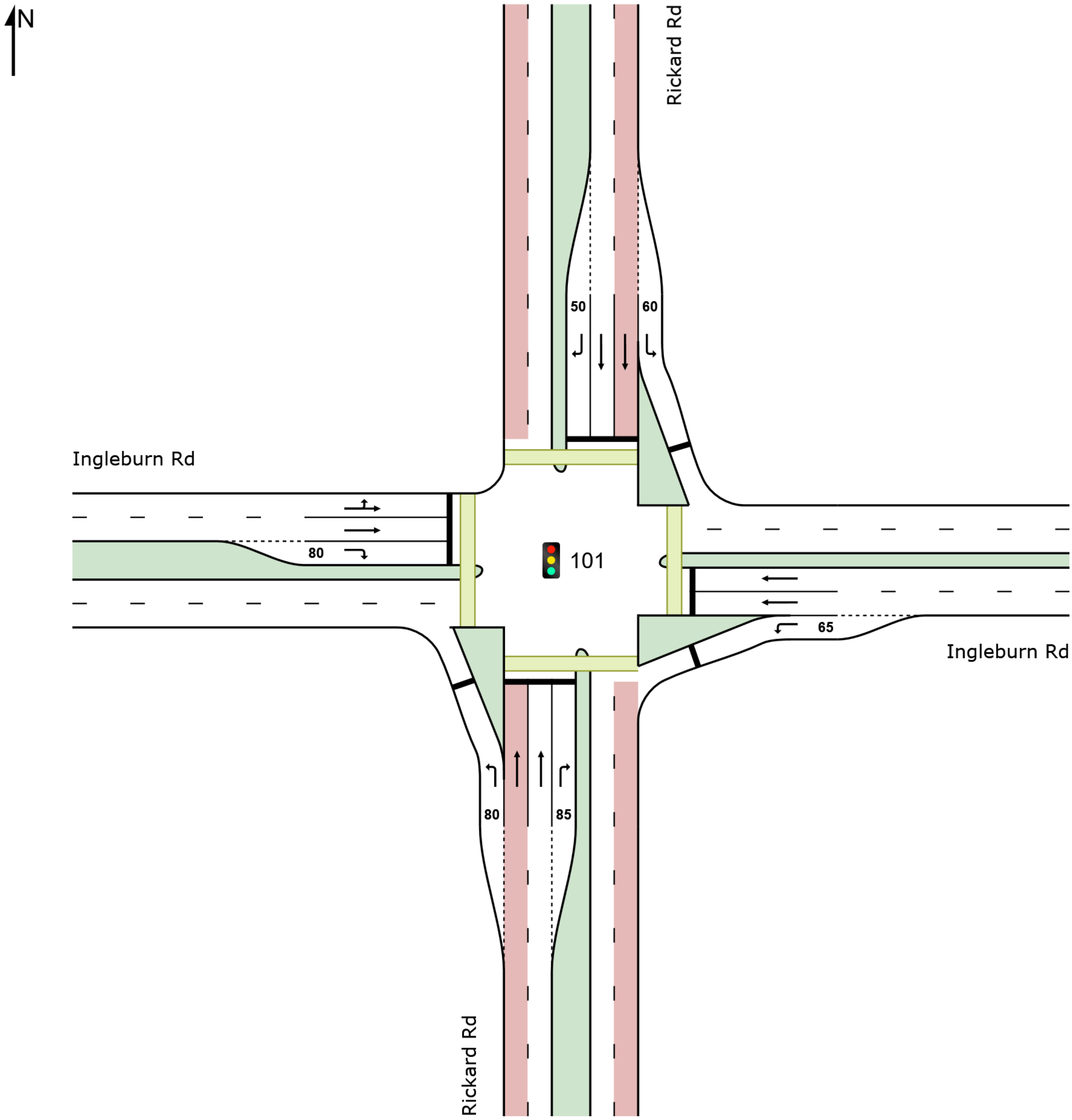
SIDRA results (2041) of intersections matching the layouts of the Aimsun model

SITE LAYOUT

Site: 101 [a] Rickard/Ingleburn_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [a] Rickard/Ingleburn_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Rickard Rd														
1	L2	371	5	391	1.3	0.349	18.0	LOS B	11.2	79.0	0.53	0.73	0.53	42.9
2	T1	639	40	673	6.3	0.966	64.3	LOS E	44.4	313.7	0.82	1.07	1.20	25.0
3	R2	537	2	565	0.4	* 1.010	106.4	LOS F	52.7	370.4	1.00	1.15	1.62	16.5
Approach		1547	47	1628	3.0	1.010	67.8	LOS E	52.7	370.4	0.81	1.01	1.18	23.5
East: Ingleburn Rd														
4	L2	238	1	251	0.4	0.206	14.1	LOS A	5.7	39.8	0.42	0.68	0.42	44.0
5	T1	636	41	669	6.4	* 0.992	94.8	LOS F	29.4	217.5	1.00	1.26	1.62	13.5
Approach		874	42	920	4.8	0.992	72.8	LOS F	29.4	217.5	0.84	1.10	1.30	18.0
North: Rickard Rd														
7	L2	23	6	24	26.1	0.064	42.3	LOS C	1.1	9.3	0.80	0.69	0.80	21.7
8	T1	222	36	234	16.2	* 0.884	65.6	LOS E	13.1	93.2	0.99	0.99	1.29	24.6
9	R2	32	9	34	28.1	0.435	69.5	LOS E	2.1	18.1	1.00	0.73	1.00	17.8
Approach		277	51	292	18.4	0.884	64.1	LOS E	13.1	93.2	0.98	0.93	1.21	23.6
West: Ingleburn Rd														
10	L2	17	7	18	41.2	0.390	51.4	LOS D	7.1	53.5	0.91	0.75	0.91	23.8
11	T1	249	10	262	4.0	0.390	45.8	LOS D	7.3	53.2	0.92	0.75	0.92	22.4
12	R2	130	3	137	2.3	* 0.999	105.8	LOS F	11.1	79.1	1.00	1.15	1.81	18.4
Approach		396	20	417	5.1	0.999	65.7	LOS E	11.1	79.1	0.94	0.88	1.21	20.5
All Vehicles		3094	160	3257	5.2	1.010	68.6	LOS E	52.7	370.4	0.85	1.01	1.22	21.7

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Rickard Rd												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
East: Ingleburn Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45
North: Rickard Rd												

P3	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Ingleburn Rd												
P4	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
All Pedestrians		200	211	54.3	LOS E	0.2	0.2	0.95	0.95	84.8	39.7	0.47

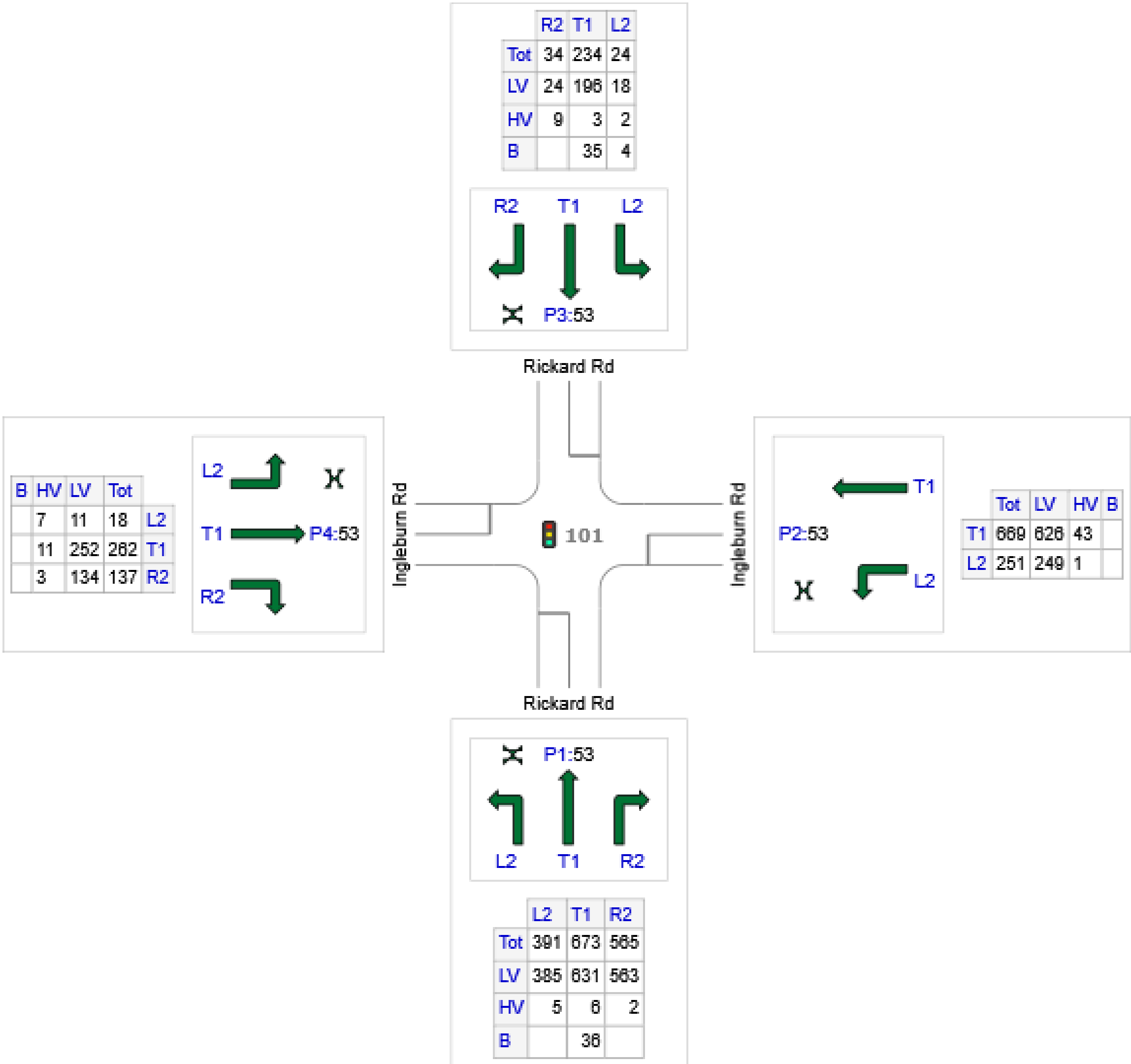
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [a] Rickard/Ingleburn_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



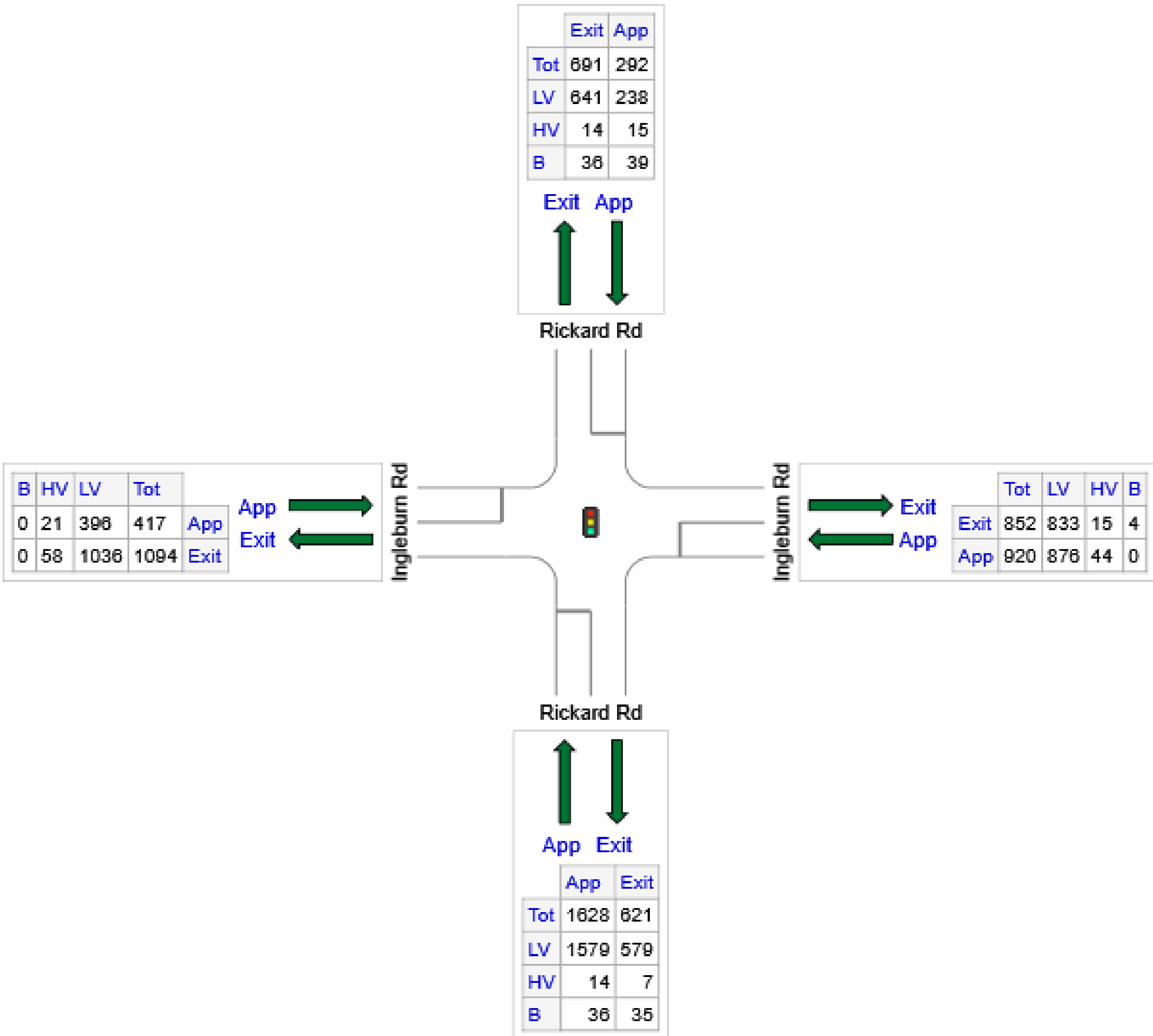
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Buses (B)
S: Rickard Rd	1628	1579	14	36
E: Ingleburn Rd	920	876	44	-
N: Rickard Rd	292	238	15	39
W: Ingleburn Rd	417	396	21	-
Total	3257	3088	94	75

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [a) Rickard/Ingleburn_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



MOVEMENT SUMMARY

Site: 101 [a] Rickard/Ingleburn_2041_PM_Aimsun (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Rickard Rd														
1	L2	217	0	228	0.0	0.360	37.3	LOS C	10.0	69.9	0.80	0.78	0.80	33.3
2	T1	339	33	357	9.7	0.440	30.8	LOS C	14.0	98.0	0.79	0.71	0.79	34.9
3	R2	159	2	167	1.3	* 1.174	236.4	LOS F	22.5	159.0	1.00	1.52	2.60	8.6
Approach		715	35	753	4.9	1.174	78.5	LOS F	22.5	159.0	0.84	0.91	1.19	21.4
East: Ingleburn Rd														
4	L2	148	4	156	2.7	0.641	60.6	LOS E	9.0	64.2	1.00	0.82	1.02	24.1
5	T1	461	24	485	5.2	* 0.965	84.5	LOS F	18.4	134.7	1.00	1.16	1.57	14.7
Approach		609	28	641	4.6	0.965	78.7	LOS F	18.4	134.7	1.00	1.08	1.44	16.9
North: Rickard Rd														
7	L2	44	7	46	15.9	0.208	55.7	LOS D	2.5	19.7	0.93	0.74	0.93	18.5
8	T1	547	34	576	6.2	0.898	48.4	LOS D	33.4	234.6	0.92	0.97	1.12	29.0
9	R2	84	14	88	16.7	0.348	44.9	LOS D	4.3	34.7	0.86	0.77	0.86	23.3
Approach		675	55	711	8.1	0.898	48.4	LOS D	33.4	234.6	0.91	0.93	1.07	27.6
West: Ingleburn Rd														
10	L2	15	6	16	40.0	0.376	38.0	LOS C	10.5	77.9	0.80	0.69	0.80	28.5
11	T1	441	23	464	5.2	0.376	31.9	LOS C	10.7	78.0	0.80	0.68	0.80	27.7
12	R2	606	6	638	1.0	* 1.157	212.7	LOS F	83.2	587.3	1.00	1.48	2.31	10.7
Approach		1062	35	1118	3.3	1.157	135.2	LOS F	83.2	587.3	0.92	1.14	1.66	13.1
All Vehicles		3061	153	3222	5.0	1.174	91.6	LOS F	83.2	587.3	0.91	1.03	1.38	17.9

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Rickard Rd												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
East: Ingleburn Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45
North: Rickard Rd												
P3	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47

West: Ingleburn Rd											
P4 Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
All Pedestrians	200	211	54.3	LOS E	0.2	0.2	0.95	0.95	84.8	39.7	0.47

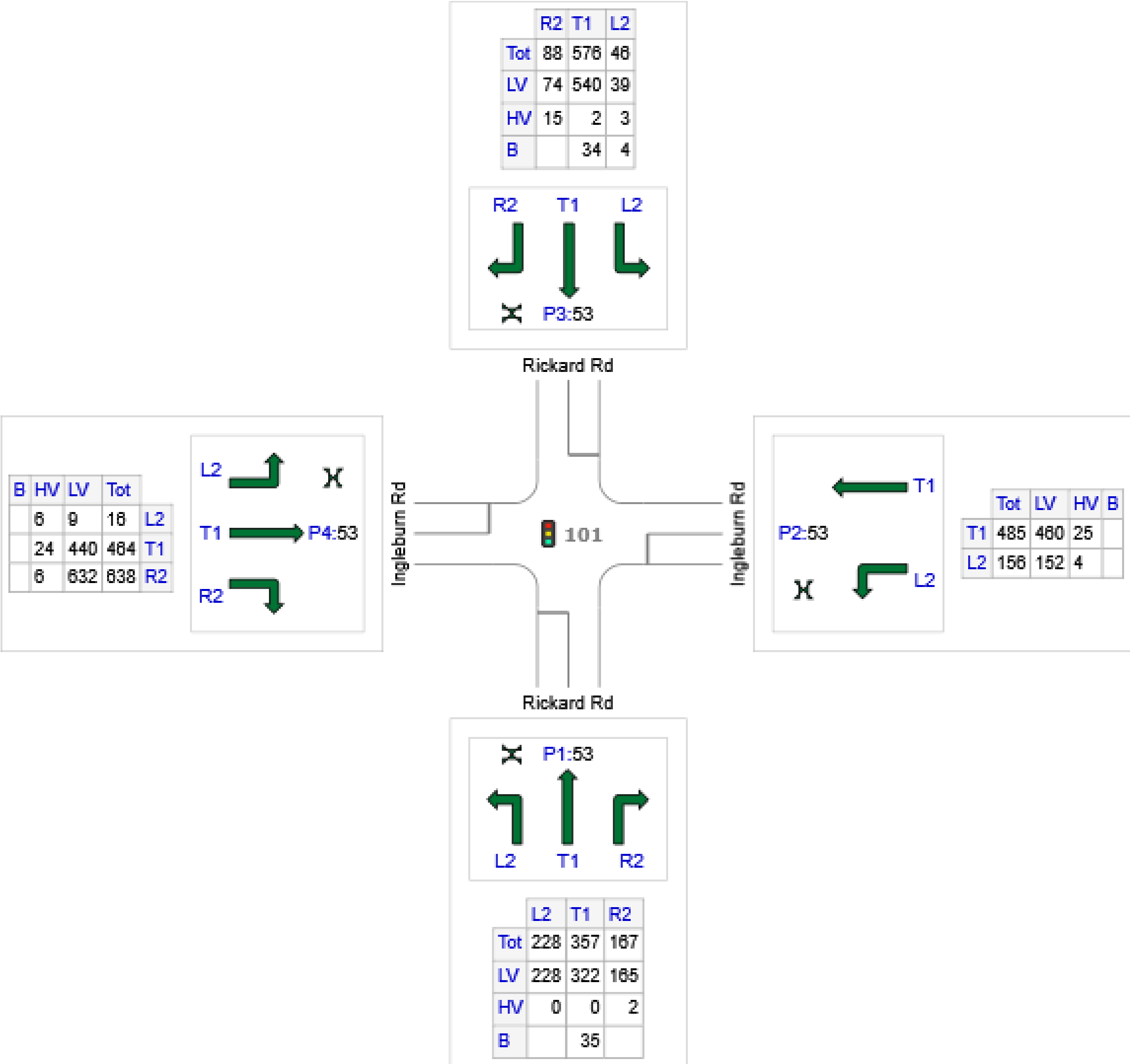
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [a) Rickard/Ingleburn_2041_PM_Aimsun (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)



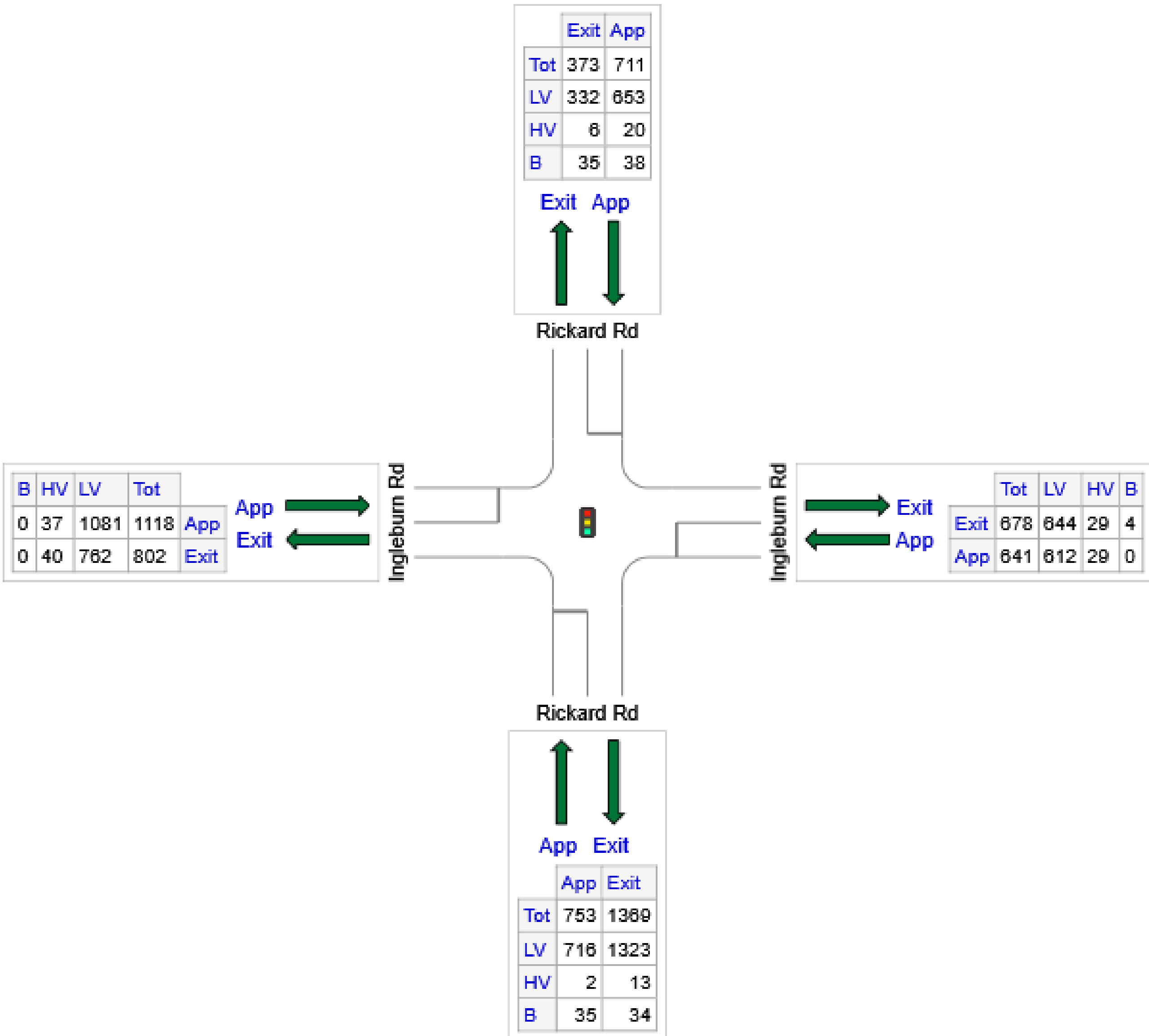
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Buses (B)
S: Rickard Rd	753	716	2	35
E: Ingleburn Rd	641	612	29	-
N: Rickard Rd	711	653	20	38
W: Ingleburn Rd	1118	1081	37	-
Total	3222	3061	88	73

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [a] Rickard/Ingleburn_2041_PM_Aimsun (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)



Rickard Rd (North):

	Exit	App
Tot	373	711
LV	332	653
HV	6	20
B	35	38

Ingleburn Rd (West):

B	HV	LV	Tot	
0	37	1081	1118	App
0	40	762	802	Exit

Ingleburn Rd (East):

	Tot	LV	HV	B
Exit	678	644	29	4
App	641	612	29	0

Rickard Rd (South):

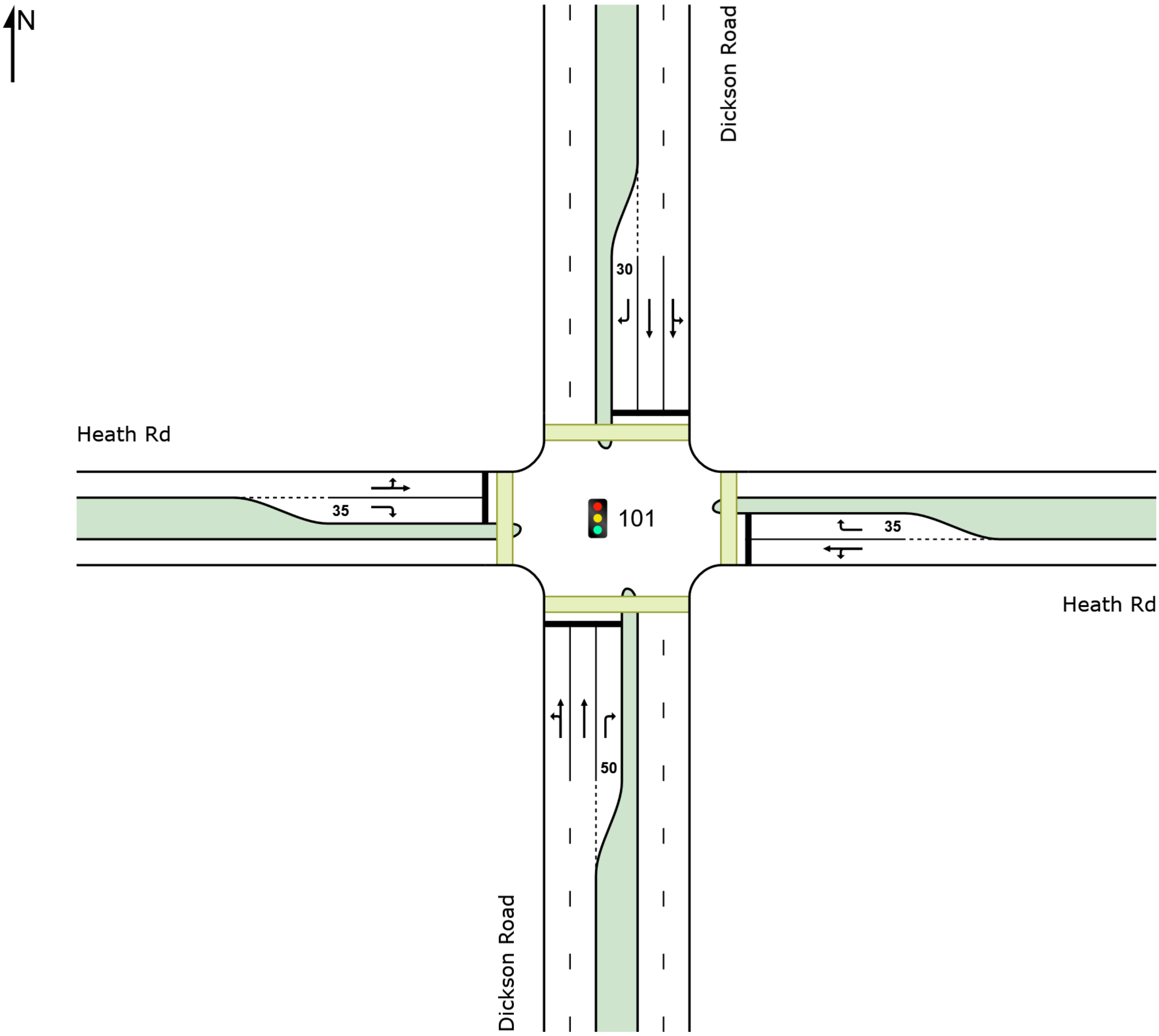
	App	Exit
Tot	753	1369
LV	716	1323
HV	2	13
B	35	34

SITE LAYOUT

Site: 101 [b) Dickson/Heath_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [b] Dickson/Heath_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Road														
1	L2	14	2	15	14.3	1.041	139.2	LOS F	31.7	224.3	1.00	1.33	1.75	17.1
2	T1	483	3	508	0.6	1.041	136.1	LOS F	31.7	224.3	1.00	1.31	1.78	17.1
3	R2	540	1	568	0.2	1.148	215.1	LOS F	79.0	553.8	1.00	1.34	2.11	12.1
Approach		1037	6	1092	0.6	1.148	177.3	LOS F	79.0	553.8	1.00	1.33	1.95	14.1
East: Heath Rd														
4	L2	80	3	84	3.8	* 1.130	197.7	LOS F	82.3	583.8	1.00	1.66	2.02	13.1
5	T1	509	6	536	1.2	1.130	193.1	LOS F	82.3	583.8	1.00	1.66	2.02	13.4
6	R2	60	1	63	1.7	0.803	84.9	LOS F	4.7	33.7	1.00	0.89	1.31	23.1
Approach		649	10	683	1.5	1.130	183.6	LOS F	82.3	583.8	1.00	1.59	1.95	13.9
North: Dickson Road														
7	L2	92	1	97	1.1	* 1.132	203.2	LOS F	43.4	307.8	1.00	1.63	2.10	13.0
8	T1	471	8	496	1.7	1.132	199.7	LOS F	43.4	307.8	1.00	1.61	2.12	12.8
9	R2	121	1	127	0.8	0.210	40.6	LOS C	6.2	43.7	0.76	0.75	0.76	31.9
Approach		684	10	720	1.5	1.132	172.0	LOS F	43.4	307.8	0.96	1.46	1.88	14.4
West: Heath Rd														
10	L2	122	0	128	0.0	0.662	48.7	LOS D	22.3	157.9	0.92	0.81	0.92	30.6
11	T1	241	5	254	2.1	0.662	44.1	LOS D	22.3	157.9	0.92	0.81	0.92	30.8
12	R2	14	2	15	14.3	0.204	79.0	LOS F	1.0	8.1	0.99	0.69	0.99	23.9
Approach		377	7	397	1.9	0.662	46.9	LOS D	22.3	157.9	0.92	0.81	0.92	30.4
All Vehicles		2747	33	2892	1.2	1.148	159.6	LOS F	82.3	583.8	0.98	1.35	1.79	15.3

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Road												
P1	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
East: Heath Rd												
P2	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	90.3	33.9	0.38

North: Dickson Road												
P3	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
West: Heath Rd												
P4	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	90.3	33.9	0.38
All Pedestrians		200	211	64.3	LOS F	0.2	0.2	0.96	0.96	92.9	37.2	0.40

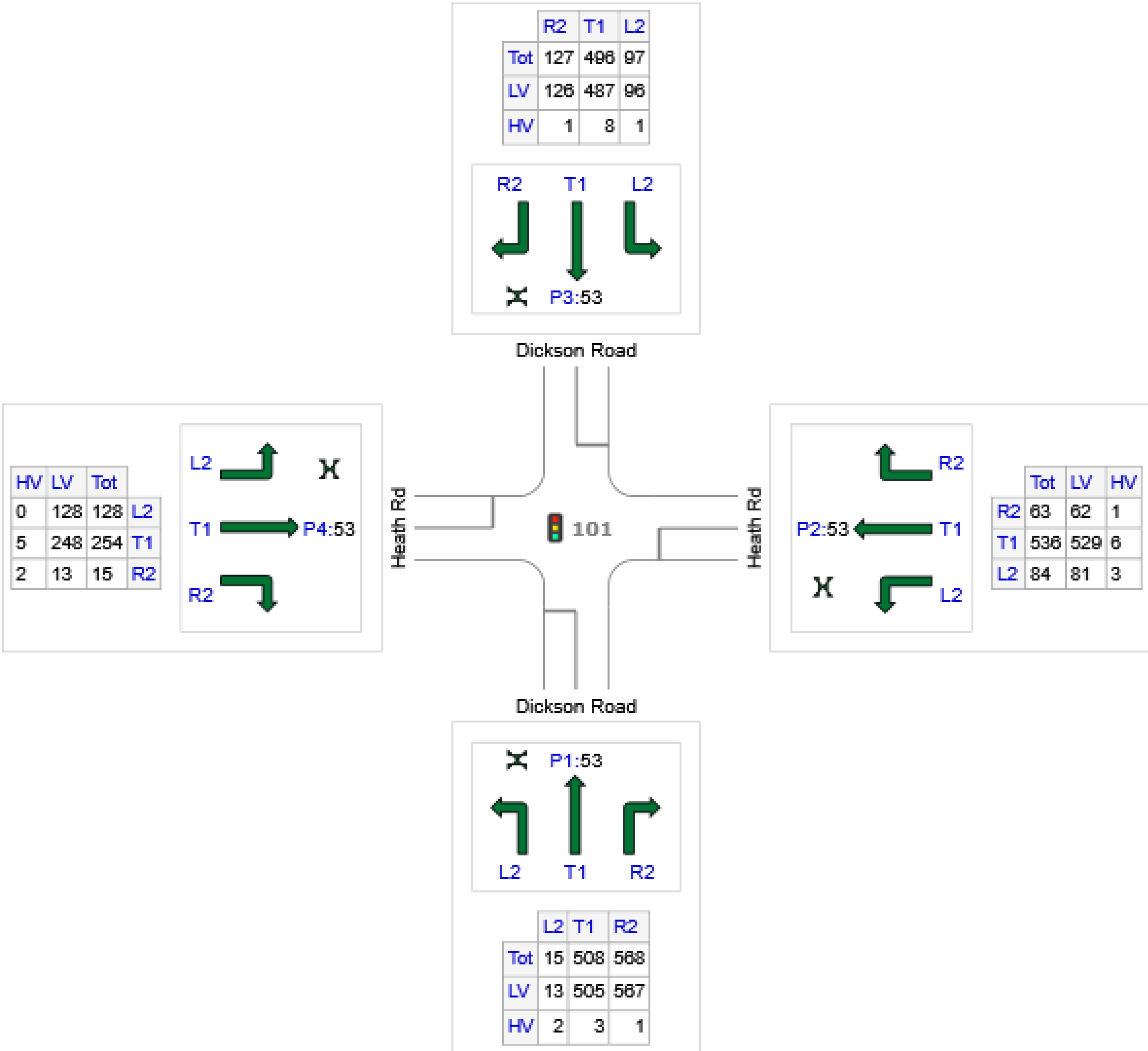
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [b) Dickson/Heath_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



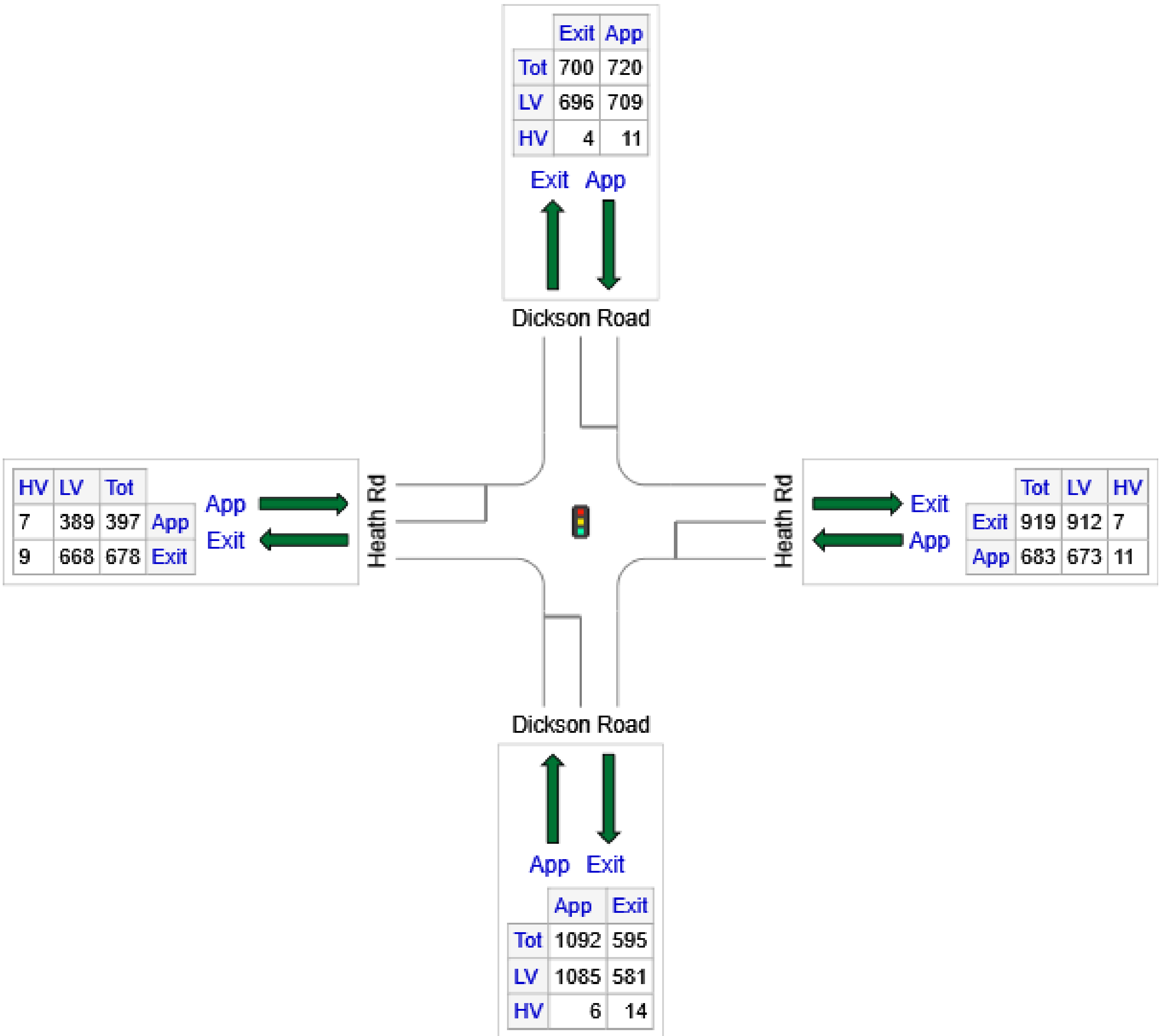
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Road	1092	1085	6
E: Heath Rd	683	673	11
N: Dickson Road	720	709	11
W: Heath Rd	397	389	7
Total	2892	2857	35

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [b) Dickson/Heath_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



MOVEMENT SUMMARY

Site: 101 [b] Dickson/Heath_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Road														
1	L2	19	0	20	0.0	0.458	64.9	LOS E	8.1	57.1	0.96	0.78	0.96	27.6
2	T1	223	2	235	0.9	0.458	60.9	LOS E	8.1	57.1	0.96	0.78	0.96	27.7
3	R2	294	2	309	0.7	* 0.808	62.3	LOS E	20.5	144.4	0.97	0.89	1.08	27.4
Approach		536	4	564	0.7	0.808	61.8	LOS E	20.5	144.4	0.97	0.84	1.02	27.5
East: Heath Rd														
4	L2	84	1	88	1.2	0.668	55.5	LOS D	17.3	122.8	0.95	0.81	0.95	29.4
5	T1	186	3	196	1.6	0.668	50.9	LOS D	17.3	122.8	0.95	0.81	0.95	29.2
6	R2	30	1	32	3.3	* 0.406	79.9	LOS F	2.3	16.2	1.00	0.72	1.00	23.8
Approach		300	5	316	1.7	0.668	55.1	LOS D	17.3	122.8	0.95	0.80	0.95	28.6
North: Dickson Road														
7	L2	180	2	189	1.1	0.801	53.3	LOS D	30.9	217.2	0.98	0.90	1.02	29.4
8	T1	586	0	617	0.0	* 0.801	48.4	LOS D	30.9	217.2	0.93	0.86	1.00	30.8
9	R2	221	0	233	0.0	0.455	34.4	LOS C	10.6	74.2	0.72	0.76	0.72	33.8
Approach		987	2	1039	0.2	0.801	46.1	LOS D	30.9	217.2	0.89	0.84	0.94	31.2
West: Heath Rd														
10	L2	17	0	18	0.0	0.791	60.6	LOS E	22.9	161.6	0.99	0.91	1.06	28.1
11	T1	312	3	328	1.0	* 0.791	56.0	LOS D	22.9	161.6	0.99	0.91	1.06	28.3
12	R2	20	0	21	0.0	0.265	78.8	LOS F	1.5	10.4	1.00	0.70	1.00	24.1
Approach		349	3	367	0.9	0.791	57.6	LOS E	22.9	161.6	0.99	0.89	1.05	28.0
All Vehicles		2172	14	2286	0.6	0.808	53.1	LOS D	30.9	217.2	0.93	0.85	0.98	29.3

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Road												
P1	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
East: Heath Rd												
P2	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	90.3	33.9	0.38

North: Dickson Road												
P3	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
West: Heath Rd												
P4	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	90.3	33.9	0.38
All Pedestrians		200	211	64.3	LOS F	0.2	0.2	0.96	0.96	92.9	37.2	0.40

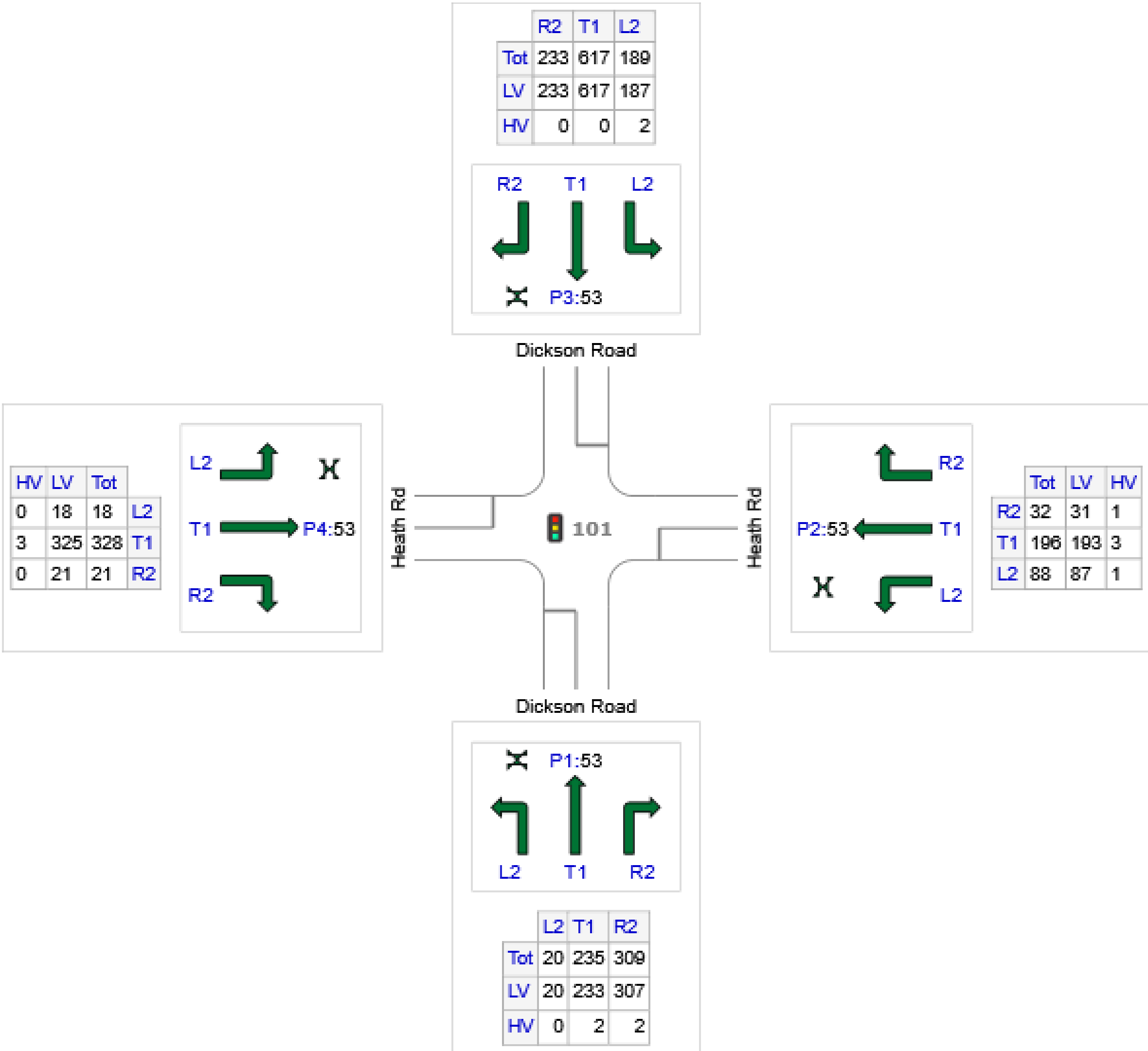
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [b] Dickson/Heath_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



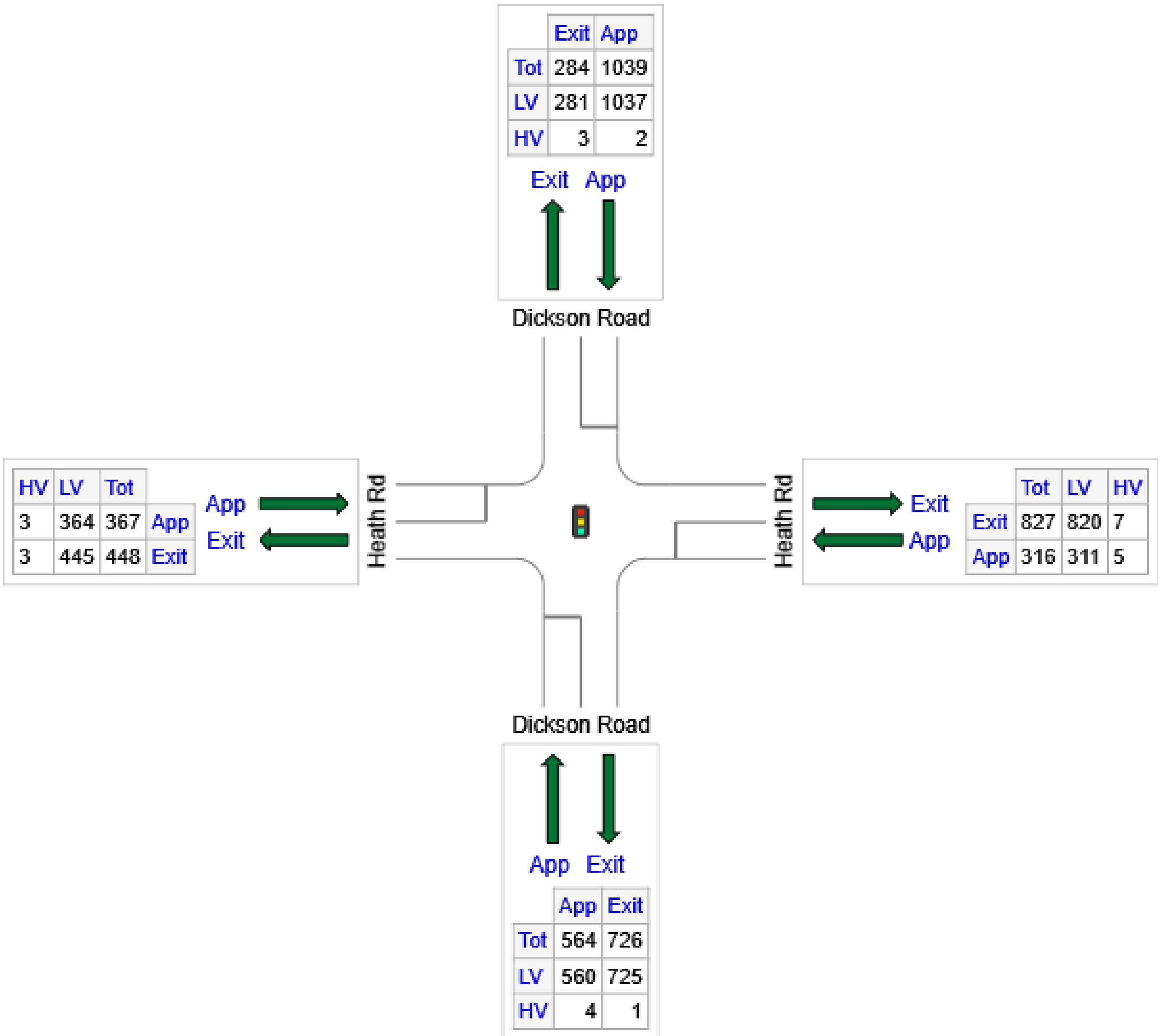
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Road	564	560	4
E: Heath Rd	316	311	5
N: Dickson Road	1039	1037	2
W: Heath Rd	367	364	3
Total	2286	2272	15

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [b] Dickson/Heath_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

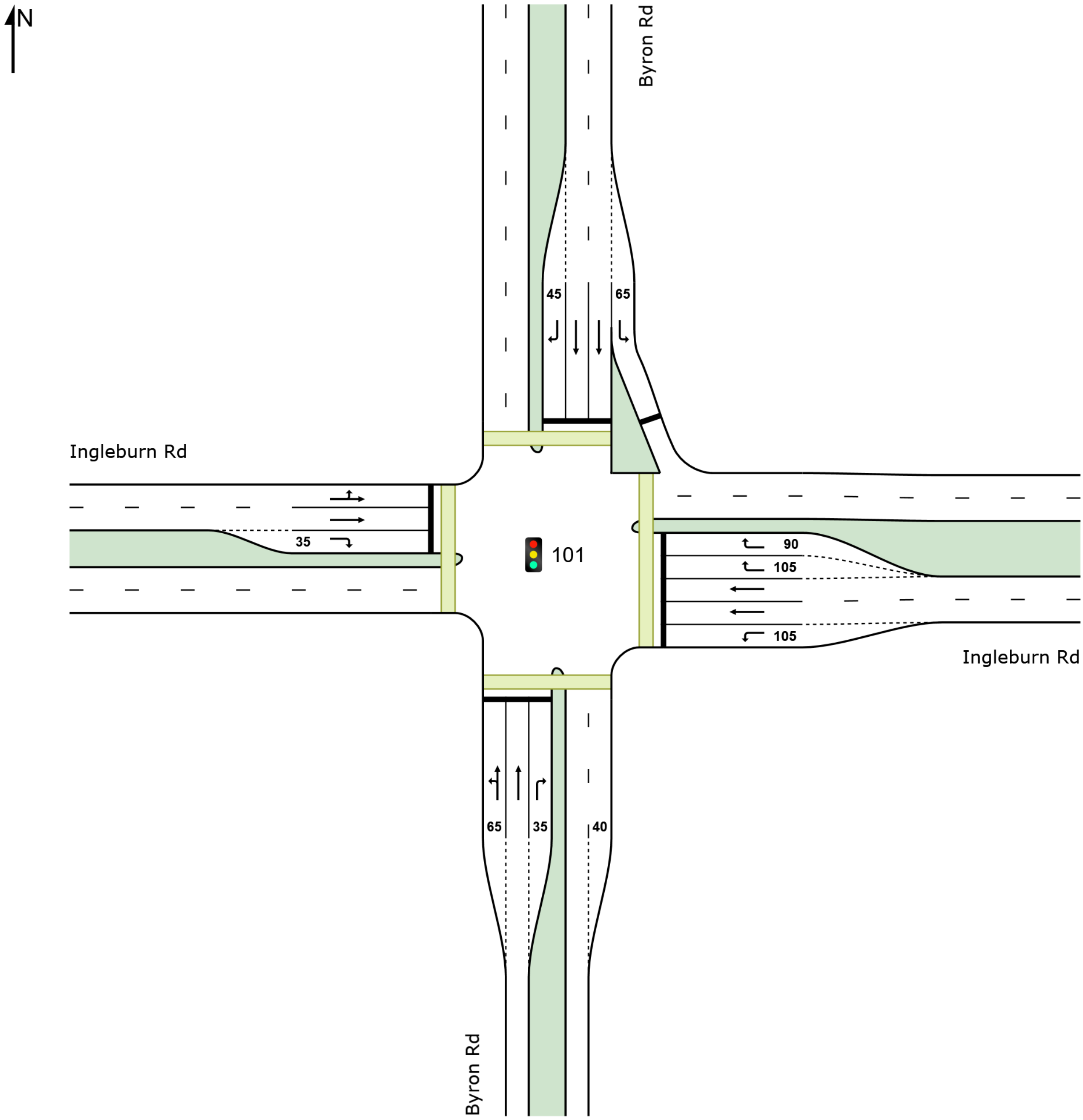


SITE LAYOUT

Site: 101 [c) Ingleburn/Byron_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [c] Ingleburn/Byron_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Byron Rd														
1	L2	138	1	145	0.7	* 0.705	28.8	LOS C	17.1	120.4	0.92	0.81	0.92	35.1
2	T1	685	2	721	0.3	0.705	24.5	LOS B	17.2	120.4	0.92	0.80	0.92	36.6
3	R2	215	0	226	0.0	* 0.943	88.1	LOS F	18.1	126.6	0.93	1.07	1.41	23.5
Approach		1038	3	1093	0.3	0.943	38.3	LOS C	18.1	126.6	0.92	0.86	1.02	31.9
East: Ingleburn Rd														
4	L2	97	3	102	3.1	0.102	21.7	LOS B	3.2	23.3	0.50	0.70	0.50	41.1
5	T1	911	62	959	6.8	* 0.954	81.3	LOS F	41.6	308.5	1.00	1.15	1.34	22.1
6	R2	45	0	47	0.0	0.298	80.1	LOS F	1.7	11.7	1.00	0.71	1.00	22.0
Approach		1053	65	1108	6.2	0.954	75.8	LOS F	41.6	308.5	0.95	1.09	1.25	23.4
North: Byron Rd														
7	L2	24	5	25	20.8	0.043	36.2	LOS C	1.1	9.0	0.67	0.68	0.67	33.3
8	T1	242	2	255	0.8	0.356	43.8	LOS D	10.4	73.6	0.83	0.72	0.83	29.2
9	R2	48	0	51	0.0	0.200	64.1	LOS E	3.1	21.7	0.93	0.74	0.93	20.1
Approach		314	7	331	2.2	0.356	46.3	LOS D	10.4	73.6	0.83	0.72	0.83	28.1
West: Ingleburn Rd														
10	L2	37	2	39	5.4	* 0.712	59.7	LOS E	23.1	165.3	0.96	0.86	0.96	22.0
11	T1	660	14	695	2.1	0.712	51.0	LOS D	23.1	165.3	0.95	0.84	0.95	28.9
12	R2	33	2	35	6.1	0.455	81.3	LOS F	2.5	18.3	1.00	0.73	1.00	21.0
Approach		730	18	768	2.5	0.712	52.8	LOS D	23.1	165.3	0.95	0.83	0.95	28.1
All Vehicles		3135	93	3300	3.0	0.954	55.1	LOS D	41.6	308.5	0.93	0.92	1.06	27.4

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Byron Rd												
P1	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
East: Ingleburn Rd												
P2	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	100.5	47.1	0.47

North: Byron Rd											
P3	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
West: Ingleburn Rd											
P4	Full	50	53	33.8	LOS D	0.1	0.1	0.92	0.92	64.9	40.5	0.62
All Pedestrians		200	211	56.7	LOS E	0.2	0.2	0.95	0.95	89.1	42.2	0.47

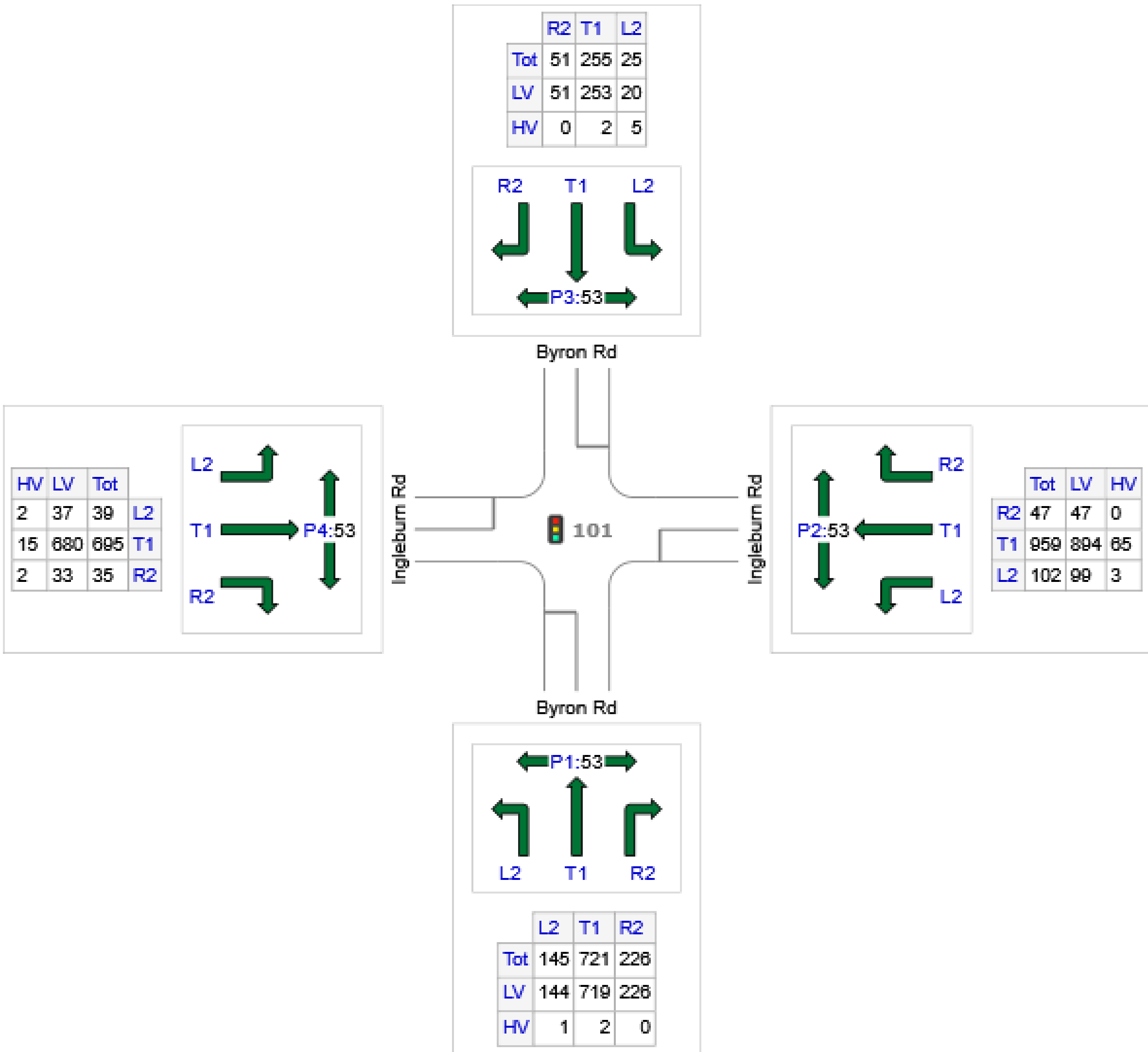
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [c] Ingleburn/Byron_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



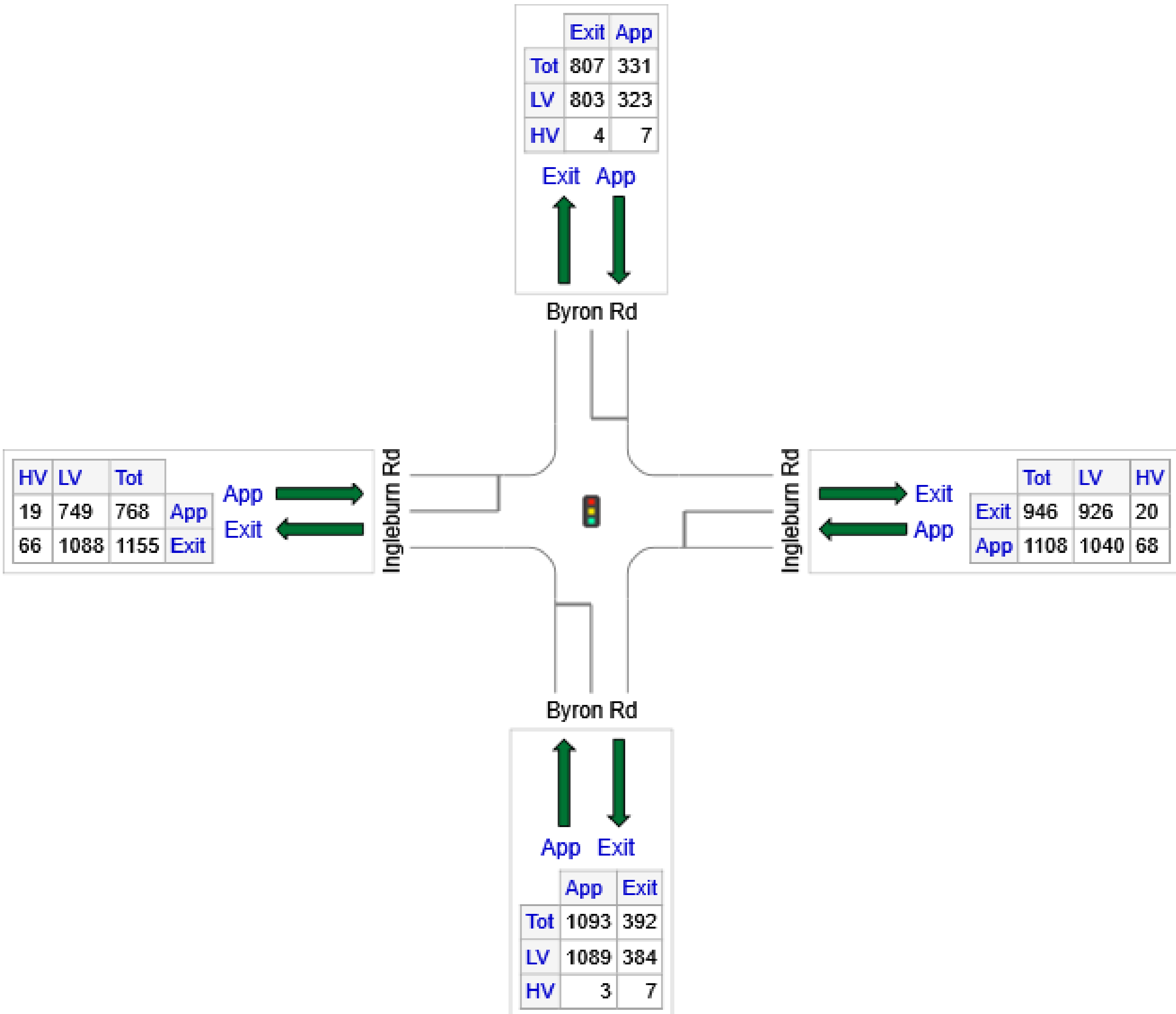
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Byron Rd	1093	1089	3
E: Ingleburn Rd	1108	1040	68
N: Byron Rd	331	323	7
W: Ingleburn Rd	768	749	19
Total	3300	3202	98

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [c] Ingleburn/Byron_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



Byron Rd (north):

	Exit	App
Tot	807	331
LV	803	323
HV	4	7

Ingleburn Rd (west):

HV	LV	Tot	
19	749	768	App
66	1088	1155	Exit

Ingleburn Rd (east):

	Tot	LV	HV
Exit	946	926	20
App	1108	1040	68

Byron Rd (south):

	App	Exit
Tot	1093	392
LV	1089	384
HV	3	7

MOVEMENT SUMMARY

Site: 101 [c] Ingleburn/Byron_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Byron Rd														
1	L2	21	1	22	4.8	0.437	35.5	LOS C	5.2	36.6	0.94	0.76	0.94	32.5
2	T1	233	1	245	0.4	* 0.437	31.2	LOS C	5.2	36.7	0.95	0.76	0.95	33.8
3	R2	27	0	28	0.0	0.165	68.9	LOS E	1.8	12.8	0.96	0.72	0.96	26.8
Approach		281	2	296	0.7	0.437	35.1	LOS C	5.2	36.7	0.95	0.75	0.95	32.7
East: Ingleburn Rd														
4	L2	214	2	225	0.9	0.259	31.3	LOS C	9.1	64.1	0.64	0.75	0.64	37.8
5	T1	1017	31	1071	3.0	* 0.918	64.0	LOS E	41.7	299.6	0.99	1.06	1.21	25.6
6	R2	205	0	216	0.0	0.478	68.8	LOS E	7.0	49.3	0.98	0.79	0.98	24.1
Approach		1436	33	1512	2.3	0.918	59.8	LOS E	41.7	299.6	0.94	0.97	1.09	27.0
North: Byron Rd														
7	L2	295	0	311	0.0	0.325	26.5	LOS B	12.1	84.9	0.62	0.75	0.62	37.9
8	T1	718	0	756	0.0	* 0.896	53.1	LOS D	39.8	278.8	0.92	0.92	1.04	26.8
9	R2	68	1	72	1.5	0.160	50.2	LOS D	3.8	27.1	0.83	0.75	0.83	23.3
Approach		1081	1	1138	0.1	0.896	45.7	LOS D	39.8	278.8	0.84	0.86	0.92	28.9
West: Ingleburn Rd														
10	L2	68	0	72	0.0	0.484	49.0	LOS D	13.2	96.5	0.89	0.79	0.89	24.8
11	T1	342	27	360	7.9	0.484	44.4	LOS D	13.2	96.5	0.88	0.75	0.88	30.7
12	R2	80	2	84	2.5	* 0.923	93.9	LOS F	6.7	48.1	1.00	0.99	1.55	19.2
Approach		490	29	516	5.9	0.923	53.1	LOS D	13.2	96.5	0.90	0.80	0.99	27.3
All Vehicles		3288	65	3461	2.0	0.923	52.1	LOS D	41.7	299.6	0.90	0.89	1.01	28.0

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Byron Rd												
P1	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
East: Ingleburn Rd												
P2	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	100.5	47.1	0.47

North: Byron Rd												
P3	Full	50	53	64.3	LOS F	0.2	0.2	0.96	0.96	95.4	40.5	0.42
West: Ingleburn Rd												
P4	Full	50	53	30.9	LOS D	0.1	0.1	0.92	0.92	62.1	40.5	0.65
All Pedestrians		200	211	55.9	LOS E	0.2	0.2	0.95	0.95	88.4	42.2	0.48

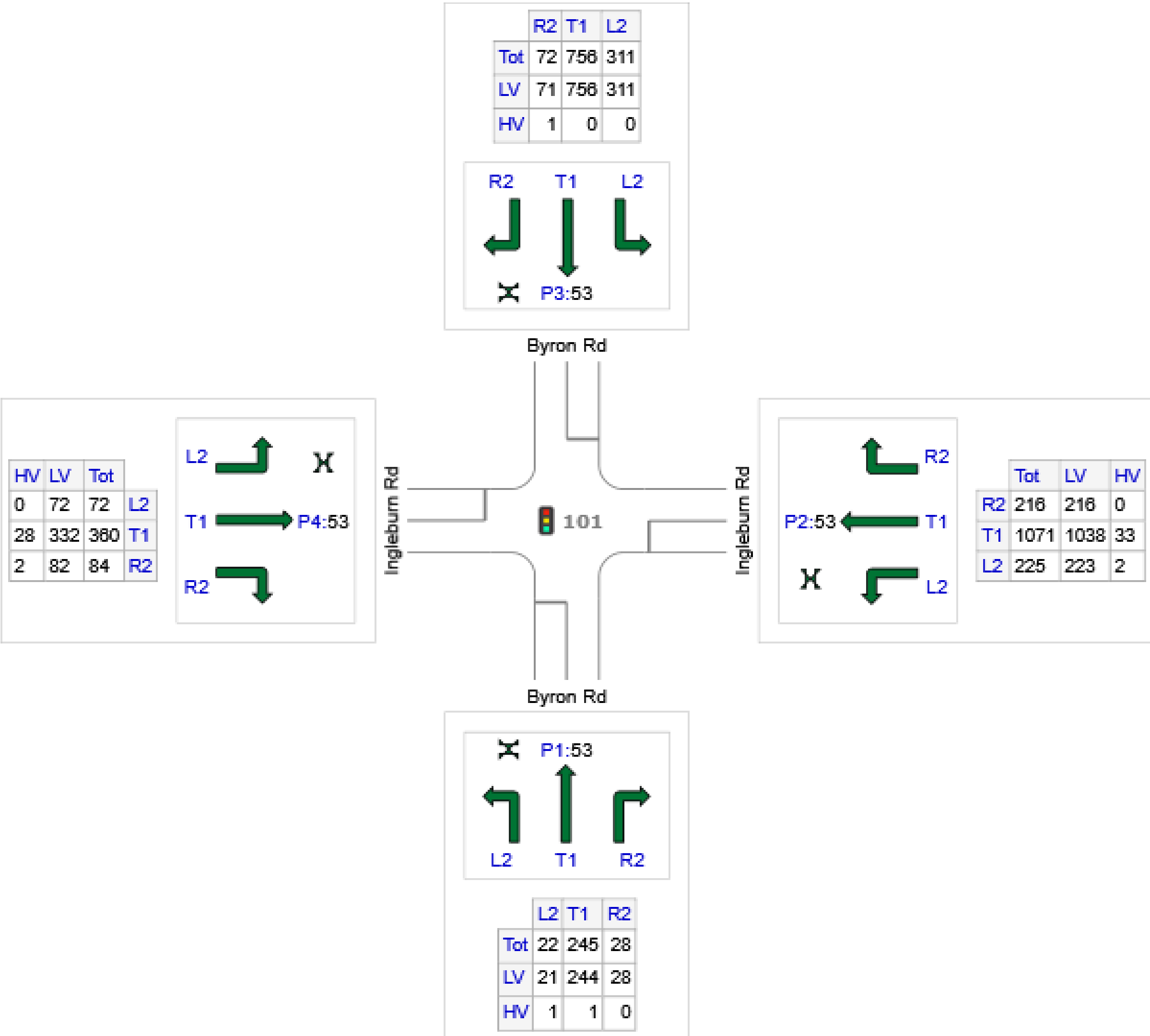
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [c] Ingleburn/Byron_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



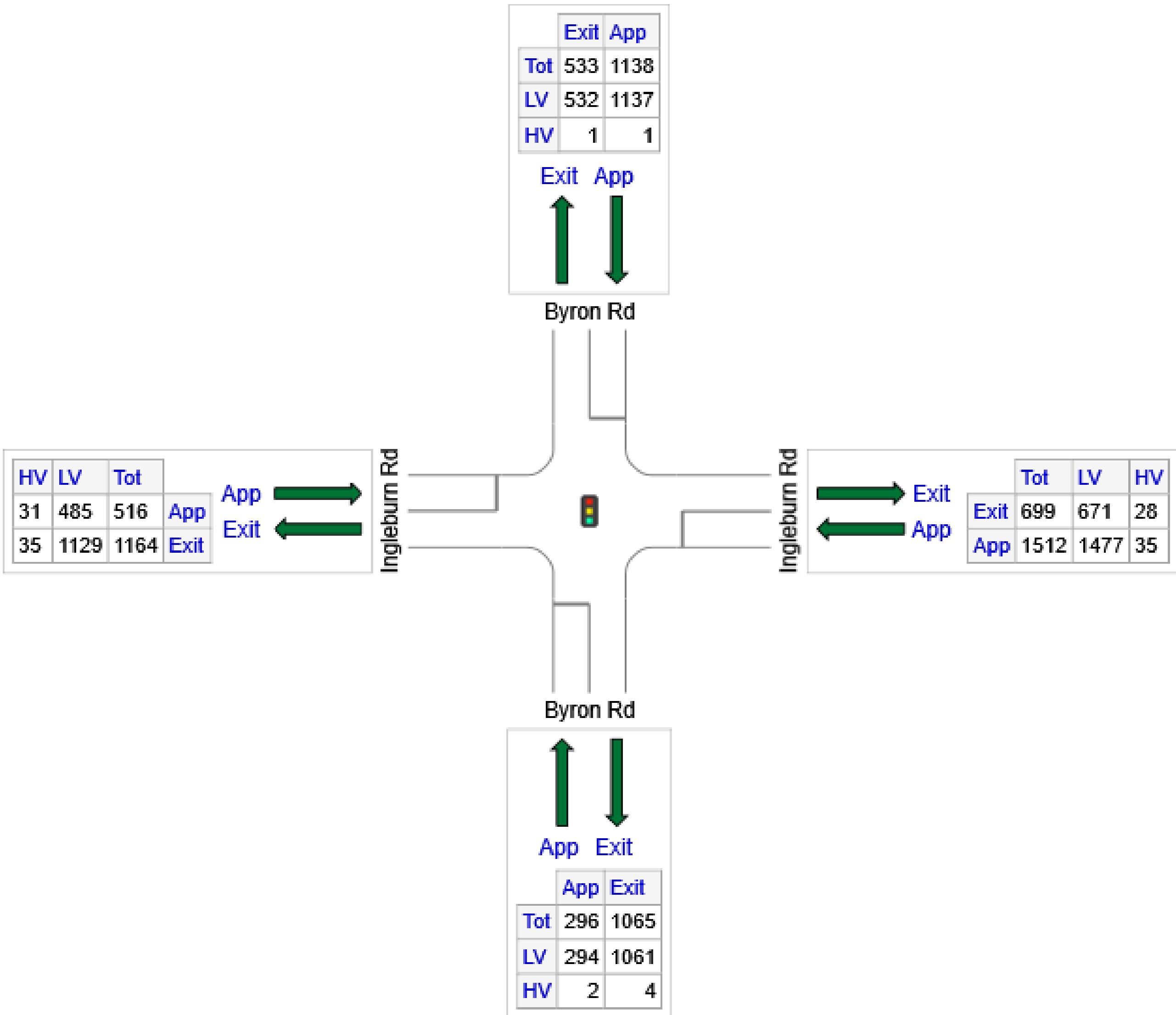
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Byron Rd	296	294	2
E: Ingleburn Rd	1512	1477	35
N: Byron Rd	1138	1137	1
W: Ingleburn Rd	516	485	31
Total	3461	3393	68

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [c] Ingleburn/Byron_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 140 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



North (Byron Rd):

	Exit	App
Tot	533	1138
LV	532	1137
HV	1	1

West (Ingleburn Rd):

HV	LV	Tot	
31	485	516	App
35	1129	1164	Exit

East (Ingleburn Rd):

	Tot	LV	HV
Exit	699	671	28
App	1512	1477	35

South (Byron Rd):

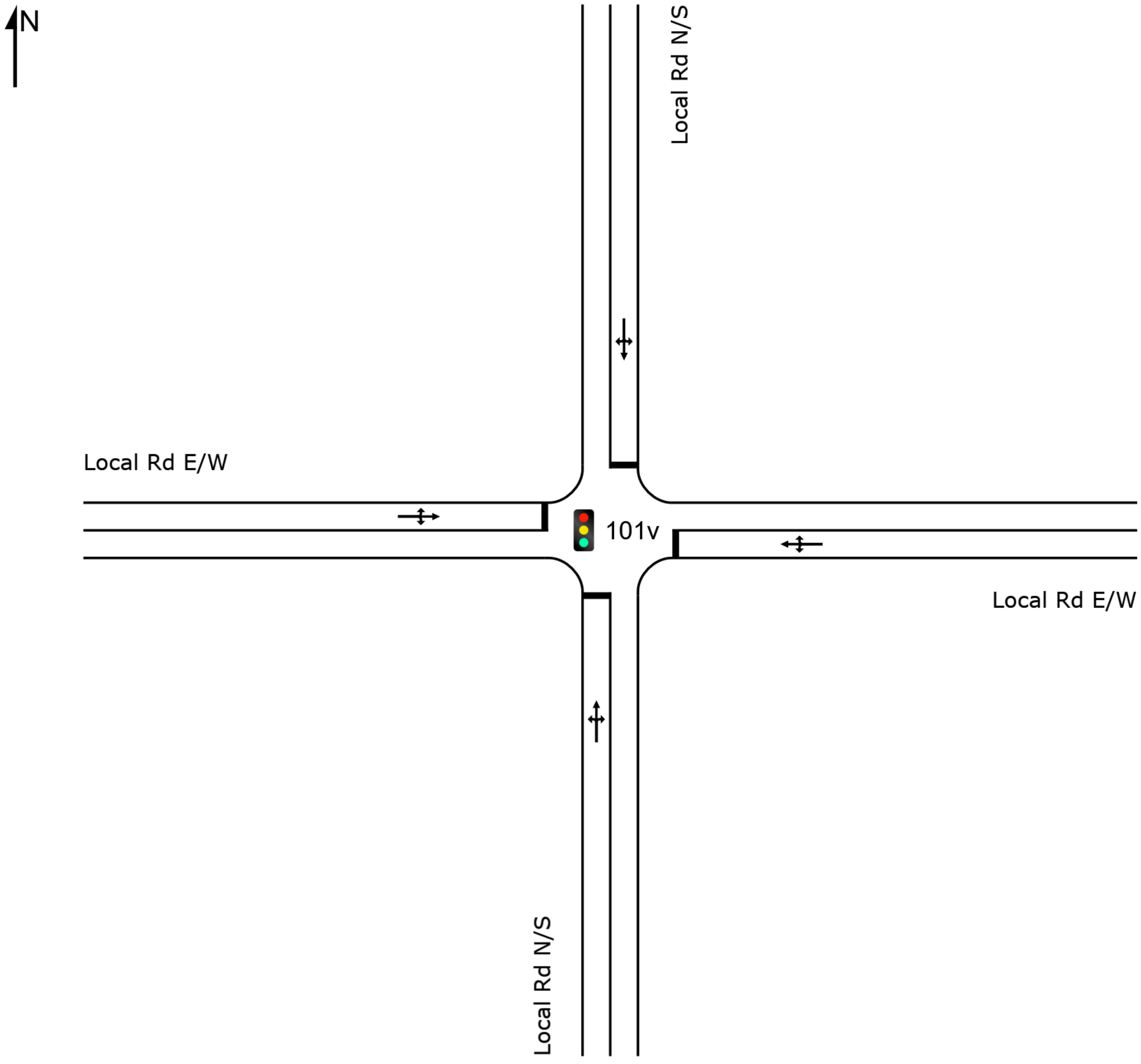
	App	Exit
Tot	296	1065
LV	294	1061
HV	2	4

SITE LAYOUT

Site: 101v [d) Local road parallel Bringelly_2041_AM2 (Site Folder: 2041_AM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101v [d] Local road parallel Bringelly_2041_AM2 (Site Folder: 2041_AM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 40 seconds (Site User-Given Cycle Time)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Local Rd N/S														
1	L2	3	0	3	0.0	0.158	14.9	LOS B	1.3	9.6	0.77	0.60	0.77	33.0
2	T1	82	2	86	2.4	0.158	11.5	LOS A	1.3	9.6	0.77	0.60	0.77	38.8
3	R2	1	0	1	0.0	0.158	15.0	LOS B	1.3	9.6	0.77	0.60	0.77	32.8
Approach		86	2	91	2.3	0.158	11.7	LOS A	1.3	9.6	0.77	0.60	0.77	38.5
East: Local Rd E/W														
4	L2	1	0	1	0.0	0.443	13.2	LOS A	4.5	31.9	0.77	0.67	0.77	33.9
5	T1	255	0	268	0.0	0.443	9.8	LOS A	4.5	31.9	0.77	0.67	0.77	34.3
6	R2	35	1	37	2.9	* 0.443	13.4	LOS A	4.5	31.9	0.77	0.67	0.77	38.6
Approach		291	1	306	0.3	0.443	10.3	LOS A	4.5	31.9	0.77	0.67	0.77	34.9
North: Local Rd N/S														
7	L2	1	0	1	0.0	0.456	17.6	LOS B	3.4	23.9	0.86	0.79	0.86	36.3
8	T1	4	0	4	0.0	0.456	14.2	LOS A	3.4	23.9	0.86	0.79	0.86	35.7
9	R2	186	1	196	0.5	* 0.456	17.6	LOS B	3.4	23.9	0.86	0.79	0.86	35.8
Approach		191	1	201	0.5	0.456	17.5	LOS B	3.4	23.9	0.86	0.79	0.86	35.8
West: Local Rd E/W														
10	L2	32	1	34	3.1	0.391	12.9	LOS A	4.3	30.4	0.75	0.65	0.75	39.1
11	T1	249	4	262	1.6	0.391	9.5	LOS A	4.3	30.4	0.75	0.65	0.75	34.5
12	R2	2	0	2	0.0	0.391	13.0	LOS A	4.3	30.4	0.75	0.65	0.75	33.5
Approach		283	5	298	1.8	0.391	9.9	LOS A	4.3	30.4	0.75	0.65	0.75	35.0
All Vehicles		851	9	896	1.1	0.456	11.9	LOS A	4.5	31.9	0.78	0.68	0.78	35.5

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

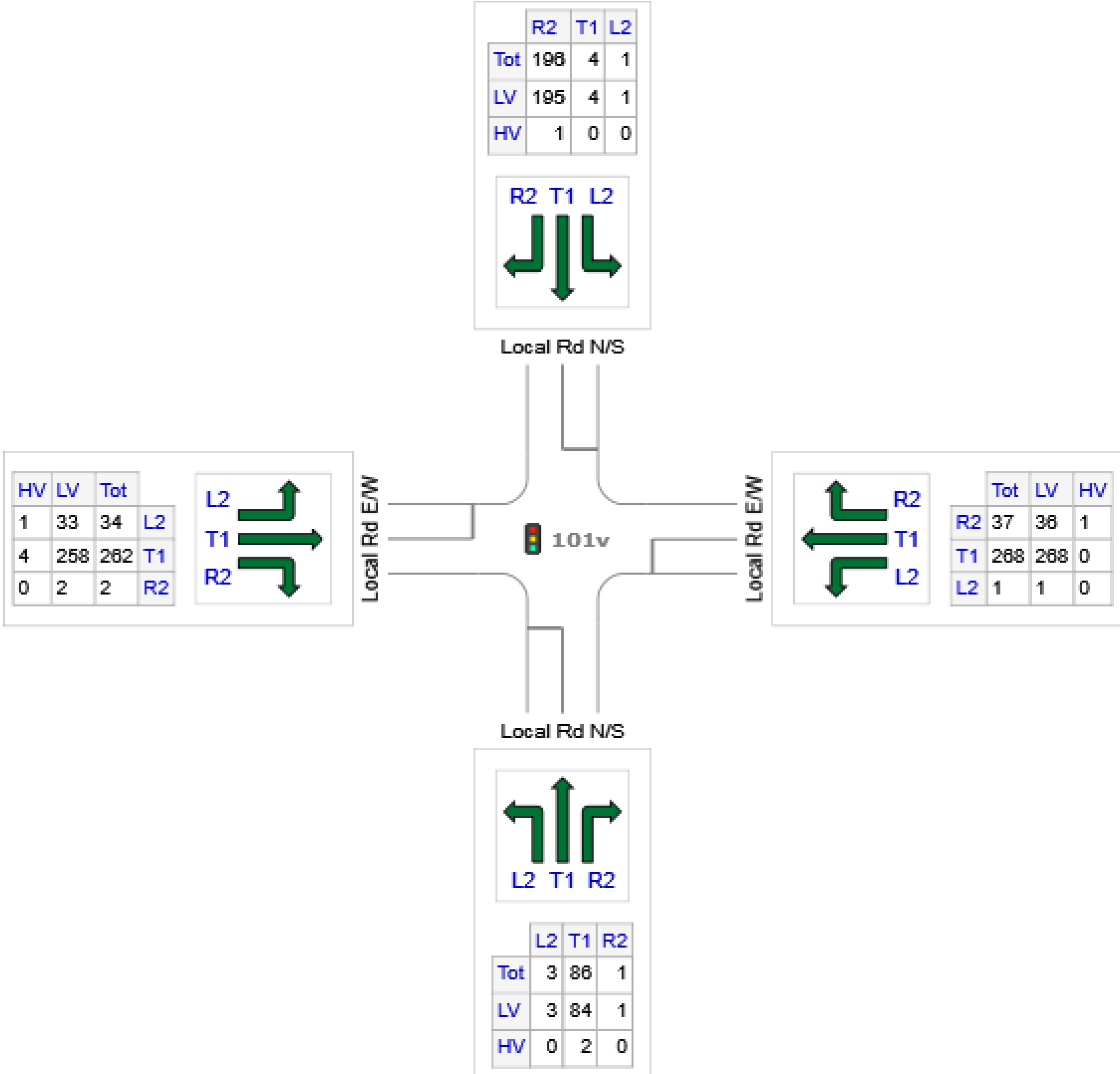
* Critical Movement (Signal Timing)

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101v [d] Local road parallel Bringelly_2041_AM2 (Site Folder: 2041_AM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 40 seconds (Site User-Given Cycle Time)



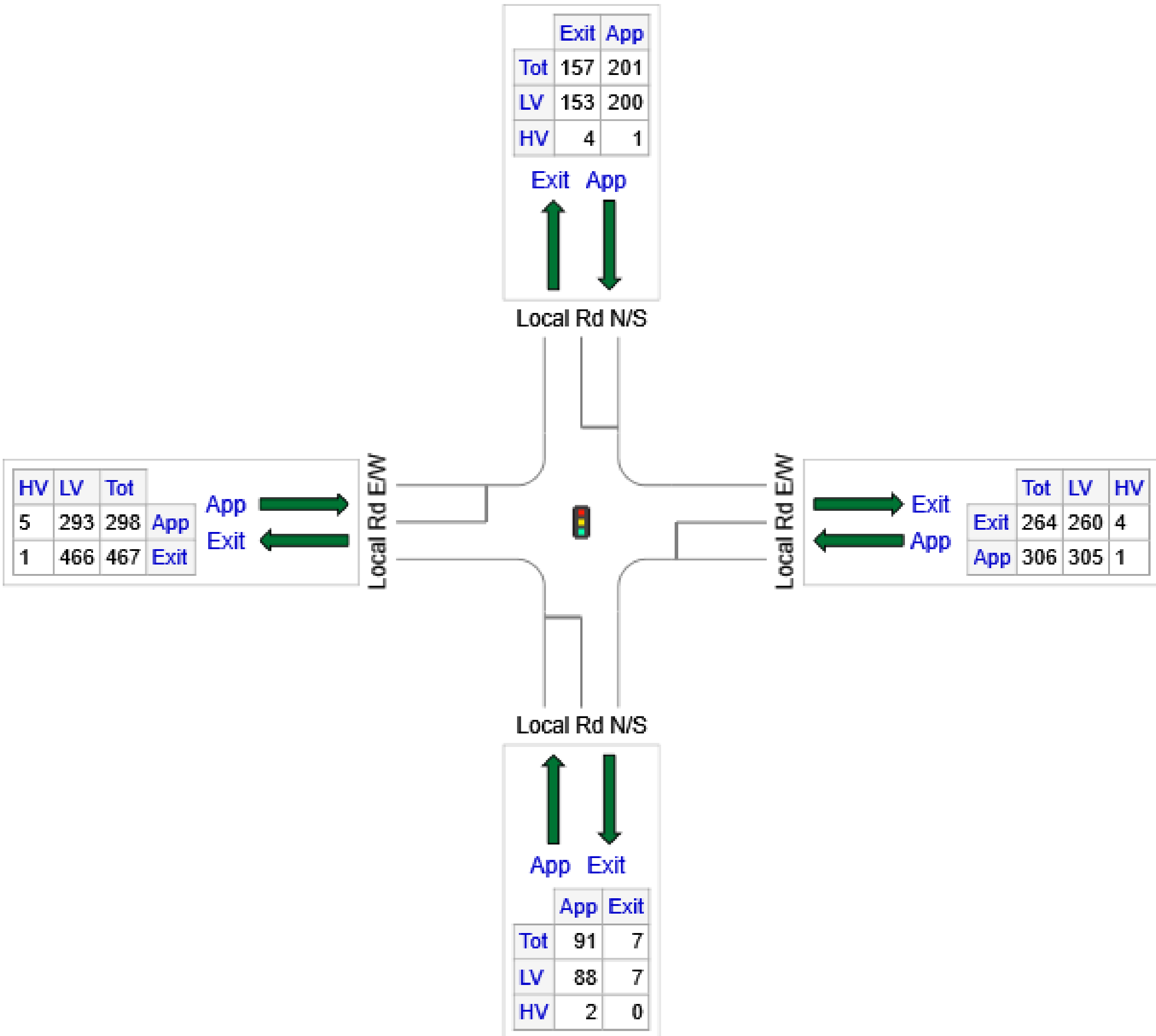
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Local Rd N/S	91	88	2
E: Local Rd E/W	306	305	1
N: Local Rd N/S	201	200	1
W: Local Rd E/W	298	293	5
Total	896	886	9

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101v [d) Local road parallel Bringelly_2041_AM2 (Site Folder: 2041_AM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 40 seconds (Site User-Given Cycle Time)



MOVEMENT SUMMARY

Site: 101v [d] Local road parallel Bringelly_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 40 seconds (Site Optimum Cycle Time - Minimum Delay)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Local Rd N/S														
1	L2	108	0	114	0.0	0.373	16.7	LOS B	3.2	22.5	0.85	0.73	0.85	31.3
2	T1	75	0	79	0.0	0.373	13.3	LOS A	3.2	22.5	0.85	0.73	0.85	36.9
3	R2	1	0	1	0.0	0.373	16.8	LOS B	3.2	22.5	0.85	0.73	0.85	31.1
Approach		184	0	194	0.0	0.373	15.3	LOS B	3.2	22.5	0.85	0.73	0.85	33.7
East: Local Rd E/W														
4	L2	1	0	1	0.0	0.575	14.6	LOS B	6.2	44.1	0.85	0.73	0.85	33.2
5	T1	326	4	343	1.2	0.575	11.2	LOS A	6.2	44.1	0.85	0.73	0.85	33.7
6	R2	34	4	36	11.8	0.575	14.8	LOS B	6.2	44.1	0.85	0.73	0.85	37.9
Approach		361	8	380	2.2	0.575	11.6	LOS A	6.2	44.1	0.85	0.73	0.85	34.2
North: Local Rd N/S														
7	L2	7	0	7	0.0	0.797	25.5	LOS B	6.1	42.8	1.00	1.01	1.40	33.2
8	T1	14	0	15	0.0	0.797	22.1	LOS B	6.1	42.8	1.00	1.01	1.40	32.4
9	R2	233	2	245	0.9	* 0.797	25.5	LOS B	6.1	42.8	1.00	1.01	1.40	32.8
Approach		254	2	267	0.8	0.797	25.3	LOS B	6.1	42.8	1.00	1.01	1.40	32.8
West: Local Rd E/W														
10	L2	44	0	46	0.0	0.751	16.4	LOS B	11.5	80.6	0.90	0.90	1.04	37.5
11	T1	523	2	551	0.4	0.751	13.0	LOS A	11.5	80.6	0.90	0.90	1.04	32.9
12	R2	10	0	11	0.0	* 0.751	16.5	LOS B	11.5	80.6	0.90	0.90	1.04	31.8
Approach		577	2	607	0.3	0.751	13.3	LOS A	11.5	80.6	0.90	0.90	1.04	33.3
All Vehicles		1376	12	1448	0.9	0.797	15.3	LOS B	11.5	80.6	0.90	0.85	1.03	33.4

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

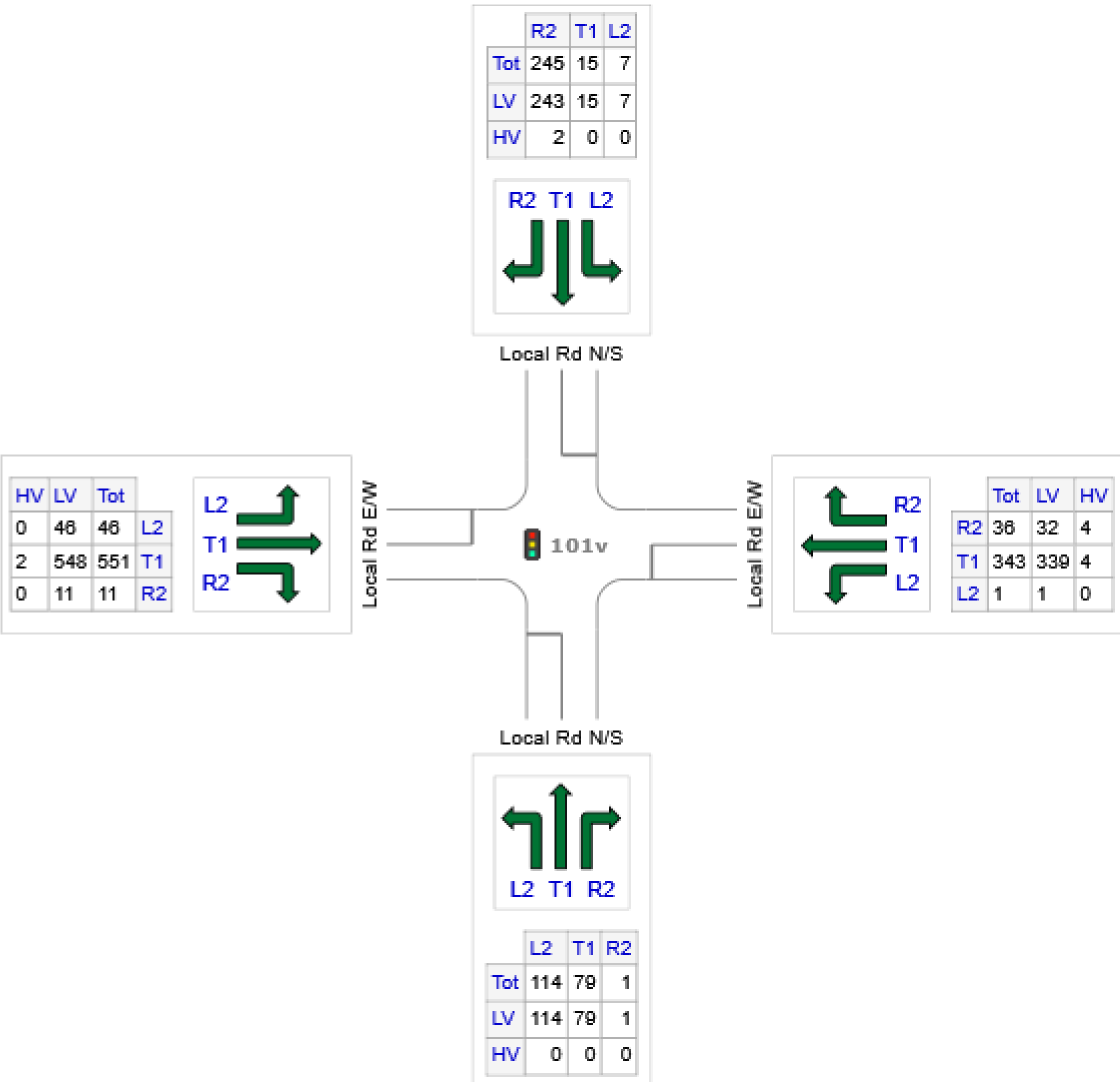
* Critical Movement (Signal Timing)

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101v [d] Local road parallel Bringelly_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 40 seconds (Site Optimum Cycle Time - Minimum Delay)



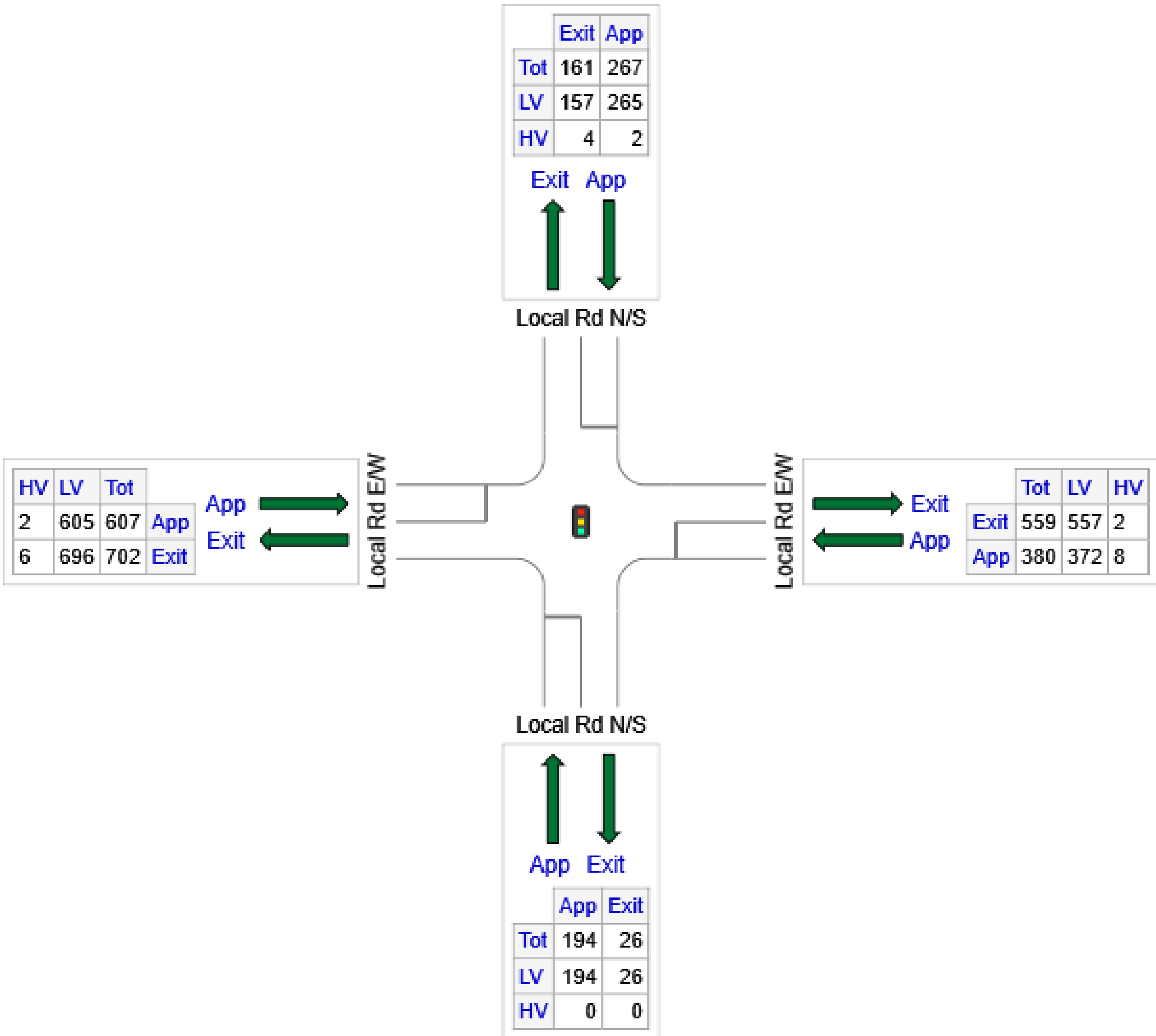
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Local Rd N/S	194	194	0
E: Local Rd E/W	380	372	8
N: Local Rd N/S	267	265	2
W: Local Rd E/W	607	605	2
Total	1448	1436	13

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101v [d) Local road parallel Bringelly_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

Local Rd 2
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 40 seconds (Site Optimum Cycle Time - Minimum Delay)

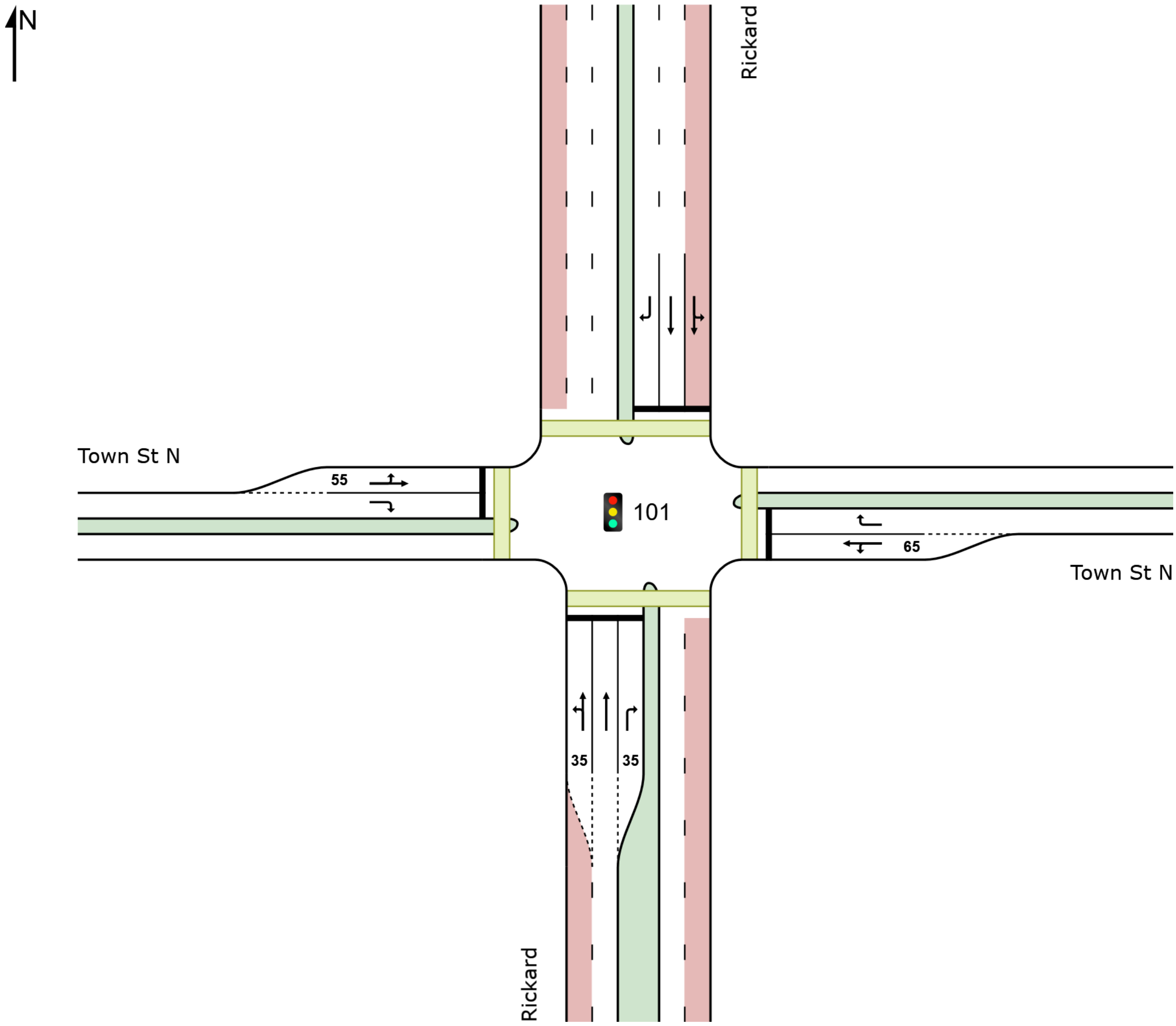


SITE LAYOUT

Site: 101 [e) Rickard/Town St N_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [e] Rickard/Town St N_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Rickard														
1	L2	127	0	134	0.0	0.697	34.9	LOS C	5.5	47.8	0.89	0.82	0.95	21.8
2	T1	389	73	409	18.8	0.697	31.5	LOS C	11.2	79.3	0.91	0.81	0.96	21.4
3	R2	260	0	274	0.0	* 0.949	67.5	LOS E	15.7	110.2	0.99	1.14	1.64	16.6
Approach		776	73	817	9.4	0.949	44.1	LOS D	15.7	110.2	0.93	0.92	1.19	19.2
East: Town St N														
4	L2	317	1	334	0.3	0.901	49.5	LOS D	23.0	162.2	0.98	1.07	1.32	19.8
5	T1	110	2	116	1.8	0.901	46.1	LOS D	23.0	162.2	0.98	1.07	1.32	20.6
6	R2	235	3	247	1.3	* 0.931	62.7	LOS E	13.7	97.2	1.00	1.16	1.57	17.3
Approach		662	6	697	0.9	0.931	53.6	LOS D	23.0	162.2	0.98	1.10	1.41	19.0
North: Rickard														
7	L2	208	5	219	2.4	0.597	34.7	LOS C	11.0	93.8	0.91	0.81	0.91	24.2
8	T1	460	70	484	15.2	* 0.971	63.8	LOS E	26.2	185.5	0.99	1.25	1.54	14.1
9	R2	180	5	189	2.8	0.669	45.4	LOS D	8.3	59.4	0.99	0.84	1.05	18.8
Approach		848	80	893	9.4	0.971	52.8	LOS D	26.2	185.5	0.97	1.06	1.28	17.1
West: Town St N														
10	L2	51	0	54	0.0	0.268	36.8	LOS C	3.7	26.0	0.89	0.73	0.89	21.1
11	T1	42	0	44	0.0	* 0.268	33.4	LOS C	3.7	26.0	0.89	0.73	0.89	23.8
12	R2	102	1	107	1.0	0.873	58.2	LOS E	5.5	38.7	1.00	1.05	1.53	15.7
Approach		195	1	205	0.5	0.873	47.3	LOS D	5.5	38.7	0.95	0.90	1.23	18.6
All Vehicles		2481	160	2612	6.4	0.971	49.9	LOS D	26.2	185.5	0.96	1.01	1.28	18.4

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Rickard												
P1	Full	50	53	39.3	LOS D	0.1	0.1	0.94	0.94	70.4	40.5	0.57
East: Town St N												
P2	Full	50	53	39.3	LOS D	0.1	0.1	0.94	0.94	65.4	33.9	0.52

North: Rickard											
P3 Full	50	53	39.3	LOS D	0.1	0.1	0.94	0.94	73.0	43.8	0.60
West: Town St N											
P4 Full	50	53	39.3	LOS D	0.1	0.1	0.94	0.94	65.4	33.9	0.52
All Pedestrians	200	211	39.3	LOS D	0.1	0.1	0.94	0.94	68.5	38.0	0.55

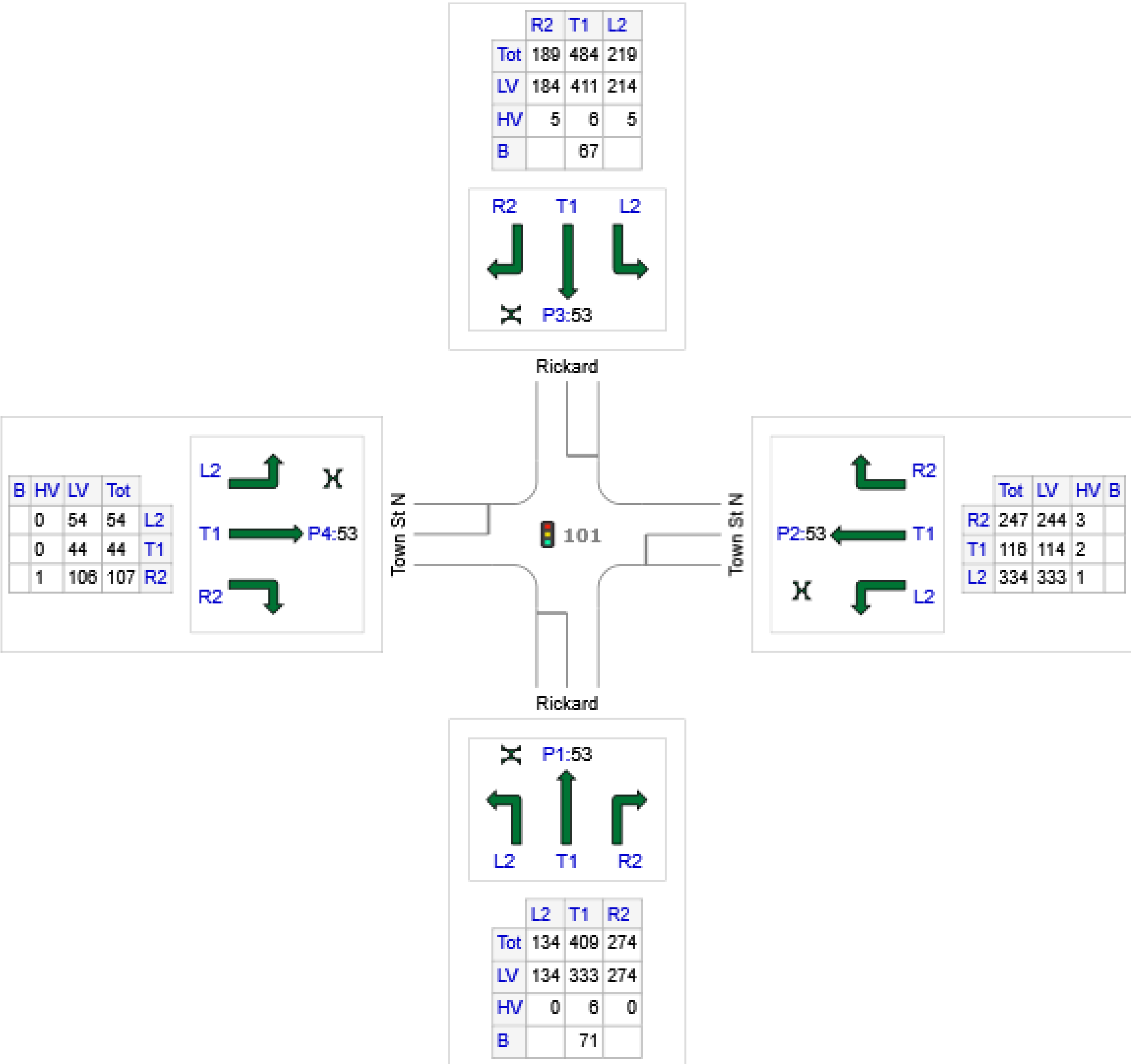
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [e) Rickard/Town St N_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



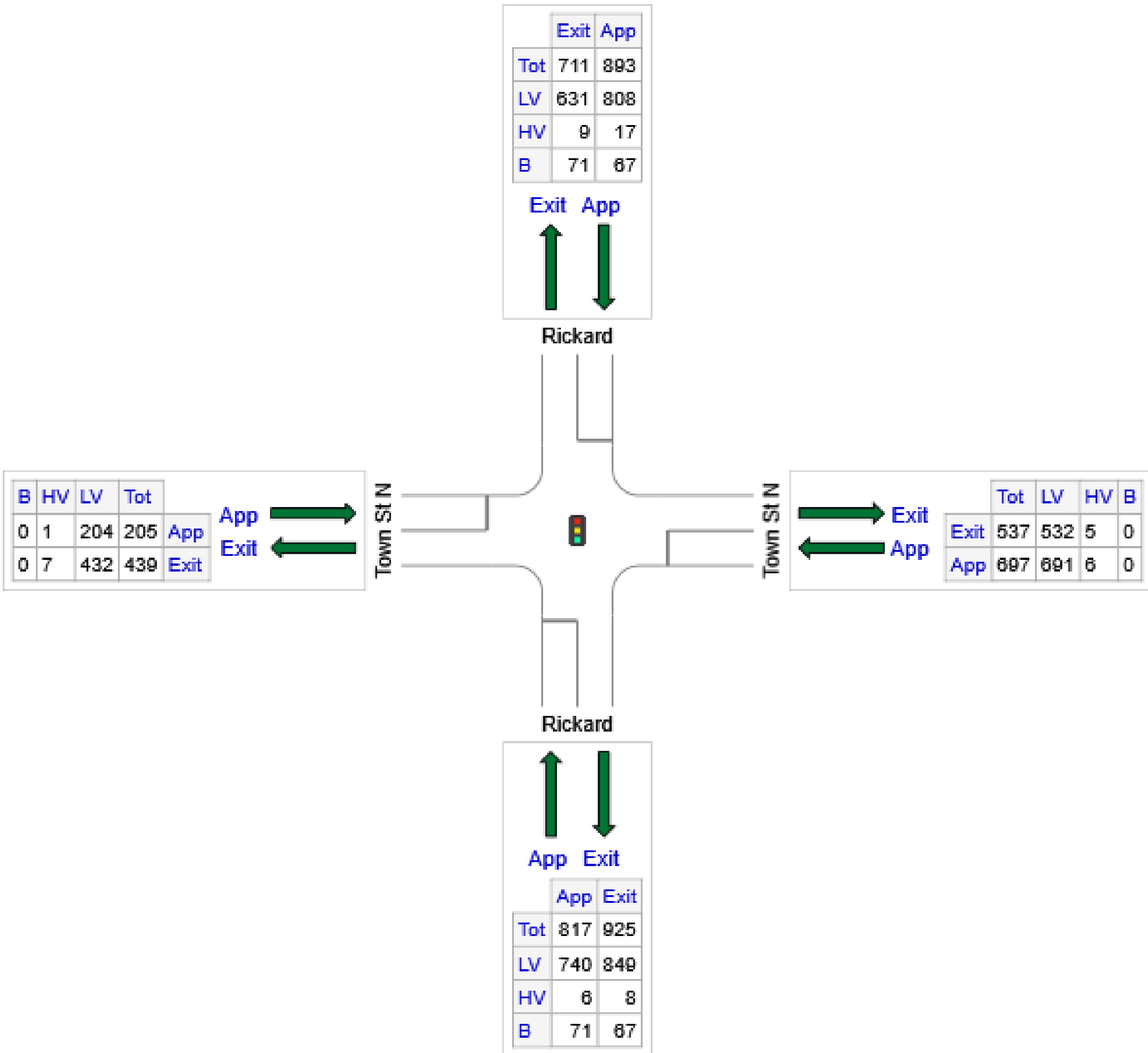
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Buses (B)
S: Rickard	817	740	6	71
E: Town St N	697	691	6	-
N: Rickard	893	808	17	67
W: Town St N	205	204	1	-
Total	2612	2443	31	138

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [e] Rickard/Town St N_2041_PM2 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 90 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

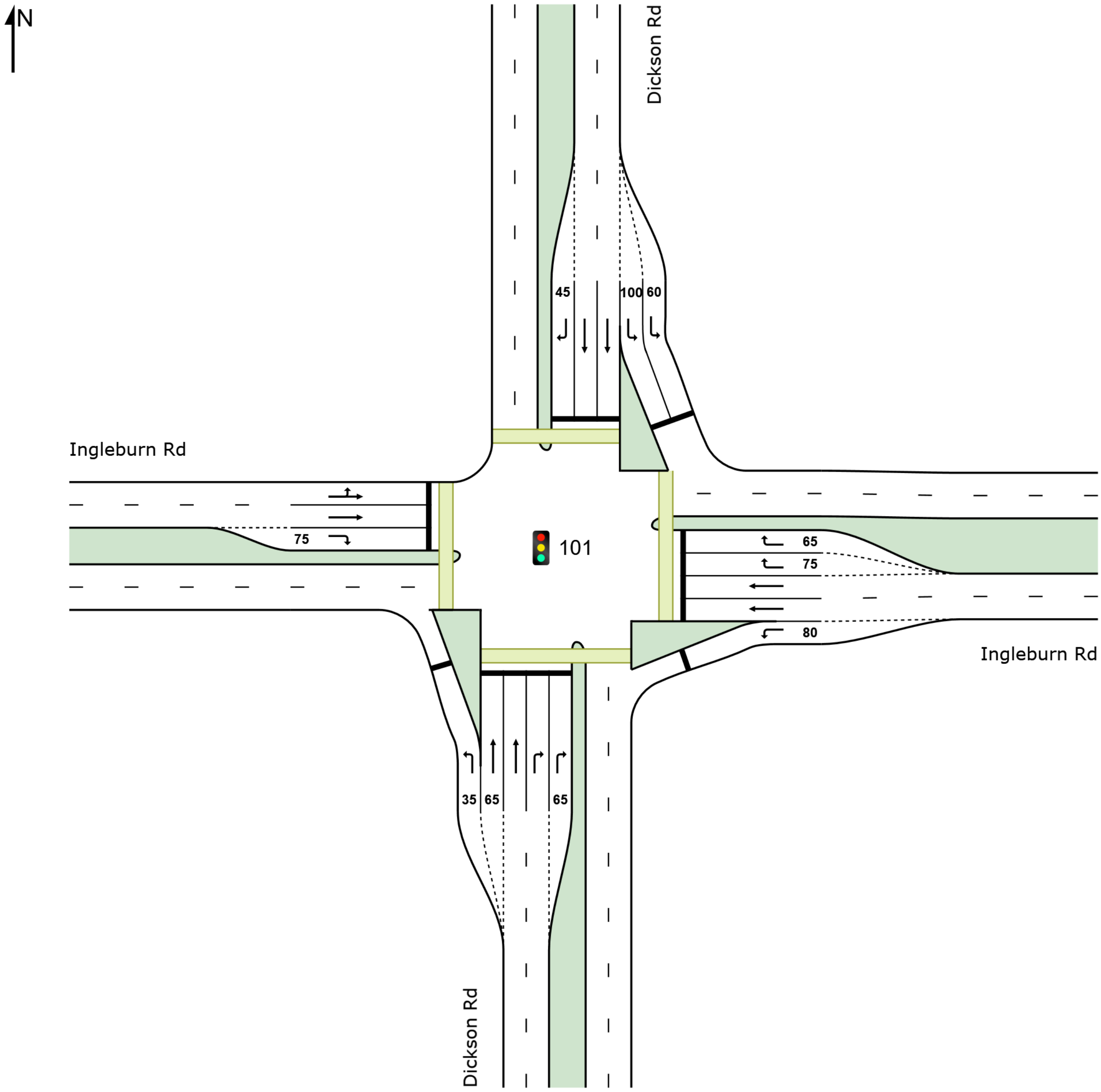


SITE LAYOUT

Site: 101 [f] Ingleburn/Dickson_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [f] Ingleburn/Dickson_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Rd														
1	L2	106	1	112	0.9	0.183	30.2	LOS C	3.9	27.3	0.75	0.73	0.75	37.3
2	T1	476	1	501	0.2	0.641	39.3	LOS C	11.9	83.5	0.96	0.80	0.96	34.9
3	R2	304	0	320	0.0	* 0.783	56.5	LOS E	8.4	58.5	1.00	0.92	1.22	29.0
Approach		886	2	933	0.2	0.783	44.1	LOS D	11.9	83.5	0.95	0.83	1.02	32.9
East: Ingleburn Rd														
4	L2	353	1	372	0.3	0.334	16.2	LOS B	8.9	62.8	0.54	0.72	0.54	43.8
5	T1	539	38	567	7.1	0.354	20.5	LOS B	9.3	68.7	0.72	0.61	0.72	44.7
6	R2	852	13	897	1.5	* 0.792	40.3	LOS C	21.5	152.8	0.94	0.89	1.02	35.5
Approach		1744	52	1836	3.0	0.792	29.3	LOS C	21.5	152.8	0.79	0.77	0.83	39.5
North: Dickson Rd														
7	L2	266	14	280	5.3	0.140	16.8	LOS B	3.2	23.5	0.51	0.69	0.51	46.2
8	T1	233	8	245	3.4	* 0.402	42.9	LOS D	5.5	39.7	0.94	0.76	0.94	33.4
9	R2	54	1	57	1.9	0.517	58.6	LOS E	2.9	20.7	1.00	0.75	1.01	30.3
Approach		553	23	582	4.2	0.517	31.9	LOS C	5.5	39.7	0.74	0.73	0.74	38.0
West: Ingleburn Rd														
10	L2	72	0	76	0.0	0.403	45.5	LOS D	5.8	41.8	0.93	0.77	0.93	34.6
11	T1	159	13	167	8.2	* 0.403	41.7	LOS C	5.8	41.8	0.94	0.76	0.94	34.9
12	R2	6	1	6	16.7	0.063	56.2	LOS D	0.3	2.5	0.97	0.65	0.97	29.9
Approach		237	14	249	5.9	0.403	43.3	LOS D	5.8	41.8	0.94	0.76	0.94	34.7
All Vehicles		3420	91	3600	2.7	0.792	34.5	LOS C	21.5	152.8	0.83	0.78	0.87	37.0

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Rd												
P1	Full	50	53	44.3	LOS E	0.1	0.1	0.94	0.94	78.0	43.8	0.56
East: Ingleburn Rd												
P2	Full	50	53	44.3	LOS E	0.1	0.1	0.94	0.94	78.0	43.8	0.56

North: Dickson Rd												
P3	Full	50	53	44.3	LOS E	0.1	0.1	0.94	0.94	75.4	40.5	0.54
West: Ingleburn Rd												
P4	Full	50	53	44.3	LOS E	0.1	0.1	0.94	0.94	75.4	40.5	0.54
All Pedestrians		200	211	44.3	LOS E	0.1	0.1	0.94	0.94	76.7	42.2	0.55

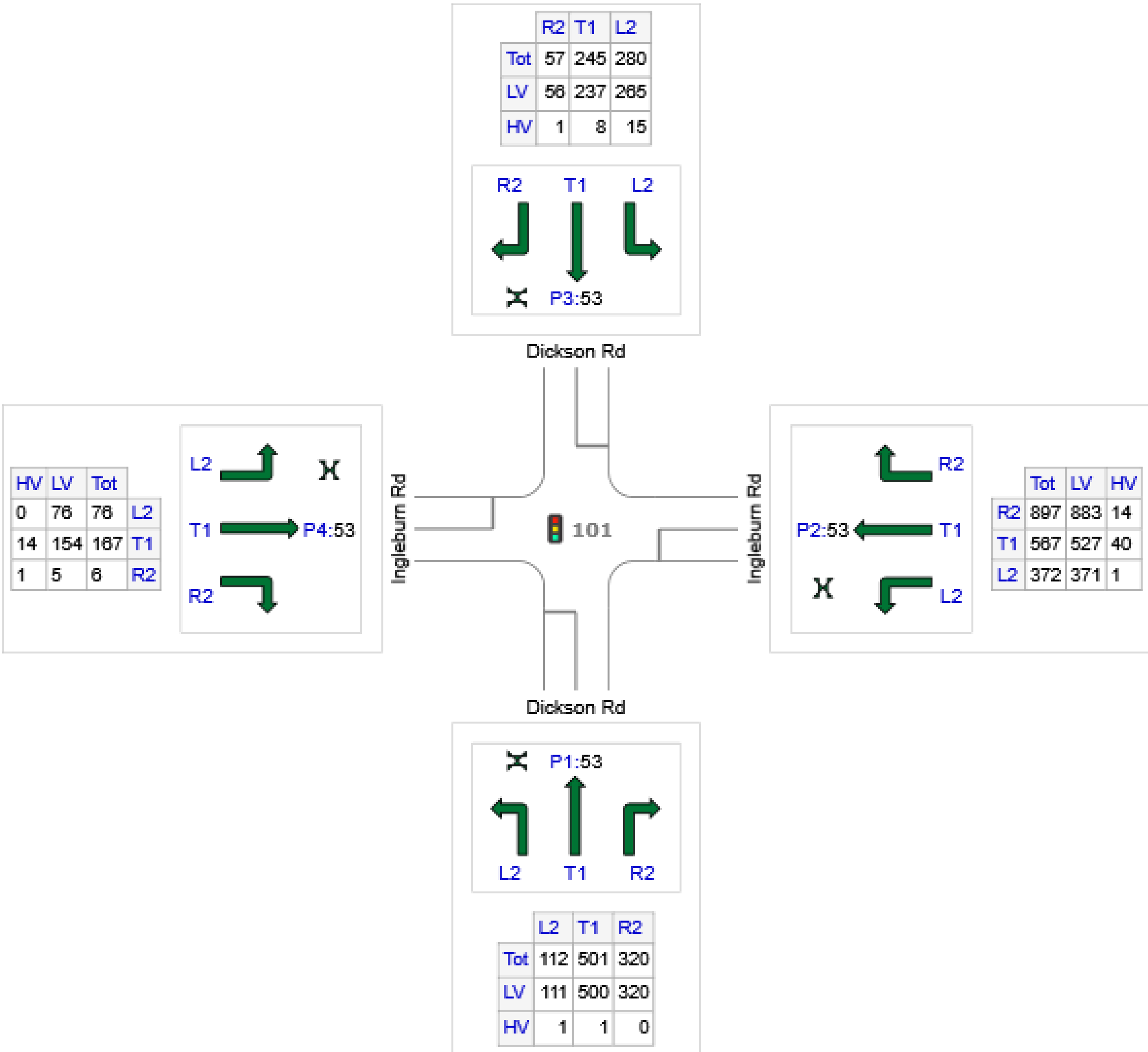
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [f) Ingleburn/Dickson_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



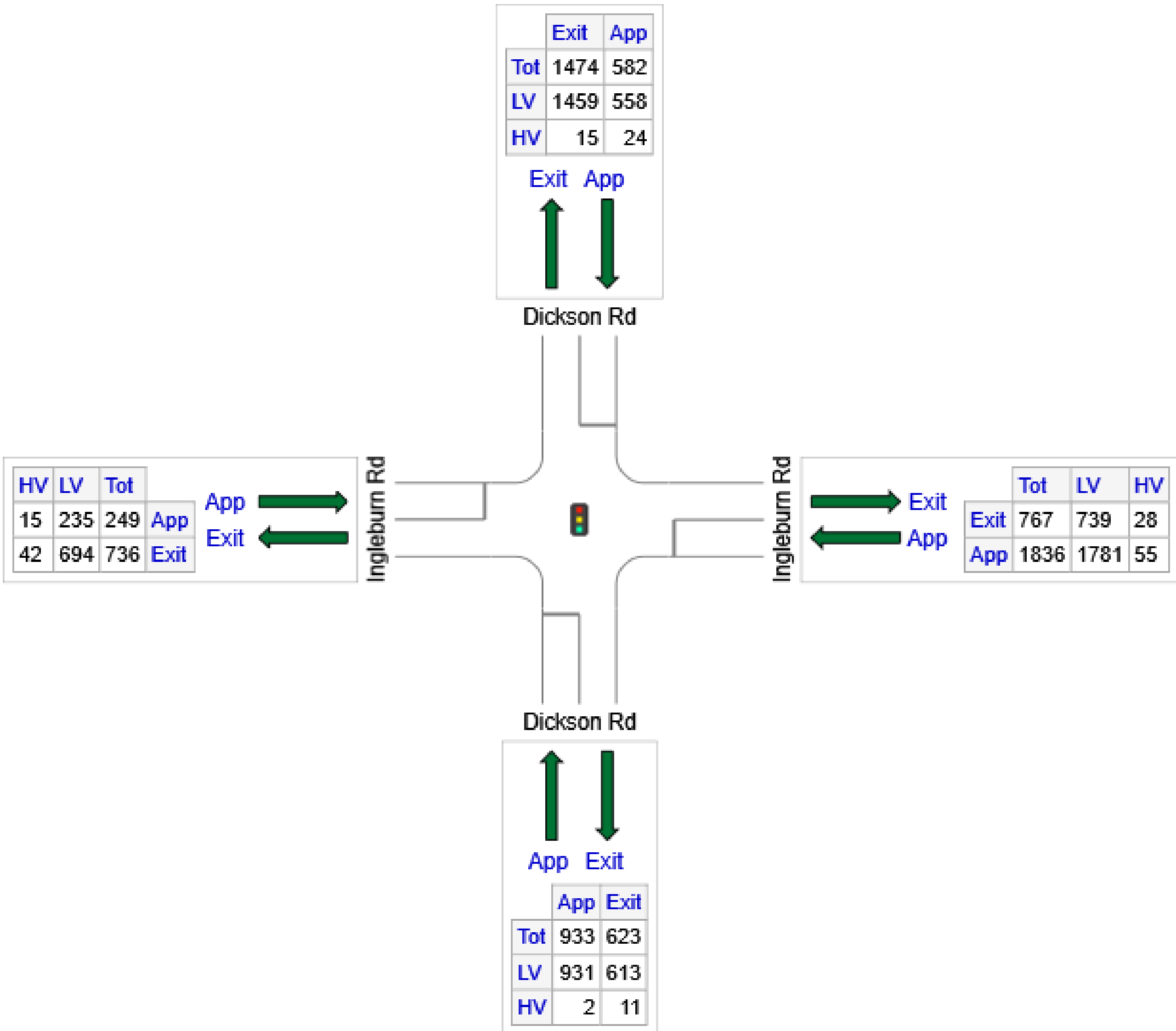
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Rd	933	931	2
E: Ingleburn Rd	1836	1781	55
N: Dickson Rd	582	558	24
W: Ingleburn Rd	249	235	15
Total	3600	3504	96

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [f) Ingleburn/Dickson_2041_AM1 (Site Folder: 2041_AM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 100 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



MOVEMENT SUMMARY

Site: 101 [f] Ingleburn/Dickson_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Rd														
1	L2	67	1	71	1.5	0.149	41.3	LOS C	3.2	22.5	0.81	0.73	0.81	33.5
2	T1	124	3	131	2.4	* 0.255	51.2	LOS D	3.5	25.0	0.94	0.72	0.94	31.4
3	R2	114	1	120	0.9	0.557	67.9	LOS E	3.7	25.8	1.00	0.77	1.03	26.6
Approach		305	5	321	1.6	0.557	55.3	LOS D	3.7	25.8	0.93	0.74	0.94	29.8
East: Ingleburn Rd														
4	L2	312	0	328	0.0	0.574	43.2	LOS D	16.2	113.2	0.90	0.83	0.90	32.9
5	T1	267	23	281	8.6	0.380	45.2	LOS D	7.2	54.1	0.91	0.74	0.91	34.2
6	R2	458	11	482	2.4	* 0.932	80.4	LOS F	17.2	122.7	1.00	1.05	1.46	25.4
Approach		1037	34	1092	3.3	0.932	60.2	LOS E	17.2	122.7	0.95	0.90	1.15	29.4
North: Dickson Rd														
7	L2	974	11	1025	1.1	0.423	15.9	LOS B	13.9	98.5	0.51	0.73	0.51	46.8
8	T1	885	1	932	0.1	0.601	25.4	LOS B	23.5	164.4	0.76	0.72	0.76	39.7
9	R2	427	0	449	0.0	* 0.898	55.2	LOS D	26.9	188.5	0.86	0.94	1.12	31.1
Approach		2286	12	2406	0.5	0.898	26.9	LOS B	26.9	188.5	0.67	0.76	0.72	40.2
West: Ingleburn Rd														
10	L2	65	1	68	1.5	0.663	59.4	LOS E	10.0	74.3	1.00	0.83	1.03	30.9
11	T1	254	27	267	10.6	* 0.663	54.8	LOS D	10.0	74.3	1.00	0.83	1.03	31.0
12	R2	52	0	55	0.0	0.393	65.4	LOS E	3.2	22.5	0.99	0.75	0.99	27.8
Approach		371	28	391	7.5	0.663	57.1	LOS E	10.0	74.3	1.00	0.82	1.03	30.5
All Vehicles		3999	79	4209	2.0	0.932	40.5	LOS C	26.9	188.5	0.79	0.80	0.88	34.9

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Rd												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
East: Ingleburn Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50

North: Dickson Rd												
P3	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Ingleburn Rd												
P4	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
All Pedestrians		200	211	54.3	LOS E	0.2	0.2	0.95	0.95	86.7	42.2	0.49

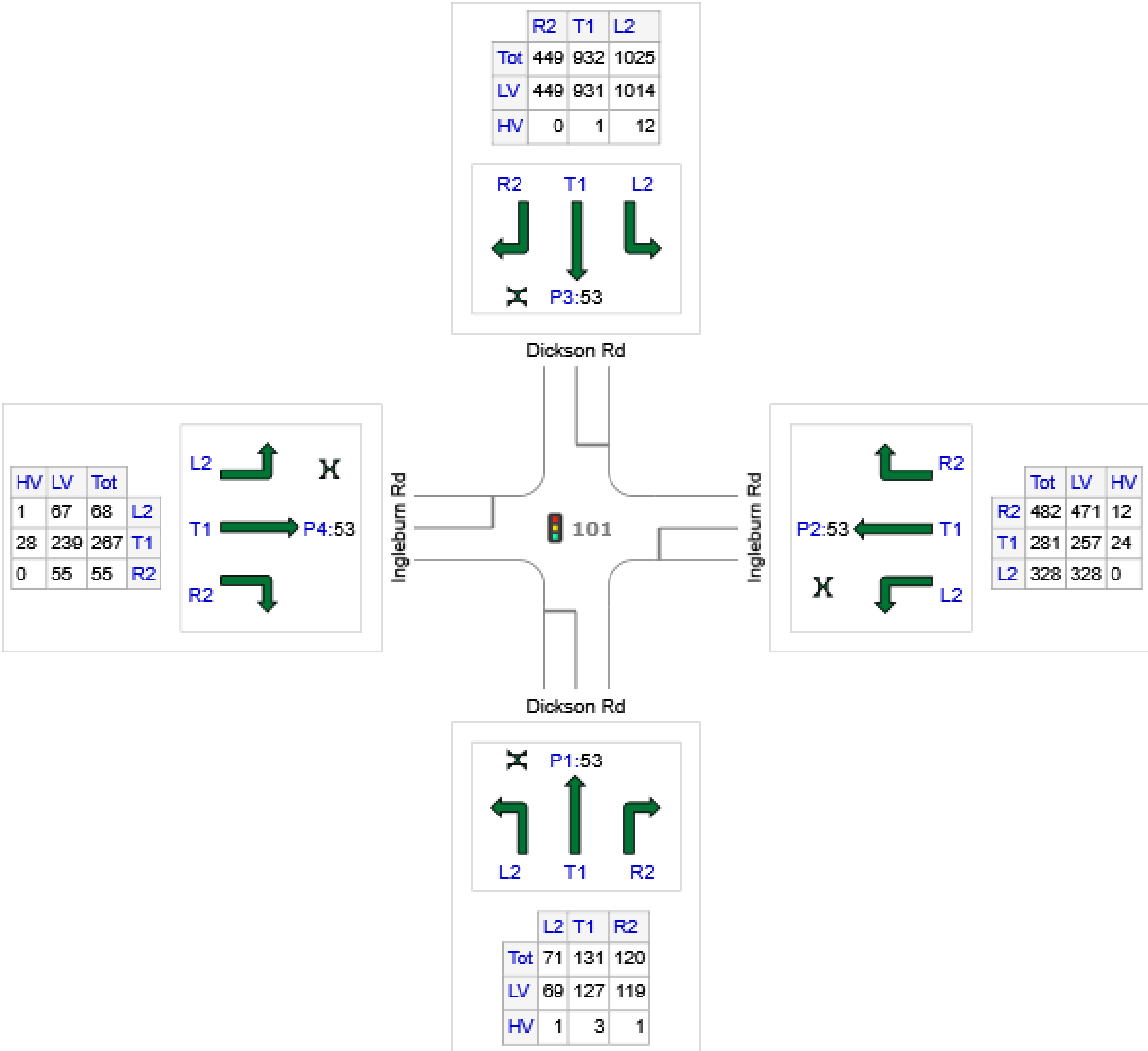
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [f) Ingleburn/Dickson_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



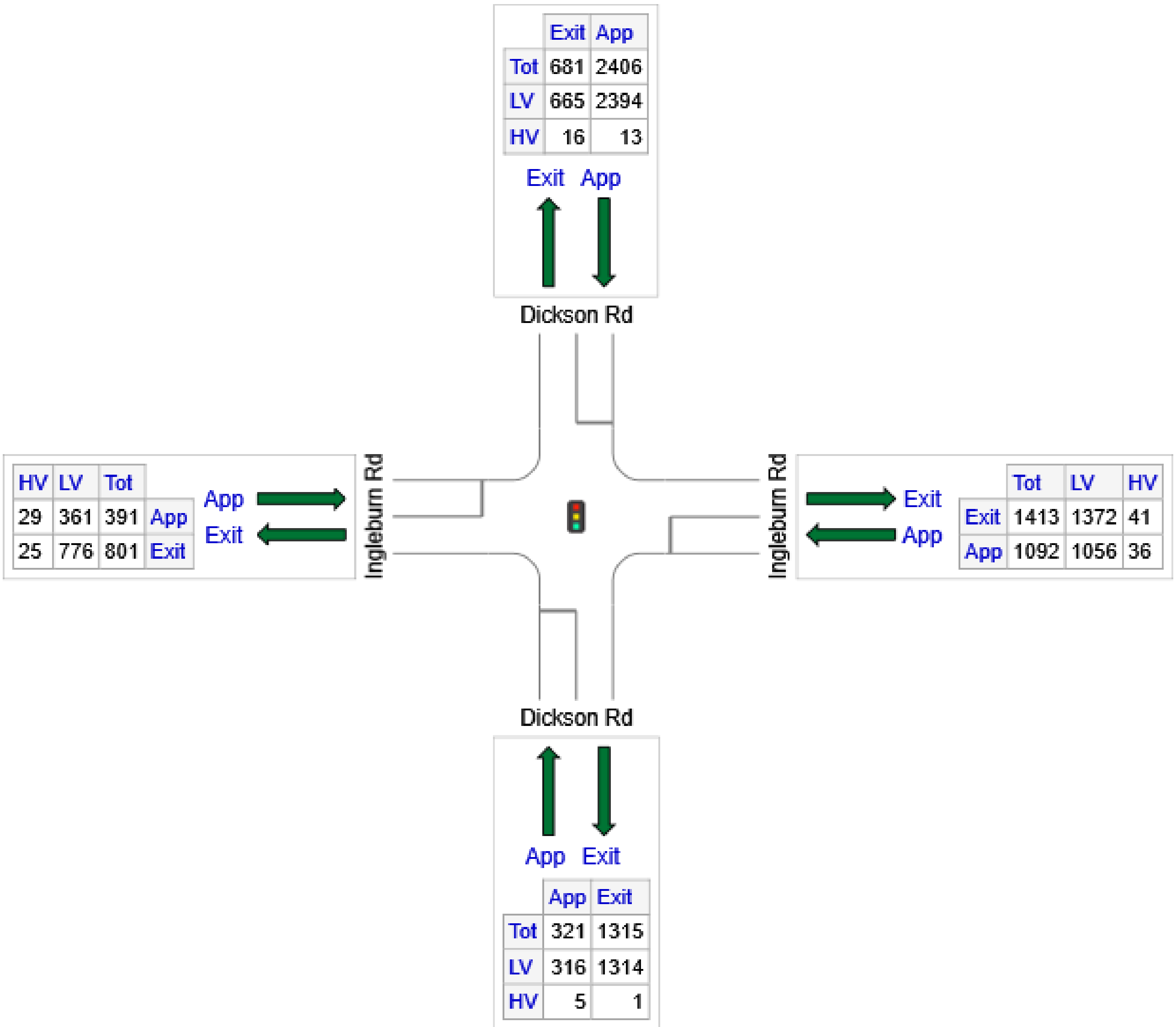
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Rd	321	316	5
E: Ingleburn Rd	1092	1056	36
N: Dickson Rd	2406	2394	13
W: Ingleburn Rd	391	361	29
Total	4209	4126	83

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [f) Ingleburn/Dickson_2041_PM1 (Site Folder: 2041_PM_DoNothing)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



Appendix R

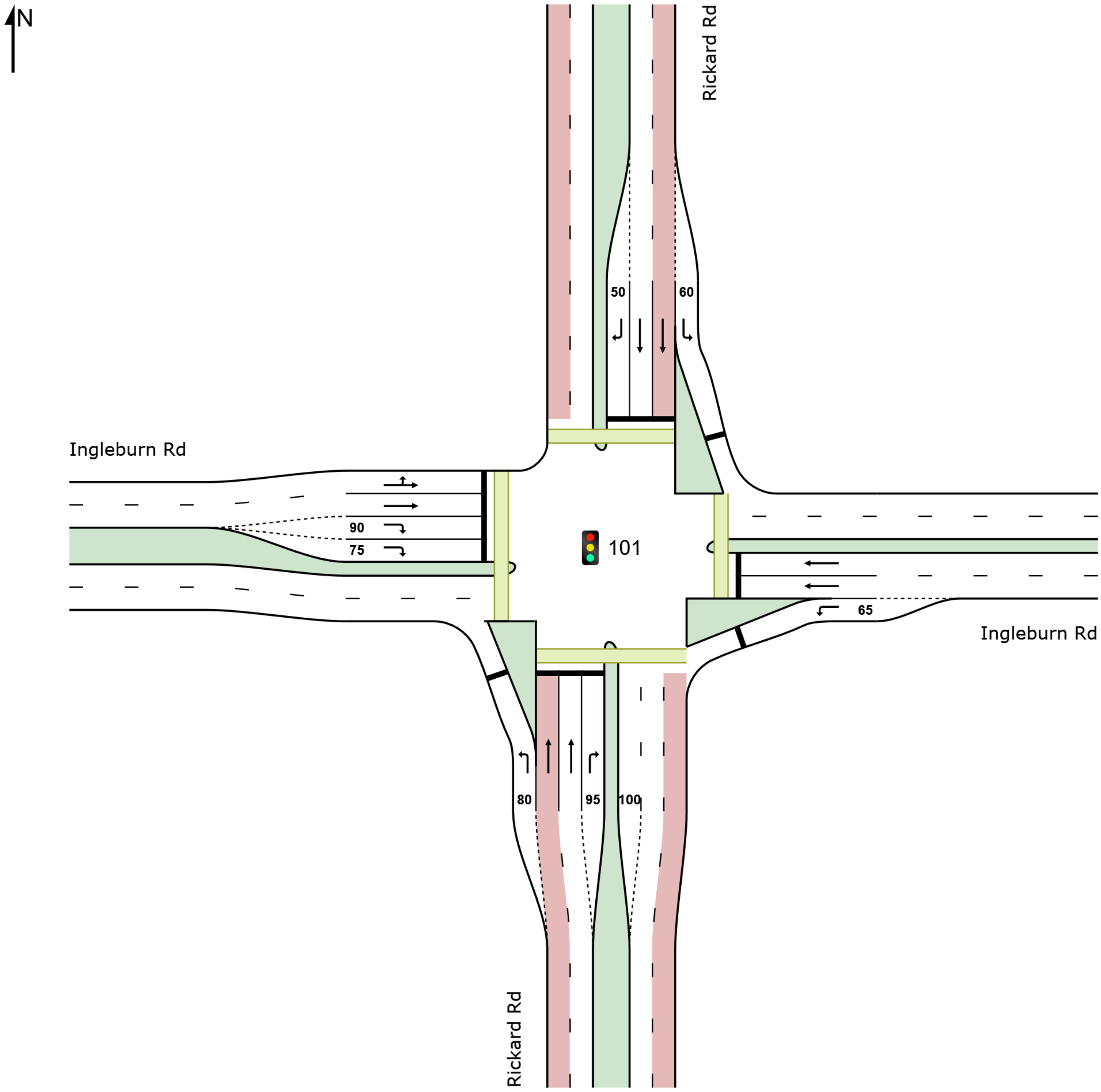
SIDRA results (2041) of upgraded intersections

SITE LAYOUT

Site: 101 [a] Rickard/Ingleburn_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [a] Rickard/Ingleburn_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Rickard Rd														
1	L2	371	5	391	1.3	0.359	19.0	LOS B	11.6	82.4	0.56	0.73	0.56	42.2
2	T1	639	40	673	6.3	0.862	33.6	LOS C	32.4	228.9	0.80	0.84	0.91	33.8
3	R2	537	2	565	0.4	* 0.925	59.7	LOS E	36.5	256.1	0.89	0.98	1.18	24.2
Approach		1547	47	1628	3.0	0.925	39.2	LOS C	36.5	256.1	0.77	0.86	0.92	31.4
East: Ingleburn Rd														
4	L2	238	1	251	0.4	0.198	12.9	LOS A	5.2	36.8	0.39	0.67	0.39	45.0
5	T1	636	41	669	6.4	* 0.926	69.3	LOS E	25.5	188.3	1.00	1.11	1.38	17.1
Approach		874	42	920	4.8	0.926	54.0	LOS D	25.5	188.3	0.83	0.99	1.11	22.0
North: Rickard Rd														
7	L2	23	6	24	26.1	0.071	45.0	LOS D	1.1	9.7	0.83	0.69	0.83	20.9
8	T1	222	36	234	16.2	* 0.884	65.6	LOS E	13.1	93.2	0.99	0.99	1.29	24.7
9	R2	32	9	34	28.1	0.435	69.5	LOS E	2.1	18.1	1.00	0.73	1.00	17.9
Approach		277	51	292	18.4	0.884	64.3	LOS E	13.1	93.2	0.98	0.93	1.22	23.6
West: Ingleburn Rd														
10	L2	17	7	18	41.2	0.359	49.4	LOS D	6.9	52.1	0.90	0.74	0.90	24.5
11	T1	249	10	262	4.0	0.359	43.8	LOS D	7.2	51.9	0.90	0.73	0.90	23.2
12	R2	130	3	137	2.3	* 0.948	81.4	LOS F	6.2	44.4	1.00	0.93	1.46	21.9
Approach		396	20	417	5.1	0.948	56.4	LOS D	7.2	52.1	0.93	0.80	1.08	22.6
All Vehicles		3094	160	3257	5.2	0.948	47.8	LOS D	36.5	256.1	0.83	0.90	1.02	26.8

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Rickard Rd												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
East: Ingleburn Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45
North: Rickard Rd												

P3	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Ingleburn Rd												
P4	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
All Pedestrians		200	211	54.3	LOS E	0.2	0.2	0.95	0.95	86.1	41.3	0.48

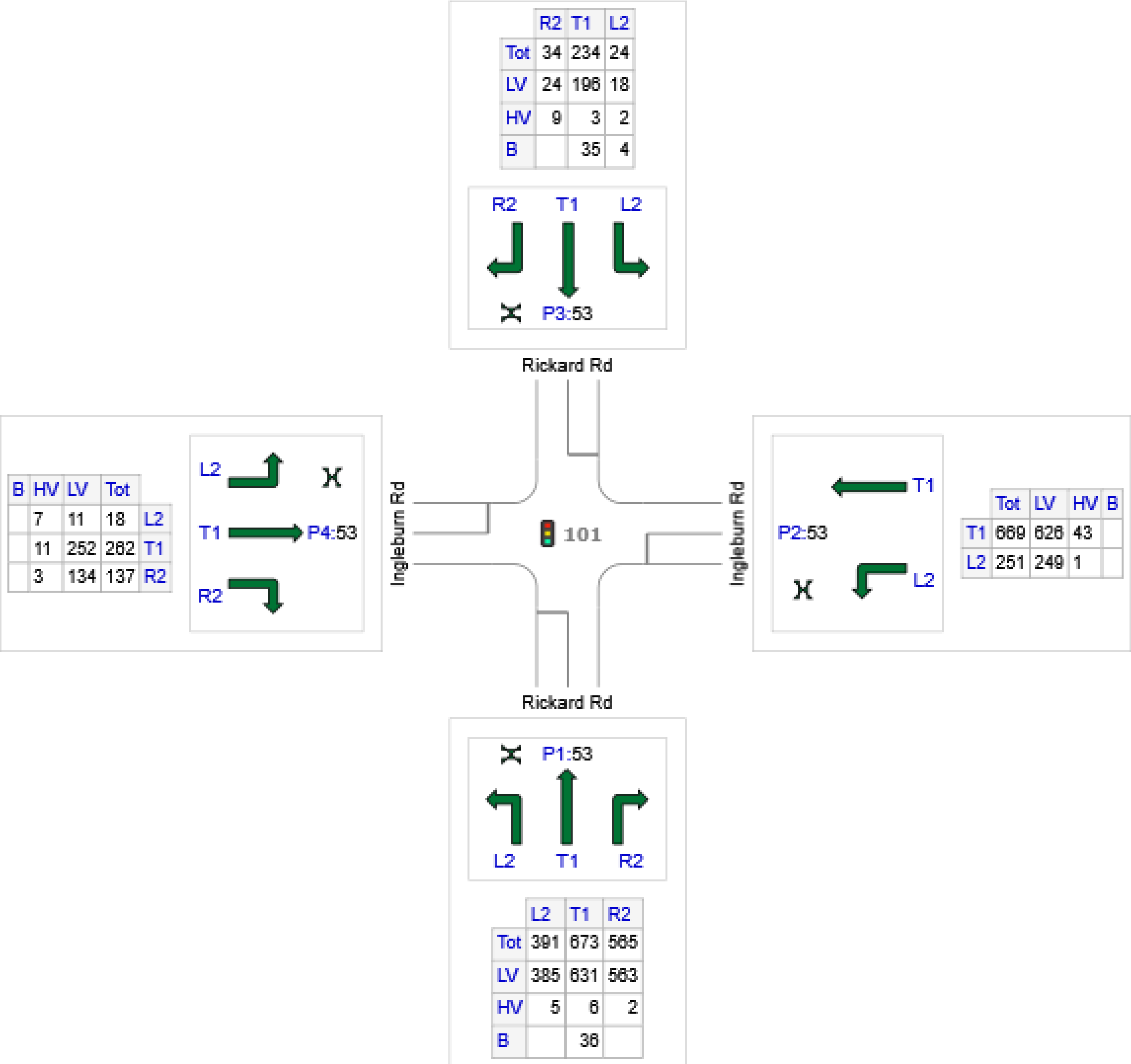
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [a) Rickard/Ingleburn_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



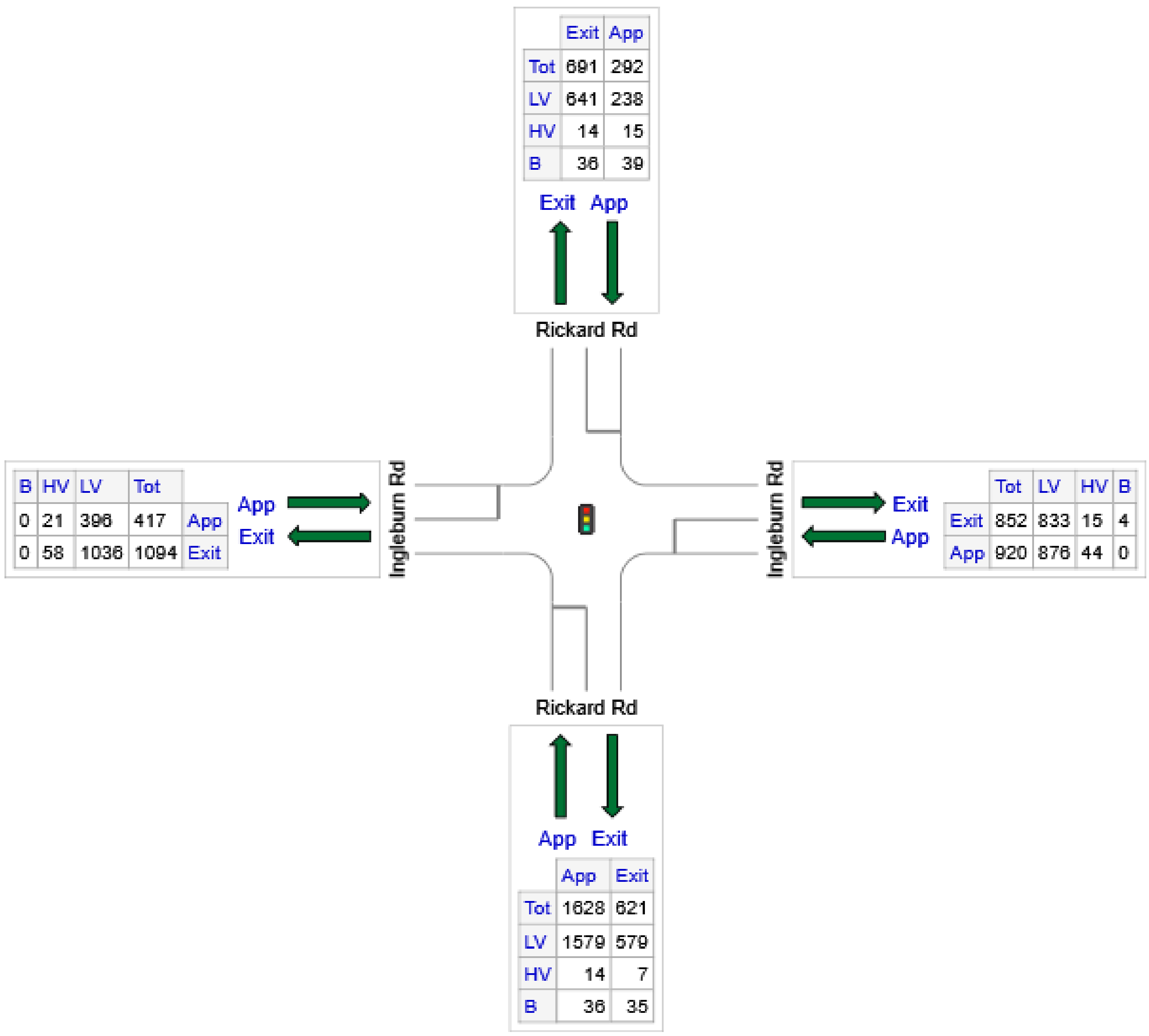
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Buses (B)
S: Rickard Rd	1628	1579	14	36
E: Ingleburn Rd	920	876	44	-
N: Rickard Rd	292	238	15	39
W: Ingleburn Rd	417	396	21	-
Total	3257	3088	94	75

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [a] Rickard/Ingleburn_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



MOVEMENT SUMMARY

Site: 101 [a] Rickard/Ingleburn_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Rickard Rd														
1	L2	217	0	228	0.0	0.202	16.7	LOS B	5.8	40.9	0.48	0.69	0.48	43.9
2	T1	339	33	357	9.7	0.508	35.9	LOS C	15.2	106.4	0.85	0.75	0.85	32.9
3	R2	159	2	167	1.3	* 0.992	102.5	LOS F	13.4	94.9	1.00	1.14	1.75	17.0
Approach		715	35	753	4.9	0.992	44.9	LOS D	15.2	106.4	0.77	0.82	0.94	29.7
East: Ingleburn Rd														
4	L2	148	4	156	2.7	0.293	41.0	LOS C	7.1	50.5	0.82	0.77	0.82	29.8
5	T1	461	24	485	5.2	* 0.858	62.5	LOS E	15.5	113.7	1.00	0.99	1.25	18.4
Approach		609	28	641	4.6	0.858	57.2	LOS E	15.5	113.7	0.96	0.93	1.15	21.0
North: Rickard Rd														
7	L2	44	7	46	15.9	0.085	34.6	LOS C	1.9	14.8	0.73	0.69	0.73	24.3
8	T1	547	34	576	6.2	* 0.959	69.8	LOS E	40.5	284.5	0.98	1.16	1.36	24.0
9	R2	84	14	88	16.7	0.581	64.0	LOS E	5.2	41.9	1.00	0.79	1.02	19.2
Approach		675	55	711	8.1	0.959	66.8	LOS E	40.5	284.5	0.97	1.09	1.28	23.3
West: Ingleburn Rd														
10	L2	15	6	16	40.0	0.296	28.9	LOS C	8.8	65.9	0.68	0.59	0.68	32.8
11	T1	441	23	464	5.2	0.296	23.2	LOS B	9.1	66.5	0.69	0.59	0.69	32.6
12	R2	606	6	638	1.0	* 0.954	71.4	LOS F	30.1	212.6	0.98	0.97	1.25	24.0
Approach		1062	35	1118	3.3	0.954	50.8	LOS D	30.1	212.6	0.85	0.81	1.01	26.1
All Vehicles		3061	153	3222	5.0	0.992	54.2	LOS D	40.5	284.5	0.88	0.90	1.08	25.2

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Rickard Rd												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
East: Ingleburn Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45
North: Rickard Rd												

P3	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Ingleburn Rd												
P4	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
All Pedestrians		200	211	54.3	LOS E	0.2	0.2	0.95	0.95	86.1	41.3	0.48

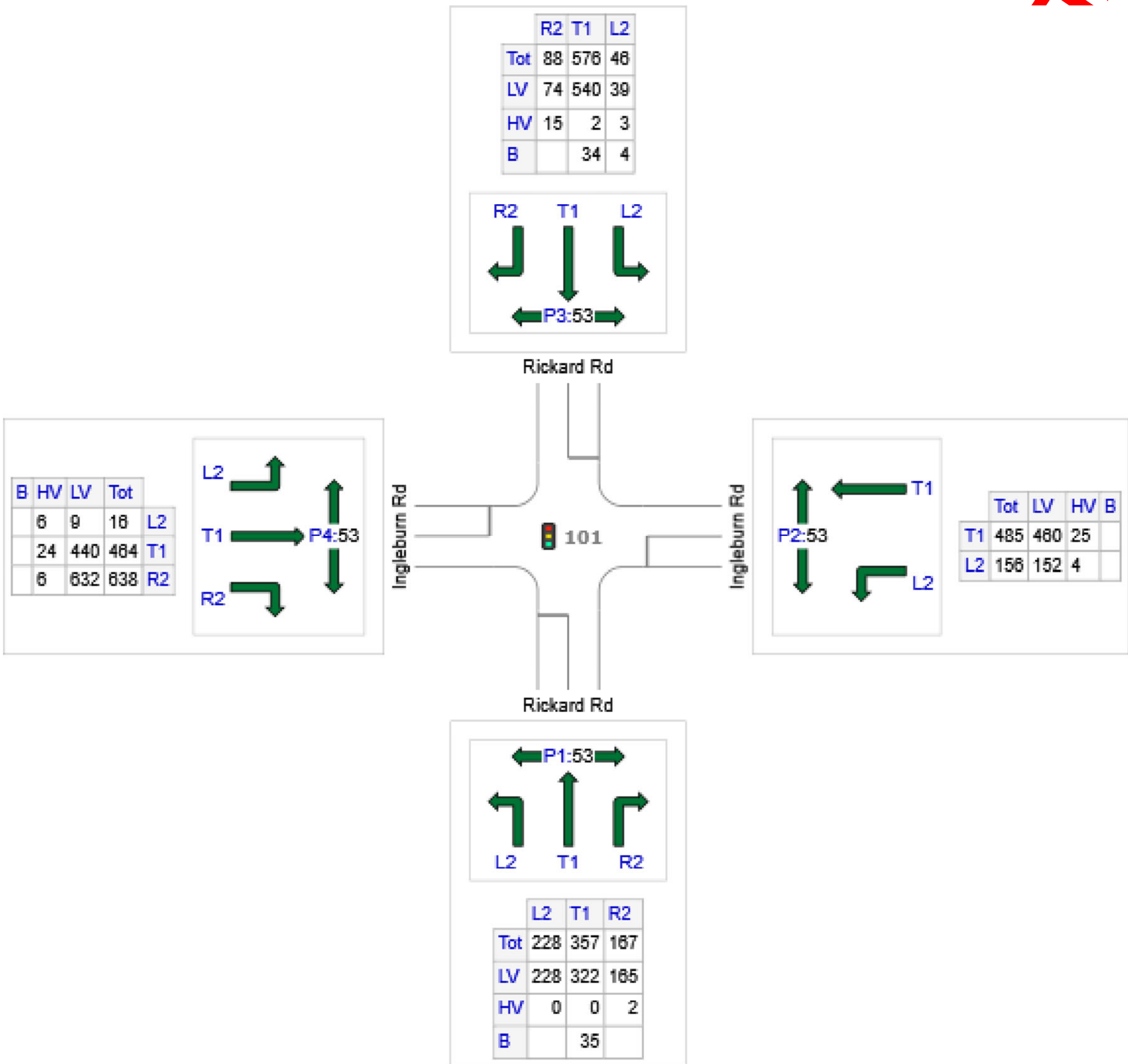
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [a) Rickard/Ingleburn_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



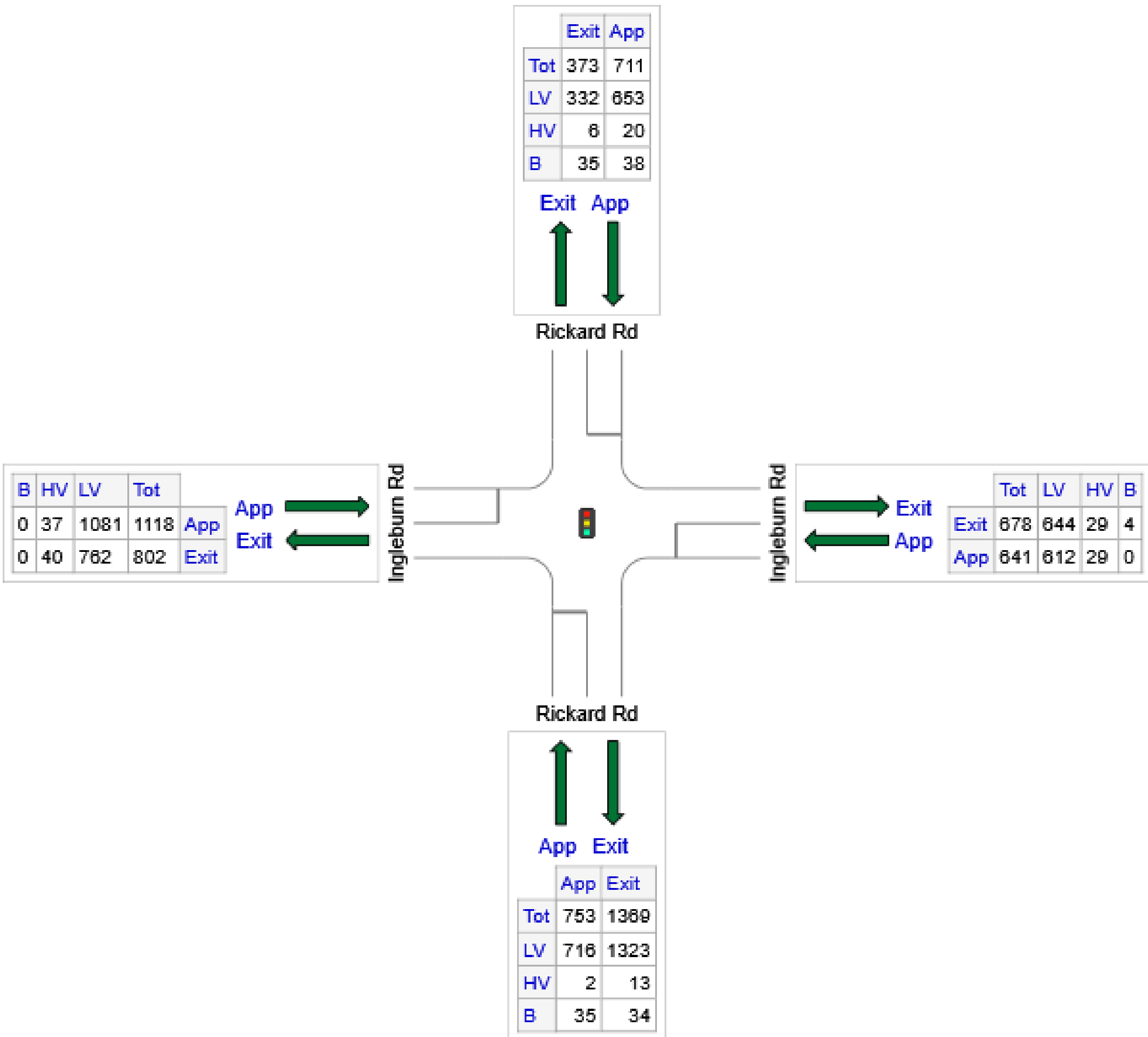
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Buses (B)
S: Rickard Rd	753	716	2	35
E: Ingleburn Rd	641	612	29	-
N: Rickard Rd	711	653	20	38
W: Ingleburn Rd	1118	1081	37	-
Total	3222	3061	88	73

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [a] Rickard/Ingleburn_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



Rickard Rd (north):

	Exit	App
Tot	373	711
LV	332	653
HV	6	20
B	35	38

Ingleburn Rd (west):

B	HV	LV	Tot	
0	37	1081	1118	App
0	40	762	802	Exit

Ingleburn Rd (east):

	Tot	LV	HV	B
Exit	678	644	29	4
App	641	612	29	0

Rickard Rd (south):

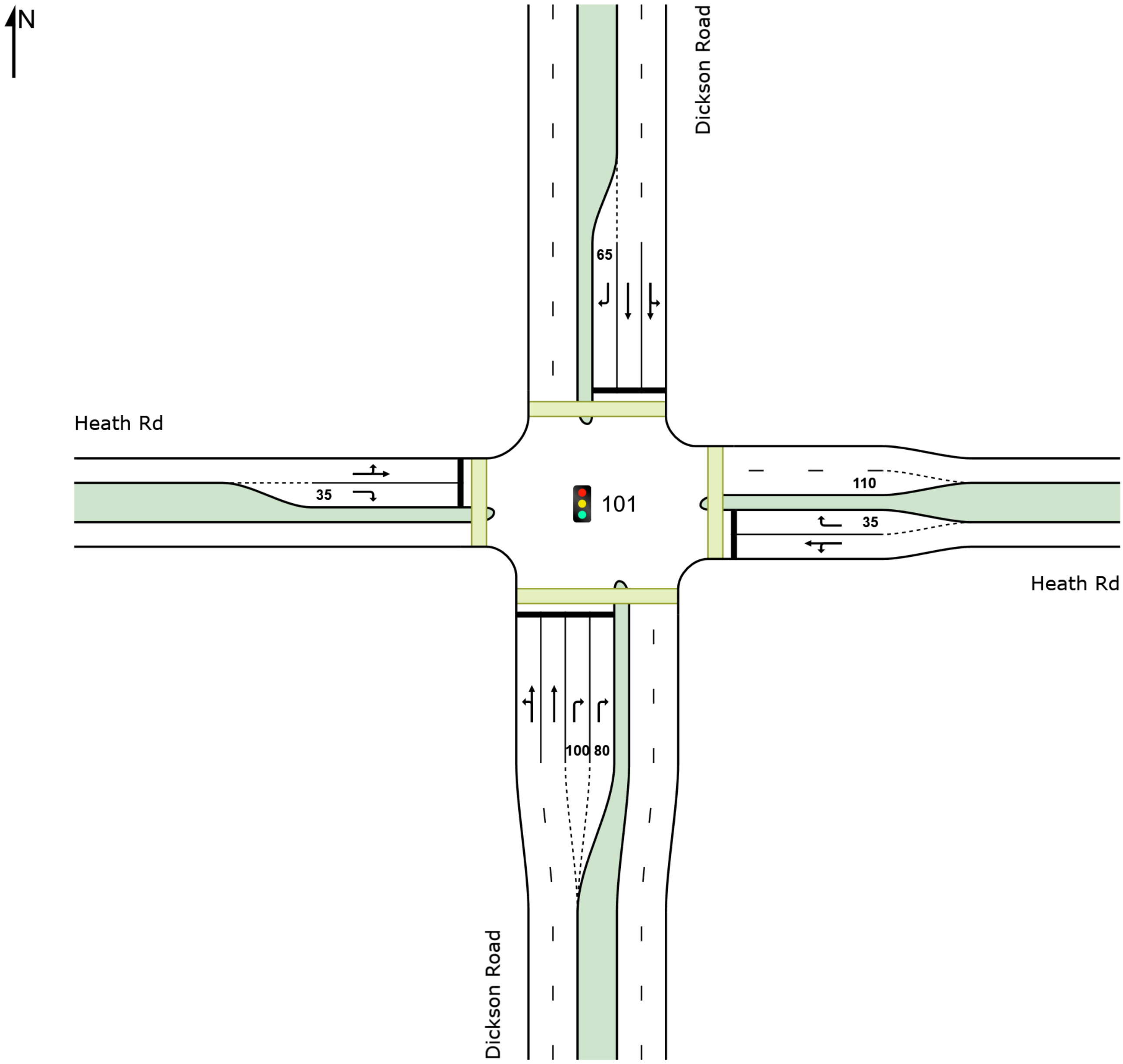
	App	Exit
Tot	753	1369
LV	716	1323
HV	2	13
B	35	34

SITE LAYOUT

Site: 101 [b] Dickson/Heath_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated

Layout pictures are schematic functional drawings reflecting input data. They are not design drawings.



MOVEMENT SUMMARY

Site: 101 [b] Dickson/Heath_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Road														
1	L2	14	2	15	14.3	0.477	43.4	LOS D	12.6	89.1	0.87	0.77	0.87	33.4
2	T1	483	3	508	0.6	0.477	39.2	LOS C	12.7	89.5	0.88	0.77	0.88	33.7
3	R2	540	1	568	0.2	0.924	66.6	LOS E	24.9	174.5	0.98	0.93	1.20	26.6
Approach		1037	6	1092	0.6	0.924	53.5	LOS D	24.9	174.5	0.93	0.85	1.05	29.6
East: Heath Rd														
4	L2	80	3	84	3.8	* 0.927	61.6	LOS E	42.2	299.2	0.99	1.08	1.25	28.2
5	T1	509	6	536	1.2	0.927	57.0	LOS E	42.2	299.2	0.99	1.08	1.25	28.1
6	R2	60	1	63	1.7	0.688	70.8	LOS F	4.0	28.3	1.00	0.82	1.16	25.4
Approach		649	10	683	1.5	0.927	58.8	LOS E	42.2	299.2	0.99	1.06	1.24	27.8
North: Dickson Road														
7	L2	92	1	97	1.1	* 0.919	74.2	LOS F	21.1	149.8	1.00	1.11	1.37	25.2
8	T1	471	8	496	1.7	0.919	69.7	LOS E	21.1	149.8	1.00	1.11	1.38	26.0
9	R2	121	1	127	0.8	0.753	66.8	LOS E	7.9	55.3	1.00	0.87	1.17	26.0
Approach		684	10	720	1.5	0.919	69.8	LOS E	21.1	149.8	1.00	1.07	1.34	25.9
West: Heath Rd														
10	L2	122	0	128	0.0	0.543	35.1	LOS C	17.2	121.5	0.83	0.75	0.83	34.6
11	T1	241	5	254	2.1	0.543	30.5	LOS C	17.2	121.5	0.83	0.75	0.83	34.8
12	R2	14	2	15	14.3	0.175	67.4	LOS E	0.9	6.9	0.99	0.69	0.99	26.1
Approach		377	7	397	1.9	0.543	33.4	LOS C	17.2	121.5	0.83	0.75	0.83	34.3
All Vehicles		2747	33	2892	1.2	0.927	56.1	LOS D	42.2	299.2	0.95	0.94	1.14	28.7

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Road												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
East: Heath Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45

North: Dickson Road											
P3 Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Heath Rd											
P4 Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	80.3	33.9	0.42
All Pedestrians	200	211	54.3	LOS E	0.2	0.2	0.95	0.95	84.2	38.9	0.46

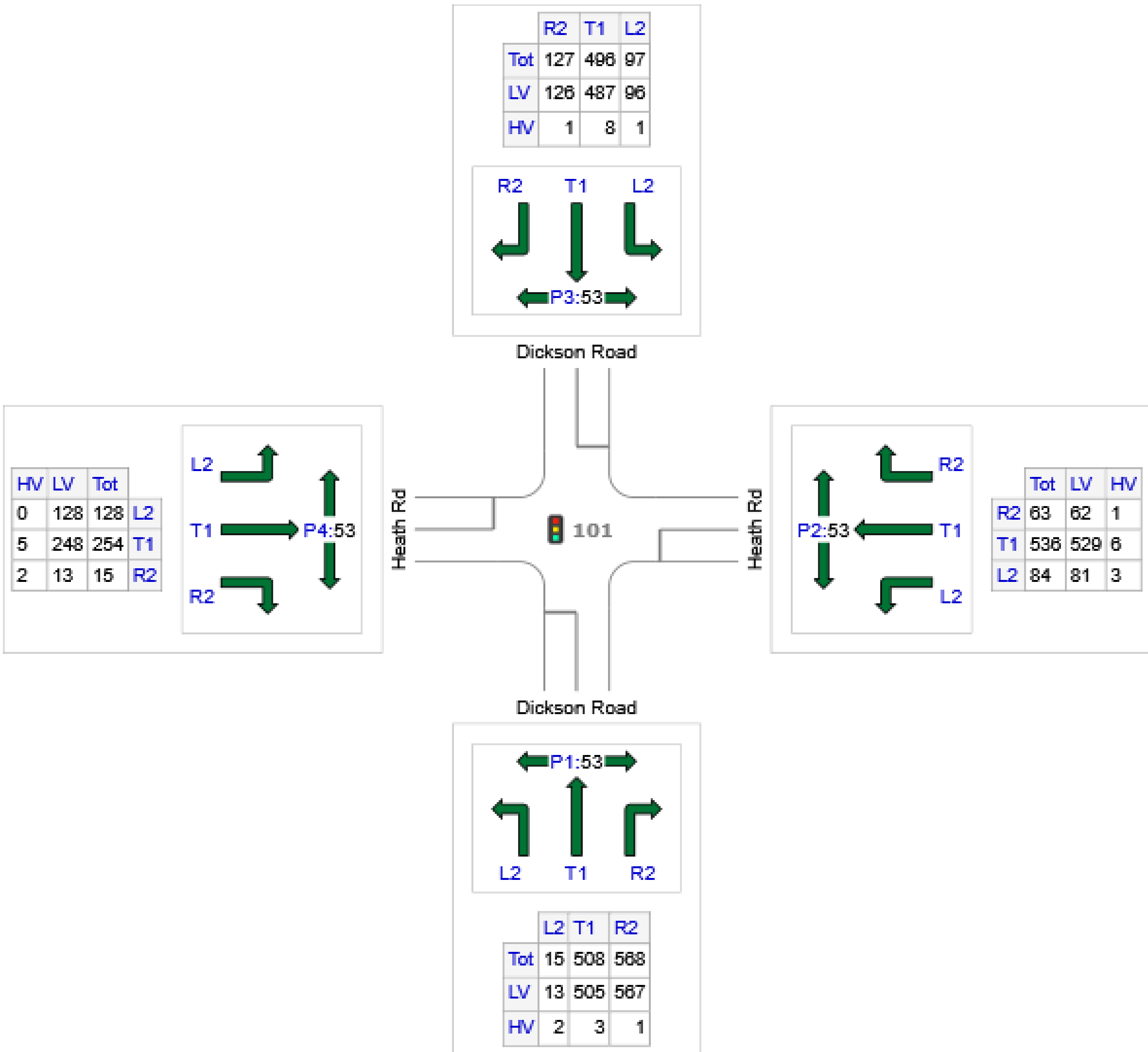
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [b] Dickson/Heath_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



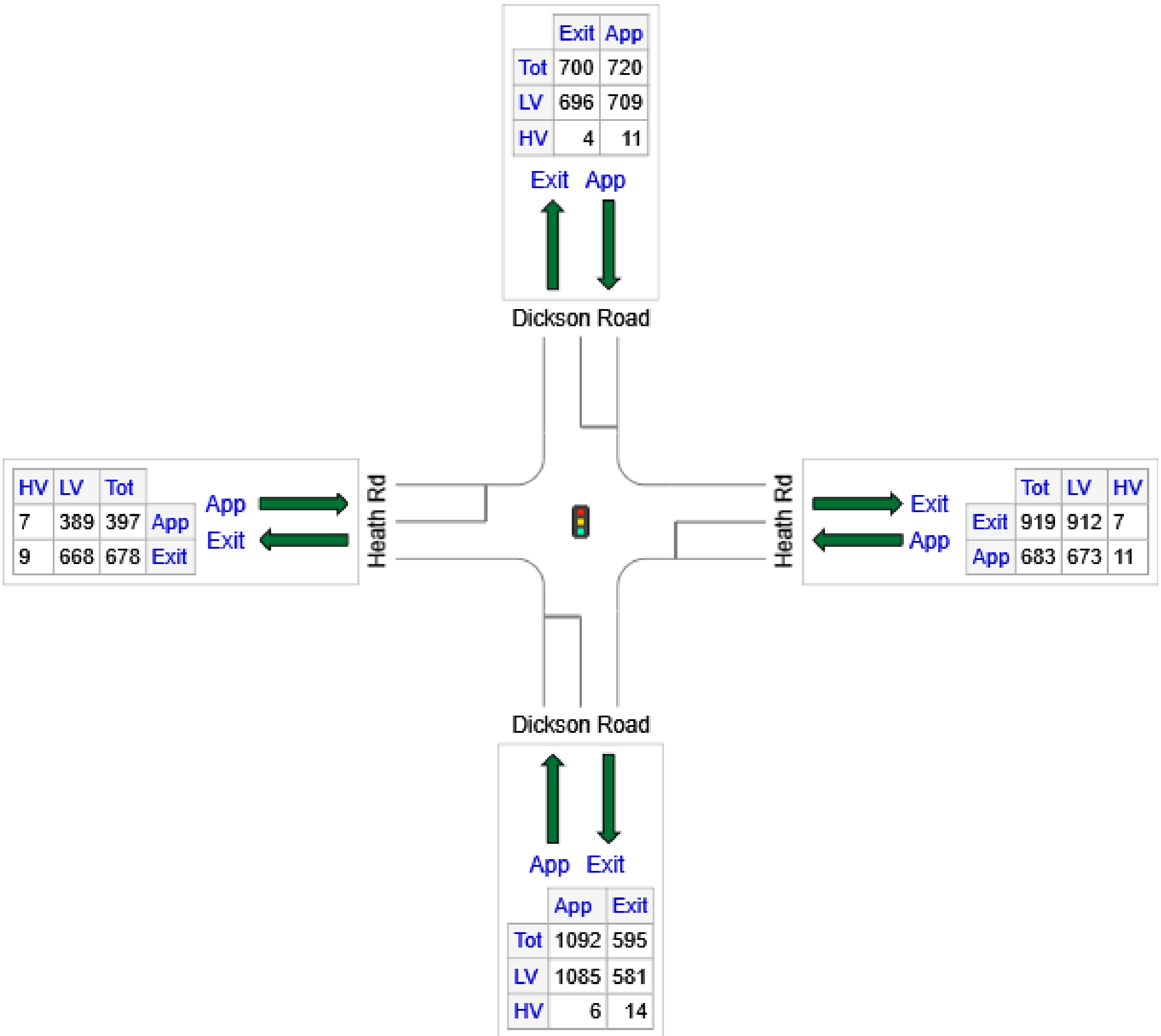
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Road	1092	1085	6
E: Heath Rd	683	673	11
N: Dickson Road	720	709	11
W: Heath Rd	397	389	7
Total	2892	2857	35

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [b] Dickson/Heath_2041_AM1_Upgrade_v1 (Site Folder: 2041_AM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



MOVEMENT SUMMARY

Site: 101 [b] Dickson/Heath_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] veh/h	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Dickson Road														
1	L2	19	0	20	0.0	0.392	53.5	LOS D	6.7	47.5	0.93	0.77	0.93	30.4
2	T1	223	2	235	0.9	0.392	49.5	LOS D	6.7	47.5	0.93	0.77	0.93	30.6
3	R2	294	2	309	0.7	* 0.661	57.8	LOS E	11.0	77.2	0.97	0.81	0.99	28.5
Approach		536	4	564	0.7	0.661	54.2	LOS D	11.0	77.2	0.96	0.79	0.96	29.4
East: Heath Rd														
4	L2	84	1	88	1.2	0.573	43.7	LOS D	14.1	99.7	0.90	0.78	0.90	32.7
5	T1	186	3	196	1.6	0.573	39.1	LOS C	14.1	99.7	0.90	0.78	0.90	32.2
6	R2	30	1	32	3.3	* 0.348	68.1	LOS E	1.9	13.8	1.00	0.72	1.00	25.8
Approach		300	5	316	1.7	0.573	43.3	LOS D	14.1	99.7	0.91	0.77	0.91	31.6
North: Dickson Road														
7	L2	180	2	189	1.1	0.680	41.7	LOS C	21.5	150.9	0.92	0.83	0.92	32.4
8	T1	586	0	617	0.0	* 0.680	37.3	LOS C	21.5	150.9	0.91	0.80	0.91	34.3
9	R2	221	0	233	0.0	0.406	39.8	LOS C	10.8	75.3	0.84	0.79	0.84	32.2
Approach		987	2	1039	0.2	0.680	38.7	LOS C	21.5	150.9	0.90	0.80	0.90	33.4
West: Heath Rd														
10	L2	17	0	18	0.0	0.678	45.4	LOS D	17.9	126.1	0.94	0.81	0.94	31.9
11	T1	312	3	328	1.0	* 0.678	40.8	LOS C	17.9	126.1	0.94	0.81	0.94	32.1
12	R2	20	0	21	0.0	0.227	67.3	LOS E	1.3	8.8	0.99	0.70	0.99	26.3
Approach		349	3	367	0.9	0.678	42.5	LOS D	17.9	126.1	0.94	0.80	0.94	31.7
All Vehicles		2172	14	2286	0.6	0.680	43.7	LOS D	21.5	150.9	0.92	0.80	0.92	31.8

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.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

* Critical Movement (Signal Timing)

Pedestrian Movement Performance

Mov ID	Crossing	Input Vol. ped/h	Dem. Flow ped/h	Aver. Delay sec	Level of Service	AVERAGE BACK OF QUEUE [Ped ped	Dist] m	Prop. Que	Effective Stop Rate	Travel Time sec	Travel Dist. m	Aver. Speed m/sec
South: Dickson Road												
P1	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	88.0	43.8	0.50
East: Heath Rd												
P2	Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	82.9	37.2	0.45

North: Dickson Road											
P3 Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	85.4	40.5	0.47
West: Heath Rd											
P4 Full	50	53	54.3	LOS E	0.2	0.2	0.95	0.95	80.3	33.9	0.42
All Pedestrians	200	211	54.3	LOS E	0.2	0.2	0.95	0.95	84.2	38.9	0.46

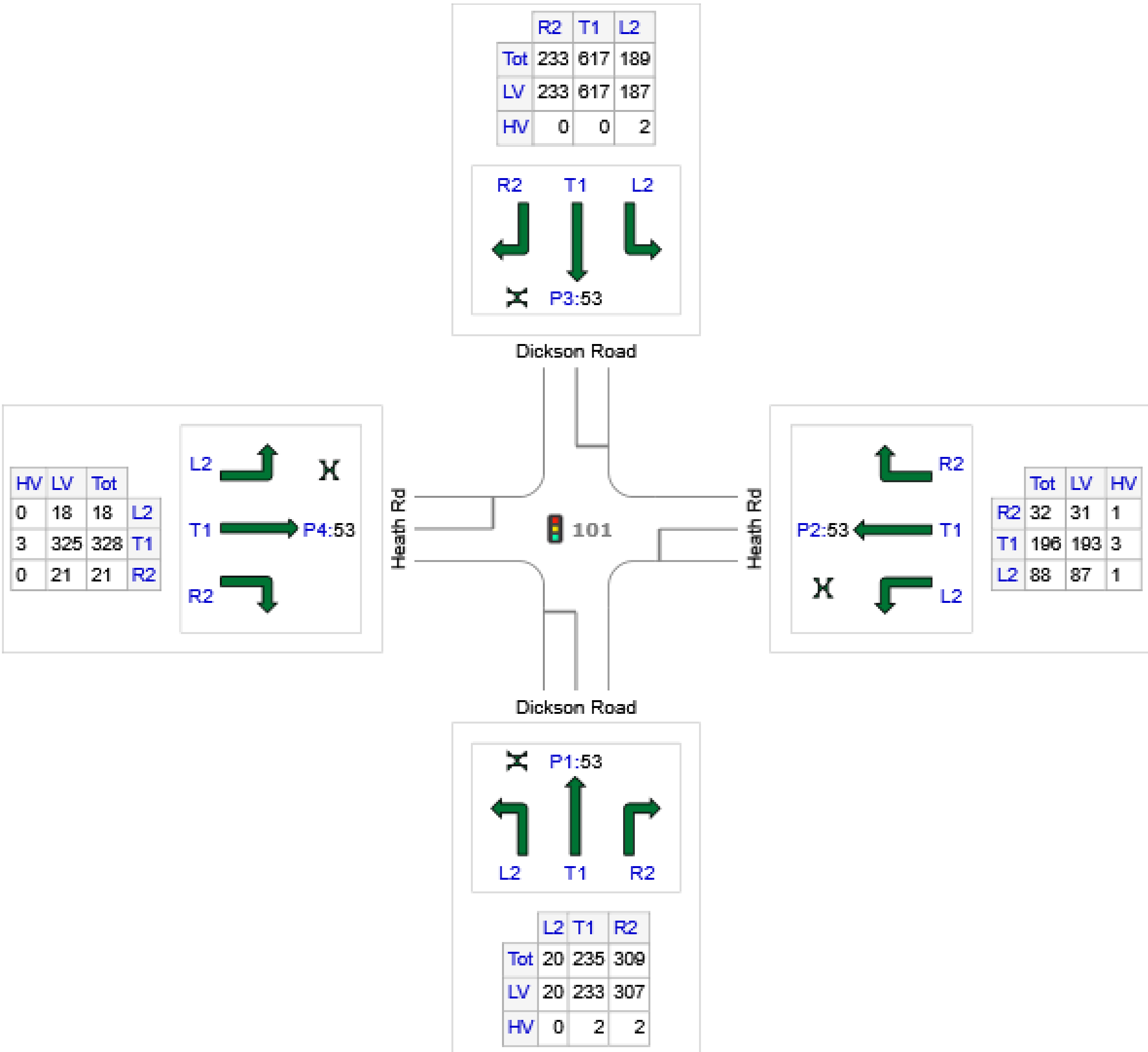
Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

OD MOVEMENT DEMAND FLOWS

Site Origin - Destination Movement Demand Flow Rates (veh/h) and Pedestrian Flow Rates (ped/h)

Site: 101 [b) Dickson/Heath_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated   Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.



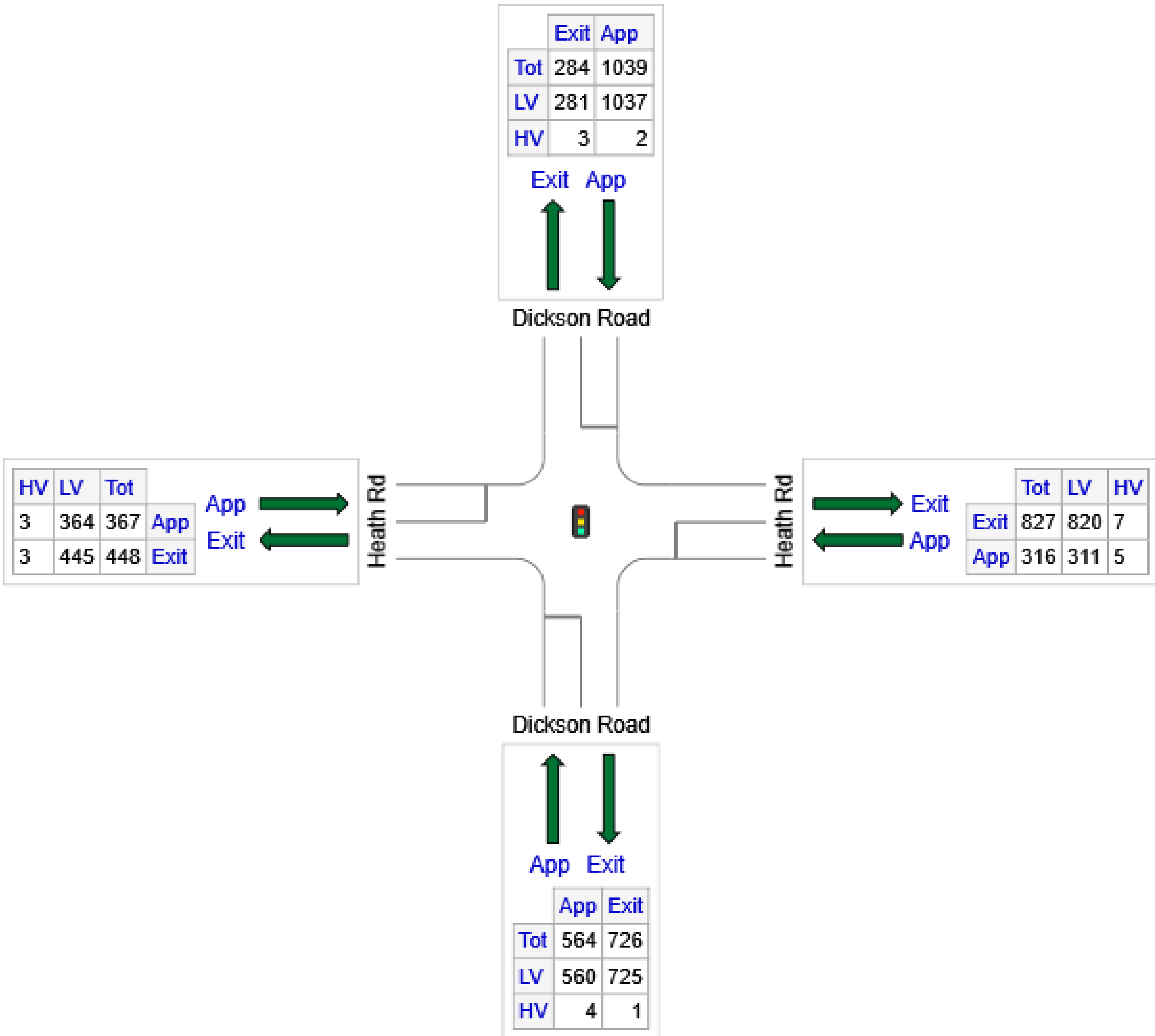
	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Dickson Road	564	560	4
E: Heath Rd	316	311	5
N: Dickson Road	1039	1037	2
W: Heath Rd	367	364	3
Total	2286	2272	15

APPROACH AND EXIT FLOWS

Total Values for All Movement Classes Based on Site Demand Flow Rates (veh/h)

Site: 101 [b] Dickson/Heath_2041_PM_Upgrade_v1 (Site Folder: 2041_PM_Upgrade)]

New Site
Site Category: (None)
Signals - EQUISAT (Fixed-Time/SCATS) Isolated Cycle Time = 120 seconds (Site User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

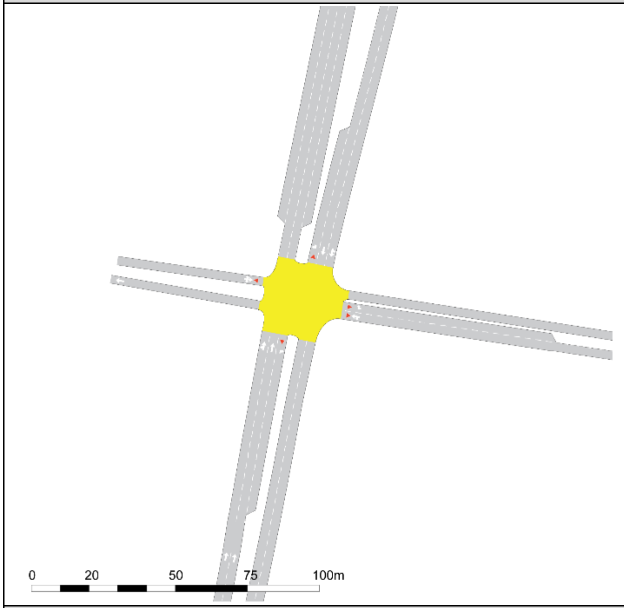


Appendix S

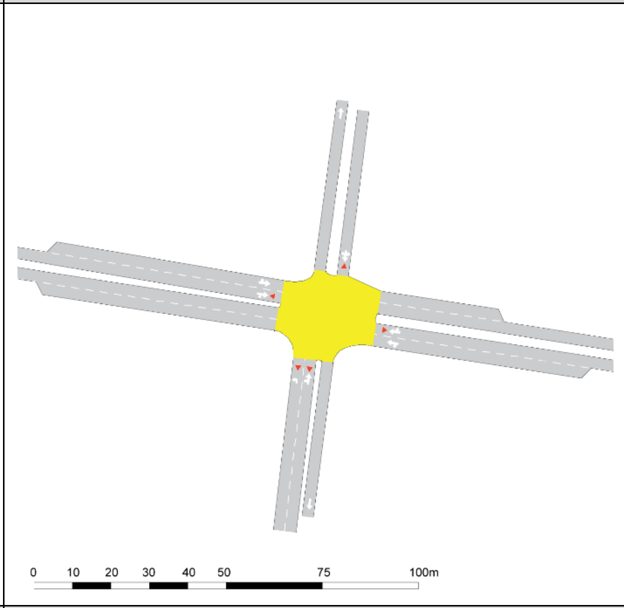
Concept intersection layouts

Intersection map

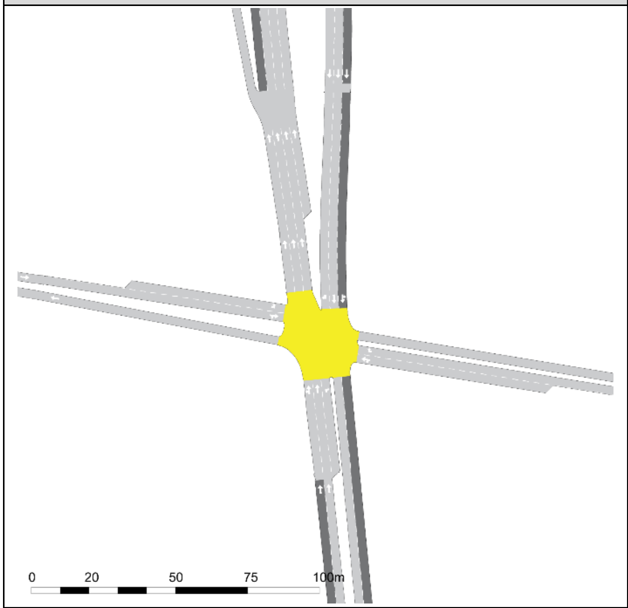
1 - Other E-W Link 1 / Dickson Rd



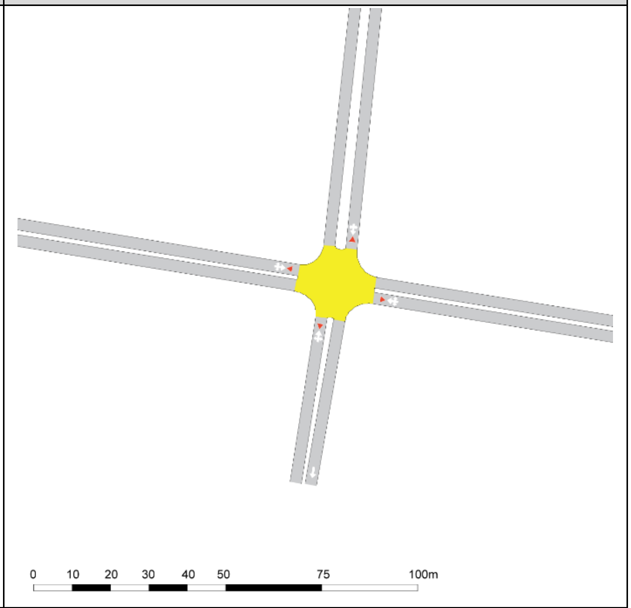
2 - Other E-W Link 1_Intersection 2



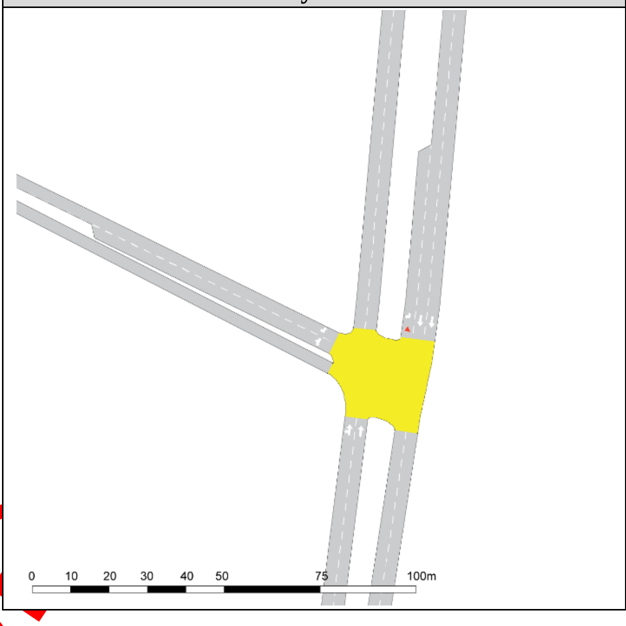
3 - Other E-W Link 1 / Rickard Rd



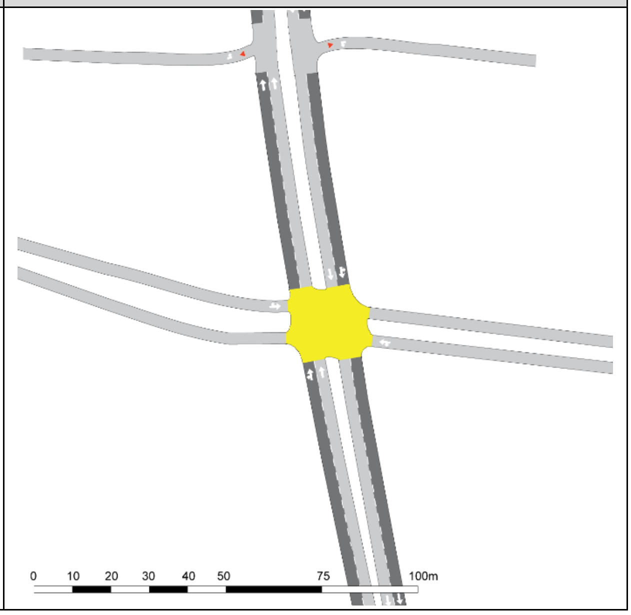
4 - Other E-W Link 1_Intersection 4



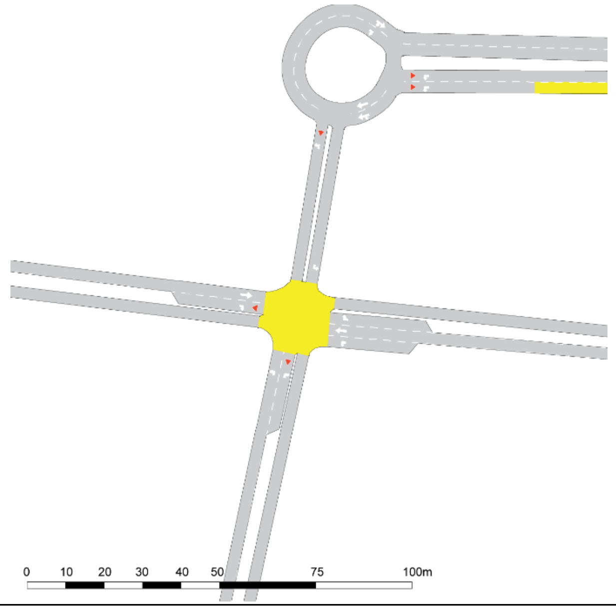
5 - Other E-W Link 1 / Byron Rd



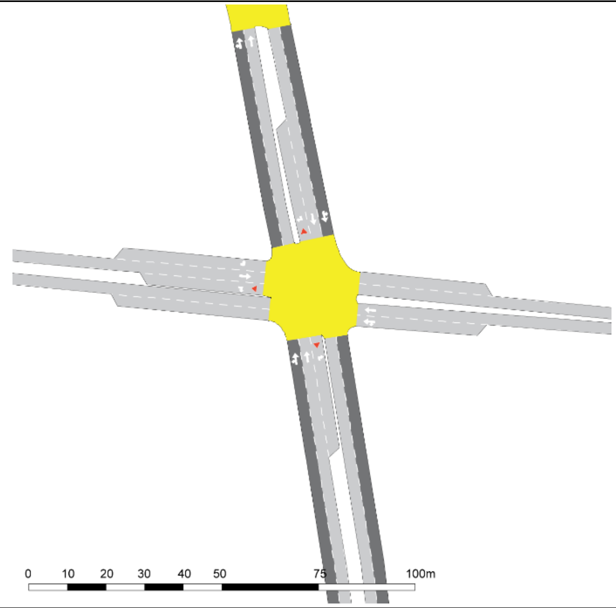
6 - Rickard Rd / Other E-W Link 2



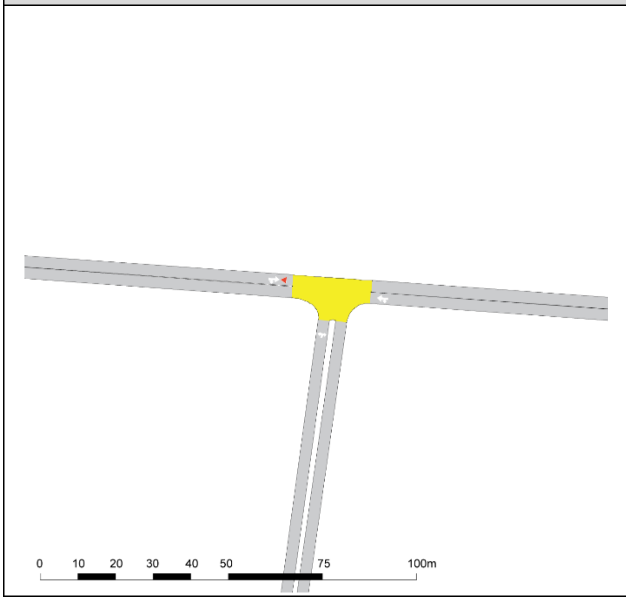
7 - Other E-W Link 2 / Other N-S Link 1



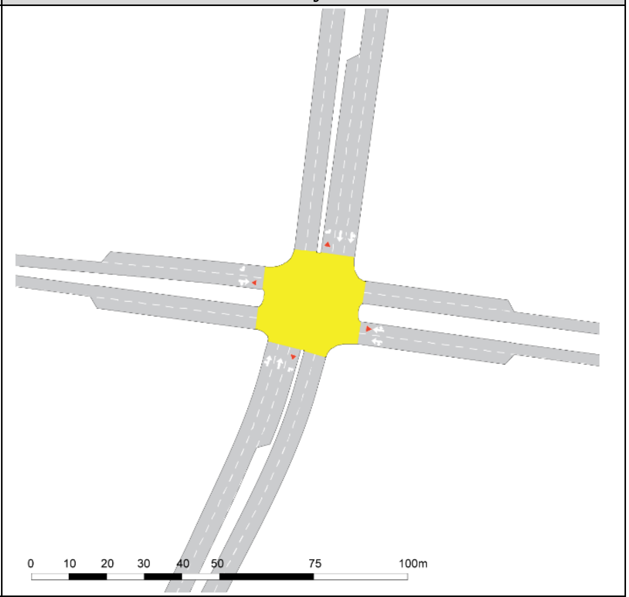
8 - Other E-W Link 2 / Rickard Rd



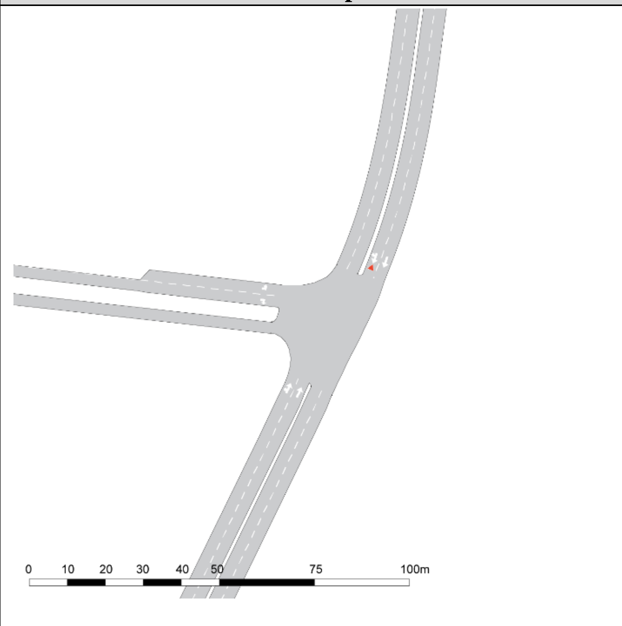
9 - Other E-W Link 2 / Other N-S Link 2



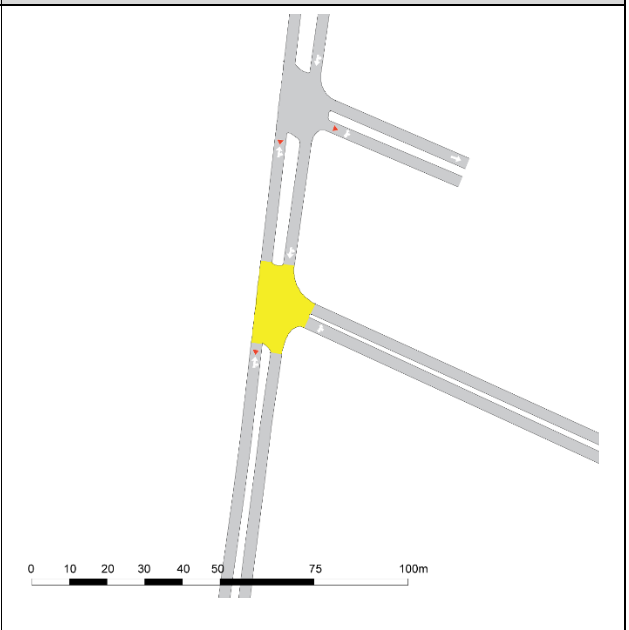
10 - Other E-W Link 2 / Byron Rd



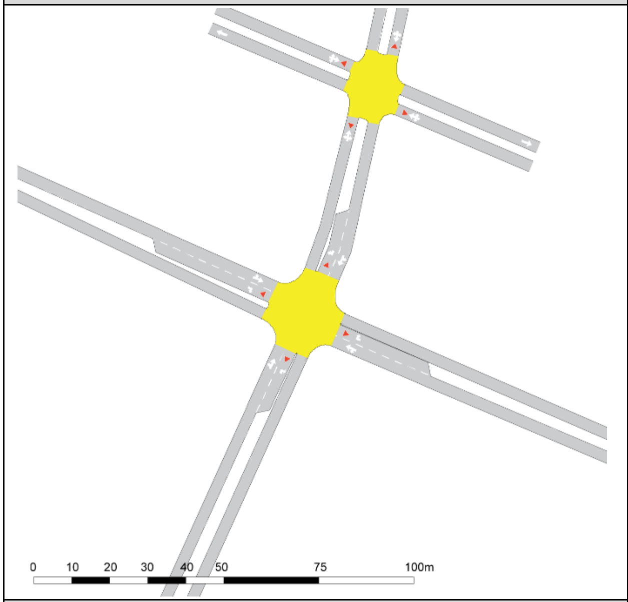
11 - Other E-W Link 2 / Cowpasture Rd



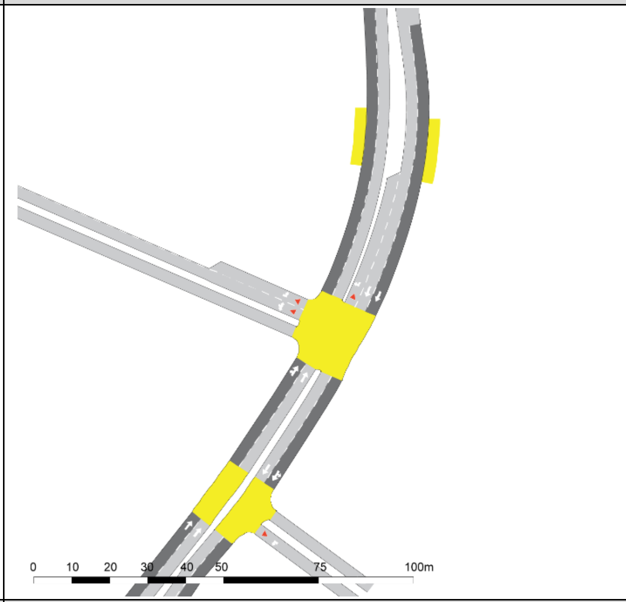
12 - Other E-W Link 5_Intersection 1



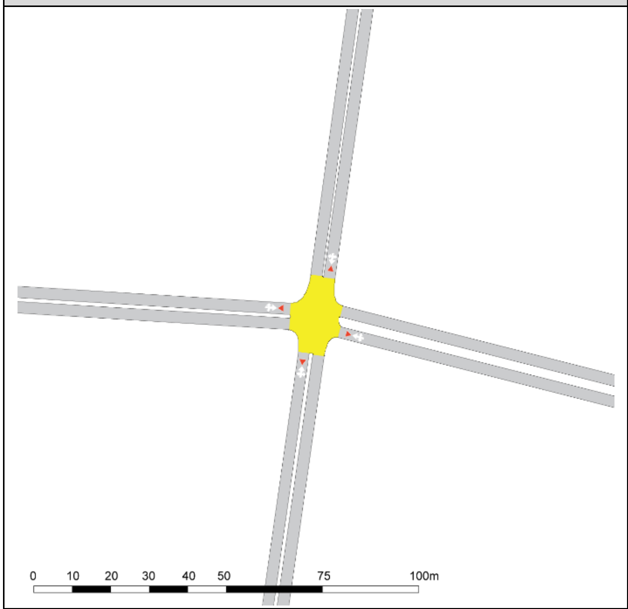
13 - Other E-W Link 5 / Other N-S Link 1



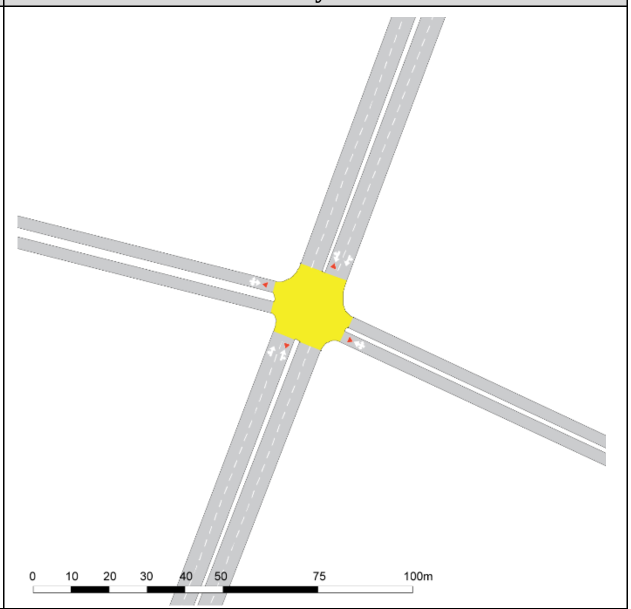
14 - Other E-W Link 5 / Rickard Rd



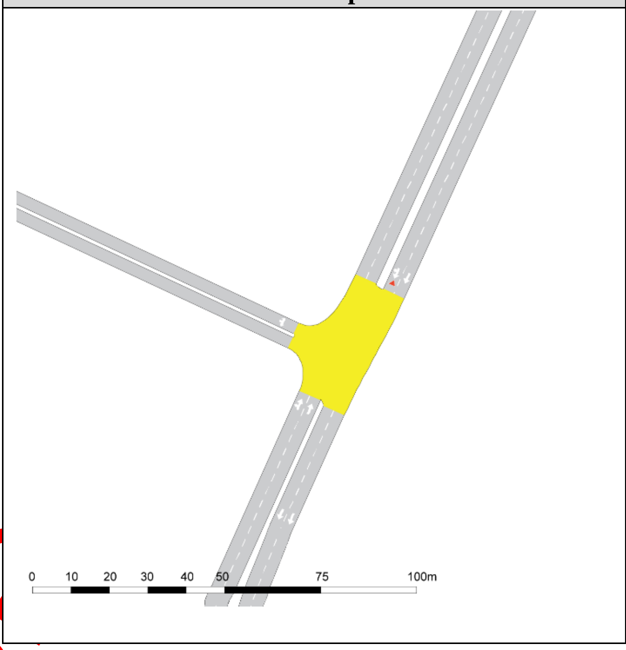
15 - Other E-W Link 4 / Other N-S Link 2



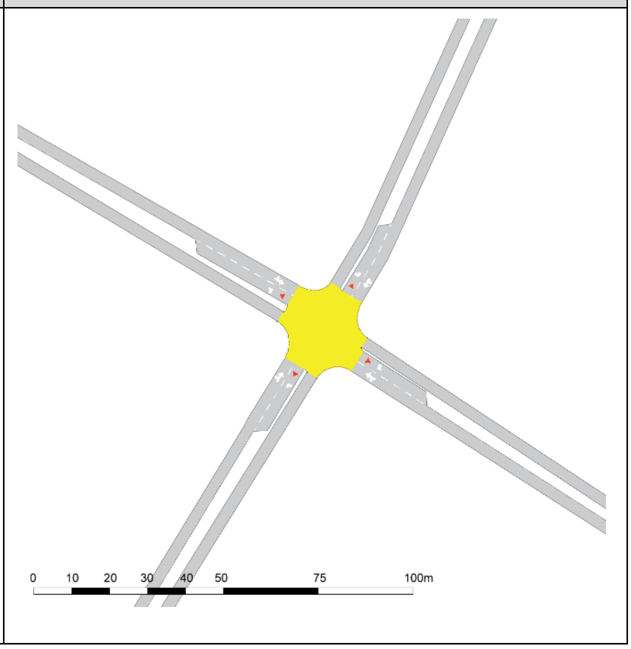
16 - Other E-W Link 4 / Byron Rd



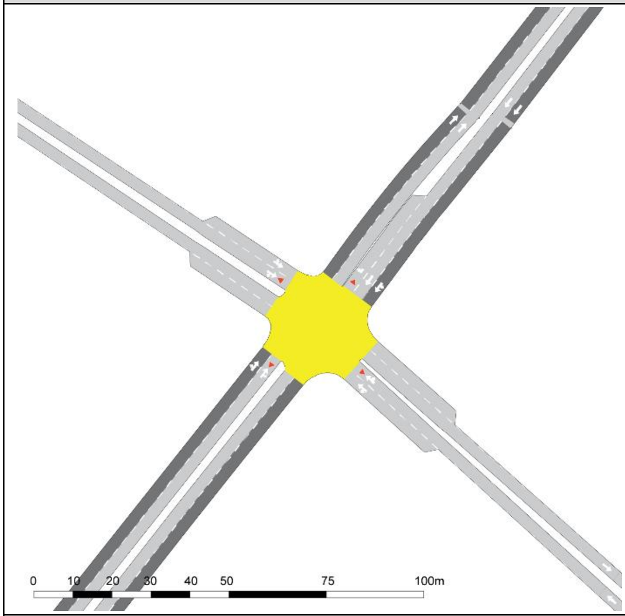
17 - Other E-W Link 4 / Cowpasture Rd



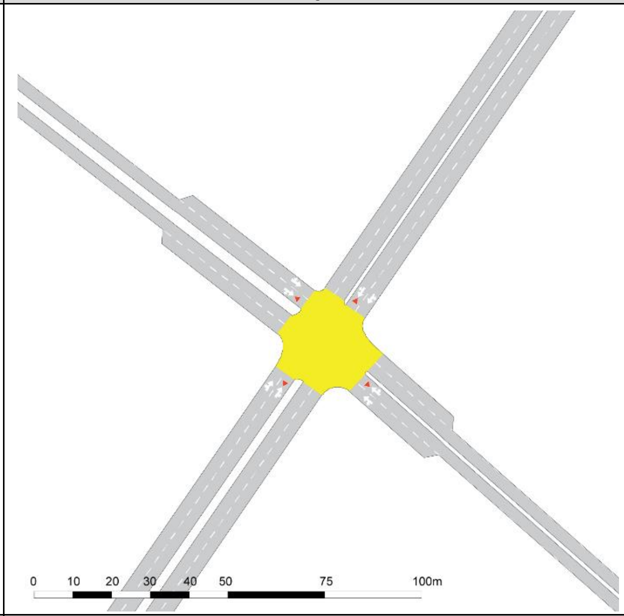
18 - Other E-W Link 6 / Other N-S Link 1



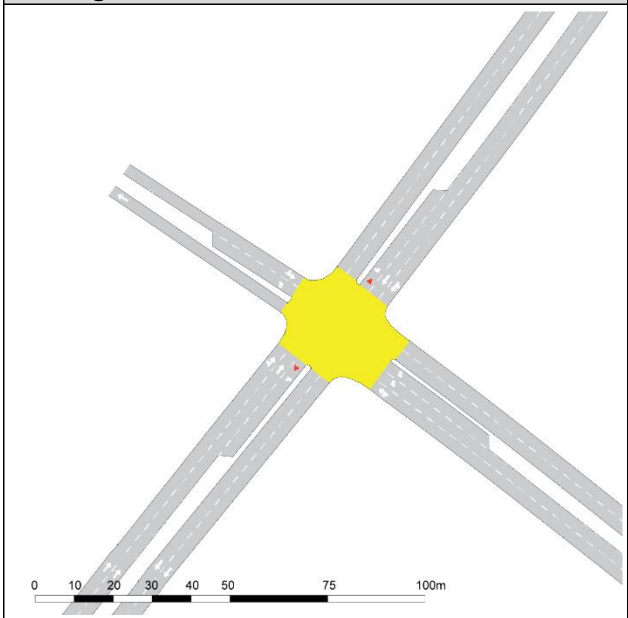
19 - Other E-W Link 6 / Rickard Rd



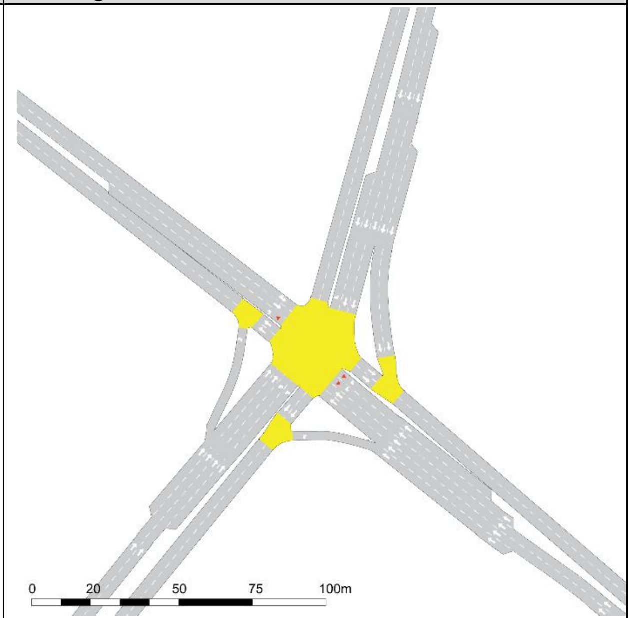
20 - Other E-W Link 6 / Byron Rd



21 - Ingleburn Rd / Eastwood Rd

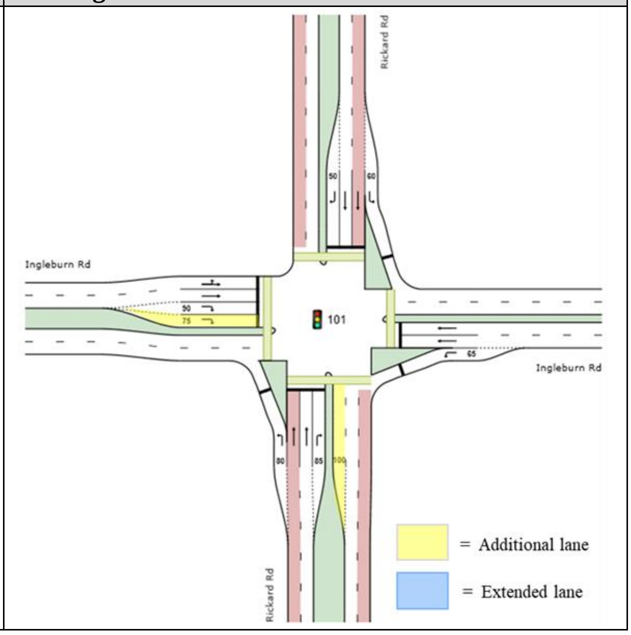


22 - Ingleburn Rd / Dickson Rd

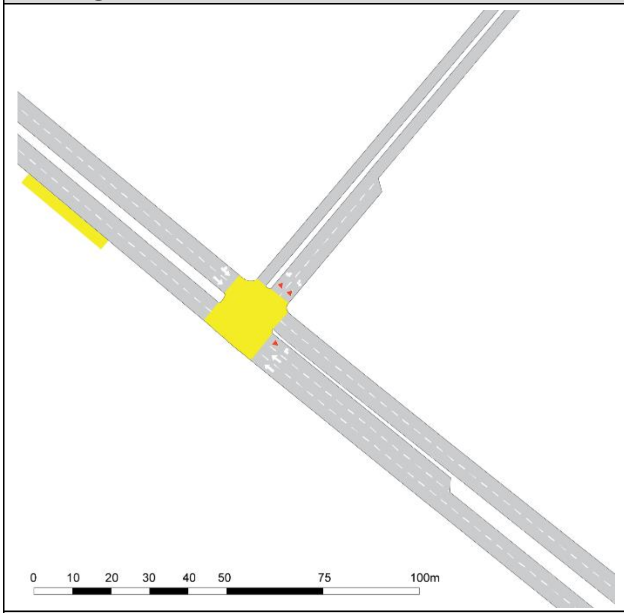


23 - Ingleburn Rd / Other N-S Link 1

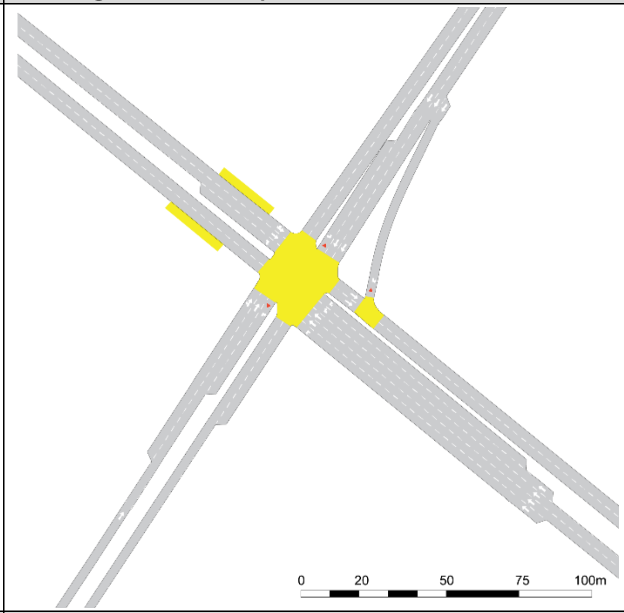
24 - Ingleburn Rd / Rickard Rd



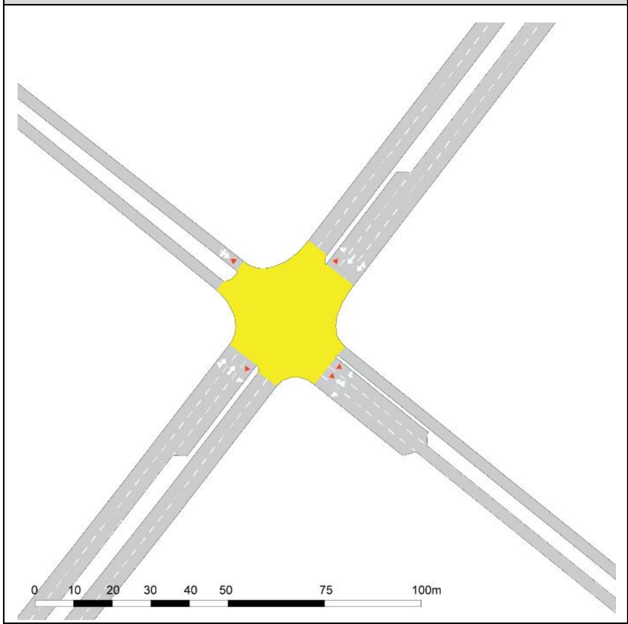
25 - Ingleburn Rd / Other N-S Link 2



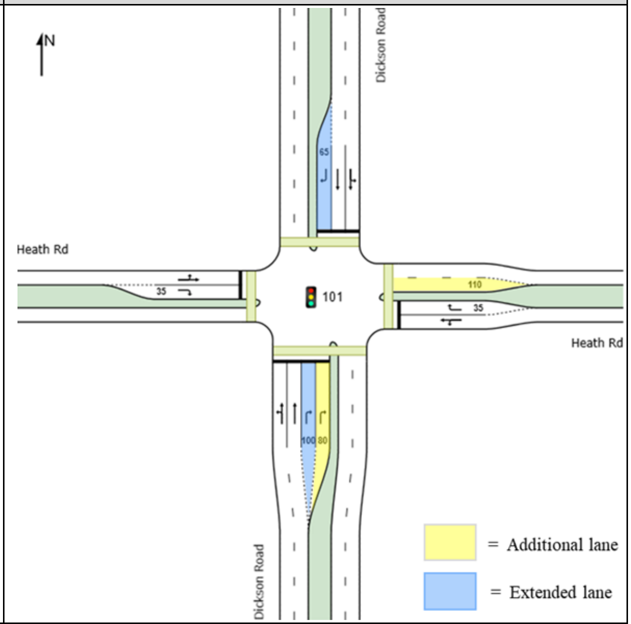
26 - Ingleburn Rd / Byron Rd



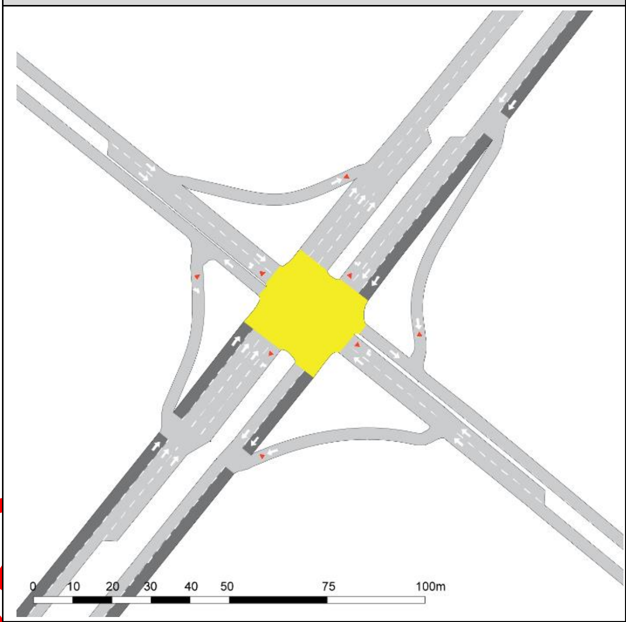
27 - Heath Rd / Eastwood Rd



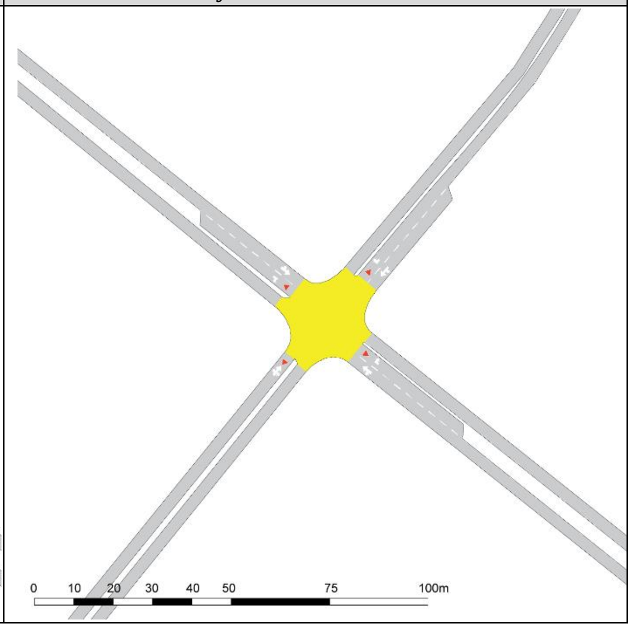
28 - Heath Rd / Dickson Rd



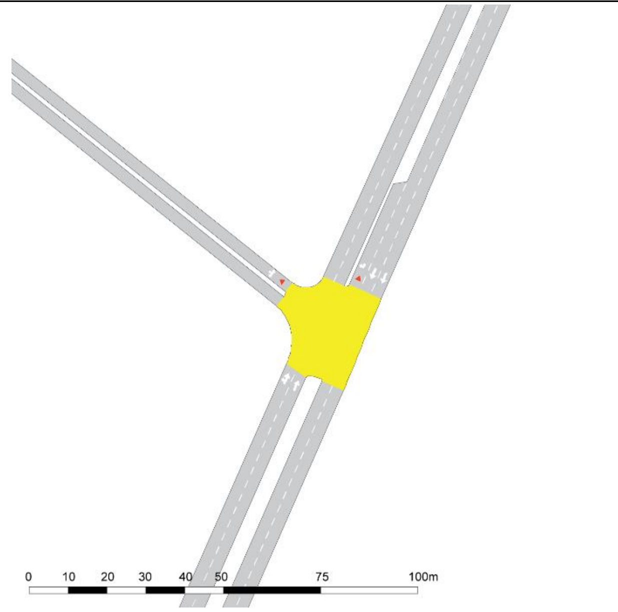
29 - Heath Rd / Rickard Rd



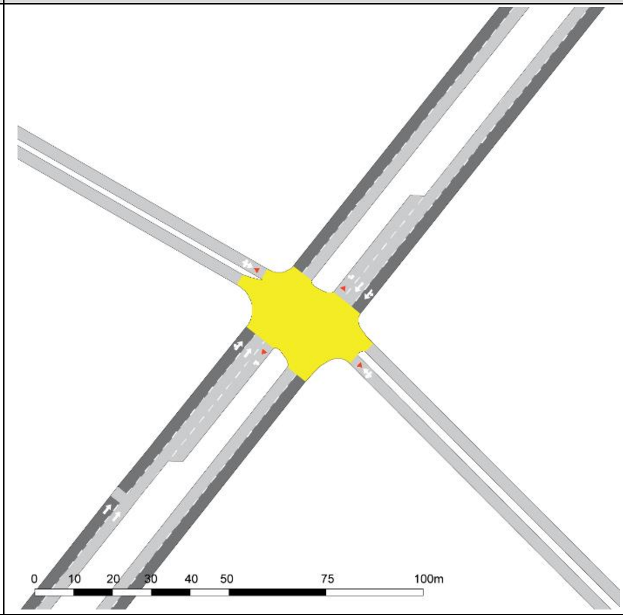
30 - Heath Rd / Byron Rd



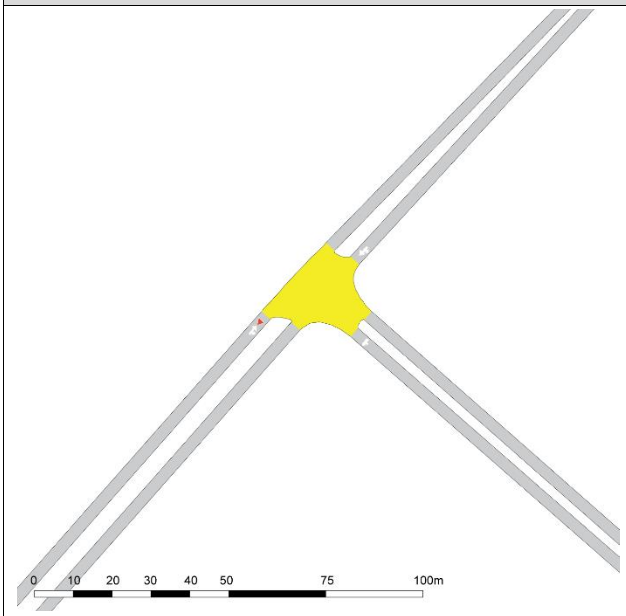
31 - Other E-W Link 7 / Dickson Rd



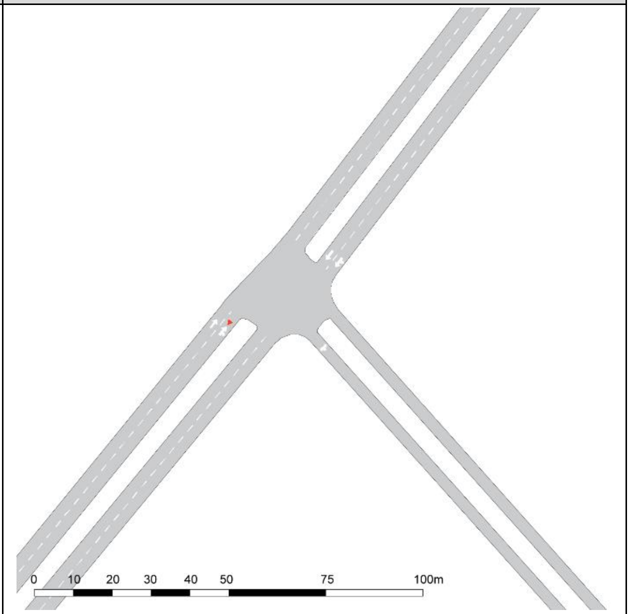
32 - Other E-W Link 7 / Rickard Rd



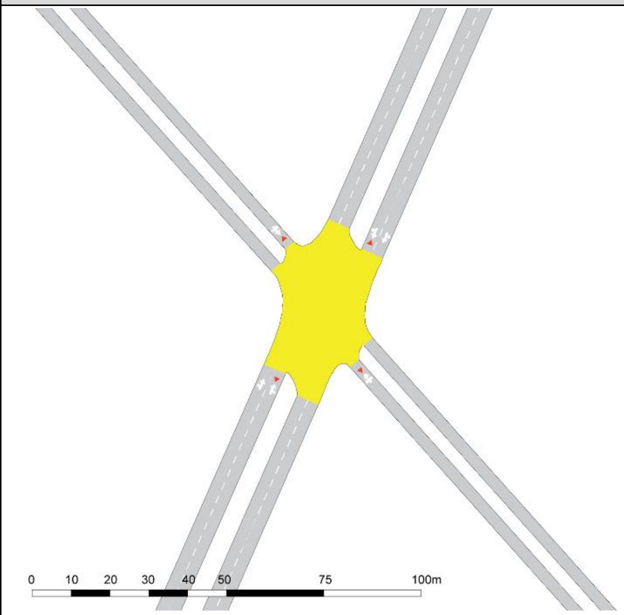
33 - Other E-W Link 8 / Other N-S Link 3



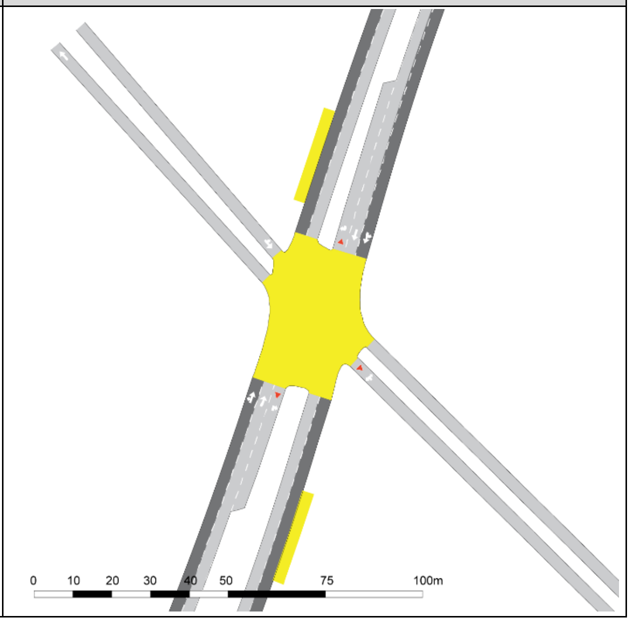
34 - Other E-W Link 9 / Eastwood Rd



35 - Other E-W Link 9 / Dickson Rd



36 - Other E-W Link 9 / Rickard Rd



37 - Other E-W Link 9 / Other N-S Link 3