APPENDIX A

PROPOSED TRAFFIC MODELLING METHODOLOGY

MEMO

TO: Steering Group

FROM: Ryan Miller

SUBJECT: **Proposed traffic modelling methodology for St Marys Development Site**

OUR REF: 2197037A-ITP-MEM-006 Rev B.docx

DATE: **27 March 2017**

WSP | Parsons Brinckerhoff has been commissioned by Lend Lease to undertake the St Marys Development Site Regional Traffic Modelling study. This memo documents our proposed traffic modelling methodology and approach for the study based on ongoing consultation with the Projects Steering Group members. This document is provided for Steering Group review, endorsement and approval.

1. SCOPE AND METHODOLOGY OF TRAFFIC MODELLING

We propose the following three-stage traffic modelling methodology for this project as shown in Figure 1.1.

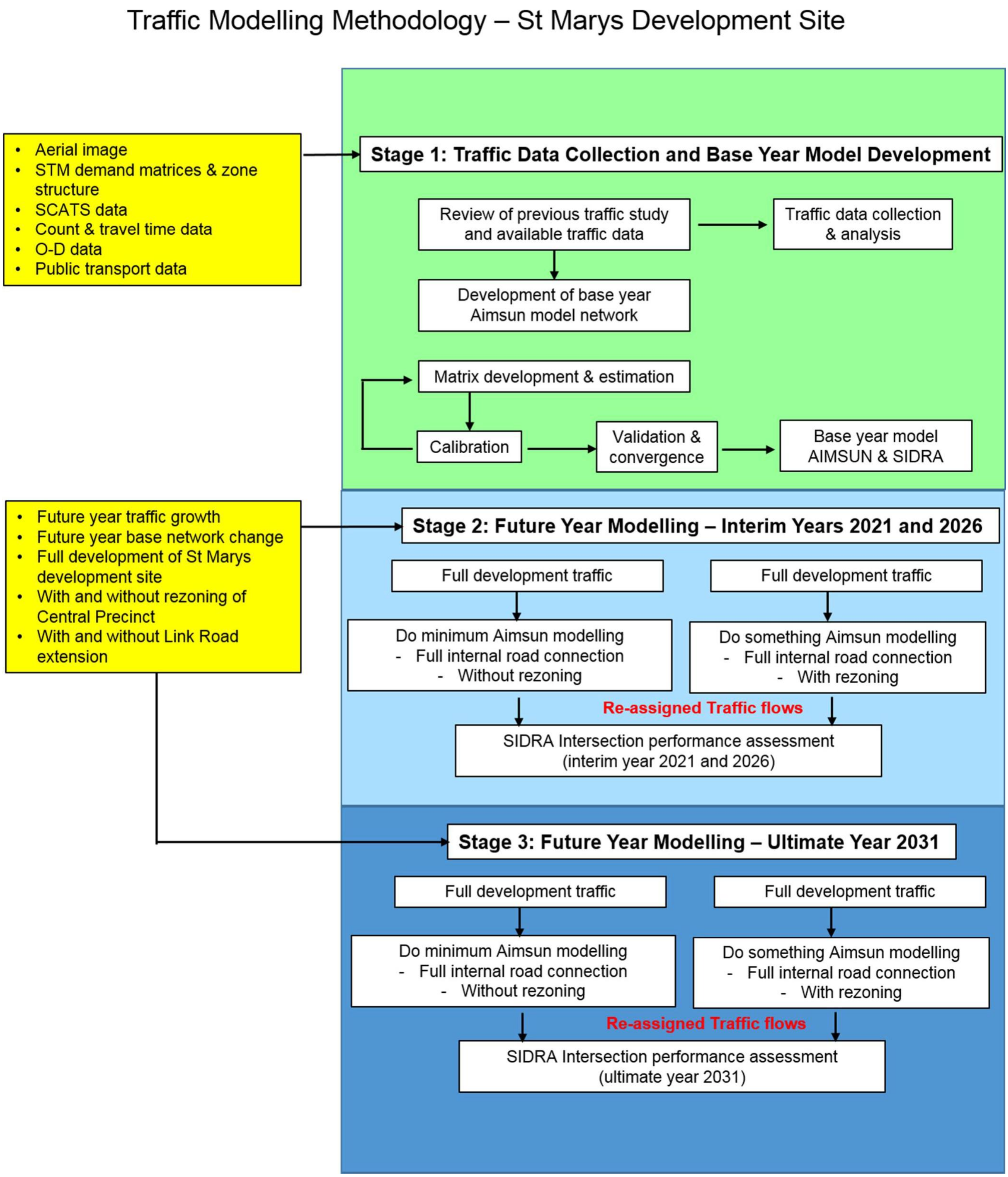


Figure 1.1 Proposed traffic modelling methodology

The summary of tasks is as follows:

- **Project inception**
  - Confirm traffic modelling scope and methodology
  - Gain written approval from Project Steering Group (PSG) members with regards traffic modelling scope and methodology including traffic generation to be utilised and future model year.
  - Determine in consultation with Transport for NSW – Transport, Performance and Analytics, the appropriateness of the future year traffic volumes from Sydney Strategic Transport Model (STM). **Please note that Transport for NSW has advised that the RMS EMME model should be utilised in lieu of the TfNSW STM model.**
  - Determine in consultation with Roads and Maritime Services, the appropriateness of the future year traffic volumes from the RMS EMME model.
- **Stage 1: Traffic data collection and base year model development (AIMSUN & SIDRA)**
  - Extract information from previous traffic studies
  - Traffic volumes and queue lengths at key intersections
  - Travel time surveys
  - Liaison with key stakeholders for the traffic information collection.
  - Develop 2016 existing base model
  - Calibrate and validate existing model in both AIMSUN and SIDRA
  - Base model report/memo
- **Stage 2: Future year base and something models (AIMSUN & SIDRA) – interim years 2021 and 2026**
  - Develop future interim year base models
  - Develop future interim year do something with and without rezoning
  - Develop future interim year do something with and without Link Road extension
  - Network impact and intersection performance assessment
- **Stage 3: Future year based and do something models (AIMSUN & SIDRA) – ultimate year 2031**
  - Develop future ultimate year base models
  - Develop future ultimate year do something with and without rezoning
  - Develop future ultimate year do something with and without Link Road extension
  - Network impact and intersection performance assessment
- **Draft and final reports and model files**

The 'with rezoning' scenario will be utilise an increase of 500 dwellings within Central Precinct.

Two traffic modelling packages were identified as suitable and complementary to each other for this project.

- AIMSUN (developed by TSS) for the development of a regional mesoscopic traffic model, primarily to assess the impact of the future traffic growth (background and development) on the traffic route choice
- SIDRA for the development of individual/corridor intersection models to assess the detailed intersection performance based on the output (e.g. route choice) from the AIMSUN mesoscopic model

→ Although discrepancies may arise due to the nature and the different levels of details of the above two modelling packages, the results of each will be cross checked to ensure consistency.

1.1 Development land use types, yields, staging and occupancy

The following development land use types, yields, years of staging and occupancy as at December 2016 are shown below for both the 'with' and 'without' rezoning scenarios. Please note that 1,897 dwellings were occupied at Jordan Springs and 1,950 at Ropes Crossing at December 2016.

With Rezoning of Central Precinct – this includes the assessment of 500 dwellings in addition to the proposed 1,430 which totals 1,930 dwellings.

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
JORDAN SPRINGS	Residential dwellings	3,437	1,897	2,800	3,437	3,437	3,437	3,437
	Apartments	599	0	300	599	599	599	599
	Shopping Centre	0	0	0	0	0	0	0
	Retail (m2)	25,000	15,000	20,000	25,000	25,000	25,000	25,000
	Commercial	0	0	0	0	0	0	0
	Childcare	200 children	60	90	120	150	200	200
	Medical Centre	3 doctors	3	3	3	3	3	3
	School	460 children	0	0	0	250	300	460
	Other	-	-	-	-	-	-	-
JORDAN SPRINGS EAST	Residential dwellings	1,930 dwellings	0	400	800	1,500	1,930	1,930
	Shopping Centre	800 m2	0	0	800	800	800	800

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
	Retail	2,000 m2	0	0	2,000	2,000	2,000	2,000
	Commercial	0 m2	0	0	0	0	0	0
	Childcare	180 children	0	40	80	160	180	180
	Medical Centre	5 doctors	0	0	5	5	5	5
	Sporting Field	380	0	0	0	0	0	380
	Employment Area (m2)	0ha	0	0	0	0	0	0
ROPES CROSSING	Residential dwellings	2,345 dwellings	1,950	2,345	2,345	2,345	2,345	2,345
	Shopping Centre	0	0	0	0	0	0	0
	Retail	12,340 m2	12,340	12,340	12,340	12,340	12,340	12,340
	Commercial	14,471 m2	14,471	14,471	14,471	14,471	14,471	14,471
	Childcare	120 children	120	120	120	120	120	120
	Medical Centre	3 doctors	3	3	3	3	3	3
	School	320 children	250	265	280	295	320	320
	Other	-	-	-	-	-	-	-

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
NORTH DUNHEVED	Residential dwellings	NA	NA	NA	NA	NA	NA	NA
	Shopping Centre	NA	NA	NA	NA	NA	NA	NA
	Retail	NA	NA	NA	NA	NA	NA	NA
	Commercial	NA	NA	NA	NA	NA	NA	NA
	Childcare	NA	NA	NA	NA	NA	NA	NA
	Medical Centre	NA	NA	NA	NA	NA	NA	NA
	School	NA	NA	NA	NA	NA	NA	NA
	Industrial (m2)	14 ha	0	0	0	0	0	63,000
SOUTH DUNHEVED	Residential dwellings	NA	NA	NA	NA	NA	NA	NA
	Shopping Centre	NA	NA	NA	NA	NA	NA	NA
	Retail	NA	NA	NA	NA	NA	NA	NA
	Commercial	NA	NA	NA	NA	NA	NA	NA
	Childcare	NA	NA	NA	NA	NA	NA	NA
	Medical Centre	NA	NA	NA	NA	NA	NA	NA

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
	School	NA	NA	NA	NA	NA	NA	NA
	Industrial (m2)	8 ha	0	0	0	0	36,000	36,000

Without Rezoning of Central Precinct – this includes the assessment of 1,430 dwellings and employment area land.

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
JORDAN SPRINGS	Residential dwellings	3,437	1,897	2,800	3,437	3,437	3,437	3,437
	Apartments	599	0	300	599	599	599	599
	Shopping Centre	0	0	0	0	0	0	0
	Retail (m2)	25,000	15,000	20,000	25,000	25,000	25,000	25,000
	Commercial	0	0	0	0	0	0	0
	Childcare	200 children	60	90	120	150	200	200
	Medical Centre	3 doctors	3	3	3	3	3	3
	School	460 children	0	0	0	250	300	460
	Other	-	-	-	-	-	-	-

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
JORDAN SPRINGS EAST	Residential dwellings	1,430 dwellings	0	400	800	1,430	1,430	1,430
	Shopping Centre	800 m2	0	0	800	800	800	800
	Retail	2,000 m2	0	0	2,000	2,000	2,000	2,000
	Commercial	0 m2	0	0	0	0	0	0
	Childcare	180 children	0	40	80	160	180	180
	Medical Centre	5 doctors	0	0	5	5	5	5
	Sporting Field	380	0	0	0	0	0	380
	Employment Area (m2)	21.4 ha	0	0	0	48,150	96,300	96,300
ROPES CROSSING	Residential dwellings	2,345 dwellings	1,950	2,345	2,345	2,345	2,345	2,345
	Shopping Centre	0	0	0	0	0	0	0
	Retail	12,340 m2	12,340	12,340	12,340	12,340	12,340	12,340
	Commercial	14,471 m2	14,471	14,471	14,471	14,471	14,471	14,471
	Childcare	120 children	120	120	120	120	120	120
	Medical Centre	3 doctors	3	3	3	3	3	3

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
	School	320 children	250	265	280	295	320	320
	Other	-	-	-	-	-	-	-
NORTH DUNHEVED	Residential dwellings	NA	NA	NA	NA	NA	NA	NA
	Shopping Centre	NA	NA	NA	NA	NA	NA	NA
	Retail	NA	NA	NA	NA	NA	NA	NA
	Commercial	NA	NA	NA	NA	NA	NA	NA
	Childcare	NA	NA	NA	NA	NA	NA	NA
	Medical Centre	NA	NA	NA	NA	NA	NA	NA
	School	NA	NA	NA	NA	NA	NA	NA
	Industrial (m2)	14 ha	0	0	0	0	0	63,000
SOUTH DUNHEVED	Residential dwellings	NA	NA	NA	NA	NA	NA	NA
	Shopping Centre	NA	NA	NA	NA	NA	NA	NA
	Retail	NA	NA	NA	NA	NA	NA	NA
	Commercial	NA	NA	NA	NA	NA	NA	NA
	Childcare	NA	NA	NA	NA	NA	NA	NA

PRECINCT	LAND USE	TOTAL NO/SIZE/UNIT	CUMULATIVE TOTAL NO/SIZE/UNIT					
		Ultimate	2016	2017	2018	2019	2020	2021
	Medical Centre	NA	NA	NA	NA	NA	NA	NA
	School	NA	NA	NA	NA	NA	NA	NA
	Industrial (m2)	8 ha	0	0	0	0	36,000	36,000

1.2 Traffic modelling assumptions

The traffic modelling assumptions will be used based upon review of the following key reference documents.

- Jordan Springs residential subdivision, Village Six Transport Impact Assessment (GTA, 2014)
- St Marys Development Rezoning Application (Road Delay Solutions, June 2016)
- Roads and Maritime Traffic Modelling Guidelines (Roads and Maritime, 2013)
- Guide to Traffic Generating Developments (Roads and Maritime, 2002)
- Guide to Traffic Generating Developments, Updated Traffic Surveys TDT 2013/04 (Roads and Maritime, 2013)
- Traffic surveys completed in September 2016.

1.2.1 Traffic Generating Rates from Central Precinct Development

The following trip rates and proportions in and out in Table 1.1 are proposed, in line with the Roads and Maritime Guide to Traffic Generating Developments and traffic surveys.

Table 1.1 Proposed trip generation rates

Land Use	Weekday AM/PM peak trip rate	AM In/Out	PM In/Out
Residential	0.76 trips per dwelling in AM, 0.97 trips per dwelling in PM (source: *2016 traffic and residence occupancy surveys – 1,897 occupied dwellings, 1,376 trips in and out of Jordan Springs at The Northern Road intersections in the AM peak and 1,752 trips in the PM peak*)	20%/80%	80%/20%
Display homes	1 trip per dwelling in PM (First principle assumption made based on a typical operation of Lend Lease' display homes typically attended by one (1) employee and opens between 10am-5pm on weekdays.)	N/A	50%/50%
Apartments	0.5 trips per apartment in AM and PM (source: *Section 3.3.2 – Medium Density RFB* Roads and Maritime's Guide to Traffic Generating Development issue 2.2, 2002)	20%/80%	80%/20%

Land Use	Weekday AM/PM peak trip rate	AM In/Out	PM In/Out
Shopping Centre/Retail	<10,000m^2, 12.3-12.5 trips per 100m^2 GLFA in PM <20,000m^2, 6.2-6.7 trips per 100m^2 GLFA in PM <30,000m^2, 5.6-5.9 trips per 100m^2 GLFA in PM (source: *Shopping Centres* Roads and Maritime Guide to Traffic Generating Development updated traffic surveys TDT2013/04a) 30% of PM Peak trips included in the AM Peak	60%/40%	50%/50%
Commercial	1.6 trips per 100m^2 in AM, 1.2 trips per 100m^2 in PM (source: *Office Blocks* Roads and Maritime Guide to Traffic Generating Development updated traffic surveys TDT2013/04a)	80%/20%	20%/80%
Industrial Estate	0.5 trips per 100m^2 in AM and PM (source: *Industrial Estate* Roads and Maritime Guide to Traffic Generating Development updated traffic surveys TDT2013/04a)	80%/20%	20%/80%
Childcare	1.4 trips per child in AM, 0.8 trips per child in PM (source: *Section 3.11.3 – Child Care Centres* of Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002)	50%/50%	50%/50%
Medical centre	5.8 movements / practitioner in AM and PM (First principle assumption made based on a worst-case scenario for trips attracted and generated from the car parking spaces required to be provided for a medical consulting room. Penrith CC requires that 3 car parking spaces be provided for a medical professional to practice.)	50%/50%	50%/50%
School	0.8 trips per child in AM (An assumption based of 80% of school children are driven by their parents to school. 20% of school children use school bus and active travel mode (walking/cycling).)	50%/50%	N/A – occurs before PM peak
School Staff	1 trip per 30 children in AM and PM (An assumption of maximum class size is used per teaching staff. All school staff are assumed to utilise 100% car trip.)	100%/0%	0%/100%
6 sports fields floodlit	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes two teams of 20 persons per field. Assumes 20% local walking trips and the remaining single vehicle trips worst case single occupant. 192 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%
1 oval floodlit	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes two teams of 20 persons on oval. Assumes 20% local walking trips and the remaining single vehicle trips worst case single occupant. 32 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%
Multi-purpose 4 tennis courts, 1 multi use court, 1 netball	Tennis Courts are 4 trips per court in the PM peak. 100% local trips. 16 vehicle trips in PM peak. Assumes two teams of 20 persons on court. Assumes 20% local walking trips and the remaining single vehicle trips worst case single occupant. 64 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%
Cricket nets 3 lanes	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes cricket training for 1 team of say 20 persons. Assumes 20% local walking trips and the remaining single vehicle trips worst case single occupant. 16 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%

Land Use	Weekday AM/PM peak trip rate	AM In/Out	PM In/Out
Synthetic cricket wickets in fields (max 3)	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes cricket training for 3 teams of say 20 persons. Assumes 20% local walking trips and the remaining single vehicle trips worst case single occupant. 48 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%
Car parking to accommodate sportsground at maximum capacity 300 spaces.	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* The combination of all land uses tabled within exceeds 300 spaces based on trip assumptions applied. Desirable to utilised 300 vehicle trips with maximum 376 vehicle trips in PM peak proposed.	N/A – negligible in AM peak	100%/0%
Amenities block/pavilion	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes trip generation included in above land uses.	N/A – negligible in AM peak	100%/0%
Adventure playground	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes 20 persons in playground with 50% adult. Assumes 20% local walking trips and the remaining single vehicle trips with dual occupants. 8 vehicle trips in PM peak.	N/A – negligible in AM peak	100%/0%
Community activity space up to 450 m^2	No rates given for playing fields in *Roads and Maritime Guide to Traffic Generating Development issue 2.2, 2002* Assumes trip generation included in above land uses.	N/A – negligible in AM peak	100%/0%

1.2.2 Traffic distribution and assignment

Traffic distribution from the established St Marys development sites (e.g. the percentage Ropes Crossing traffic access north at Australia Drive | Palmyra Avenue or south at Forrester Road | Rope Crossing Blvd) will be established based on the 2016 OD survey results assuming that the existing traffic from the current developed sites would indicate the pattern of trip distributions.

The initial demand matrices for the study area will be extracted from the RMS EMME Strategic Model trip matrices. The RMS EMME model demand matrices will be disaggregated to reflect the more detailed zone structure in AIMSUN models. A demand matrix estimation process will be carried out in AIMSUN to update RMS EMME model demand matrices with the current traffic count data. After the matrix estimation process, trip length distribution and trip ends will be reviewed to confirm that trip patterns of the original demand has not considerably changed in the post matrix estimation. Constraining of cell values inside the demand matrices will be undertaken where appropriate. Any traffic count data discrepancies will be identified and corrected before the matrix estimation process to ensure a higher quality matrix estimation process.

The demand matrices developed during the matrix estimation process will then be assigned using the mesoscopic representation of the network, which includes more detailed coding of the network primarily by the inclusion of signal operations, demand profiling and traffic management strategies such as school zone, right turn ban, car parking restrictions etc. In a mesoscopic model, Dynamic Traffic Assignment (DTA) will be utilised to reasonably represent the dynamic nature of traffic behaviour with the variation of traffic delay at different network locations. The assessment of the network and intersection performances are reasonably accepted with the limitations of simplifying vehicle to vehicle interactions in mesoscopic traffic assignment. SIDRA intersection analysis software and Highway Capacity Manual (HCM 2010) will be used to verify the performance of intersection and network capacity in conjunction with AIMSUN.

1.2.3 Future Traffic growth

The future year traffic growth will be estimated for the purpose of assessing the future road network performance. Traffic growth rates will be estimated considering the following three indicators:

- The cordon matrices and link analysis will be collected from the RMS EMME model by Roads and Maritime
- The historical traffic counts at the Roads and Maritime traffic count stations
- Population and employment forecasts sourced from the NSW Bureau of Statistics and Analytics (TPA) website

In terms of the application of the RMS EMME model results, the relative growth factor will be calculated from the future 2021/2031 RMS EMME model demands divided by the 2016 RMS EMME model demands. This growth factor and/or absolute difference will be applied into the equivalent part of calibrated / validated AIMSUN model. In addition, redistribution of traffic in the future RMS EMME model assignment model will be assessed with screen line and select link analysis to capture traffic growth rates in the wider road network.

The future road network assumptions inside the model area will be based on the assumptions of the future RMS EMME models and these assumptions will be supplied to WSP | Parsons Brinckerhoff by RMS to incorporate into the future St Marys mesoscopic traffic model.

1.2.4 Major Project and Regional Road Upgrades

A number of proposed growth areas have been planned in the Western Sydney region which may impact the trip characteristics of the study area. These include:

- Northwest Growth Centre – located immediately north-east of the study area
- Western Sydney Park lands – located along the M7 Motorway
- Badgerys Creek Airport (Western Sydney Airport)
- Western Sydney Priority Growth Area
- Western Sydney Employment Area
- South West Growth Centre
- North Penrith Defence Site.

A number of road upgrades are also proposed in the future to service the above development sites. A number of the major upgrades include:

- The Northern Road
- Erskine Park Road upgrade
- Werrington Arterial Road upgrade
- M12 Motorway development (to service the proposed Badgerys Creek Airport)
- Possible development of the Outer Sydney Orbital Motorway (M9).

1.2.5 Other assumptions

WSP | Parsons Brinckerhoff will proactively liaise with the PSG given there are concerns over traffic generation and distribution and growth assumptions. It is envisaged that the majority of the traffic modelling assumptions will be adopted from the Roads and Maritime Traffic Modelling Guidelines, and all exceptions from these guidelines will be documented in the traffic model report.

1.3 Stage 1: Traffic data collection

Traffic data will be collected within the study area shown below and a traffic model will be built for the purposes of assessing the traffic impacts associated with the proposed St Marys Development site.

The following traffic data in Table 1.2 will be collected within the study area.

Table 1.2 Traffic data categories

Category	Data type	Availability	Source
Model development	Intersection layout	Supplied	Aerial photography and SCATS Access database
	Signal phasing and timing	Supplied	SCATS phasing diagrams and history file
	Road section speed	Online and site visit	Network inventory of signed speeds via desktop resources such as street-view and site visit
	Travel demand	Supplied	Cordon traffic matrices from RMS EMME Model from 2016, 2021, 2026 and 2031
	Bus services	Online	Timetables for schedule services and school services in the AM and PM peak periods
Model calibration	Traffic counts	Supplied	Existing historic traffic data (if available)
		Supplied	SCATS detector counts
		To be collected	Study traffic counts
		To be collected	Mid-block tube counts
	Traffic generation	To be collected / site observations	Traffic counts of entry and exit flows at selected developments
	Car parking supply	Supplied / To be discussed	Traffic counts of entry and exit flows at selected car parks
Model validation	Travel time	To be collected	Journey time surveys along key corridors
	Queue length	To be collected	Queue lengths at key locations
	O-D surveys	To be collected	Origin – destination surveys of existing Jordan Springs and Ropes Crossing development

The model study area, the locations of the intersection counts and queue length surveys are shown in Figure 1.2.

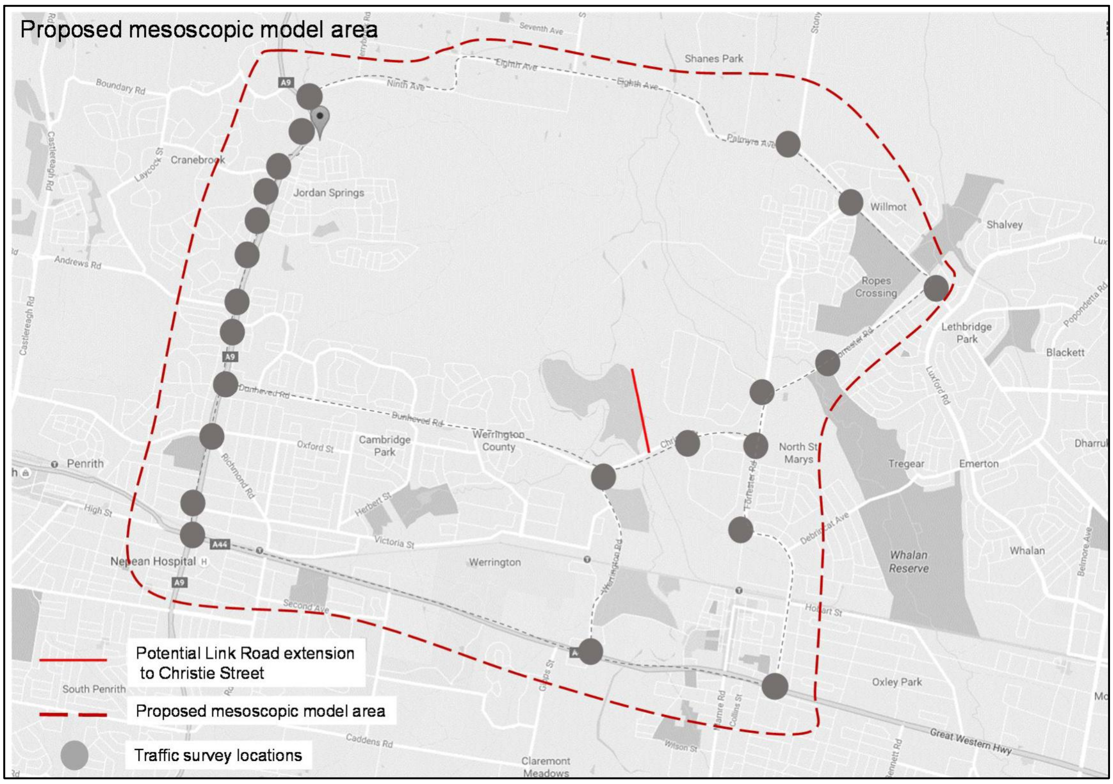


Figure 1.2 Proposed mesoscopic model study area

The following travel time routes will be surveyed for traffic model validation as shown in Figure 1.3.

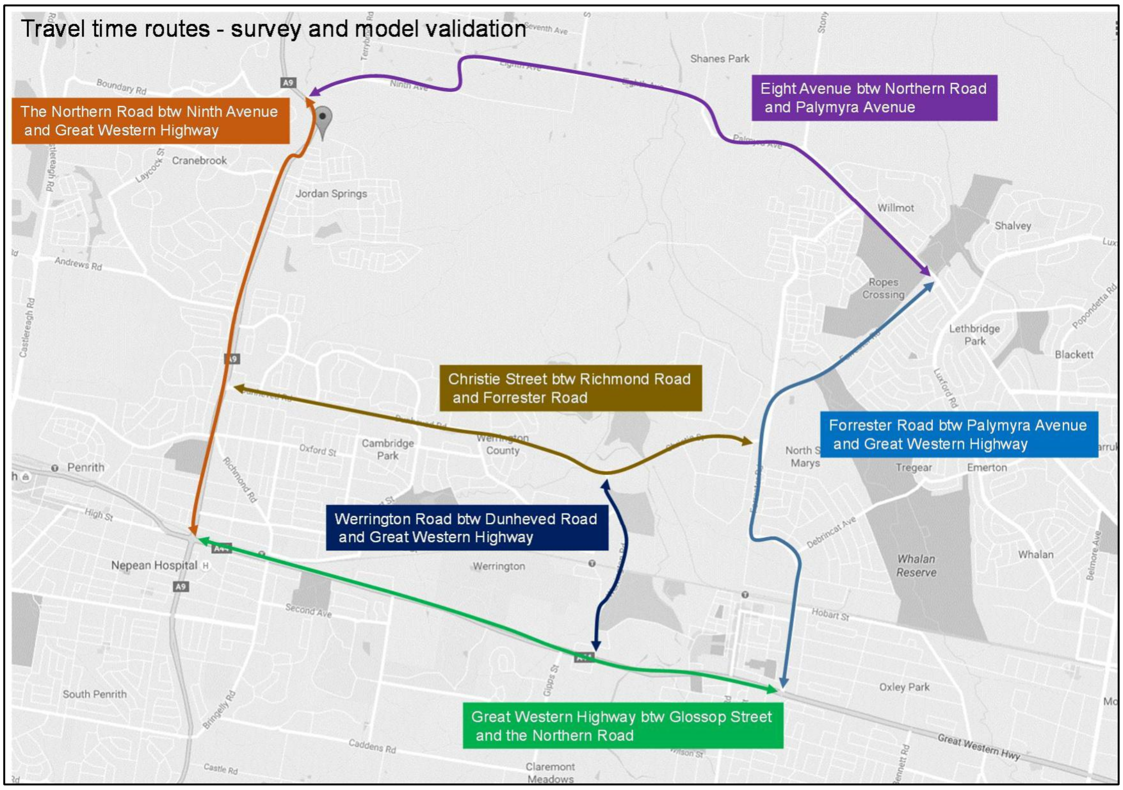


Figure 1.3 Travel time routes for survey and model validation

1.4 Stage 1: Base model development (AIMSUN & SIDRA)

WSP | Parsons Brinckerhoff will develop a 2016 (selected for calibration purposes) base year AIMSUN model for weekday AM and PM peaks (two hours for each peak). The peak hours will be determined from the traffic survey data.

The base model network will be built based on aerial photography, detailed civil plans (where relevant) and site observations. The following features will be coded into the AIMSUN models including stop line positions, banned turns, permitted turning movements, bus stops, bus routes, traffic signal timings and posted speed limits.

Origin-Destination (OD) demand matrices will be synthesised using a combination of data provided by the RMS EMME model and intersection counts described in section 1.4. RMS EMME model zone trip generation, population and employment data will be reviewed and compare against traffic counts and land use data provided by Lend Lease to ensure model correctness.

1.4.1 Model calibration

The performance and operation of each intersection and the network as a whole will be observed on site during both peak periods, and the base models will be calibrated to reflect how the traffic currently operates within the study area.

The AIMSUN model will be calibrated to the Roads and Maritime *Traffic Modelling Guidelines (2013)* as shown in Table 1.3. Please note that as GEH measures "Goodness-of-fit" of the model comparing model flows with observed counts, any limitations to achieve the level of model calibration will be documented in the model development report. Since the high flow movements are the most influential in terms of network operations, the calibration will work progressively from high to low flows, correcting, adjusting and tuning the model as required. Also, we will be mindful that at some locations, modest to low flows on some movements, such as right turns, can have significant impact as well.

Table 1.3 Calibration criteria

Criteria	Roads and Maritime Guidelines
Percentage of link volumes with GEH ≤ 5	95%
Percentage of turn volumes with GEH ≤ 5	85%
Percentage of link and turn volumes with GEH ≤ 10	100%
R-squared value to be included with plots and to be	>0.9
All counts RMSE	=<30
Percentage of screen-line/corridor/cordon total with GEH ≤ 4	All

As part of model calibration process, the model performance (e.g. traffic delays) will also be checked to ensure it reflects our knowledge of study area and observations of traffic operation during site inspection.

1.4.2 Model validation

Following the model calibration, the AIMSUN base models will be validated against the observed travel times through the study area in accordance with the Roads and Maritime Traffic Modelling Guidelines. It will also be validated against queue length data at surveyed locations.

Travel time validation will be carried out as per Roads and Maritime *Traffic Modelling Guidelines (2013)* (model and observed travel times difference within 15% or 1 minute whichever is the greater for 95% of routes). The operation of the model will be adjusted during the validation process to tune the model such that the travel times align with those observed, while maintaining traffic levels and patterns to those observed by the traffic counts. The proposed travel time routes for model validation are shown in Figure 1.3.

Queue length validation will be undertaken by comparing queue length from the SIDRA models to the observed queue length (where available), as the mesoscopic module of AIMSUN utilises simplified car following and lane changing models to simulate vehicle operation.

Upon the completion of the base model development, calibration and validation, a report will be prepared which will document the work undertaken and outcomes achieved. This report will be issued to Lend Lease and RMS. It is recommended that the models and reports be issued to Roads and Maritime for review and comment prior to the future year road network investigations.

1.4.3 Base model development traffic

Penrith City Council has requested Lend Lease to determine the impacts on road and intersection operation under existing conditions (2016). This is due to traffic being generated by the already developed Jordan Springs and Ropes Crossing developments on the road network. In order to ascertain intersection operation with and without this development in 2016, an origin-destination (O-D) survey was undertaken to determine existing travel patterns for both Jordan Springs and Ropes Crossing. These trips would then be removed from traffic count data collected in 2016 to determine changes in intersection operation and determine any traffic related impacts from these developments in 2016. The comparison of intersection performance will be completed utilising SIDRA.

1.5 Stage 2: Future year do minimum models (AIMSUN & SIDRA) – interim years 2021 and 2026

It is proposed that the following mesoscopic modelling to be undertaken for a nominated interim years 2021 and 2026.

This includes a future year 2021 and 2026 base models plus future year 2021 and 2026 do minimum models.

- → Future base without development using the ultimate version of internal and external road network in 2021 and 2026.
- → Full completion of all the development sites to assess the network and intersection performance <u>without</u> additional link (e.g. Link Road extension to Christie Street) to the external road network. This assessment will be undertaken using the ultimate version of internal and external road network in 2021 and 2026.
- → Full completion of Central Precinct to assess the network and intersection performance <u>with</u> Link Road extension to Christie Street. This assessment will be undertaken using the ultimate version of internal and external road network in 2021 and 2026.

Following the availability of mesoscopic model results, detailed intersection modelling will be undertaken using SIDRA for the key intersections within the study area. The intersection models will use traffic demand extracted from the Mesoscopic model and will include the key intersections listed below. The intersection models will be used to assess potential mitigation measures to improve intersection operations. SIDRA intersection models will be developed for the following intersections:

1. The Northern Road and Ninth Avenue
2. The Northern Road and Greenwood Parkway and Borrowdale Way
3. The Northern Road and Jordan Springs Boulevard
4. Richmond Road and Trinity Drive
5. Richmond Road and Dunheved Road
6. Richmond Road and Parker Street and Coreen Avenue and Oxford Street

7. Great Western Highway and Parker Street
8. Christie Street, Dunheved Road and Werrington Road
9. Werrington Road and Great Western Highway
10. Great Western Highway and Glossop Street
11. Forrester Road, Christie Street and Boronia Road
12. Forrester Road, Ropes Crossing Boulevard and Links Road
13. Palymyra Avenue and Australis Drive
14. Palymyra Avenue and Forrester Road
15. Dunheved Road and John Oxley Avenue
16. Dunheved Road and Greenbank Drive (East)
17. Dunheved Road and Greenbank Drive (West)
18. Jordan Springs Boulevard and Lakeside Parade
19. Greenwood Parkway, Discovery Way and Water Gum Drive
20. Link Road extension and Christie Street.

1.6 Stage 3: Future year do something models (AIMSUN & SIDRA) – ultimate year 2031

It is proposed that the mesoscopic modelling would be undertaken for the following scenarios in ultimate year, or 10 years after the full completion of the St Marys Development site (e.g. 2031).

- Future base without development using the ultimate version of internal and external road network in 2031.
- Full completion of all the development sites to assess the network and intersection performance without additional link (e.g. Link Road extension to Christie Street) to the external road network. This assessment will be undertaken using the ultimate version of internal and external road network in 2031.
- Full completion of Central Precinct to assess the network and intersection performance with Link Road extension to Christie Street. This assessment will be undertaken using the ultimate version of internal and external road network in 2031.

All the scenarios in Stage 2 and 3 will include the following:

- Background traffic growth from 2016 to 2031; Note that only one employment and population forecast will be used in the future traffic demands forecast. The population and employment forecasts to be used will be agreed with Roads and Maritime/Transport for NSW and/or the Councils prior to the future year traffic modelling.
- Future road network upgrades in 2021, 2026 and 2031, subject to confirmation by Transport for NSW, Roads and Maritime and the Councils
- Staged development of Western Precinct (Jordan Springs) and Eastern Precinct (Ropes Crossing) development sites, other than Central Precinct (2016 & 2021), provided by Lend Lease.
- Rezoning and staged development of Central Precinct (2016 & 2021), provided by Lend Lease.

Following the availability of mesoscopic model results, detailed intersection modelling will be undertaken using SIDRA for the key intersections within the study area. The intersection models will use traffic demand extracted from the Mesoscopic model and will include the key intersections such as the Link Road extension. The intersection models will be used to assess potential mitigation measures to improve intersection operations. SIDRA intersection models will be developed for the following intersections:

1. The Northern Road and Ninth Avenue

2. The Northern Road and Greenwood Parkway and Borrowdale Way
3. The Northern Road and Jordan Springs Boulevard
4. Richmond Road and Trinity Drive
5. Richmond Road and Dunheved Road
6. Richmond Road and Parker Street and Coreen Avenue and Oxford Street
7. Great Western Highway and Parker Street
8. Christie Street, Dunheved Road and Werrington Road
9. Werrington Road and Great Western Highway
10. Great Western Highway and Glossop Street
11. Forrester Road, Christie Street and Boronia Road
12. Forrester Road, Ropes Crossing Boulevard and Links Road
13. Palymyra Avenue and Australis Drive
14. Palymyra Avenue and Forrester Road
15. Dunheved Road and John Oxley Avenue
16. Dunheved Road and Greenbank Drive (East)
17. Dunheved Road and Greenbank Drive (West)
18. Jordan Springs Boulevard and Lakeside Parade
19. Greenwood Parkway, Discovery Way and Water Gum Drive
20. Link Road extension and Christie Street.

1.7 Summary of Aimsun model scenarios to be assessed

Table 1.4 Proposed mesoscopic models

Network	Existing Year	Future Interim Year	Future Interim Year	Future Ultimate Year	Traffic demands (4)				Road network	
	2016	**2021**	**2026**	**2031**	**Jordan Springs**	**Central Precinct**	**Ropes Crossing**	**North & South Dunheved**	**Internal connection**	**External Road**
2016 Base	*AM & PM*	*N/A*	*N/A*	*N/A*	*Existing*	*None*	*Existing*	*Existing*	*Existing*	*Existing*
2021 Base	*N/A*	*AM & PM*	*N/A*	*N/A*	*Existing*	*None*	*Existing (2)*	*Existing (2)*	*Existing*	*As per RMS model*
Interim year 2021 Do something Central Residential	*N/A*	*AM & PM*	*N/A*	*N/A*	*Full*	*With Rezoning*	*Full*	*Full*	*Completed*	*With and Without Link Road (3) extension*
2021 Do something	*N/A*	*AM & PM*	*N/A*	*N/A*	*Full*	*Without Rezoning*	*Full*	*Full*	*Completed*	*With and Without Link Road (3) extension*
2026 Base	*N/A*	*N/A*	*AM & PM*	*N/A*	*Existing*	*None*	*Existing (2)*	*Existing (2)*	*Existing*	*As per RMS model*
2026 Do something	*N/A*	*N/A*	*AM & PM*	*N/A*	*Full*	*With Rezoning*	*Full*	*Full*	*Completed*	*With and without Link Road*

Central Residential										*(3) extension*
2026 Do something	*N/A*	*N/A*	*AM & PM*	*N/A*	*Full*	*Without Rezoning*	*Full*	*Full*	*Completed*	*With and without Link Road (3) extension*
2031 Base	*N/A*	*N/A*	*N/A*	*AM & PM*	*Existing*	*None*	*Existing (2)*	*Existing (2)*	*Existing*	*As per RMS model*
2031 Do something Central Residential	*N/A*	*N/A*	*N/A*	*AM & PM*	*Full*	*With Rezoning*	*Full*	*Full*	*Completed*	*With and without Link Road (3) extension*
2031 Do something	*N/A*	*N/A*	*N/A*	*AM & PM*	*Full*	*Without Rezoning*	*Full*	*Full*	*Completed*	*With and without Link Road (3) extension*
	Total number of models: 28 (2 for 2016, 10 for interim year 2021, 10 for interim year 2026 and 10 for ultimate year 2031)									

(1) Development traffic demands are subject to confirmation of staged implementation plan from Lend Lease
(2) Existing traffic demands in future year models needs further discussion as to whether development is included or not for the 'with' and 'without' development comparisons
(3) The Link Road extension will create a four way intersection with Christie Street and Lee Holm Road
(4) Traffic demands for all existing and future year models include open space and recreational facilities.

2. APPROACH TO INTERSECTION OPERATING AT LEVEL OF SERVICE E OR F

- WSP | PB will assess intersection performance based on the intersection performance criteria in Table 4.2 of the RMS Guide to Traffic Generating Developments and Section 14.3 of the RMS Modelling Guidelines (see below).
- Signalised intersections will be assessed on the performance of the intersection as a whole and on each leg of the intersection including worst performing legs. Roundabout and sign-controlled intersections will be assessed on the performance of the most-delayed movement and the intersection as a whole.
- Intersections operating at LoS E or F in whichever scenario will be considered as candidates for upgrades.
- The Degree of Saturation and LoS will be used to interpolate which year an intersection reaches the point at which upgrades are needed.
- Intersection and approach performance to be reported.
- Future year with full development scenarios will be used to test a set of upgrades that address the congestion issues. The upgrades will seek to improve performance while minimising the impact on surrounding land.

Table 4.2
Level of service criteria for intersections

Level of Service	Average Delay per Vehicle (secs/veh)	Traffic Signals, Roundabout	Give Way & Stop Signs
A	< 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays & spare capacity	Acceptable delays & spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode	At capacity, requires other control mode

For intersections under base case (existing and future) conditions that fail the performance measures (LoS, DoS & back of queue) as defined within Section 14.3 of the RMS Modelling Guidelines, an appropriate performance measure (i.e. trigger for intersection upgrade) shall be agreed between Council, RMS and TfNSW.

14.3.1 Degree of Saturation (DoS)

Degree of saturation (x) is defined as the ratio of demand (arrival) flow to capacity, x = qa /Q (also known as volume / capacity, v / c, ratio). DoS above 1.0 represent oversaturated conditions (demand flows exceed capacity), and degrees of saturation below 1.0 represent undersaturated conditions (demand flows are below capacity).

The following table represents Practical Degree of Saturation for different intersection types. If the value is greater than the corresponding values provided in the table for any lane, then the intersection requires appropriate treatment to maintain the acceptable level of DoS. Any change in these values should be justified and evidence provided as to why the value should be changed.

Table 14.2 Maximum practical degree of saturation

Intersection type	Maximum practical degree of saturation
Signals	0.90
Roundabouts	0.85
Sign-controlled	0.80
Continuous lanes	0.98

The delay (RMS NSW) option uses the guidelines specified in following Table 2 of the "*Guide to Traffic Generating Developments*" published by the Roads and Traffic Authority of New South Wales, Australia (draft version 2.2 of October 2002). This is the default method when the NSW version of SIDRA INTERSECTION is used.

The following table represents LoS definitions for vehicles (RMS NSW method) based on delay only.

Table 14.3 Control delay for vehicle LoS calculations

LoS	Control delay per vehicle in seconds (d) (including geometric delay)
	All intersection types
A	d < 14
B	d < 15 to 28
C	d < 29 to 42
D	d < 43 to 56
E	d ≤ 57 to 70
F	d > 70

The average delay for level of service E should be no more than 70 Seconds. If the average vehicle delay is more than 70 seconds, the intersection should be assumed to be at Level of Service F.

Note: For traffic signals, the average movement delay and level of service over all movements should be taken. For roundabouts and priority control signals intersection (with Stop and Give Way signs or operating under the T-junction rule) the critical movement for level of service assessment should be that with the worst movement delay.

3. ORIGIN – DESITINATION SURVEY METHODOLOGY

The methodology used to undertake the Origin / Destination (OD) survey used a video / numberplate matching technique. The OD survey was taken at 15 locations on 15 September 2016 for vehicle travel to/from both Jordan Springs and Ropes Crossing. Each numberplate was recorded at it passed the survey point (in each direction). The number plates were matched with records from other sites.

- Unmatched numberplates were assumed to leave through one of the non-survey roads.
- A time limit of 60 minutes was applied to exclude multiple trips through the same location.
- Records that were had errors in processing (e.g. unreadable/dirty numberplates) were excluded from the database.

A map of the 15 survey locations is shown in Figure 3.1.

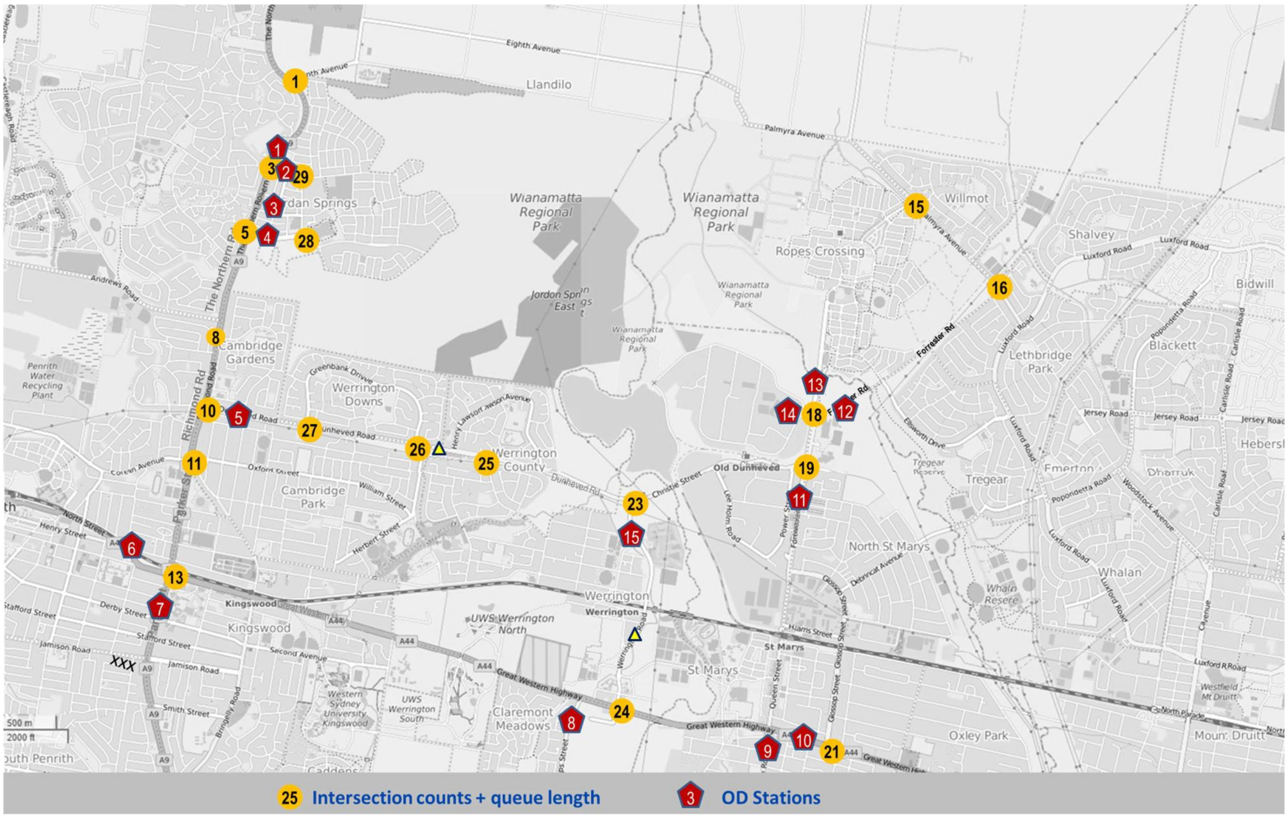


Figure 3.1 15 Origin / Destination survey locations

Level 27, Ernst & Young Centre
680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001

Tel: +61 2 9272 5100
Fax: +61 2 9272 5101

www.wsp-pb.com

4. USE OF RMS EMME MODEL

Roads and Maritime have been contacted and have provided access to their strategic EMME road model. We are in the process of replacing the STM model matrices with like matrices extracted from Roads and Maritime's EMME model.

5. USE OF LAND USE 2016 (LU16) POPULATION AND EMPLOYMENT FORECASTS

LU16 population and employment forecast model data files were not ready at the time of future year model preparation. LU14 population and employment forecasts utilised from RMS EMME model for future year modelling.

6. MID-BLOCK ROAD CAPACITIES

6.1 PCC Road Hierarchy

The following road configurations, general road meaning and land use types and general road network structure have been referenced from the PCC Development Control Plan (DCP) 2014.

Table C10.1: Road Configurations

Street/Road Type	Parking Lane Provision (m)	Width of Dedicated Travel Lanes – Both directions (m)	Verge widths (m)	Road Reserve (m)	Concrete Pathway 1.5m wide
Local	2 x 2.5	3	2 x 3.8	15.6	Both sides(9)
Collector	2 x 2.5(4)	7(4)	2 x 4.8	21.6(4)	Both sides(4)
Distributor	2 x 3.95(6)	7(6)	2 x 4.8	24.5	Both sides
Industrial	2 x 3.0(4)	7(4)	2 x 3.8	20.6(4)	Both sides(4)
Rural	n/a	7	2 x 6.0(7)	19	n/a

Local road means a road or street used primarily for property access. Local roads include laneways, access ways and rural residential roads for lots typically less than or equal to 1 hectare.

Collector road means a road which collects and distributes traffic in an area, as well as providing direct property access.

Distributor road means a road connecting arterial roads to areas of development.

Industrial road means a road providing access to industrial zoned land and for other development which generates frequent truck movements.

Rural road means a road providing access to rural areas and properties typically exceeding one (1) hectare.

Figure C10.1: Road Hierarchy

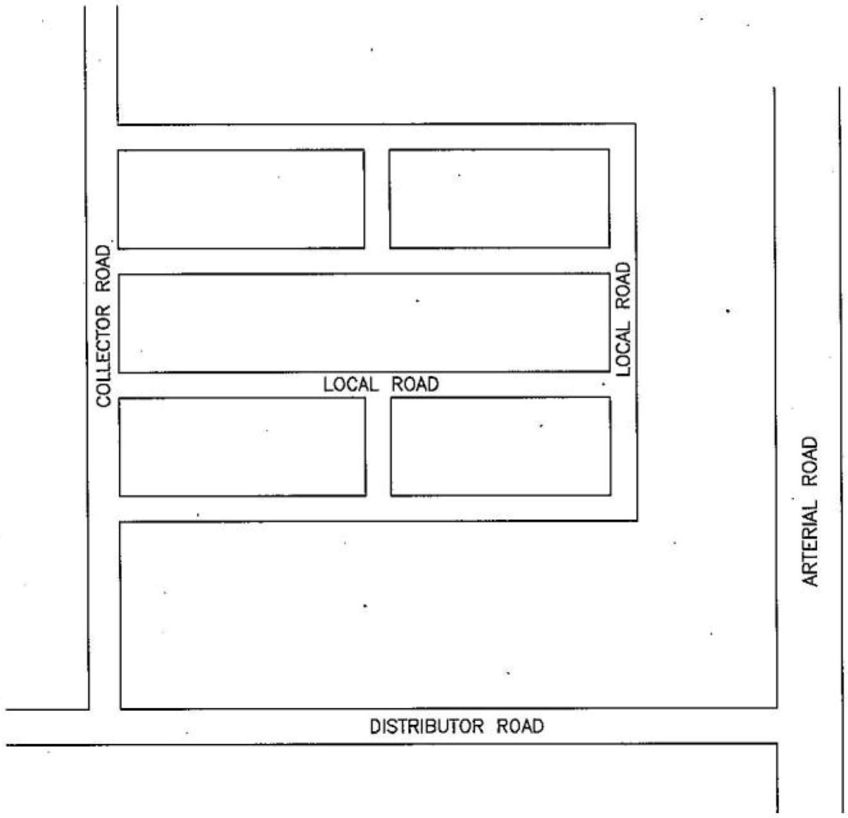


Figure C10.2: Local Road

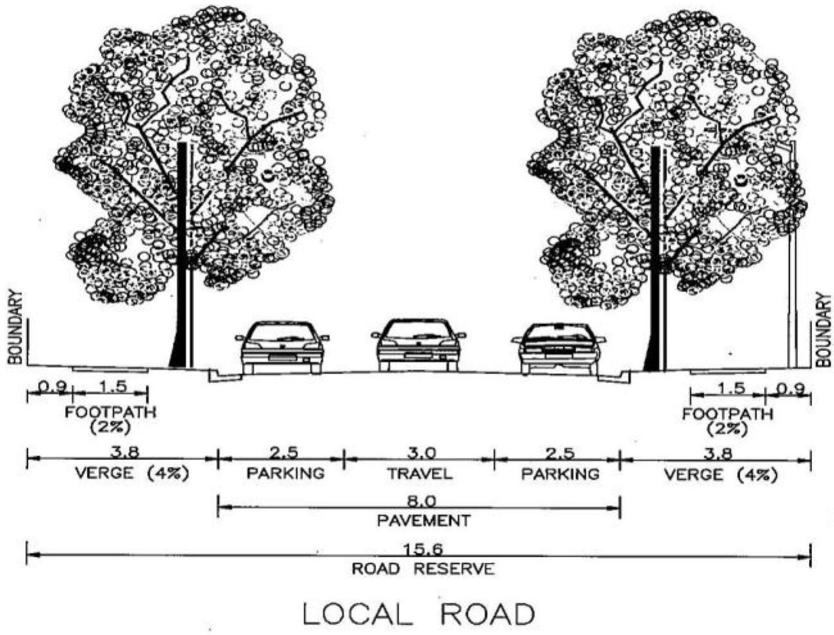


Figure C10.3: Collector Road

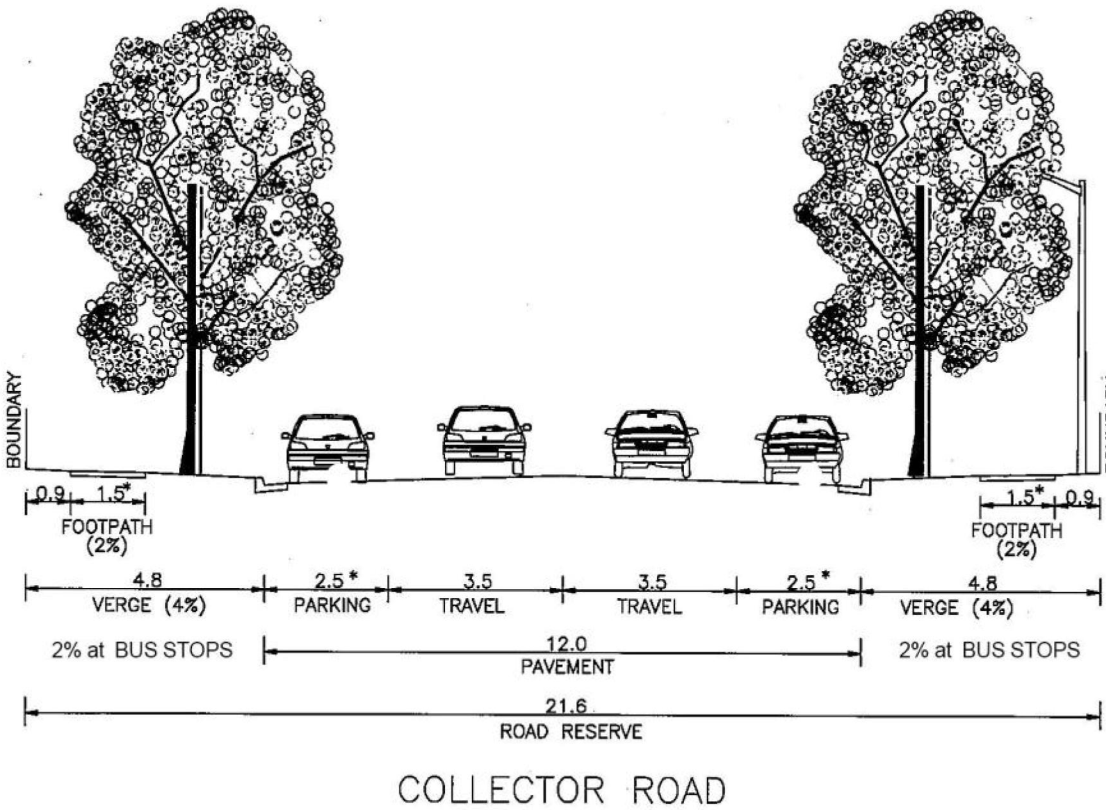


Figure C10.4: Distributor Road

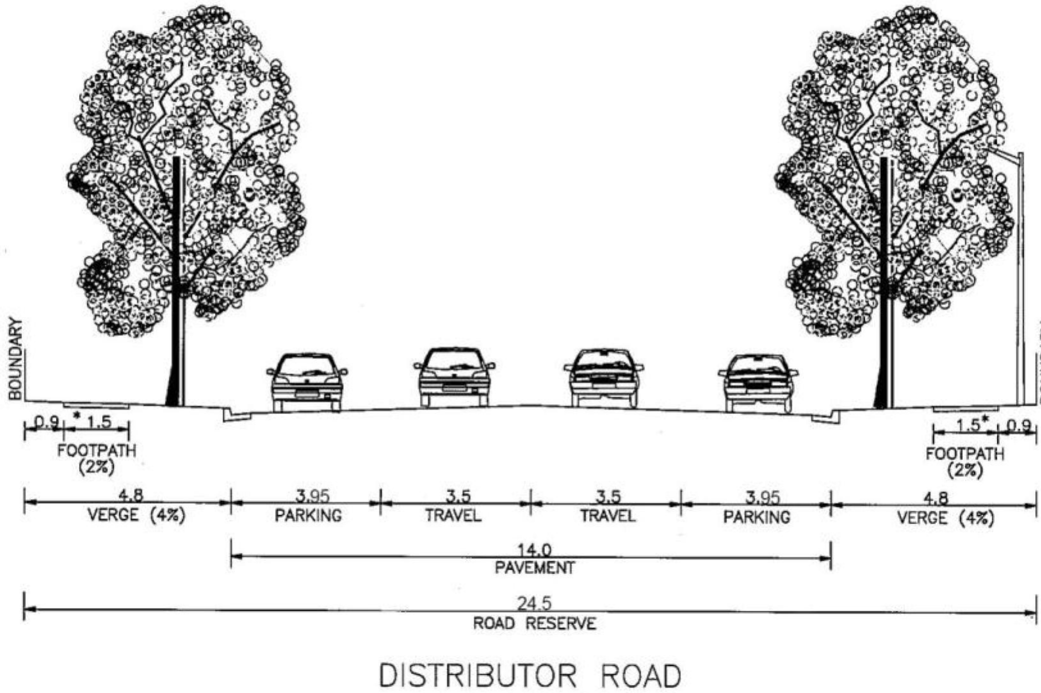
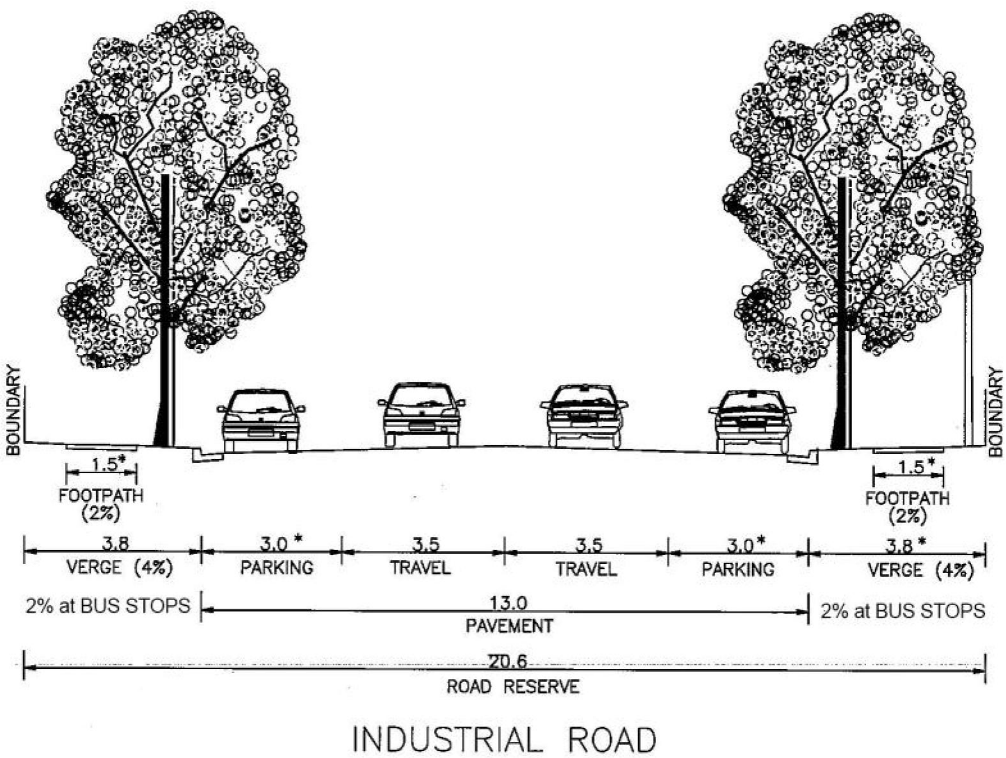


Figure C10.5: Industrial Road



Based on the information provided above it is proposed that the following key roads in the development site have the following hierarchy.

Industrial Roads:

- Links Road

Distributor Roads:

- Jordan Springs Boulevard between The Northern Road and Lakeside Parade
- Greenwood Parkway between The Northern Road and Lakeside Parade
- Ropes Crossing Boulevarde

A Distributor Road under PCC road hierarchy will be of similar nature to a Sub-Arterial Road under RMS road hierarchy.

Collector Roads:

- Greenwood Parkway east of Lakeside Parade
- Lakeside Parade
- East-west linking road between Jordan Springs and Ropes Crossing including Central Precinct (includes Lakeside Parade)

Local Road:

- Local Residential Streets
- Lower order than Collector Roads.

6.2 Previously adopted road mid-block capacities

Previously adopted mid-block capacities are shown in Table 6.1 below.

Table 6.1 Previously adopted mid-block capacities

ROAD TYPE	CAPACITY AT LEVEL OF SERVICE F (VPH)	MAXIMUM SERVICE FLOW RATE FOR LEVEL OF SERVICE D (UPGRADE THRESHOLD VPH)
Rural Two-Way Two-Lane	1,400	896
Urban Divided / Undivided Highways with Clearways and Traffic Signal Coordination	1,500	1,350
Urban Divided / Undivided Highways with interruptions	1,200	1,080
Residential Street (Environmental capacity)	700	630

Source: St Marys Development Rezoning Application Traffic Impact Assessment (Road Delay Solutions, June 2016); and
St Marys Development Transport Management Study (SKM, December 2007)

In addition, the “Jordan Springs Residential Subdivision, Village Six Transport Impact Assessment” (GTA Consultants, 21 November 2015) assumed a lane capacity of 900vph for roads within Jordan Springs, including Greenwood Parkway and Jordan Springs Boulevard.

6.3 Surveyed mid-block traffic volumes

Traffic surveys undertaken during 8 September 2016 yielded the volumes shown in Table 6.2 on local collector roads within the study area.

Table 6.2 Surveyed mid-block traffic volumes

Road Type	Peak Period	Mid-Block Traffic Volumes (vehicles per hour per lane in one direction)	
		Eastbound	Westbound
Coreen Avenue	AM	677	502
	PM	616	856
Copeland Road	AM	655	558
	PM	632	590
Dunheved Road	AM	812	638
	PM	835	990
Ropes Crossing Blvd	AM	243	465
	PM	560	305
Greenwood Parkway	AM	198	461
	PM	356	314

Source: Intersection traffic surveys (September 2016)

6.4 Functional classification

In 1993, the then Roads and Traffic Authority (RTA), prepared a report titled "*Updated Guidelines for the Functional Classification of Road in Urban Areas*". The functional classification system is based on an assessment of traffic volumes, composition and management. Four road types are defined. The following criteria are used in assessing the functional classification of roads:

- **Arterial Road** – typically a main road carrying over 15,000 vehicles per day and fulfilling a role as a major inter-regional link (over 1,500 vehicles per hour)
- **Sub-arterial Road** – defined as secondary inter-regional links, typically carrying volumes between 5,000 and 20,000 vehicles per day (500 to 2,000 vehicles per hour)
- **Collector Road** – provides a link between local roads and regional roads, typically carrying between 2,000 and 10,000 vehicles per day (250 to 1,000 vehicles per hour). At volumes greater than 5,000 vehicles per day, residential amenity begins to decline noticeably. Trunk collector or spine roads with limited property access can reasonably carry these traffic flows greater than 5,000 vehicles per day.
- **Local Road** – provides access to individual allotments, carrying low traffic volumes, typically less than 2,000 vehicles per day (250 vehicles per hour).

Peak hour flows are typically eight to twelve per cent of daily flows.

Some of the road characteristics under the functional classification are tabled below:

Table 6.3 Functional classification of roads

Road Type	Traffic volume (AADT)	Through traffic	Inter-connections	Speed limit (km/h)	Heavy vehicle restrictions
Arterial	> 15,000	Yes	Sub-arterial	70-110	No
Sub-arterial	5,000 - 20,000	Some	Arterial/Collector	60-80	No
Collector	2,000 - 10,000	Little	Sub-arterial/Local	40-60	Yes, if residential
Local	<2,000	No	Collector	40	Yes, if residential

Source: Updated Guidelines for Functional Classification of Roads in Urban Areas, RTA, 1993.

6.5 Mid-block road capacity on urban roads

The following Table 4.3 from RMS GTGD provides mid-block capacities per lane one-way.

Table 4.3
Typical mid-block capacities for urban roads with interrupted flow

Type of Road	One-Way Mid-block Lane Capacity (pcu/hr)	
Median or inner lane:	Divided Road	1,000
	Undivided Road	900
Outer or kerb lane:	With Adjacent Parking Lane	900
	Clearway Conditions	900
	Occasional Parked Cars	600
4 lane undivided:	Occasional Parked Cars	1,500
	Clearway Conditions	1,800
4 lane divided:	Clearway Conditions	1,900

6.6 Environmental capacity

The following Table 4.6 from RMS GTGD provides environmental capacity on residential streets with direct property access. Table 4.6 sets

out the recommended Environmental Capacity performance standards. This table relates to streets with direct access to residential properties. Trunk collector and spine roads with no direct property access can carry higher traffic flows.

Table 4.6
Environmental capacity performance standards on residential streets

Road class	Road type	Maximum Speed (km/hr)	Maximum peak hour volume (veh/hr)
Local	Access way	25	100
	Street	40	200 environmental goal
			300 maximum
Collector	Street	50	300 environmental goal
			500 maximum

Environment capacity in the above table directly relates to streets with direct access to residential properties. Higher order trunk collector street with no direct property access can carry higher volumes.

6.7 Proposed Mid-Block Capacities

Based on the information documented above in section 6 and meeting held with David Drozd and Walter Sinnadurai from PCC and Ryan Miller from WSP|PB on 16 February 2017, the following mid-block road capacities (assumed volumes are combined bi-directional volumes with single lane in either direction) are proposed:

Industrial Roads (1,000 vehicles per hour):

- Links Road currently carries in excess of 6,000 vehicles per day and up to 900 vehicles in the peak hour. It is estimated that Link Road carries 8,000 – 10,000 vehicles per day. This is in excess of the PCC proposal for Trunk Collector capacities of 6,000 vehicles per day and 600 vehicles in the peak hour. Based upon these volumes, Link Road operates more closely to a typical Collector Road.
- PCC advises that Links Road operates more as a Trunk Road and that Council has received several complaints from people employed in this industrial precinct about long queues during peak periods. From mid-block capacity and intersection performance analyses, Links Road currently carries 900 vehicles in the peak hour and performs at a good levels of service B in the existing AM and PM peak hours at the Links Road, Ropes Crossing Boulevard and Forrester Road intersection.
- PCC advises that Links Road will operate differently when opened and connected to Central Precinct and it would perform more as Distributor Road and therefore increase road capacity and road cross sections would apply. This was noted by WSP | PB.
- WSP | PB propose that the 1,000 vehicles per hour apply to Links Road.

The following has also been endorsed by PCC in the same meeting held with David Drzod and Walter Sinnadurai on 16 February 2017:

Distributor Roads (PCC) / Sub-Arterial Road (RMS): (2,000 vehicles per hour):

- Jordan Springs Boulevard between The Northern Road and Lakeside Parade
- Greenwood Parkway between The Northern Road and Lakeside Parade
- Ropes Crossing Boulevarde.
- Sub Arterial roads in the study area including roads such as Dunheved Road, Christie Road, Forrester Road, Glossop Street and Coreen Avenue currently carry approximately up to 15,000 to 20,000 vehicles daily and 1,500 to 2,300 vehicles peak hourly. This is clearly in excess of the PCC proposed capacities for Distributor/Sub Arterial roads of 15,000 vehicles daily and 1,500 vehicles in the peal hour. WSP|PB propose that the higher thresholds from RMS guidelines remain.

Collector Roads: (1,000 vehicles per hour):

- Greenwood Parkway east of Lakeside Parade
- Lakeside Parade
- East-west linking road between Jordan Springs and Ropes Crossing including Central Precinct (includes Lakeside Parade)
- Typical Collector Roads are carrying in excess of 600 vehicles per hour let alone Major Collector Roads. WSP |PB proposes that the 1,000 vehicles per hour remain for typical Collector Roads.

Local Road (typically less than 250 vehicles per hour):

- Local Residential Streets

→ Lower order than Collector Roads.

7. TRIP CONTAINMENT

Trip containment is not included in the RMS Guide to Traffic Generating Development Guide. The RMS Guide states the following:

> Note that not all trips are external trips. As a guide, about 25% of trips are *internal* to the subdivision, involving local shopping, schools and local social visits. When reviewing the impact of the traffic generated on sub-regional and regional roads, some adjustment is necessary, depending on the location of shops, schools and recreational facilities.

The RMS guide states that about 25% of trips are internal based upon residential dwellings. The development site has local shops, schools, medical centres and sporting facilities all generating traffic and internal trips.

A 5% internal trip containment percentage will be adopted.

8. CHANGES TO TRANPORT MODE SHARE

A 5% shift to bus public transport will be adopted.

Ryan Miller
Principal Traffic Engineer
+61 2 92725324
RyMiller@pb.com.au

Memorandum

To: Ryan Miller

From: Sean Porter

CC: Kalina Koloff

Date: 24th March 2017

Subject: **St Marys Development Site: Land Use and Development Yield Assumptions to Inform Regional Traffic Modelling**

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1 Background

This memorandum has been prepared by Lendlease to confirm land use assumptions, development yields and the anticipated delivery programme for the St Marys Development Site. This information is provided to WSP | PB for the purpose of underpinning traffic modelling work which is currently in progress.

It is understood that this memorandum will be appended to a document which outlines the governing assumptions of the traffic modelling and will be endorsed by a Steering Committee.

The St Marys Development Site comprises of six (6) discrete precincts, viz:

- Eastern Precinct
- Ropes Creek Precinct
- North Dunheved
- South Dunheved
- Central Precinct
- Western Precinct.

The Eastern and Ropes Creek Precincts have been consolidated into the development known as "Ropes Crossing". Ropes Crossing is substantially complete.

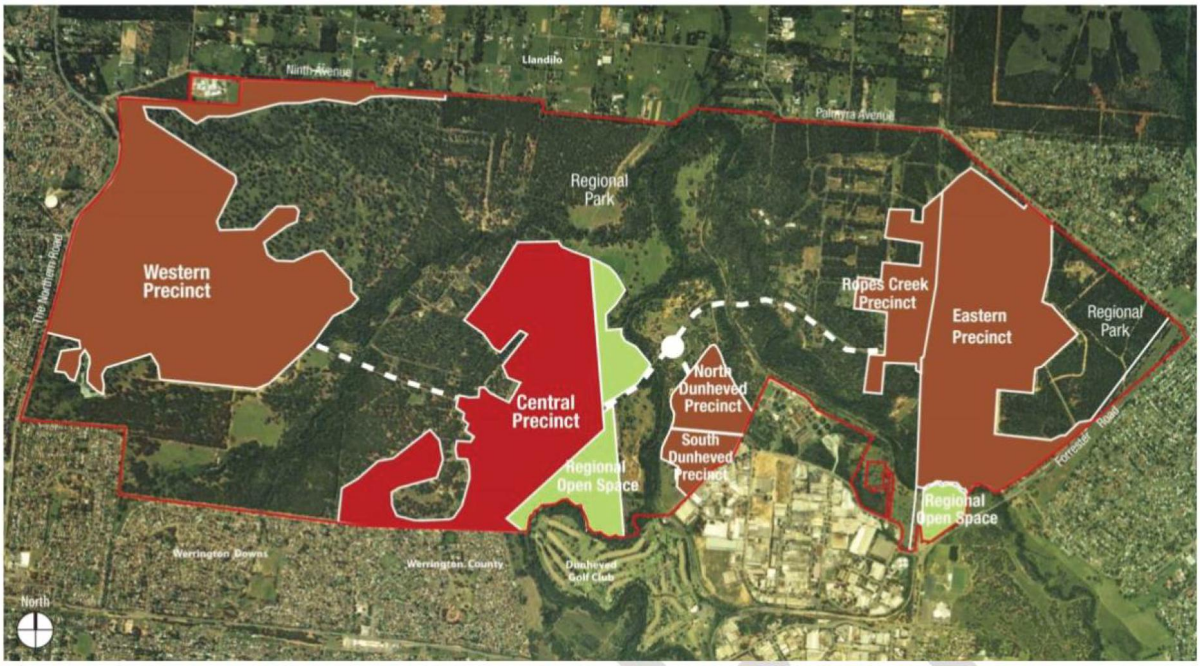
The North and South Dunheved Precincts are yet to be developed.

The Central Precinct (Jordan Springs East) is currently under construction with DA approvals for approximately 900 lots.

The Western Precinct (Jordan Springs) is substantially complete.

An overview of the St Marys Development Site is provided in **Figure 1**.

Figure 1 St Marys Development Site



2 Land Use Areas

A summary of the land uses across the precincts is provided in **Table 1**.

Table 1 St Marys Development Site Land Use and Development Yield

Precinct	Development Name	Land Use Type	Land Use Area (ha)	Dwelling Yield	Other
Western	Jordan Springs	Residential	-	3,437	-
		Medium density (apartments)	-	599	-
		Retail	2.5	-	-
		Medical Centre	-	-	3 doctors
		Childcare	-	-	200 children
		School	-	-	460 children
Central	Jordan Springs East	Residential	-	1,430^	-
		Retail	0.28	-	-
		Commercial	0	-	-
		Medical Centre	-	-	5 doctors
		Childcare	-	-	180 children
		Sporting fields	-	-	380 people
		Employment	38^	-	9.6 ha GFA^
North Dunheved	Dunheved	Employment	22	-	9.9 ha GFA
South Dunheved					
Eastern	Ropes Crossing	Residential	-	2,345	-

^ Note: The potential to rezone the employment land within Jordan Springs East is currently being explored with the Department of Planning and Environment. Should the land be rezoned from the current use of employment to residential the following amendments are anticipate: lot yield increase to 1,930; employment land use reduce to 0 and employment GFA reduce to 0.

Precinct	Development Name	Land Use Type	Land Use Area (ha)	Dwelling Yield	Other
Ropes Creek		Retail	1.2	-	-
		Commercial	1.4	-	-
		Medical Centre	-	-	3 doctors
		Childcare	-	-	120 children
		School	-	-	320 people

3 Delivery Programme

The delivery programme for the four development areas is nominated in **Table 2**.

Table 2 Delivery Programme

Development Name	Land Use Type	Land Use Area (ha)	Dwelling Yield	Other	Cumulative Total by Year					
					2016	2017	2018	2019	2020	2021
Jordan Springs	Residential	-	3,437	-	1,897	2,800	3,347	3,347	3,347	3,347
	Medium density (apartments)	-	599	-	0	300	599	599	599	599
	Retail	2.5	-	-	1.5	2.0	2.5	2.5	2.5	2.5
	Medical Centre	-	-	3 doctors	3	3	3	3	3	3
	Childcare	-	-	200 children	60	90	120	150	200	200
	School	-	-	460 children	0	0	0	250	300	460
Jordan Springs East	Residential	-	1,430	-	0	400	800	1,430	1,430	1,430
	Retail	0.28	-	-	0	0	0.28	0.28	0.28	0.28
	Commercial	0	-	-	0	0	0	0	0	0
	Medical Centre	-	-	5 doctors	0	0	5	5	5	5
	Childcare	-	-	180 children	0	40	80	160	180	180
	Sporting fields	-	-	380 people	0	0	0	0	0	380
	Employment	38^	-	9.6 ha GFA^	0	0	0	4.8	9.6	9.6
Dunheved	Employment	22	-	9.9 ha GFA	0	0	0	0	0	9.9
Ropes Crossing	Residential	-	2,345	-	1,950	2,345	2,345	2,345	2,345	2,345
	Retail	1.2	-	-	1.2	1.2	1.2	1.2	1.2	1.2
	Commercial	1.4	-	-	1.4	1.4	1.4	1.4	1.4	1.4
	Medical Centre	-	-	3 doctors	3	3	3	3	3	3
	Childcare	-	-	120 children	120	120	120	120	120	120
	School	-	-	320 people	250	265	280	295	320	320

^ Note: The potential to rezone the employment land within Jordan Springs East is currently being explored with the Department of Planning and Environment. Should the land be rezoned from the current use of employment to residential the following amendments are anticipate: lot yield increase to 1,930; employment land use reduce to 0 and employment GFA reduce to 0.

I trust that this correspondence is satisfactory. Should you require any additional information please do not hesitate to contact me.

Yours sincerely,

Sean Porter
Development Manager
Lend Lease Communities

APPENDIX B

AIMSUN MESOSCOPIC MODEL CALIBRATION AND VALIDATION REPORT

MARYLAND DEVELOPMENT COMPANY PTY LTD

St Marys Development Site Regional Traffic Modelling

Aimsun Mesoscopic Model Calibration and Validation Report

CONFIDENTIAL

MARCH 2017

St Marys Development Site Regional Traffic Modelling

Aimsun Mesoscopic Model Calibration and Validation Report

Maryland Development Company Pty Ltd

Confidential

REV	DATE	DETAILS
	22/03/2017	Draft report
A	24/03/2017	Draft report

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Filename: 2197037A-ITP-REP-001-RevA.docx

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GLOSSARY

DUE	Dynamic User Equilibrium
GEH	GEH Statistic
GPS	Global Positioning System
OD	Origin-Destination
SCATS	Sydney Coordinated Adaptive Traffic System
STFM	Sydney Transport Forecast Model
Roads and Maritime	Roads and Maritime Service
TfNSW	Transport for NSW
ADI	Australian Defence Industries
LGA	Local Government Area
SREP	Sydney Regional Environmental Plan
IDM	Intersection Diagnostic Monitor

1 Project background

The St Marys Development site is being developed Maryland Development Company Pty Ltd a subsidiary of Lend Lease. The St Marys Development Site comprises of six discrete precincts identified as: Eastern Precinct (Ropes Crossing), Ropes Creek Precinct (Ropes Crossing); North Dunheved; South Dunheved; Central Precinct (Jordan Springs East); and Western Precinct (Jordan Springs). By 2016 both Jordan Springs and Ropes Crossing were substantially complete with a large proportion of residential dwellings built and occupied. Similarly, planning and construction work has substantially commenced at Jordan Springs East with occupation of the first dwellings expected in early 2018. The North and South Dunheved Precincts are planned for development upon the completion of the Jordan Springs East precinct.

Extensive traffic and transport modelling work was completed in 2004 to underpin the phased development of the St Marys Development Site. However, as the project has progressed the assumptions underpinning the 2004 traffic and transport modelling have materially changed and as such, Penrith City Council requested that a Traffic Steering Committee be reformed to inform a more contemporary modelling approach that is underpinned by assumptions that more accurately reflect the nature and extent of the development. The Traffic Steering Committee includes representatives of Roads and Maritime Services (Roads and Maritime), the Department of Planning & Environment (DP&E), Transport for NSW (TfNSW), Penrith City Council (PCC) and Blacktown City Council (BCC).

WSP | Parsons Brinckerhoff was commissioned by Maryland Development Company Pty Limited to prepare traffic modelling and reporting in accordance with the agreed expectations of the Traffic Steering Committee. The development of a contemporary traffic model has been undertaken according to the agreed scopes of a steering committee and generally in accordance with the Roads and Maritime *Modelling Guidelines*.

1.1 Background

The St Marys Australian Defence Industries (ADI) site was endorsed by the NSW Government for inclusion on the Urban Development Program (UDP) in 1993.

On 19 January 2001, the Sydney Regional Environmental Plan No. 30 – St Marys (SREP 30) was gazetted. SREP 30 rezoned 1,535 hectares of land on the site to permit a range of urban uses and a large area of regional parkland. The overall site comprises six development precincts, as shown in Figure 1.1, including Jordan Springs (West Precinct), Central Precinct and South Dunheved Precinct in the Penrith Local Government Area (LGA) and Ropes Crossing (Eastern Precinct), Ropes Creek Precinct and North Dunheved Precinct in the Blacktown LGA.

Figure 1.1 St Marys development area showing precinct locations

The Central Precinct (total area 133 hectares) is located within the Penrith City Council LGA and is bounded by existing residential development in the suburbs of Werrington County and Werrington Downs to the south, land zoned for Regional Open Space to the east and land zoned for Regional Park to the north and west.

It was declared a release area by the Minister for Planning on 29 September 2006, with the Precinct Plan adopted by Penrith City Council in March 2009. An Amendment to the Precinct Plan was submitted to and exhibited by Council in 2016. The Precinct Plan amendment sought to adjust a number of structural elements within the Central Precinct; including the road hierarchy, village centre location and rationalisation of open space elements. In addition, the Precinct Plan amendment also sought to capture the increased development capacity of the Precinct (i.e., yield). The amendment to the Central Precinct Precinct Plan is currently under assessment.

The current status (2016) of the balance St Marys Development precincts is as follows:

- Jordan Springs:
  - Declared a release area in September 2006
  - Precinct Plan adopted by PCC on 23 March 2009 and currently being developed
- Ropes Crossing:
  - Declared a release area in June 2003
  - Precinct Plan adopted by Blacktown City Council in February 2004 and largely completed in 2014
- North and South Dunheved Precincts:
  - Declared a release area in June 2003
  - Precinct Plan adopted by Penrith City Council in December 2006 and by Blacktown City Council in January 2007
  - Development to commence shortly
- Ropes Creek Precinct:
  - Declared a release area in September 2006 and Precinct Plan lodged with Blacktown City Council.

The contemporary traffic modelling work focusses on:

- External intersection performance and impacts of the development
- Trip generations in and out of all six precincts
- Internal intersection and mid-block road performance within the St Marys Development site
- The investigation of the potential extension of Links Road to Christie Street from the St Marys Development Site.

1.2 Scope of works and model use

The scope of works includes the development of an Aimsun mesoscopic model to assess the impacts of the development traffic on the surrounding road network at the anticipated full completion year in 2021, 5 years after opening in 2026, and 10 years after opening in 2031. The base model will be used as follows:

- To provide relevant information to estimate the capacity of the east-west internal link which connects the Central Precinct with Jordan Springs, Ropes Crossing and Dunheved Precincts.
- To investigate scenarios with and without the extension of Links Road to Christie Street, a north-south link road which would connect the Central Precinct to Dunheved Road.
- To inform:
  - the proportional contribution of the St Marys Development Site traffic on the road network with the study area
  - the extent of intersection upgrades required with and without the St Marys Development Site on the existing and future road networks.

1.3 Report purpose

This calibration and validation report outlines the steps taken in the development of 2016 AM and PM peak base models, including data analysis, network coding, demand development, model calibration and validation. This report is aimed at modelling practitioners and provides a technical synopsis of the model development process and a summary of the model outcomes measured against the recommended calibration and validation criteria with the intention of producing a 'fit for purpose' model to be used in testing the future year modelling scenarios.

1.4 Report structure

This report documents the methods and process used in the development of the St Marys Development Aimsun Mesoscopic Model. It demonstrates that the model was developed, calibrated and validated to a satisfactory standard and validates against observed traffic operations. The report outlines the overall methodology followed and is split into four chapters, as follows:

- Chapter 2 – Model development: describes the initial steps in the model development process including the data used, data analysis, interpretation, existing model utilisation and network development.
- Chapter 3 – Traffic demand development: provides the methodology and results of prior and post traffic matrices adjustment.
- Chapter 4 – Mesoscopic model calibration and validation: provides the base model outputs and results regarding the calibration of the model and validation of network performance.
- Chapter 5 – Summary and conclusions: summarises the outcomes of the model development, calibration and validation.

2 Model development

This chapter describes the methods used in the development of the St Marys Development mesoscopic traffic model. This includes a description of the software used, data collected, analysis and application of the data collected, and the development of the model network.

2.1 Modelling software

Aimsun version 8.1.3 (R40314) was used for the base model development, network refinements, demand estimation, calibration and validation.

2.2 Study area

The study area is highlighted on Figure 2.1 represents the extent of the mesoscopic model area. The St Marys Development is located approximately 45 km west of Sydney CBD, between and north of the retail and commercial centres of Penrith and St Marys. It is to the north of the Western Rail Line, Great Western Highway and M4 Western Motorway.

The entire site is roughly 7 km wide east to west and 2 km wide north to south. It is bounded by The Northern Road to the west, Ninth Avenue, Eighth Avenue and Palmyra Avenue to the north, Forrester Road and Christie Street to the east and the neighbouring suburbs of Werrington County, Werrington Downs and Cambridge Gardens to the south.

The study area includes north-south arterial roads (Parker Street/Richmond Road/The Northern Road in the west) and the Great Western Highway and M4 Motorway in the south. The Northern Road corridor provides access to Penrith CBD and the M4 Motorway in the south as well as Richmond in the north. On the eastern side, Forrester Road and Glossop Street provide access across the Western Rail Line to St Marys and via Mamre Road to the M4 Motorway. Dunheved Road and Christie Street provide a sub-arterial connection between these north-south corridors, as well as providing access to the Dunheved Industrial Area and the surrounding suburbs such as Werrington and Werrington County. Werrington Road connects Dunheved Road and Christie Street to the Great Western Highway. The study area partially includes the University of Western Sydney Penrith Campus and Nepean Hospital.

The descriptions of key road corridors inside the model area are outlined below:

- **Great Western Highway (GWH) Corridor:** Running east-west and parallel to the M4, GWH services a number of Sydney's Western suburbs. Within the St Marys and Penrith region, the GWH varies between two and three lane carriage ways, with a speed limit of 80 km/h. Between Glossop Street and Parker Street, there are ten signalised intersections along the GWH, with several priority intersections accessing local roads.
- **The Northern Road Corridor:** A north-south arterial road, accessing the Great Western Highway and South Windsor, The Northern Road provides connectivity to the major collector roads within the Jordan Springs and Werrington regions. Operating between 60 and 70 km/h, this sub-arterial corridor services higher levels of traffic demand within the study area.
- **Ninth Avenue Corridor**: Ninth Avenue is a collector road, located on the northern boundary of the study area that services schools and rural residential premises in the Llandilo and Jordan Springs suburbs. Ninth Avenue is a one lane dual carriageway with an allocated speed limit of 60 km/h.
- **Forrester Road Corridor:** Predominantly a two lane dual carriageway, Forrester Road runs north-south connecting Palmyra Avenue and the Great Western Highway. Servicing vehicles within St Marys and Ropes Crossing, Forrester Road is another major sub-arterial corridor within the study area. Similar to the Northern Road, Forrester Road operates between 60 and 70 km/h, with a number of signalised and priority controlled intersections accessing local roads.

- **Dunheved Road/Christie Street Corridor:** An east-west sub-arterial road, almost parallel to the Great Western Highway within the study area, with a speed limit of 60 km/h. This corridor also forms the southern boundary of the proposed development site between The Northern Road and Forrester Road. It is a one lane carriageway in each direction and provides right turning pocket lanes at several T-junctions.
- **Werrington Road:** A north-south one lane sub-arterial road, providing a vital connection between the Great Western Highway and Dunheved Road and Christie Street.

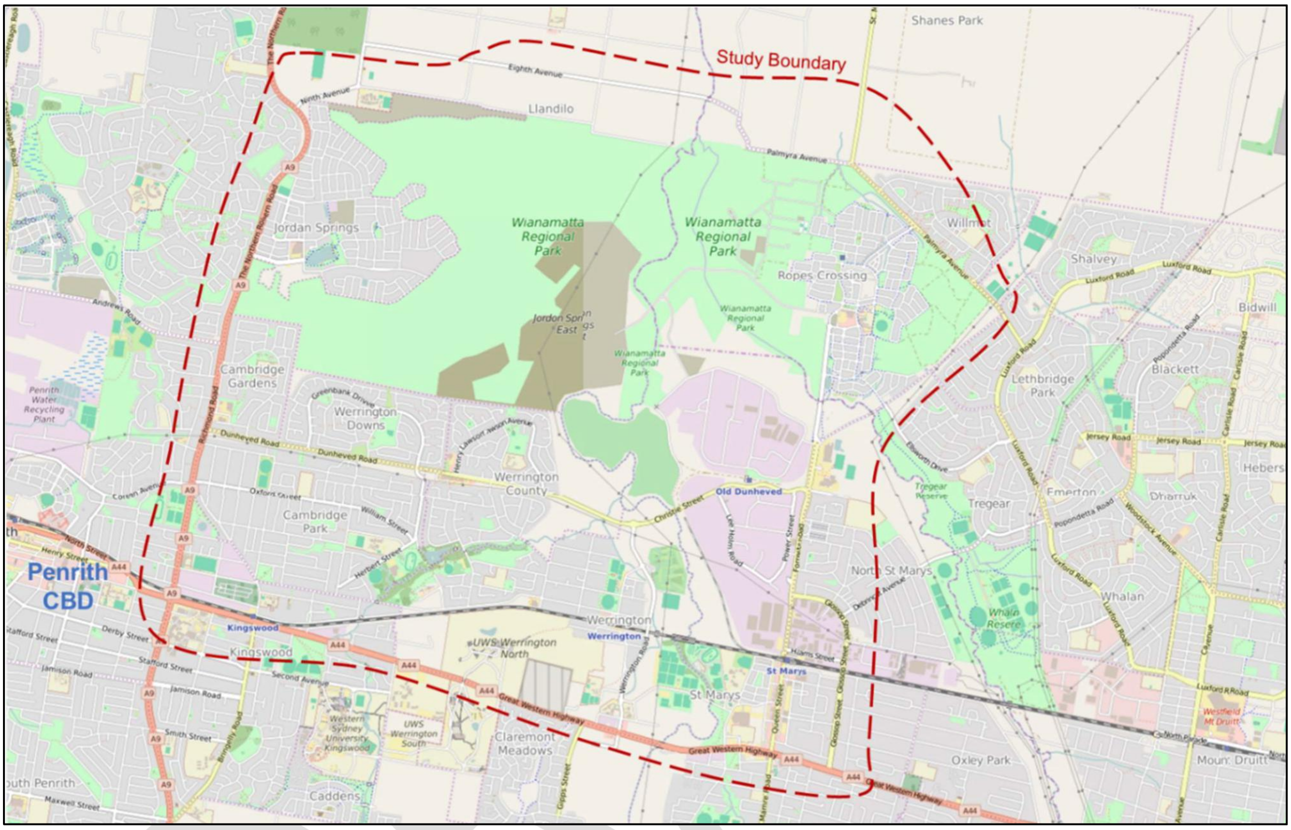

Figure 2.1 Model study area

2.3 Site visit

Site inspections were carried out during the AM (7.30 am to 9.00 am) and PM (4.00 pm to 6.00 pm) peak hours on Thursday, 8 September 2016. These site visits were conducted on the same day as the traffic surveys being undertaken by TTM. The objective of the site visit was to understand the traffic operations in the study area and identify the locations experiencing traffic congestion during the weekday AM and PM peak periods.

2.4 Base model development methodology

The overall proposed traffic modelling methodology is illustrated below in Figure 2.2. This process is designed to comply with the Roads and Maritime *Traffic Modelling Guidelines* (February 2013).

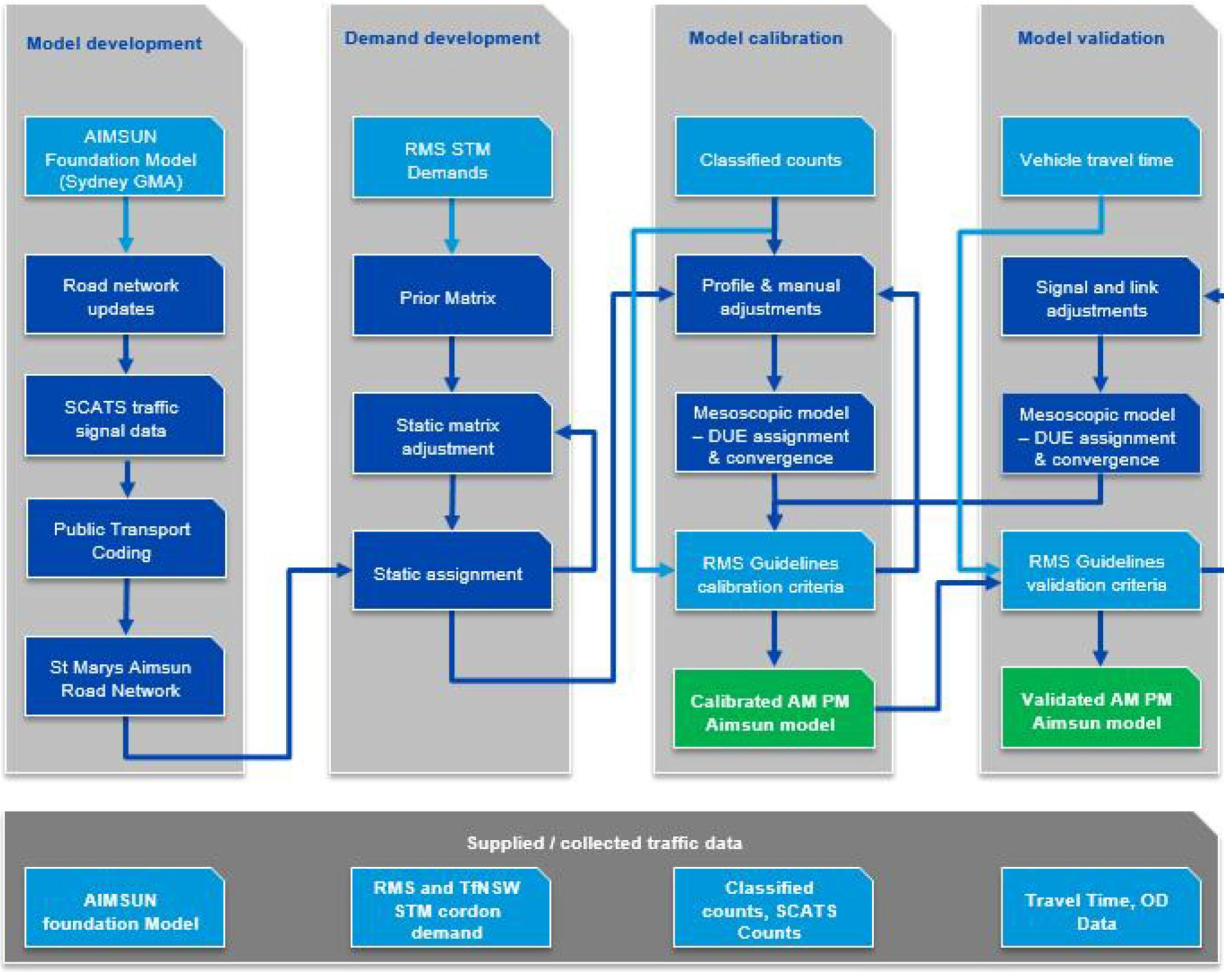

Figure 2.2 Base Traffic Model methodology

2.5 Model time periods

The Aimsun model incorporates both the weekday AM and PM peaks. The modelled peak hour periods are:

- AM peak: 7.00 am to 9.00 am
- PM peak: 4.00 pm to 6.00 pm.

A one hour warm-up period was applied upfront to provide a good representation of traffic conditions within the road network prior to the two-hour peak period, with a one hour cool-down period applied to maximise the traffic release following the peak period.

2.6 Transport network

2.6.1 Road geometry

Prior to the network refinement, the study area was carefully checked using *Google Maps* aerial photography and street view images as well as site visit observations to ensure model details corresponded to the existing road network. Key features that were checked within the study area included:

- length of short/turning lanes
- lane configurations
- on-street parking restrictions
- speed limits
- priority control at intersections (giveaway or stop signs)
- school zones.

2.6.2 Signal operations

The Sydney Coordinated and Adaptive Traffic System (SCATS) traffic signal data for the signalised intersections (locations shown in Figure 2.3) within the study area were collected on 8 September 2016 (the same date of the site visit and the collection of classified intersection counts). The data provided by Roads and Maritime included:

- SCATS Intersection Diagnostic Monitor (IDM) files, which contain the phase time, frequency and cycle length dataTraffic Control Site (TCS) graphics plots, showing phasing plans, signal groups and detector locations

It should be noted that data was unavailable at two locations TCS 3331 Dunheved Road | Henry Lawson Avenue and TCS 3135 Queen Street | Charles Hackett Drive. Roads and Maritime confirmed that these sites were not available due to them being dial up sites. The signal phasing and timings of these two intersections were therefore estimated based on the nearby traffic signals where applicable.

The SCATS signal information that was analysed and entered into the model, was based on the average cycle and phase times with separate control plans developed for each hour of the model. As part of the development of these control plans, the following adjustments were made to the observed data to facilitate the modelling process:

- Conversion of actuated signals to fixed time signals
- Addition to the average green time of the low-frequency alternative phase, to allow for a minimum of 6 seconds phase time during each traffic signal cycle
- Definition of movement priorities (such as filter right turns) were updated in accordance with the provided phasing data and the information provided by Roads and Maritime
- Coordination of signals on key corridors to ensure an appropriate cycle time was modelled (e.g. similar cycle times at the adjacent traffic signals)
- A standard inter-green time of 6 seconds was applied, incorporating 4 seconds of amber time and 2 seconds of all-red time.

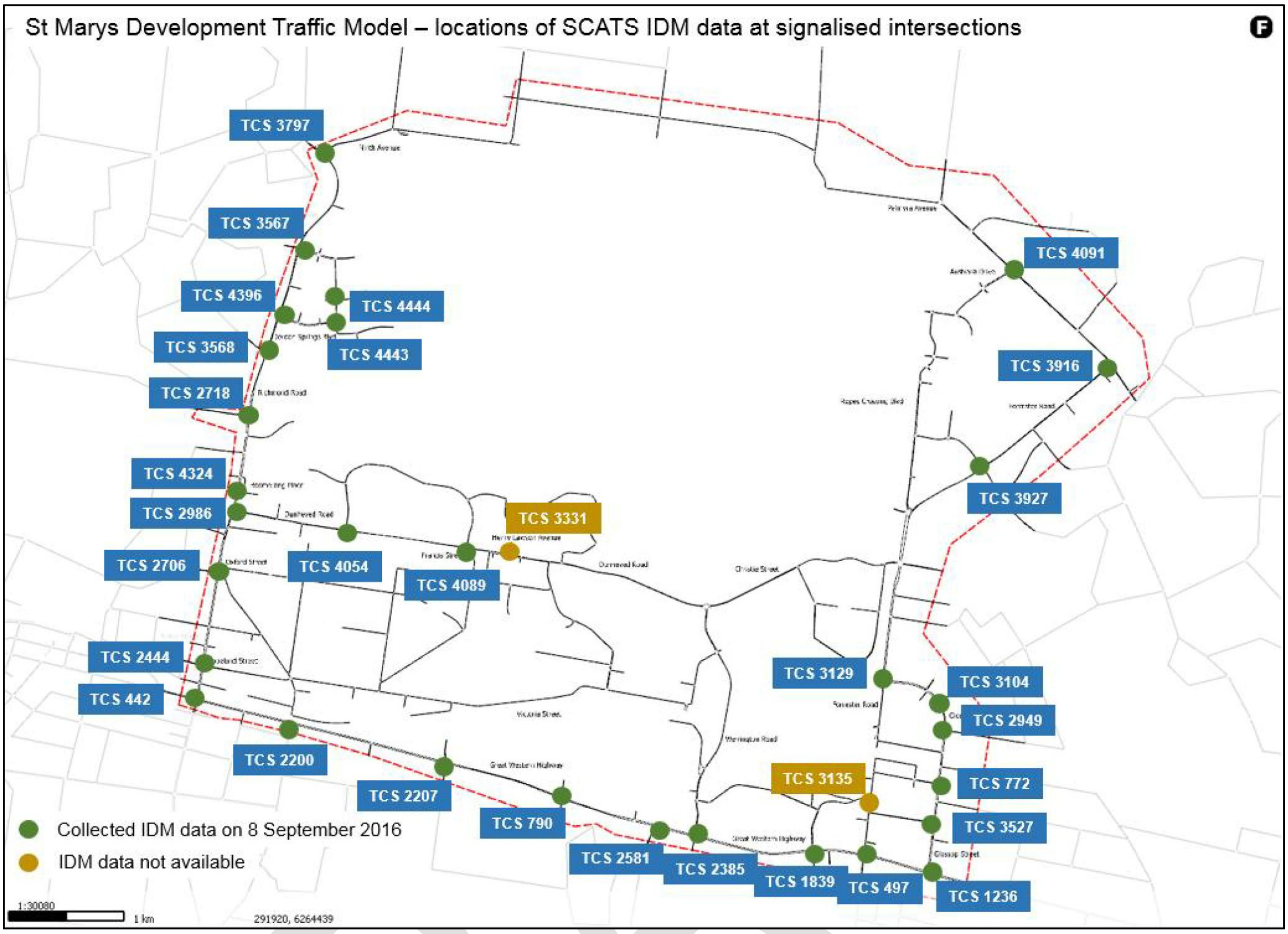

Figure 2.3 Locations of signalised intersections and supplied IDM data

2.6.3 Bus operation data

Bus route information was extracted from the Greater Sydney General Transit Feed Specification (GTFS) open-source data. Bus Stop IDs, dwell times and bus routes within this data package were allocated GPS coordinates, which were imported into geospatial software (QGIS). These exported locations and bus paths were cross-referenced with *Busways timetable data*. A list of the bus routes coded in the traffic model is shown in Table 2.1.

Table 2.1 Bus routes coded in the traffic model

Bus route	Locations
673	Windsor to Penrith via Bligh Park
674	Windsor to Mt Druitt via Bligh Park
677	Richmond to Penrith via Londonderry and Northern Road
678	Richmond to Penrith via Agnes Banks, Castlereagh and Cranebrook
758	Mt Druitt to St Marys via Emerton and Shalvey
759	Mt Druitt to St Marys via Emerton, Willmot and Ropes Crossing
774	Penrith to Mt Druitt via St Marys and Oxley Park
775	Penrith to Mt Druitt via St Marys and Erskine Park

Bus route	Locations
776	Penrith to Mt Druitt via St Marys and St Clair
780	Mt Druitt to Ropes Crossing
781	Penrith to St Marys via Glenmore Park, Orchard Hills and Claremont Meadows
782	Penrith to St Marys via Cambridge Gardens and Werrington Station
783	Penrith to Jordan Springs
785	Penrith to Werrington Station via Cambridge Park

The above bus routes were imported into QGIS and allocated to their respective bus stops within the study area. In conjunction with the timetable data, unique features such as bus bays, kerbside and island bus stops were noted within the GIS model. By compiling these features within the software, they could easily be imported into the AIMSUN model. Some bus routes were altered or simplified due to the exclusion of minor local streets in the traffic model. Additional school bus services were also included in the traffic model.

A final accuracy check was performed along the major roads within the study area, particularly along the Great Western Highway, Richmond Road, Ropes Crossing Boulevard, Ninth Avenue and Glossop Street to confirm that the GIS representation of the bus network aligned with the existing conditions. The typical bus dwell time of 20 seconds was assumed during peak periods.

2.7 Traffic data collection and analysis

Traffic surveys were carried out on Thursday 8 September 2016 and 15 September 2016 by TTM. These surveys included:

- Intersection turning counts – 30 locations
- Classified mid-block traffic counts – 10 locations
- Origin-destination survey – 15 locations
- Travel time surveys – six routes
- Queue length surveys – 19 locations
- SCATS detector counts in one hour intervals (collected at 11 locations in addition to the TTM traffic counts).

The traffic data was collected for the following intervals, which captured most trips associated with commuting, schooling, business and other key activities in the study area:

- AM peak: 6.00 am–10.00 am
- PM peak: 3.00 pm–7.00 pm.

The locations of the traffic surveys are summarised in Figure 2.4.

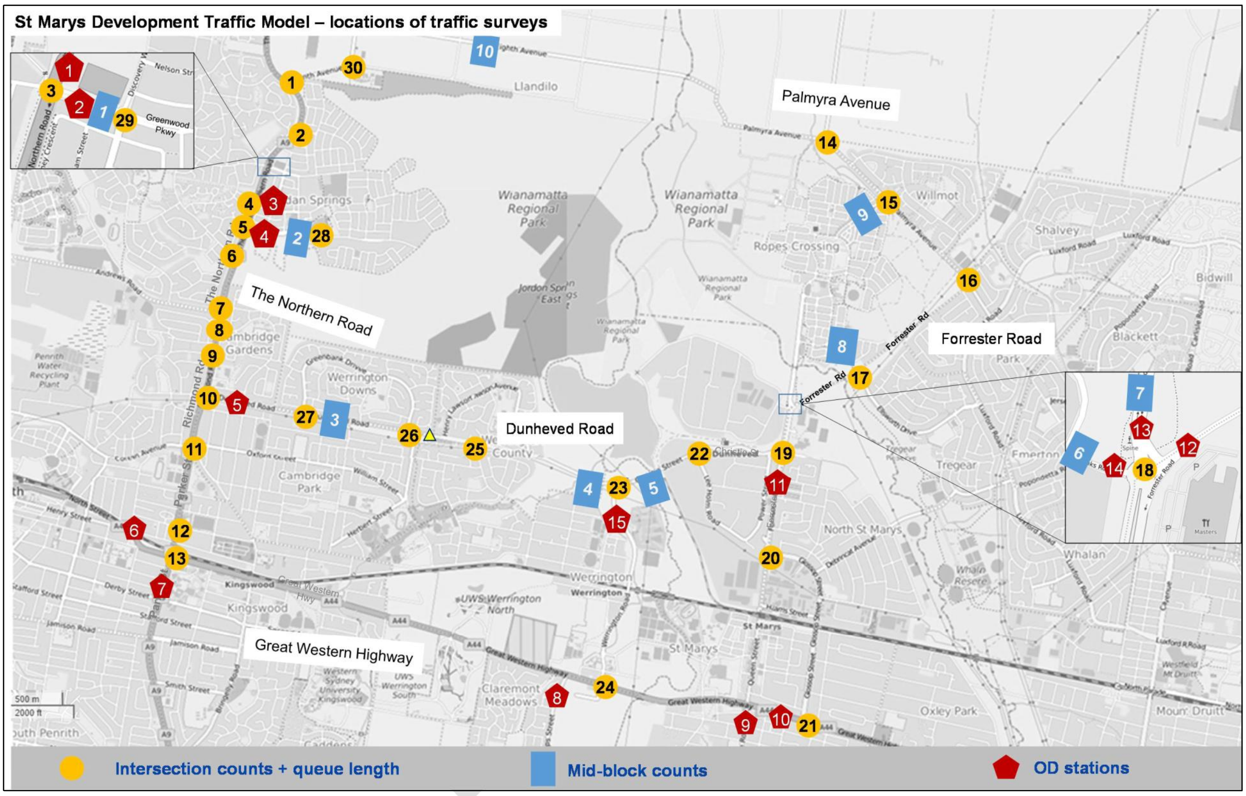

Figure 2.4 Traffic data collection locations

2.7.1 Classified intersection counts

Intersection turning movement counts were supplied by TTM Group at the following 30 locations as shown in Figure 2.4:

1. The Northern Road and Ninth Avenue (signalised – TCS 3797)
2. The Northern Road and Jardine Way (priority)
3. The Northern Road and Greenwood Parkway (signalised – TCS 3567)
4. The Northern Road and Watkin Street (priority)
5. The Northern Road and Jordan Springs Road (signalised – TCS 4396)
6. The Northern Road and Sherringham Road (signalised – TCS 3568)
7. The Northern Road, Andrews Road, and Richmond Road (signalised – TCS 2718)
8. Richmond Road and Trinity Drive (priority)
9. Richmond Road and Boomerang Place (signalised – TCS 4324)
10. Richmond Road and Dunheved Road (signalised – TCS 2986)
11. Richmond Road and Oxford Street (signalised – TCS 2706)
12. Parker Street and Copeland Street (signalised – TCS 2444)
13. Great Western Highway and Parker Street (signalised – TCS 442)
14. Palmyra Avenue and Stony Creek Road (signalised – TCS 4091)
15. Palmyra Avenue and Australis Drive (signalised – TCS 4091)
16. Palmyra Avenue and Forrester Road (signalised – TCS 3916)
17. Forrester Road, Susannah Drive and Ellsworth Drive (signalised – TCS 3927)
18. Forrester Road and Ropes Crossing Boulevard (roundabout)
19. Forrester Road and Christie Street (roundabout)
20. Forrester Road and Glossop Street (signalised – TCS 3129)
21. Great Western Highway and Glossop Street (signalised – TCS 1236)
22. Christie Street and Lee Holm Road (priority)
23. Dunheved Street and Werrington Road (roundabout)
24. Great Western Highway and Werrington Road (signalised – TCS 2385)
25. Dunheved Road and John Oxley Avenue (priority)
26. Dunheved Road and Greenbank Drive East (signalised – TCS 4089)
27. Dunheved Road and Greenbank Drive West (signalised – TCS 4054)
28. Jordan Springs Boulevard and Lakeside Parade (signalised – TCS 4443)
29. Greenwood Parkway and Discovery Way (roundabout)
30. Ninth Ave and Terrybrook Road (priority).

2.7.2 Processing of SCATS detector counts

All SCATS detector counts were collected at hourly intervals. The processing of the SCATS intersection turn count data included the following process:

- Allocation of detectors to turns (based on lane markings) to enable data to be utilised in the model.
- Consistency checks to ensure that traffic levels rise and fall in reasonably consistent patterns between adjacent intersections and along the corridor as a whole.
- The average percentage of trucks for the SCATS sites was determined based on the adjacent TTM classified turning counts along the individual corridor.
- At locations with many shared turning lanes, balancing was required using assumptions based on the proportion of turning demands. Turns that were counted by dedicated detectors remained unchanged. Only shared lane detectors were adjusted in the balancing process.

2.7.3 Flow balancing

Balancing of traffic flows between intersections was undertaken where appropriate to ensure that link flows between adjacent intersections were approximately in line with the SCATS and manual traffic counts. A significant amount of time was spent on this process due to several discrepancies between adjacent count sites. The balancing process is based on matching the upstream and downstream flows and includes the following steps:

1. Analyses of all road links based on intersection traffic counts, and identification of those road links with noticeable discrepancy between the upstream incoming and the downstream outgoing midblock traffic volumes.
2. If there was a side access, then the associated land uses were reviewed to see whether this discrepancy could be justified by such land use. For instance, the southbound traffic volume on The Northern Road had a discrepancies between Trinity Drive and Boomerang Place in both weekday AM and PM peak, primarily due to Star Circuit which provided access to commercial properties including Caltex, McDonalds and Coles Supermarket.
3. Where there were no side street accesses in between two surveyed intersections, it was then assumed that the traffic volumes at either the upstream or downstream intersection might have been miscounted. In this case, further checks at the other nearby intersections along the same corridor were undertaken, and where necessary manual adjustments to the traffic count were made to minimise this discrepancy in the traffic volumes between the adjacent mid-blocks.

The intersection counts, following the above mentioned balancing process, were used for the calibration of the modelled traffic flows.

2.7.4 Origin-destination survey results

Vehicle origin-destination (OD) surveys were conducted to assess the travel patterns and distribution associated with the existing Jordan Springs and Ropes Crossing developments at the following 15 station locations:

1. The Northern Road, north of Greenwood Parkway
2. Greenwood Parkway, east of The Northern Road
3. Watkin Street, east of The Northern Road
4. Jordan Springs Boulevard, east of The Northern Road
5. Dunheved Road, east of Richmond Road
6. High Street, west of Parker Street
7. Parker Street, south of Great Western Highway

8. Gipps Street, south of Great Western Highway
9. Mamre Road, Great Western Highway
10. Great Western Highway, east of Queen Street
11. Forrester Road, between Maple Road and Christie Street
12. Forrester Road, east of Ropes Crossing Boulevard
13. Ropes Crossing Boulevard, north of Forrester Road
14. Links Road, west of Forrester Road
15. Werrington Road, south of Christie Street.

The surveys were undertaken using Automatic Number Plate Recognition (ANPR) technology, on Thursday 15 September 2016, one week after the classified intersection counts were undertaken. The following assumptions were used by TTM to match the number plates between multiple sites.

- Unmatched numberplates were assumed to have left the network through one of the non-survey roads
- A time limit of 60 minutes was applied to exclude multiple trips through the same locations
- Records that had errors in processing (e.g. unreadable number plates) were excluded.

The key OD survey results for the existing Jordan Springs development site are summarised in Table 2.2 and Table 2.3.

Table 2.2 OD survey results – Jordan Springs Development – AM peak

Jordan Springs Development (OD Station 2, 3 ,4)	OD Station	Out of the site – AM		Into the site – AM	
		7.00–8.00	8.00–9.00	7.00–8.00	8.00–9.00
The Northern Road north	1	62%	70%	54%	67%
Dunheved Road	5	5%	4%	5%	9%
Great Western Highway west	6	3%	4%	0%	0%
Parkers Street south	7	31%	22%	41%	24%
Percent captured (of the total trips)		62%	55%	41%	31%

Table 2.3 OD survey results – Jordan Springs Development – PM peak

Jordan Springs Development (OD Station 2, 3 ,4)	OD Station	Out of the site – PM		Into the site – PM	
		4.00–5.00	5.00–6.00	4.00–5.00	5.00–6.00
The Northern Road north	1	69%	78%	72%	60%
Dunheved Road	5	3%	2%	12%	9%
Great Western Highway west	6	3%	5%	0%	1%
Parkers Street south	7	25%	15%	16%	31%
Percent captured (of the total trips)		64%	62%	34%	33%

The OD survey of the existing Jordan Springs development site has a capture rate between 55% and 65% for the outbound trips and this drops to below 41% for the inbound trips.

The key findings from the captured OD trips for the Jordan Springs development site were as follows:

- In both the AM and PM peak, approximately between 54% and 78% of the traffic is travelling in and out of the Jordan Springs development site via The Northern Road (north)
- Approximately between 15% and 41% of the captured in and out trips travelled into the Jordan Springs development site via Parker Street south.

The remaining trips which travelled via the Great Western Highway and Dunheved Road are mostly less than 5%. For the Ropes Crossing development site, capture rates at the OD station (No 13) located on the Ropes Crossing Blvd, were mostly less than 20% of the total traffic exiting or entering the existing development site. Thus the trip distribution from the OD station (No 13) was deemed to be indicative only for the Ropes Crossing development site. The captured trip distribution to and from the Ropes Crossing development site indicates that the majority (between 50% to 70%) of southbound traffic travelled via Forrester Road for both the AM and PM peak periods and about 10% to 15% of traffic travelled via Dunheved Road.

2.7.5 Travel time survey results

Floating car travel time surveys were undertaken by TTM on six routes and presented in Figure 2.5 .Travel time data were collected in each peak hour during the AM and PM peak periods on Thursday, 8 September 2016.

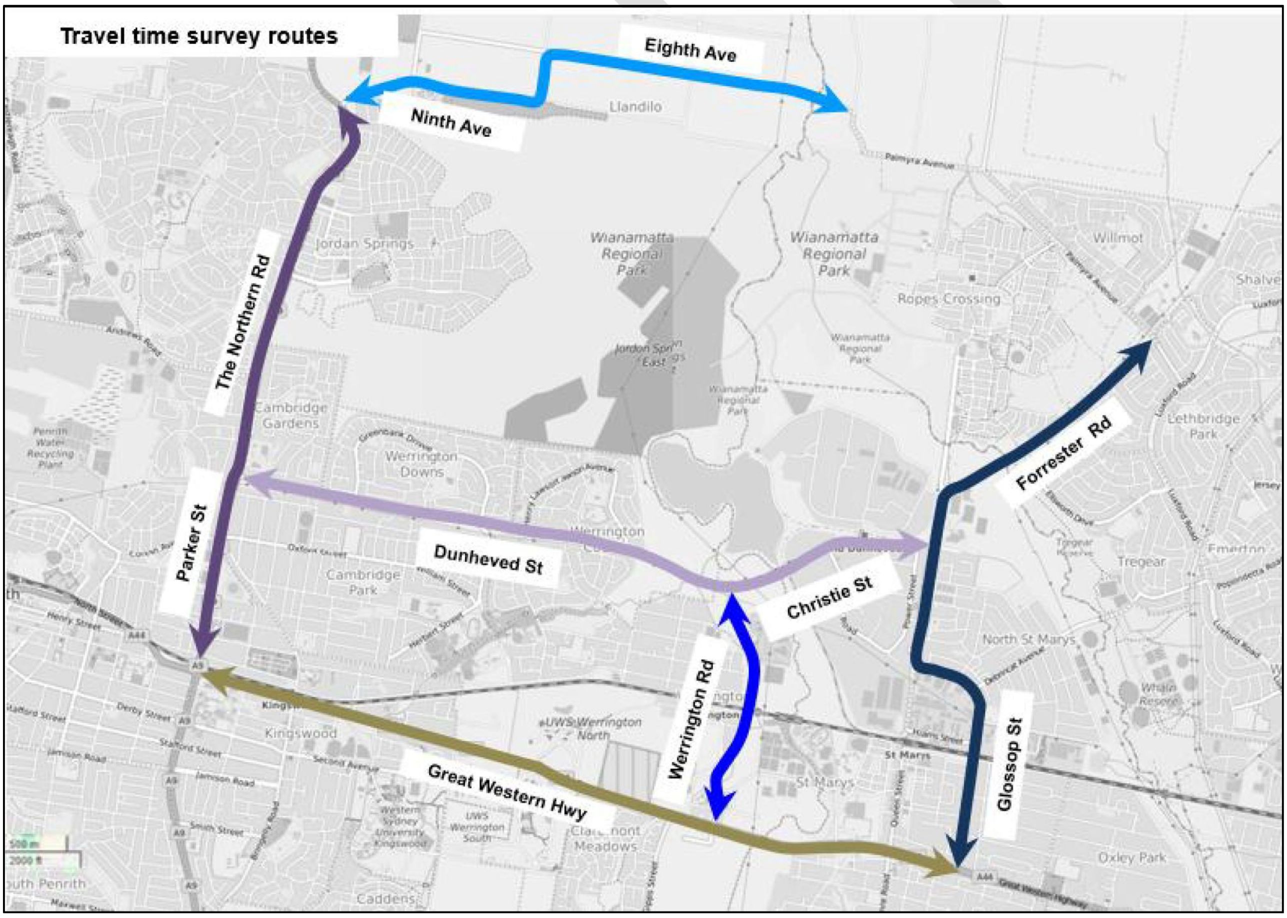

Figure 2.5 Travel time survey routes

Table 2.4 and Table 2.5 summarise average travel time and travel speed results for the above six routes.

Table 2.4 Average travel time summary

Route no. and name	Length (km)	Direction	AM (Minute)		PM (Minute)	
			7.00–8.00	8.00–9.00	4.00–5.00	5.00–6.00
1.The Northern Road/Richmond Road/Parker Street between Great Western Highway–Ninth Avenue	4.5	NB	07:17	08:06	08:09	08:08
	4.7	SB	08:58	10:52	09:32	10:19
2.Forrest Road/Glossop Street between Palmyra Avenue and The Northern Road	5.7	NB	07:51	07:42	07:51	07:51
	5.6	SB	08:34	09:07	08:54	08:54
3. Eight Avenue/Ninth Avenue between South Creek Road and Third Avenue and The Northern Road	4.7	EB	05:14	05:31	05:24	05:29
	4.6	WB	05:02	05:39	05:32	05:41
4. Christine Street/Dunheved Road between Forrest Road and Richmond Road	5.8	EB	07:46	08:03	06:45	08:03
	5.9	WB	08:27	08:19	10:19	08:40
5.Werrington Road between Dunheved Road and Great Western Highway	2.1	NB	02:39	02:50	03:48	03:07
	2.1	SB	03:25	04:16	03:31	04:04
6.Great Western Highway between Glossop Street and The Northern Road (Parker Street)	6.5	EB	07:48	08:49	11:04	11:31
	6.5	WB	09:32	12:01	14:34	13:38

Table 2.5 Average travel speed summary

Route no. and name	Length (km)	Direction	AM (km/hour)		PM (km/hour)	
			7.00–8.00	8.00–9.00	4.00–5.00	5.00–6.00
1.The Northern Road/Richmond Road/Parker Street between Great Western Highway–Ninth Avenue	4.5	NB	37	33	33	33
	4.7	SB	31	26	30	27
2.Forrest Road/Glossop Street between Palmyra Avenue and The Northern Road	5.7	NB	44	44	44	44
	5.6	SB	39	37	38	38
3. Eight Avenue/Ninth Avenue between South Creek Road and Third Avenue and The Northern Road	4.7	EB	54	51	52	51
	4.6	WB	55	49	50	49
4. Christine Street/Dunheved Road between Forrest Road and Richmond Road	5.8	EB	45	43	52	43
	5.9	WB	42	43	34	41
5.Werrington Road between Dunheved Road and Great Western Highway	2.1	NB	48	44	33	40
	2.1	SB	37	30	36	31
6.Great Western Highway between Glossop Street and The Northern Road (Parker Street)	6.5	EB	50	44	35	34
	6.5	WB	41	32	27	29

The average travel speed survey results demonstrated that:

- The recorded average speed on The Northern Road was between 33 km/h and 37 km/h in both directions for both the AM and PM peak periods.
- The recorded average speed on Dunheved Road ranged between 40 km/h and 45 km/h in both directions for both the AM and PM peak periods; with the only exception being those travelling during 4.00 pm and 5.00 pm where an eastbound speed of 52 km/h and westbound speed of 34 km/h were observed.
- In both peak periods, the recorded average speed on Werrington Road was mostly between 40 km/h to 45 km/h in the northbound direction, and below 37 km/h in the southbound direction.
- In the AM peak, the average speed recorded on the Great Western Highway was higher than 44 km/h and 32 km/h in the respective eastbound and westbound directions. However, in the PM peak, the westbound speed was below 30 km/h.
- On Forrester Road, the northbound speed was approximately 44 km/h whilst the southbound speed was constantly below 40 km/h in both the AM and PM peak period.
- The average speed on Ninth Avenue ranged between 49 km/h and 55 km/h in both the AM and PM period.
- On most of the routes, the average speeds in the PM peak were lower than those in the AM peak, indicating that the road network is generally more congested in the PM peak.
- The directional difference in travel time results was particularly noticeable on The Northern Road, Dunheved Road, the Great Western Highway and Werrington Road, indicating peak directional flows on those corridors.

It was perceived that the following factors contributed to the low travel speed which was recorded during the traffic survey:

- High traffic demand and the traffic delays at traffic signals
- The need to merge into adjacent lanes to avoid on-street car parking and bus stops
- Navigating around the right turning traffic filtering across high opposing through traffic volumes
- Reduced travel speeds in the 40 km/h school zones near some road sections during 8.00 am and 9.00 am.

2.7.6 Queue length survey results

Queue length survey results were reviewed and issued in the memorandum: *Jordan Springs East, St Marys Development Site – SIDRA Base Year Model* (November, 2016). Although the queue length survey results were used to gain an appreciation of the network congestion, they were only used to validate SIDRA base models.

3 Traffic Demand development

3.1 Prior matrix development

The prior demand matrices from the Roads and Maritime Strategic Traffic Model (hereafter referred as the 'Strategic Model') were developed based on the following cordon areas presented in Figure 3.1. The prior demand matrices were for a two hour period and a total of all vehicles.

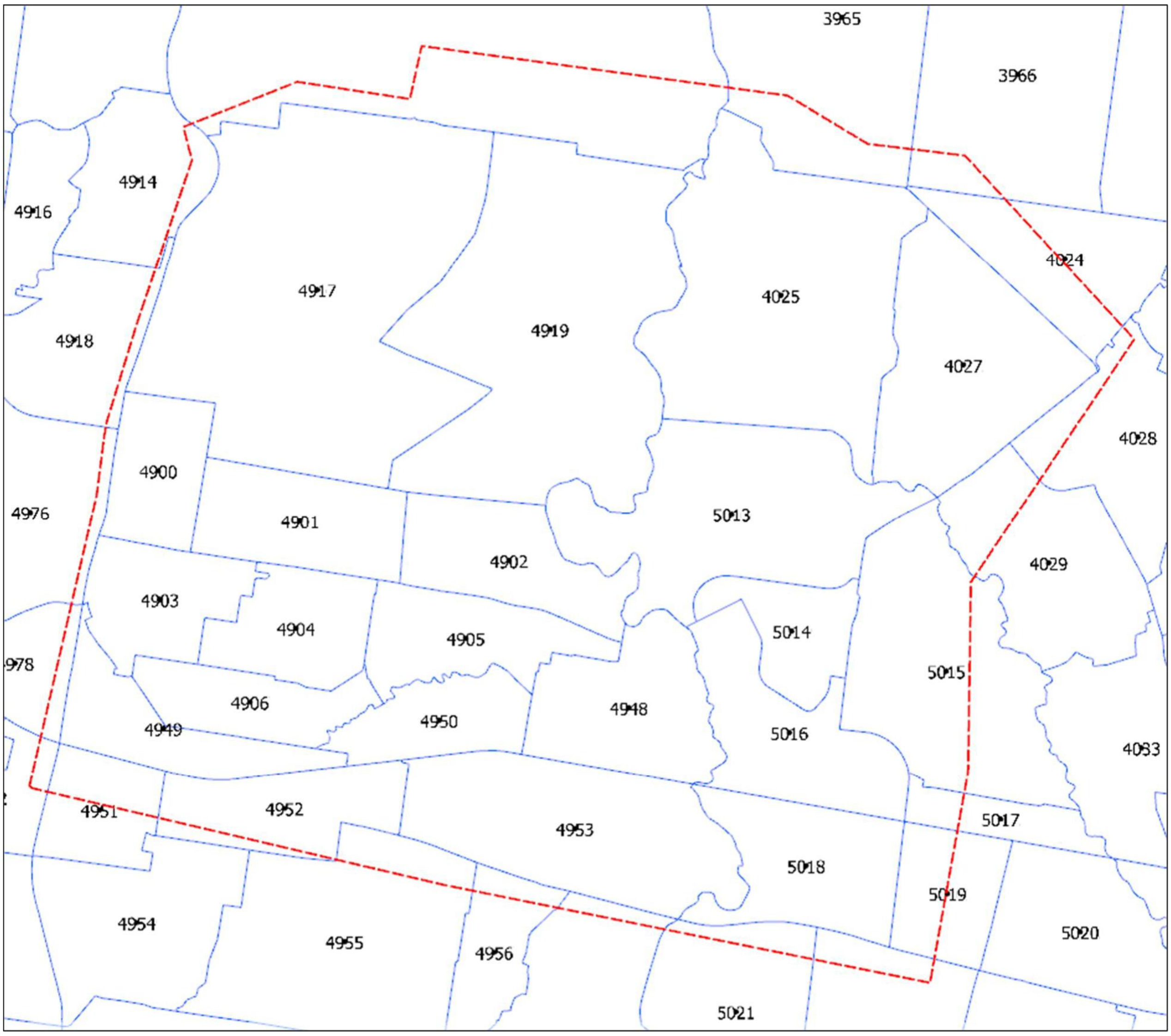

Figure 3.1 St Marys Development Traffic model cordons from the Roads and Maritime Strategic Model

Prior demand matrices from the Strategic Model cordons were subsequently converted into a format which aligned with the development of the St Marys Development mesoscopic model. This included the following steps:

1. AM and PM peak 2-hour total traffic matrices were converted into the respective peak hour matrices through the application of hourly factors which were established through the analysis of traffic counts and presented in Table 3.1.

2. Disaggregation of the unclassified total traffic matrices to 'light vehicle' and 'heavy vehicle' matrices, based on the classified travel demand matrices provided by TfNSW and the surveyed classified intersection counts.
3. Expansion of the zones from the strategic model zone system to an Aimsun zone system by utilising a zone equivalence and demand proportion process. For example, zone 4027 (Ropes Crossing) was split into four zones, designated as '4027_A', '4027_B', '4027_C' and '4027_D'; with each zone receiving a proportion of the demands as part of the prior matrix estimation.

Table 3.1 Hourly factors used in splitting two hour matrices from the Roads and Maritime Strategic Model

	7.00–8.00 am	8.00–9.00 am	4.00–5.00 pm	5.00–6.00 pm
Cars (PV and LCT)	48%	52%	49%	51%
Trucks (RT and AT)	48%	52%	61%	39%

3.2 Zone system refinement

A review of the strategic model link and zone structure was undertaken and a refined level of disaggregation of both external and internal zones was carried out for the model boundary area.

The traffic model requires the split of a larger zone into a number of smaller zones to reflect the more detailed network operation by spreading demand loading points across the network. The zone split was based on the following criteria:

- The surrounding road network and level of existing connectivity required to access the various local areas
- The number and locations of existing connectors applied in Roads and Maritime Strategic Model
- The broader land use categories such as residential, employment, shopping, recreational facilities and education
- The total generated and attracted trips during peak periods
- Land reservation for future development was also reflected in the model based on the available information

Table 3.2 summarises the outcomes of the zone splitting process along the network boundary.

Table 3.2 Zone refinement - Strategic model to St Marys Development mesoscopic model

Number of zones	Strategic model	Mesoscopic model
External zones	36	39
Internal zones	22	66
Total zones	58	105

The number of strategic model zones excludes rail link and 'kiss-and-ride' zones

It should be noted that for the demand equivalence process, kiss-and-ride demands from the strategic model zones '9XXX' were omitted. The total demand for these zones was less than 20 trips in the 2 hour peak period and represents less than 0.01% of the total cordon demands. The zone system summarised in Table 3.3 has been applied based upon the above refinement.

Table 3.3 Zone system – St Marys Development mesoscopic model

External zones	Split (No. of zones)	External zone description	Internal zones	Split (No. of zones)
1	1	The Northern Road (North)	3965	1
2	1	Terrybrook Road	4025	1
3	1	Third Avenue	4027	4
4	1	Second Avenue	4900	4
5	1	South Creek Road	4901	2
6	1	Stony Creek Road	4902	2
7	1	Captain Cook Drive west	4903	4
8	1	Captain Cook Drive east	4904	2
10	1	Palmyra Avenue	4905	2
11	1	Hatherton Road	4906	2
12	1	Ellsworth Drive	4917	13
13	3	Maple Road	4919	4
14	1	Griffiths Street	4948	1
15	1	Debrincat Avenue	4949	4
17	1	Hobart Street	4950	1
18	1	Brisbane Street	4952	1
19	1	Great Western Highway (East)	4953	3
20	1	Mamre Road (South)	5013	1
21	2	Pages Road	5014	1
22	2	Gipps Street	5016	6
23	1	First Avenue	5017	1
24	1	O'Connell Street	5018	5
25	2	Bringelly Road	5019	1
26	1	Parker Street	Notes:	
27	1	High Street	Zones 4025 and 4027 represent Ropes Crossing; Zones 4917 and 4919 represent Jordan Springs	
28	1	Cox Avenue		
29	1	Copeland Street		
30	1	Glebe Place		
31	1	Coreen Avenue		
32	1	Caloola Ave		
33	1	Cooper Street		
34	1	Andrews Road		
35	1	Sherringham Road		
36	1	Borrowdale Way		
Total 105 zones inclusive of 39 external and 66 internal zones.				

3.3 Matrix estimation

3.3.1 Prior matrix finessing

A finessing process was undertaken for the hourly matrices. The Aimsun process tool was used to adjust the origin and destination zonal total trips in the matrices at the model boundaries to match the surveyed flow data (manual turn count, automatic tube count and SCATS detector count data). The finessed matrices were then used as a starting point to undertake static matrix estimation.

3.3.2 Matrix estimation methodology

Matrix estimation is the process whereby travel demand is adjusted to produce an estimated matrix that represents the most likely travel pattern consistent with the observed counts and the routing within the model assignment. Aimsun provides a built in 'macro adjustment' process that utilises the macro level assignment process to provide a set of paths between origins and destinations which are then used to estimate trip demands that align with the traffic counts.

The matrix estimation uses both TTM and SCATS traffic counts as the primary data set for the matrix estimation. The prior matrix is based on the factored, expanded and finessed cordon matrices, for both AM and PM peak periods. A secondary manual adjustment was also undertaken following the matrix estimation process from Aimsun. The objective of the manual adjustment was to further refine the prior traffic matrix to reflect the real data input identified in surveyed traffic counts.

3.3.3 Matrix estimation/adjustment results

3.3.3.1 Trip-end total regression

Trip-end regressions have been undertaken for the both weekday AM and PM peak periods with the R-squared performance reported in Table 3.4 and the gradients of the regression line are summarised in Table 3.5.

Table 3.4 Trip-end total regression: R-squared summary

Time period	Light vehicles		Heavy vehicles	
	Origin	Destination	Origin	Destination
7.00 am–8.00 am	0.95	0.97	0.93	0.99
8.00 am–9.00 am	0.97	0.96	0.96	0.97
4.00 pm–5.00 pm	0.97	0.95	0.90	0.98
5.00 pm–5.00 pm	0.98	0.95	0.93	0.96

Table 3.5 Trip-end total regression: Gradient summary

Time period	Light vehicles		Heavy vehicles	
	Origin	Destination	Origin	Destination
7.00 am–8.00 am	0.95	0.93	0.97	0.98
8.00 am–9.00 am	0.94	0.94	0.93	0.92
4.00 pm–5.00 pm	0.98	0.99	0.99	0.98
5.00 pm–5.00 pm	1.01	1.03	0.98	1.01

The regression analysis for the trip-end totals shows that the desired level of an R-squared > 0.95 is achieved for majority of origin and destination results in both AM and PM peak periods. This indicates a high level of correlation of the trip-end totals between the adjusted prior and post matrices. The trip-end regression plots of individual vehicle types are provided in Appendix A.

3.3.3.2 Trip length distribution

The trip length distribution plots comparing the original prior matrix (from the strategic model) and the Aimsun post matrix (following the matrix estimation and manual adjustment) are presented in Figure 3.2 to Figure 3.5 for each of the peak hours covering both AM and PM peak periods for all vehicles. The trip length distribution of the individual vehicle types are provided in Appendix A.

The trip length distribution shows that the matrix estimation process has increased the proportion of trips in the shorter distance bands between 0 and 3 kilometres and generally has decreased trips in the bands greater than 3 kilometres, with the exception of 5 to 6 kilometre bands which show a small increase in all the peak hours. This shows that the trip length in the prior and post matrices have diverged in response to the adjustment process. Matrix estimation typically increases short distance trips at the expense of longer distance trips.

Overall however the trip length distribution shows a very close correlation between the prior (finessed Roads and Maritime Strategic model) and the post estimation matrices.

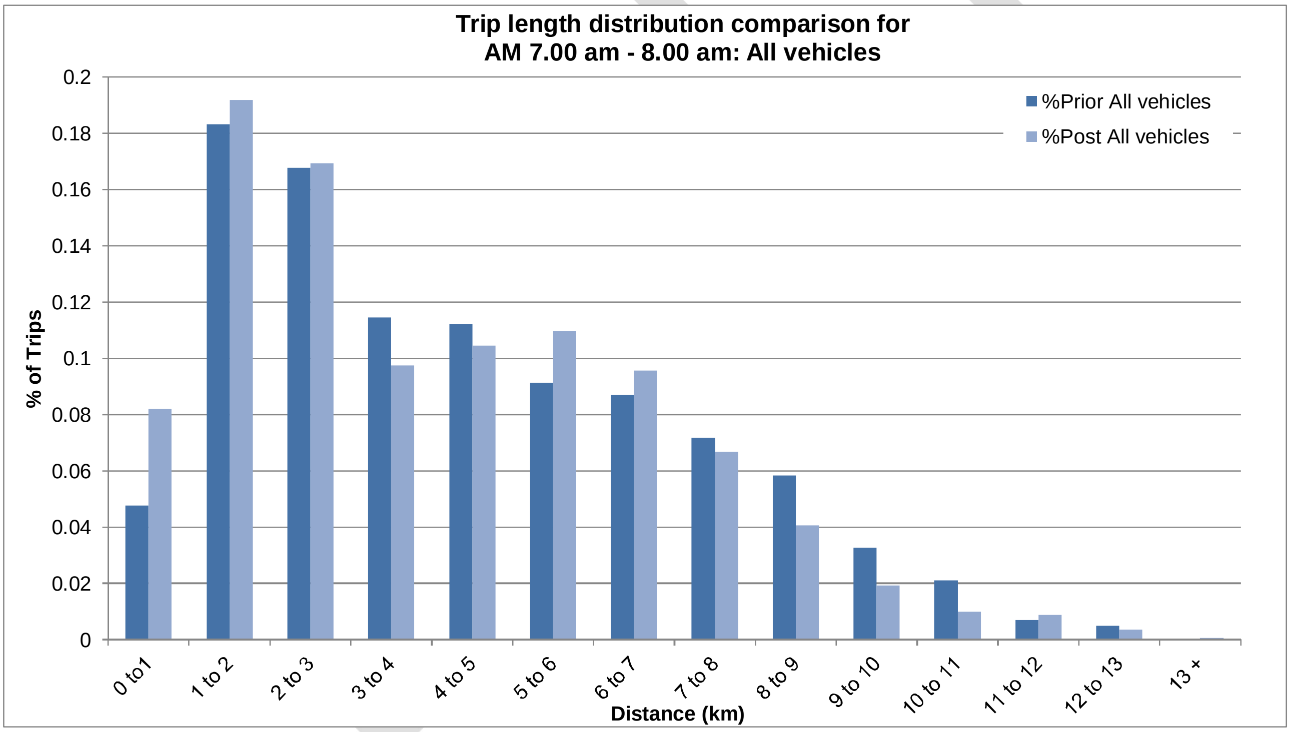

Figure 3.2 Trip length distribution comparison for 7.00 am–8.00 am

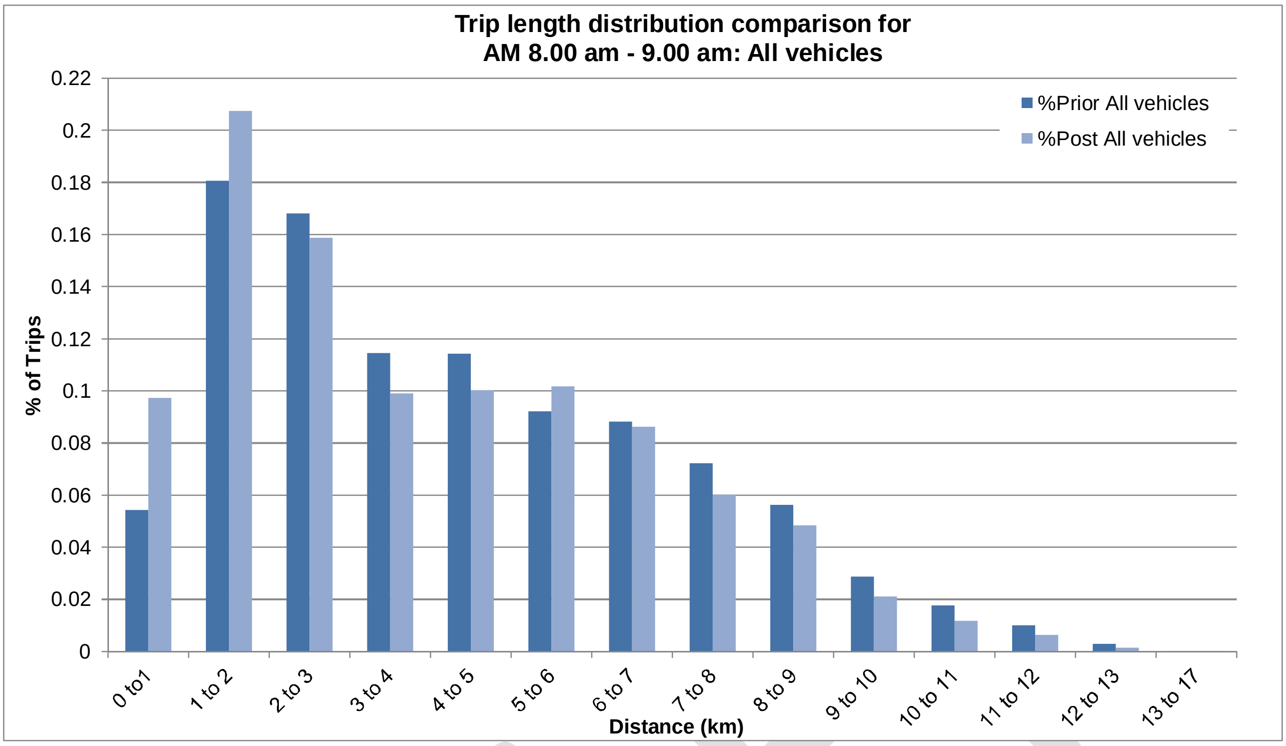

Figure 3.3 Trip length distribution comparison for 8.00 am–9.00 am

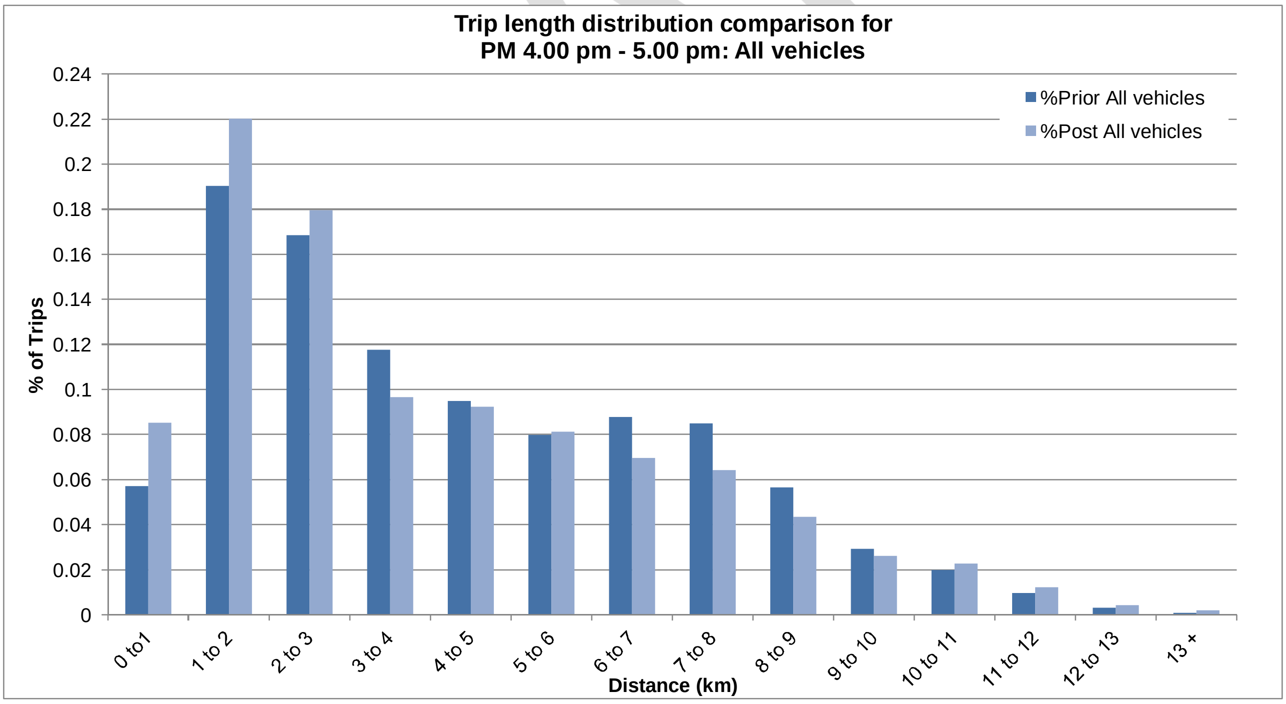

Figure 3.4 Trip length distribution comparison for 4.00 pm–5.00 pm

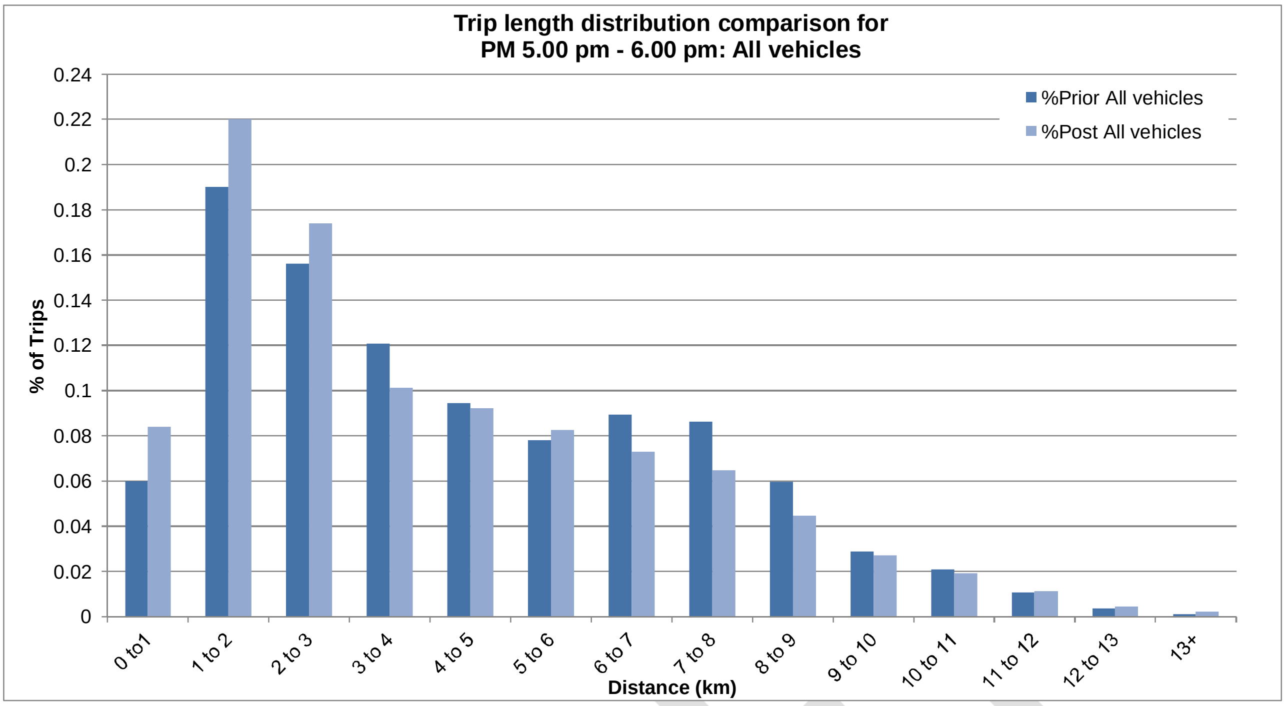

Figure 3.5 Trip length distribution comparison for 5.00 pm–6.00 pm

3.4 15 minute demand profiles

The traffic demand profile within the model has been developed for 15 minute intervals based on the classified intersection and midblock counts within the network during the peak periods along the following corridors:

- The Northern Road/Richmond Road/Parker Street
- Christie Street/Dunheved Road
- Forrester Road
- Glossop Street
- Werrington Road
- Great Western Highway.

The classified traffic profiles have been estimated such that the proportion of traffic released during each 15 minute period of the model is comparable to the proportion of observed traffic as per the surveys during the same 15 minute interval. The results are presented in Figure 3.6 and Figure 3.7.

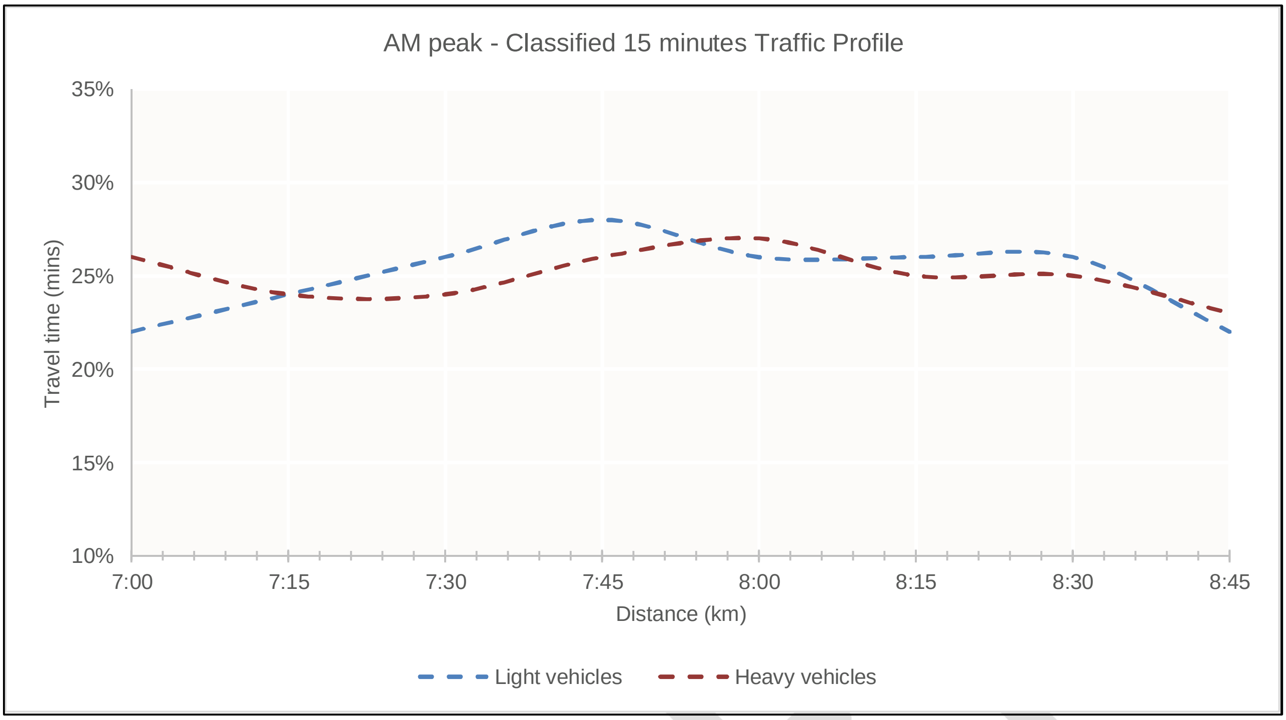

Figure 3.6 15 minutes traffic profile – AM peak

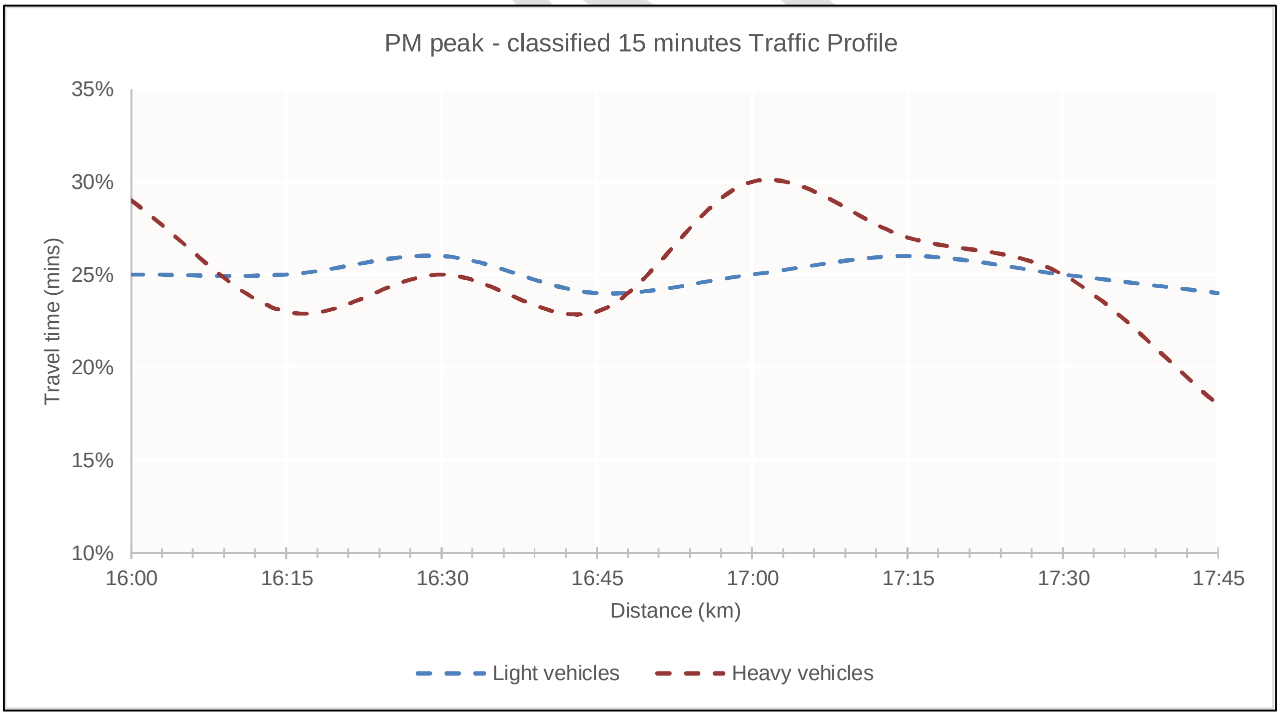

Figure 3.7 15 minutes traffic profile – PM peak

3.4.1 Warm-up and cool-down demand

The use of the warm-up and cool-down periods provides an opportunity for the network to 'load' and 'unload' traffic at both the beginning and end of the peak periods. Similar to the temporal profile, these demand factors were developed based on the observed intersection and midblock traffic flows from the TTM traffic surveys along the major corridors. Table 3.6 summarises the applied factors to estimate the warm-up and cool-down period demands.

Table 3.6 Warm-up and Cool-down demand factors

	Hour	Light vehicles	Heavy vehicles
AM Warm-up demand factor	6.00–7.00 am	79%	115%
AM Cool-down demand factor	9.00–10.00 am	79%	96%
PM Warm-up demand factor	3.00–4.00 pm	94%	126%
PM Cool-down demand factor	6.00–7.00 pm	81%	59%

(1) The warm-up demand factor is calculated as a proportion of the traffic demand in the respective 7.00–8.00 am and 4.00–5.00 pm periods.
(2) The cool-down demand factor is calculated as a proportion of the traffic demand in the respective 8.00-9.00 am and 5.00–6.00 pm periods.

4 Mesoscopic model calibration and validation

4.1 Model behaviour settings

The dynamic assignment is considered as an extension of the static assignment, which applies more complicated techniques (e.g. queue propagation algorithms) to assign the demand to the model network to account more accurately for vehicle interaction and time dependant capacity constraints.

The dynamic assignment in AIMSUN was undertaken using DUE (Dynamic User Equilibrium) as the main assignment method. DUE is the Dynamic implementation of the User Equilibrium concept, where drivers would continue to change routes until their travel time is at a minimum and they would gain no travel time saving in changing to another route. The settings applied to the DUE assignment in the St Marys Development mesoscopic model are shown in Table 4.1.

Table 4.1 Driver behaviour and DUE settings

Type	Parameter	Adopted value
Lane changing	Look-ahead distance variability	40%
Reaction time	Reaction time	1.25 seconds
	Reaction time at traffic light	1.25 seconds
Arrival type	Global arrivals	Exponential
Dynamic assignment	Feedback cycle	15 minutes
	Number of intervals	1
	Attractiveness weight	2
	User-defined cost weight	1
	Assignment model	Weighted MSA
	Path cost	Experienced
	Maximum paths from path assignment results	3
	Maximum paths per interval	5

4.2 Model calibration

4.2.1 Model calibration criteria

The calibration of the traffic model was based on confirming that the observed and modelled flows align with and achieve the standard of correlation outlined in the Roads and Maritime Service *Traffic Modelling Guidelines – Section 10.3.1*.

Achieving the model calibration depends on a wide range of factors including the following:

- quality and consistency of the traffic count data
- quality of the travel demand provided by Roads and Maritime strategic model (used as the prior traffic matrix in traffic demand development)
- representation of the network and its operation
- the level of detail required in the traffic model, which should be correlated with the project purpose.

For this project, the following model calibration criteria (as per the Roads and Maritime Services *Traffic Modelling Guideline*) in Table 4.2 was agreed by the Steering Committee.

Table 4.2 St Marys development traffic model calibration criteria

Criteria	Roads and Maritime Services Guidelines	Desired criteria
Percentage of link volumes with GEH ≤ 5	95%	95%
Percentage of turn volumes with GEH ≤ 5	85%	85%
Percentage of link and turn volumes with GEH ≤ 10	100%	100%
R-squared value to be included with plots and to be	> 0.9	> 0.9
All counts RMSE	=< 30	=< 30
Percentage of screenline/corridor/cordon total within GEH ≤ 4	All	All

All the calibration results were produced by the model simulation with seed value 560.

4.2.2 Network calibration

Network calibration documents the adjustments to the model network undertaken to improve the model's operation as well as the calibration to observed counts and validation to journey times. Network building was based on a systematic approach where links and intersection operations are modelled in the same manner, irrespective of location, taking into account the relevant operational parameters, layout and traffic control systems. A systematic approach generally provides consistency and usually results in a suitable starting point for the model calibration, after undertaking checks to remove coding errors.

Figure 4.1 highlights the 30 intersections for which the network and assignment calibration will be undertaken. A set of 19 intersections are also highlighted (red circles) as being within close proximity to the St Marys development site and as such were considered as 'critical' in assessing the traffic impacts for this project.

Amendment to, and adjustment of the model to improve the model's operation where network parameters are altered from those originally developed in the network building process is considered part of network calibration. The following changes have been made and documented here to enable these alterations to be recognised and understood for future work:

- For priority controlled intersections, adjustments were made to the *Higher Initial Safety Margin*, *Final Safety Margin* and *Give way Time Factor* parameters at a selection of side streets to increase the perception of travel costs with the give way behaviours (e.g. seagull layout for the right turn movement from John Oxley Avenue to Dunheved Road).
- In the model the *Attractiveness* parameter of a road link is correlated with the link capacity. At a few locations, such as Victoria Street which is parallel to Dunheved Road, the attractiveness was adjusted to reduce the 'rat run' which is generally identified as a gap in the DUE assignment algorithm (which does not weight the route distance as being as critical as human perception).
- The *TPF High Dynamic* parameter was used to control the traffic flow and route choice from the side street at John Oxley Avenue, Francis Street and Trinity Drive.

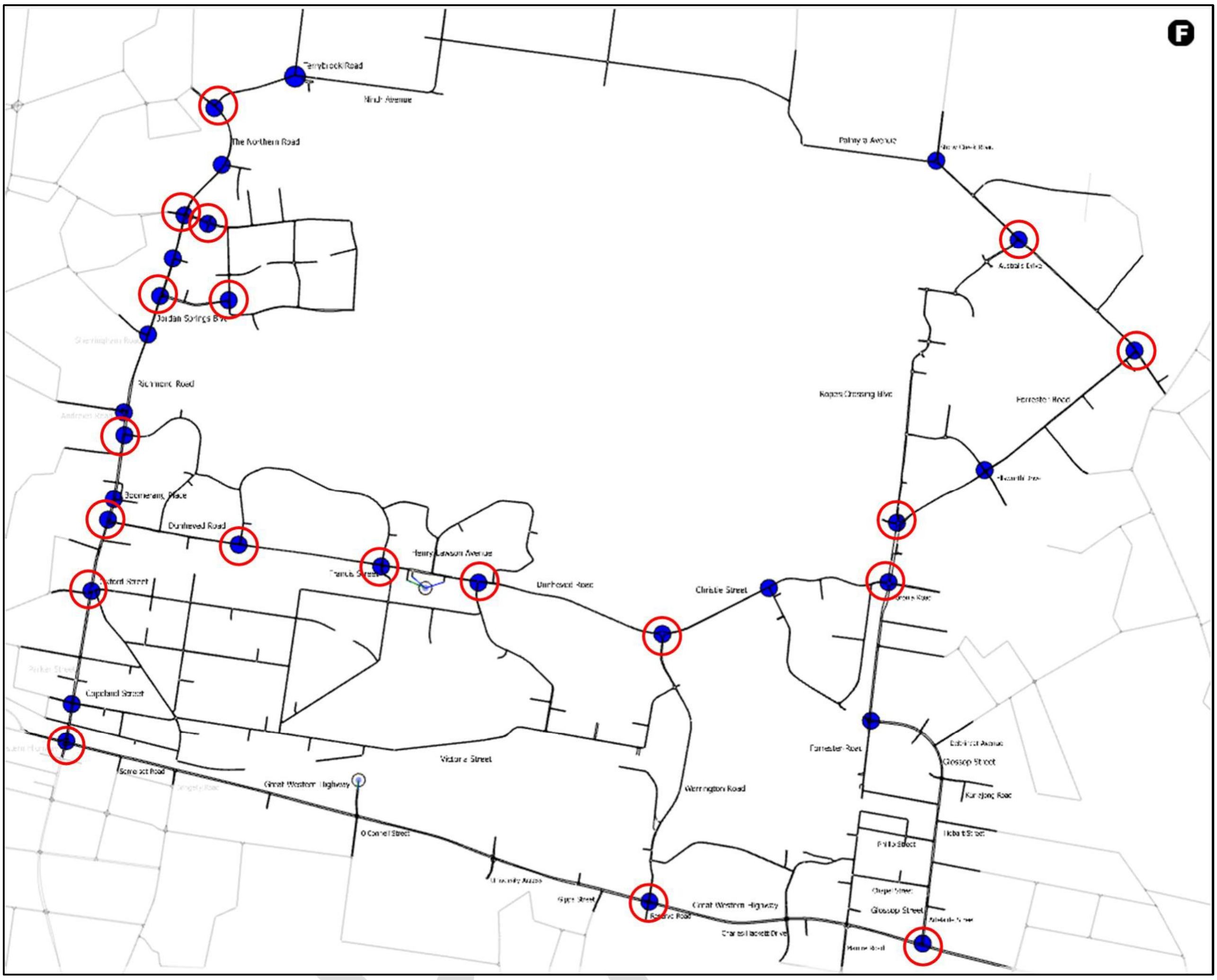

Figure 4.1 Model calibration locations

4.2.3 Assignment convergence

The convergence of the DUE assignment was monitored to ensure that the modelled flows were stable. The model assignment was set to have a maximum of 60 iterations or have a relative gap of 1%. The assignment convergence results for the respective AM and PM peaks are shown in Figure 4.2 and Figure 4.3.

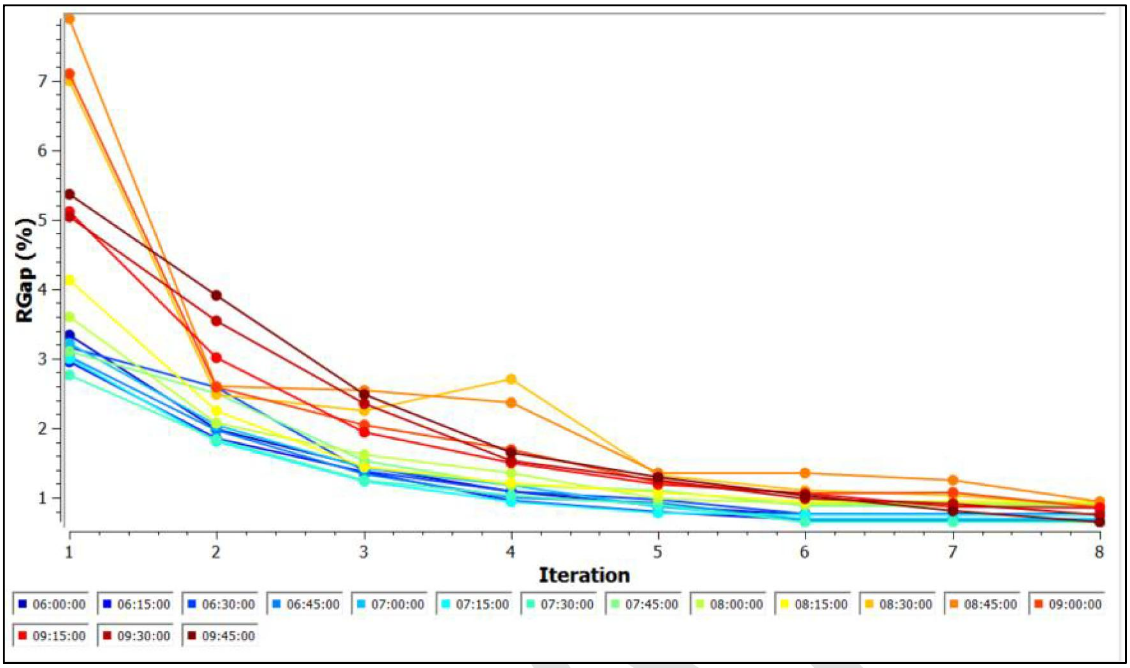

Figure 4.2 Convergence plot – DUE assignment – AM peak

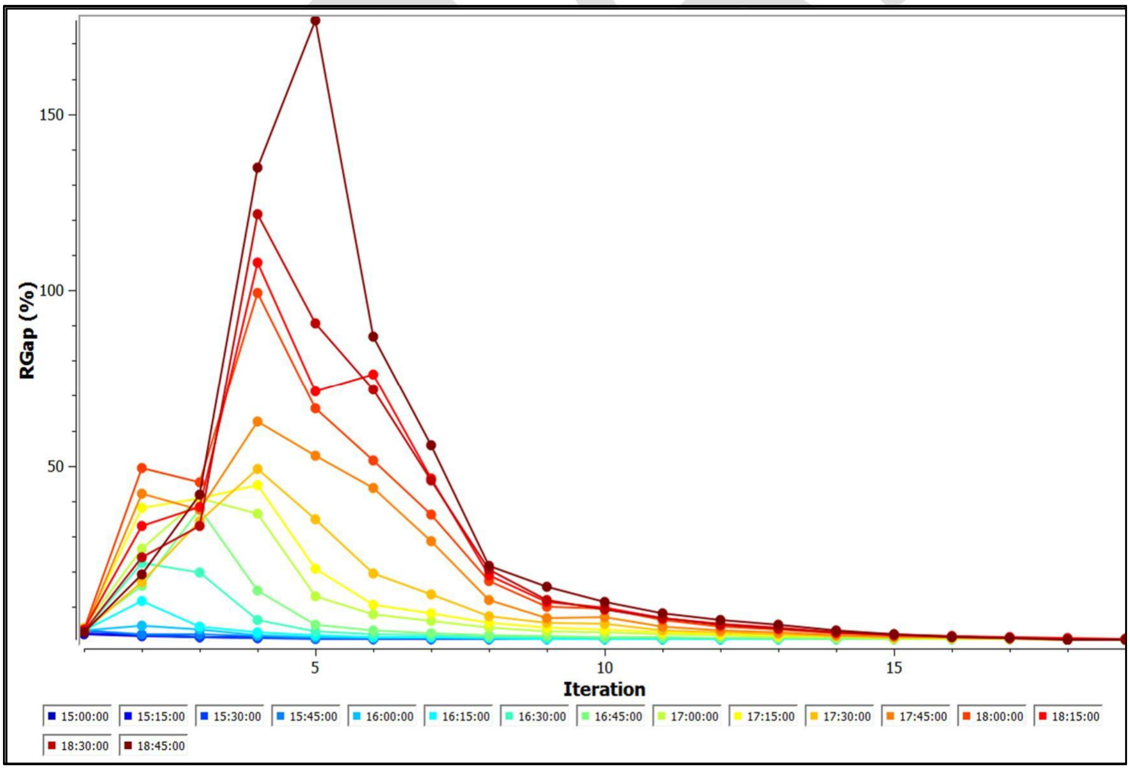

Figure 4.3 Convergence plot – DUE assignment – PM peak

For comparison, the DUE assignment convergence results for all peak periods are shown in Table 4.3.

Table 4.3 DUE assignment convergence

Time period	Number of iterations	Relative gap achieved
AM peak Model	8	1%
PM peak Model	19	1%

4.2.4 Route choice check

Route choice calibration was undertaken to establish that the model is selecting suitable and appropriate routes based on the available network and operating conditions. Route choice calibration was conducted by identifying a suitable set of key origins and destinations where there were several potential route choices and then using the software tools to review the assigned routes. The adjustment considered the appropriateness of:

- Rat-running onto adjacent residential roads (this does occur in reality but excessive levels often indicate poor representation of the residential network – e.g. the rat- run route is too fast due to insufficient delay for minor intersections, excessive delay on the main road network or a combination of both).
- Excessive swapping between adjacent parallel routes for example exiting and entering a highway or major arterial road for short sections to use the local road network.
- Different routing by time period for AM and PM peak periods. Although it can be expected that some changing in routing will occur, excessive changes where one route is considerably longer than the other can indicate problems related to excessive delay.

The route choices within the Aimsun model along the following major corridors were checked with the majority of the route choices being deemed reasonable. The routes considered were:

- The Northern Road
- Great Western Highway
- Dunheved Road
- Forrester Road
- To and from the Jordan Springs or Ropes Crossing development sites from the above mentioned key roads.

4.2.5 Assignment calibration

The assignment calibration has been based on the analysis of the correlation between the observed counts at intersection locations and the modelled traffic flows. The intersection turning count calibration results are summarised in Table 4.4 and Table 4.5 for the respective weekday AM and PM peak periods. A breakdown of the calibration results for the 19 critical intersections are also presented.

Table 4.4 Intersection turning count calibration – AM peak

AM peak		7.00–8.00 am		8.00–9.00 am	
Turning counts calibration	% of all counts	Light vehicle	Heavy vehicle	Light vehicle	Heavy vehicle
19 critical Intersections	GEH<5	88%	100%	89%	98%
	GEH<10	100%	100%	100%	100%
30 Intersections	All GEH<5	87%	100%	89%	98%
	All GEH<10	100%	100%	100%	100%
Link volumes at 19 critical intersections	All GEH<5	95%	100%	97%	95%
	All GEH<10	100%	100%	100%	100%

Table 4.5 Intersection turning count calibration – PM peak

PM peak		4.00–5.00 pm		5.00– 6.00 pm	
Turning counts calibration	% of all counts	Light vehicle	Heavy vehicle	Light vehicle	Heavy vehicle
19 critical Intersections	GEH<5	87%	99%	89%	100%
	GEH<10	100%	100%	100%	100%
30 Intersections	All GEH<5	88%	99%	90%	100%
	All GEH<10	100%	100%	100%	100%
Midblock/Link volumes at 19 critical intersections	All GEH<5	92%	100%	97%	95%
	All GEH<10	100%	100%	100%	100%

The results in the above tables demonstrated that the modelled traffic flows achieved the standard of correlation with the observed counts, by meeting all the criteria set in *Traffic Modelling Guideline* (Section 4.2.1) with only one exception.

The RMSE and R-square results at the 19 critical intersections for both peak periods are provided in Table 4.6. They show that the RMSE and R-square results for all the peak hours (7.00 am–9.00 am and 4.00 pm–6.00 pm) have met the RMS criteria (RMSE =< 30 and R-square >0.9).

Table 4.6 RMSE and R-square results for all vehicles for both peak periods (critical intersections)

Time period	7.00–8.00 am	8.00–9.00 am	4.00–5.00 pm	5.00–6.00 pm
R-Square	0.98	0.98	0.98	0.98
RMSE	19	16	17	14

4.2.6 Screenline calibration

The screenline calibration has been undertaken for the four screenlines presented in Figure 4.4, with the midblock locations of each screenline listed below.

- Screenline 1:
  - Eighth Avenue east of Terrybrook Road
  - Dunheved Road east of Richmond Road
  - Great Western Highway east of Parker Street
- Screenline 2:
  - Palmyra Avenue east of Stony Creek Road
  - Christie Street east of Werrington Road
  - Great Western Highway east of Werrington Road
- Screenline 3:
  - The Northern Road south of Jordan Springs Boulevard
  - Ropes Crossing Boulevard north of Forrester Road
  - Forrester Road north of Ellsworth Drive
- Screenline 4:
  - Richmond Road south of Dunheved Road
  - Werrington Road south of Christie Street
  - Forrester Road north of Glossop Street.

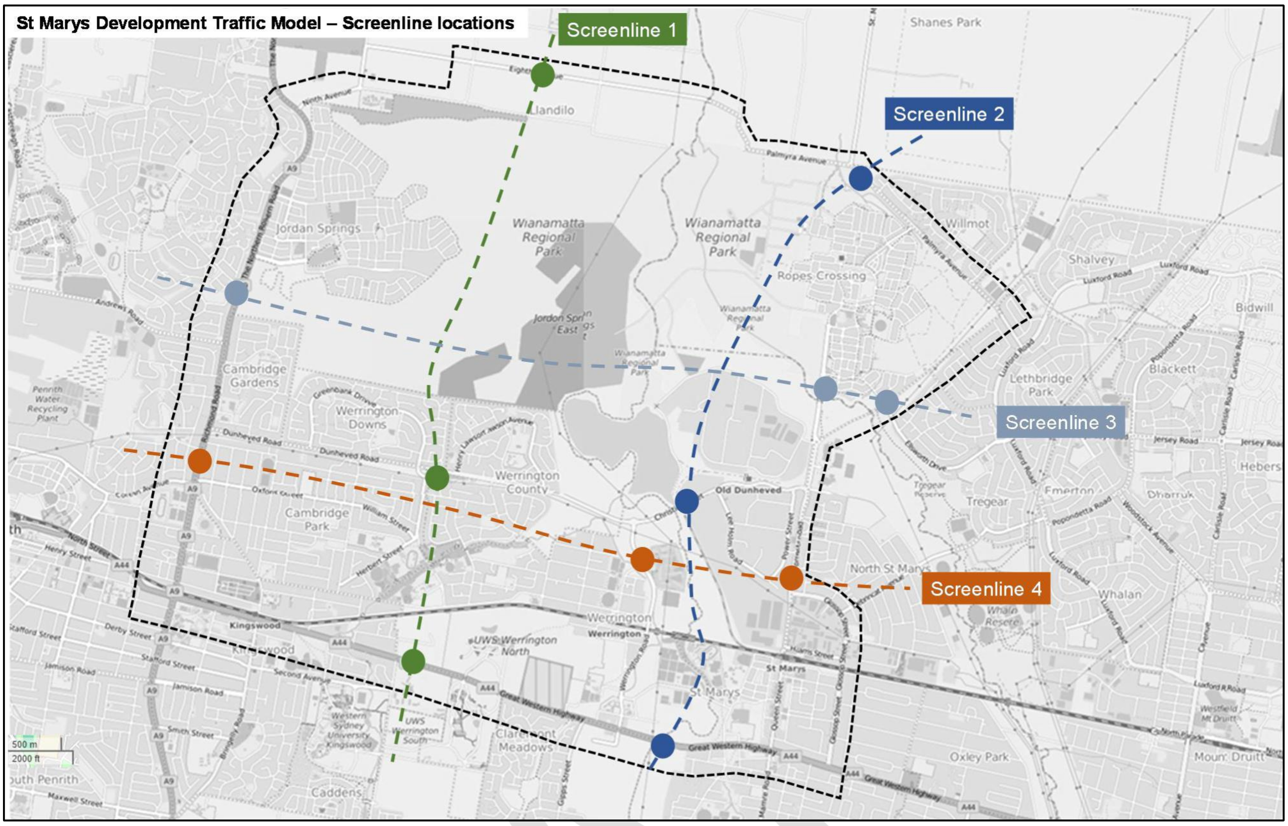

Figure 4.4 Screenline counts locations

The screenline calibration results are summarised in Table 4.7 and Table 4.8 for the respective weekday AM and PM peak.

Table 4.7 Screenline calibration results – AM peak

All vehicles	Time period	7.00–8.00 am				8.00–9.00 am			
	Direction	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH
Screenline 1	Eastbound	1,801	1,692	-109	2.6	2,134	1,951	-183	4.0
	Westbound	1,521	1,401	-120	3.1	2,418	2,431	13	0.3
Screenline 2	Eastbound	3,441	3,716	275	4.6	3,178	3,441	263	4.6
	Westbound	1,942	1,846	-96	2.2	2,780	2,811	31	0.6
Screenline 3	Northbound	1,192	1,125	-67	2.0	1,309	1,233	-76	2.1
	Southbound	1,882	1,893	11	0.3	2,038	1,991	-47	1.0
Screenline 4	Northbound	2,342	2,327	-15	0.3	2,333	2,307	-26	0.5
	Southbound	3,256	3,365	109	1.9	3,323	3,541	218	3.7

Table 4.8 Screenline calibration results – PM peak

All vehicles	Time period	4.00–5.00 pm				5.00–6.00 pm			
	Direction	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH
Screenline 1	Eastbound	2,047	2,277	230	4.9	2,073	2,252	179	3.8
	Westbound	2,602	2,844	242	4.6	2,854	3,018	164	3.0
Screenline 2	Eastbound	2,796	3,013	217	4.0	2,714	2,628	-86	1.7
	Westbound	4,052	3,978	-74	1.2	4,170	4,154	-16	0.2
Screenline 3	Northbound	2,011	2,055	44	1.0	2,091	2,022	-69	1.5
	Southbound	1,643	1,731	88	2.1	1,756	1,863	107	2.5
Screenline 4	Northbound	3,592	3,582	-10	0.2	3,672	3,388	-284	4.8
	Southbound	3,163	3,054	-109	2.0	3,344	3,109	-235	4.1

Although at a few screenline locations the results fall short of the desired criteria GEH ≤ 4, it was noted that the modelled midblock volumes and the observed counts for these screenlines still achieved the standard of correlation with GEH < 5 at all locations.

4.3 Model validation

The travel time validation of the St Marys Development mesoscopic model has been undertaken for the following six corridors as shown in Figure 4.5.

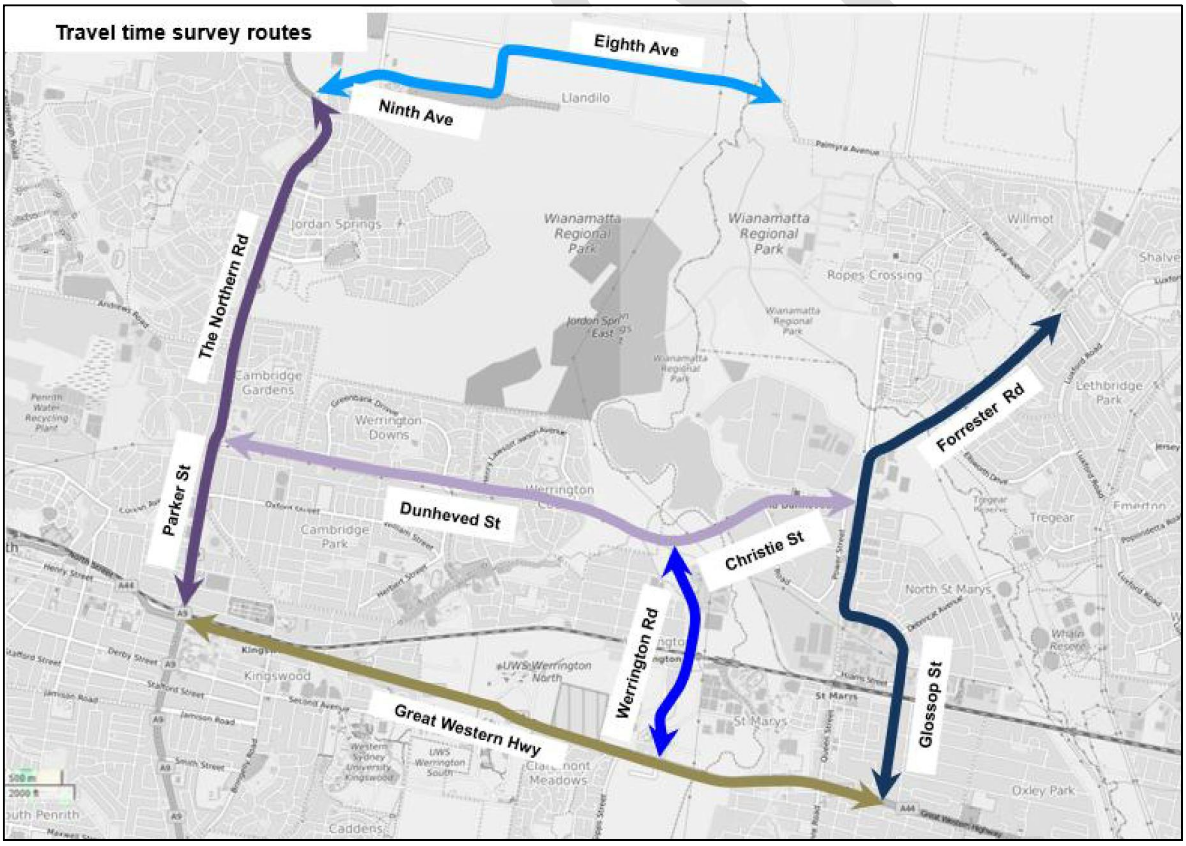

Figure 4.5 Travel time validation routes

4.3.1 Travel time validation results

The travel time validation results for the six routes are presented in Table 4.9 and Table 4.10 for the respective AM and PM peak periods. The results were produced by the model simulation with seed value 560. The Roads and Maritime *Traffic Modelling Guidelines* for car travel time validation is that the modelled time needs to be within 15% or 1 minute of the observed time, whichever is greater, for 95% of routes.

The travel time validation results indicate that the level of model validation based on travel time comparisons meets the *Roads and Maritime Modelling Guidelines* for all the routes in AM peak. The only exception was the route along Werrington Road in each of the PM peak hours.

Table 4.9 Travel time validation summary – AM peak

Direction	Distance (km)	7.00–8.00 am				8.00–9.00 am			
		Observed average	Modelled average	Difference	Percentage difference	Observed average	Modelled average	Difference	Percentage difference
Route 1 – The Northern Road									
Northbound	4.48	07:17	07:05	-12	-3%	08:06	07:49	-17	-4%
Southbound	4.74	08:58	07:52	-66	-12%	10:52	10:27	-25	-4%
Route 2 – Glossop Street									
Northbound	5.66	07:51	07:24	-27	-6%	07:42	07:33	-9	-2%
Southbound	5.62	08:34	07:51	-43	-8%	09:07	08:10	-57	-10%
Route 3 – Ninth and Third Avenue									
Eastbound	4.73	05:14	04:58	-16	-5%	05:31	05:20	-11	-3%
Westbound	4.60	05:02	05:11	9	3%	05:39	05:46	7	2%
Route 4 – Dunheved Road									
Eastbound	5.84	07:46	07:42	-4	-1%	08:03	07:54	-9	-2%
Westbound	5.98	08:27	07:42	-45	-9%	08:19	08:00	-19	-4%
Route 5 – Werrington Road									
Northbound	2.13	02:39	02:13	-26	-17%	02:50	02:25	-25	-15%
Southbound	2.11	03:25	03:01	-24	-12%	04:16	03:48	-28	-11%
Route 6 – Great Western Highway									
Eastbound	6.47	07:48	08:44	56	12%	08:49	10:00	71	14%
Westbound	6.48	09:32	09:36	4	1%	12:01	10:55	-66	-9%

Table 4.10 Travel time validation summary – PM peak

Direction	Distance (km)	4.00–5.00 pm Observed average	4.00–5.00 pm Modelled average	4.00–5.00 pm Difference	4.00–5.00 pm Percentage difference	5.00–6.00 pm Observed average	5.00–6.00 pm Modelled average	5.00–6.00 pm Difference	5.00–6.00 pm Percentage difference
Route 1 – The Northern Road									
Northbound	4.48	08:09	08:39	30	6%	08:08	08:08	0	0%
Southbound	4.74	09:32	09:44	12	2%	10:19	09:42	-37	-6%
Route 2 – Glossop Street									
Northbound	5.66	07:51	08:14	23	5%	07:51	07:50	-1	0%
Southbound	5.62	08:54	08:22	-32	-6%	08:54	08:08	-46	-9%
Route 3 – Ninth and Third Avenue									
Eastbound	4.73	05:24	04:52	-32	-10%	05:29	04:57	-32	-10%
Westbound	4.60	05:32	05:34	2	1%	05:41	05:36	-5	-2%
Route 4 – Dunheved Road									
Eastbound	5.84	06:45	07:32	47	12%	08:03	07:28	-35	-7%
Westbound	5.98	10:19	09:10	-69	-11%	08:40	08:24	-16	-3%
Route 5 – Werrington Road									
Northbound	2.13	03:48	02:23	-85	-37%	03:07	02:21	-46	-24%
Southbound	2.11	03:31	02:52	-39	-19%	04:04	03:01	-63	-26%
Route 6 – Great Western Highway									
Eastbound	6.47	11:04	11:11	7	1%	11:31	11:24	-7	-1%
Westbound	6.48	14:34	13:26	-68	-8%	13:38	12:38	-60	-7%

The under-estimation of traffic delays during the PM peak on Werrington Road was mainly noted on the section of road between the Great Western Highway and The Kingsway. On this particular section there are two different types of intersection controls which are closely spaced; a signalised intersection at the Great Western Highway and a roundabout at The Kingsway. This leads to the underestimation of link delay mainly associated with the observed delays at the roundabout and arrival-departure patterns from the traffic signal to the roundabout and vice versa. This creates random Stop and Start traffic movement patterns making it difficult to replicate vehicle to vehicle interactions in detail within the mesoscopic traffic model.

Table 4.11 summarises the travel time validation results versus the criteria in Roads and Maritime *Traffic Modelling Guidelines*. It indicates that 96% (or 46 out of 48) of all the travel time results meet the criteria.

Table 4.11 Travel time validation results vs. Criteria

Route	Direction	7.00–8.00 am	8.00–9.00 am	4.00–5.00 pm	5.00–6.00 pm
Route 1 – The Northern Road	Northbound	✓	✓	✓	✓
	Southbound	✓	✓	✓	✓
Route 2 – Glossop Street	Northbound	✓	✓	✓	✓
	Southbound	✓	✓	✓	✓
Route 3 – Ninth and Third Avenue	Eastbound	✓	✓	✓	✓
	Westbound	✓	✓	✓	✓
Route 4 – Dunheved Road	Eastbound	✓	✓	✓	✓
	Westbound	✓	✓	✓	✓
Route 5 – Wellington Road	Northbound	✓	✓	x	✓
	Southbound	✓	✓	✓	x
Route 6 – Great Western Highway	Eastbound	✓	✓	✓	✓
	Westbound	✓	✓	✓	✓

4.4 Model stability

An analysis of model stability was carried out by considering the model operation for each of the 15 minutes across the modelled time period. Five seed values (560, 28, 2849, 7771 and 86524) were used to plot the model stability in terms of 'vehicle hours travelled', and 'number of vehicles inside the network' in both AM and PM peaks. The results presented in Figure 4.6 to Figure 4.9 show acceptable variability in both the AM and PM peak models.

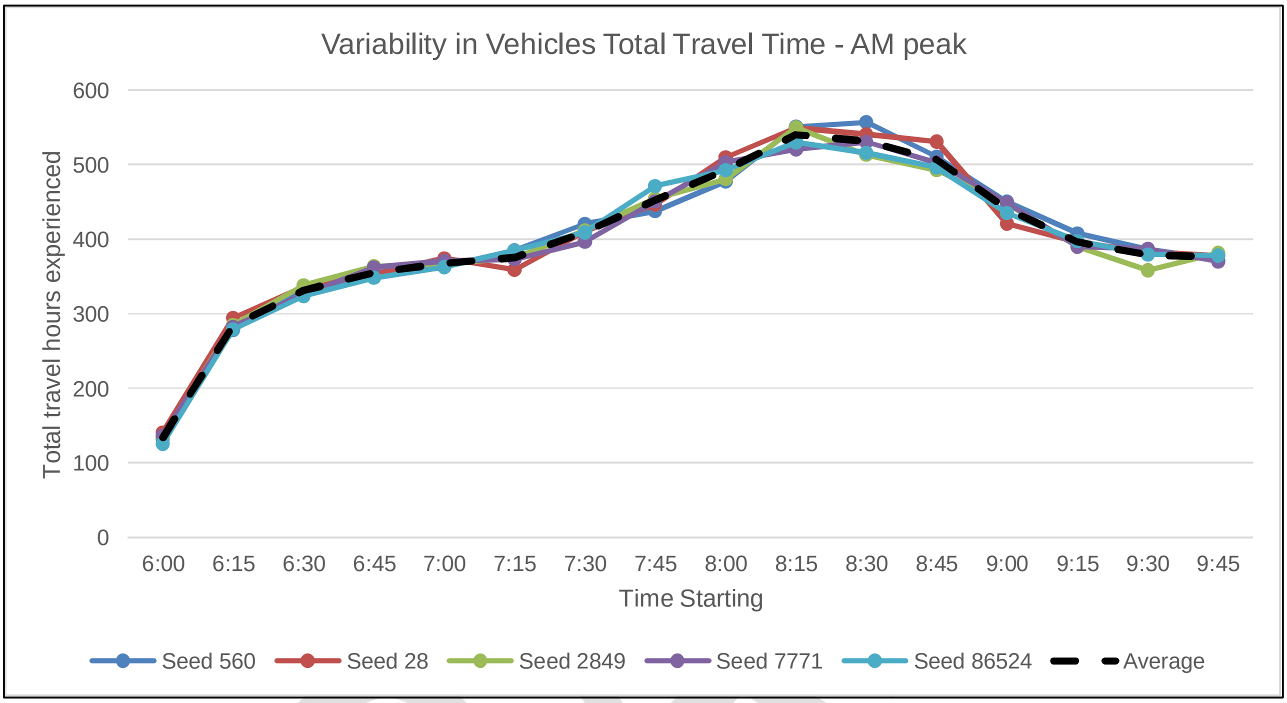

Figure 4.6 Vehicle hours travelled – AM peak

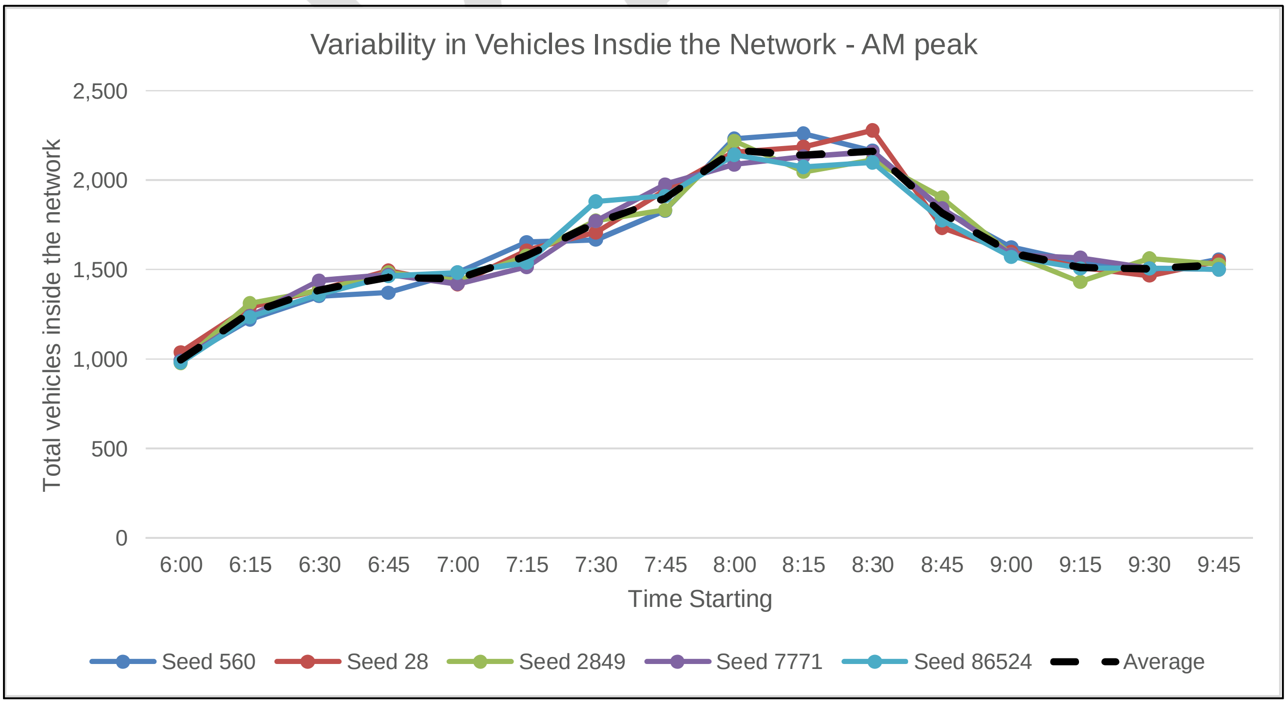

Figure 4.7 Vehicle inside the network – AM peak

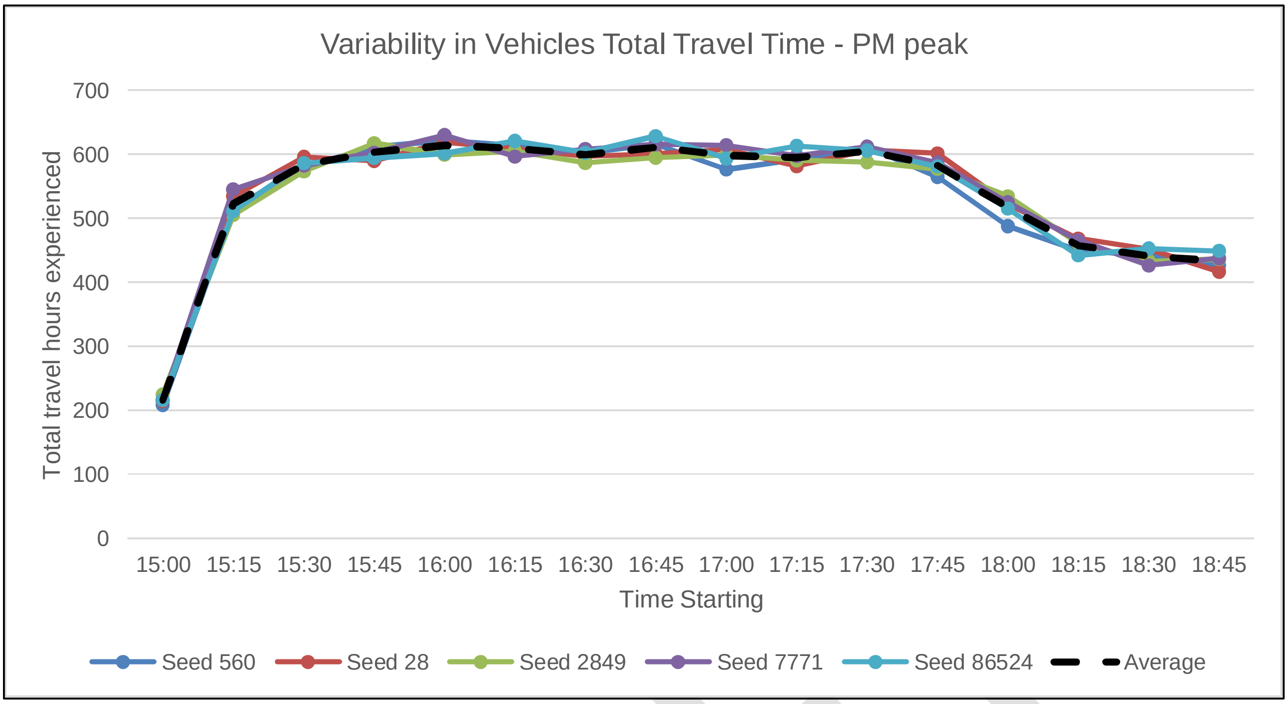

Figure 4.8 Vehicle hours travelled – PM peak

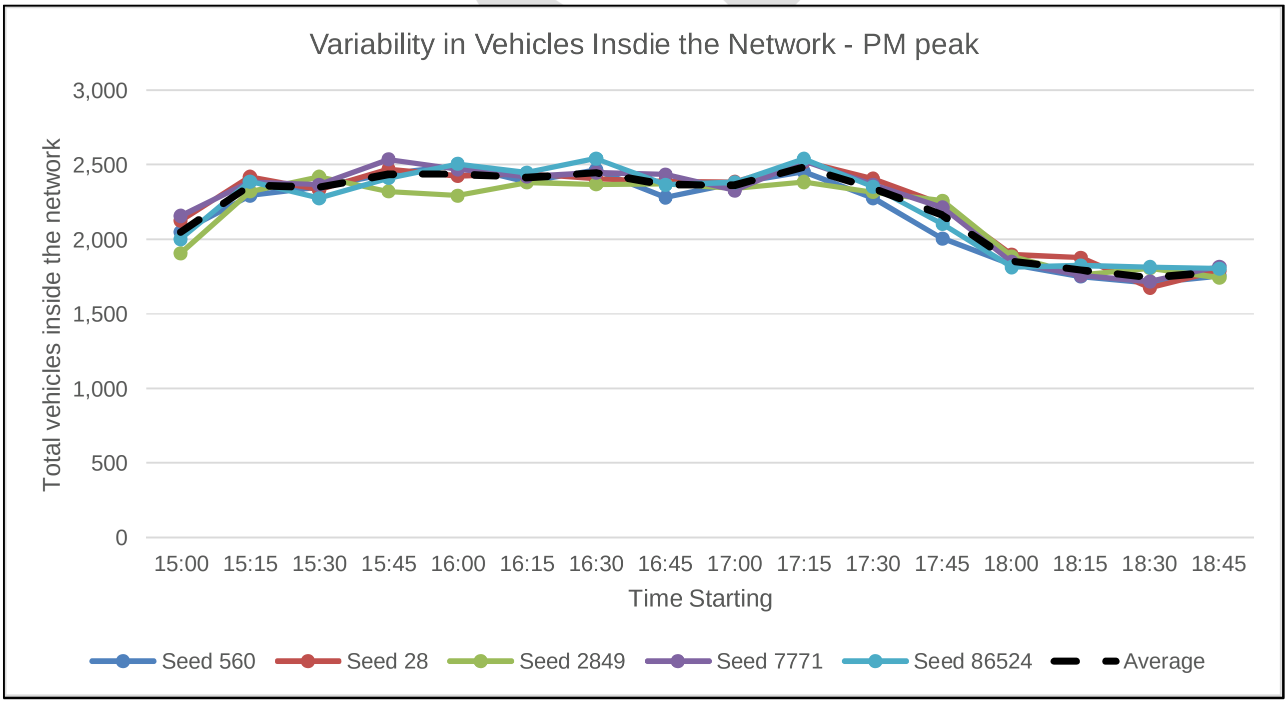

Figure 4.9 Vehicle inside the network – PM peak

4.5 Jordan Springs traffic distribution check

The path statistics results from the traffic model were compared to the OD survey results (summarised in the section 2.7.4). It is noted that the OD survey was undertaken one week after the survey of intersection traffic counts. Therefore, differences in traffic numbers between the intersections and OD survey results are likely. As such the OD survey results are mainly utilised here to check the trip distribution patterns to and from the Jordan Springs development site. For some OD pairs, the comparison of percentage differences are limited because of the low traffic volumes.

Table 4.12 and Table 4.13 summarise the comparison of AM peak results and Table 4.14 and Table 4.15 summarise the comparison of PM peak results for the respective outbound and inbound traffic.

The following is noted when comparing the OD survey and model results for both the outbound and inbound trips in the AM peak:

- The capture rates are comparable for the outbound trips, being 59% for the survey and 51% for the model results:
  - Out of the total captured trips, the majority of traffic (about 64%) was travelling northbound in the model which closely matches with OD survey (about 66%).
  - For traffic travelling southbound to Parker Street, south of the Great Western Highway, the model indicated about 18% versus 27% from the OD survey. The model indicated that 15% of the outbound traffic was heading eastbound via Dunheved Road while only 4% was recorded by the OD survey data. However in both cases, the discrepancies were estimated for a minimum of 50 vehicles/per hour.
- Similar to the results of outbound trips, the capture rates of survey and modelled data were comparable, being 36% and 39% respectively:
  - The difference between survey and modelled results was less than 35 vehicles for all the OD routes.
  - There were no vehicles recorded travelling from the Great Western Highway west (Penrith precinct) to Jordan Springs while the model results indicated approximately 15 vehicles (10% difference).

The comparison of survey and model OD results for both outbound and inbound trips in the PM peak indicated the following:

- For the outbound traffic, the capture rate from the OD survey is 25% higher than model results. This was mainly due to the differences in the northbound traffic. It was noted however that modelling results closely replicated the intersection traffic counts for the northbound traffic from the development site which indicates that the model is able to replicate the right demand.
- For the inbound traffic, the capture rates from the OD survey and model results are comparable. The majority of trips travelled via The Northern Road (north of Jordan Springs) to access the Jordan Springs development site.

Table 4.12 Jordan Springs Development outbound AM OD comparison

Jordan Springs Development (OD Station 2, 3, 4)	OD station	Survey results (vehs)	Model results (vehs)	Survey %	Model %
The Northern Road north of Jordan Springs	1	300	215	66%	64%
Dunheved Road	5	20	50	4%	15%
Great Western Highway west of the Northern Road	6	15	10	3%	3%
Parker Street south of Great Western Highway	7	120	60	26%	18%
% Capture rate		59%	51%	-	-

Table 4.13 Jordan Springs Development Inbound AM OD comparison

Jordan Springs Development (OD Station 2, 3, 4)	OD station	Survey results (vehs)	Model results (vehs)	Survey %	Model %
The Northern Road north of Jordan Springs	1	95	60	60%	45%
Dunheved Road	5	10	30	7%	23%
Great Western Highway west of the Northern Road	6	0	15	0%	11%
Parker Street south of Great Western Highway	7	50	30	33%	22%
Capture rate		36%	39%	-	-

Table 4.14 Jordan Springs Development Outbound PM OD comparison

Jordan Springs Development (OD Station 2, 3, 4)	OD station	Survey results (vehs)	Model results (vehs)	Survey %	Model %
The Northern Road north of Jordan Springs	1	326	131	74%	56%
Dunheved Road	5	12	51	3%	22%
Great Western Highway west of the Northern Road	6	17	0	4%	0%
Parker Street south of Great Western Highway	7	90	52	20%	22%
Capture rate		63%	38%		

Table 4.15 Jordan Springs Development Inbound PM OD comparison

Jordan Springs Development (OD Station 2, 3, 4)	OD station ID	Survey results (vehs)	Model results (vehs)	Survey %	Model %
The Northern Road north of Jordan Springs	1	195	142	66%	50%
Dunheved Road	5	31	83	10%	29%
Great Western Highway west of the Northern Road	6	2	17	1%	6%
Parker Street south of Great Western Highway	7	70	41	24%	15%
Capture rate		33%	39%		

4.6 Network performance

The overall operation of the network is monitored as part of the assignment. The key variables that have been reviewed are as follows:

- Input flow – this acts as a check that the trip matrices contain the correct travel demands
- Vehicles waiting to enter – this checks that the traffic is actually entering the network
- Network travel speed – reflects the level of network congestion.

Table 4.16 provides a summary of the network performance results for both AM and PM peak models.

Table 4.16 2015 Base network performance for all vehicles

Time period	Input flows (vehicles/4 hour)	Vehicles waiting to enter (vehicles)	Network travel speed (km/h)
AM peak Model	66,470	<5	40
PM peak Model	81,420	<5	37

The network statistics show that the number of unreleased vehicles at the end of both AM and PM peak model period was negligible.

The network delay for each of the modelled hours are presented in Appendix D and indicates a good representation of the overall network delay.

5 Summary

5.1 Calibration and validation summary

Table 5.1 provides a summary of the key calibration and validation results for the St Marys Development mesoscopic traffic model and how it performs against the agreed target criteria.

Table 5.1 St Marys Development traffic model calibration and validation summary

Criteria	AM peak	PM peak	Summary	Reference
Model calibration				
Prior and post matrix check (Trip-end and trip length)	✓	✓	Trip length distributions correspond to the Roads and Maritime strategic model. Whilst some trips have transferred from mid-length to short-length, these are within acceptable limits (less than average 3 to 4%).	Section 3.3.3
Assignment convergence	✓	✓	The models meet the calibration criteria for convergence.	Section 4.2.3
Assignment calibration (turning counts at intersections)	✓	✓	The results show a good degree of calibration, with over 85% of the modelled volumes at a total of 30 intersections (and 19 critical intersections) having a very good correlation (GEH < 5) with the survey counts, in each peak hour.	Section 4.2.5
Screenline calibration	✓	✓	The screenline calibration shows that the individual modelled screenline volumes are well correlated (GEH <5) with the observed screenline volumes in all cases. Only three screenline locations show the GEH values between 4 and 5.	Section 4.2.6
St Marys development site OD distribution check	✓	✓	The OD distribution of trips from/to Jordan Spring development site has a good match between the survey and model results.	Section 4.5
Route choice check			The route choices on the major corridors were checked and the results were deemed reasonable.	Section 4.2.4
Model validation				
Cars – key corridor travel time	✓	✓	Corridor travel time validation statistics show an excellent level of validation against observed data, with 46 out of 48 routes (or 96%) meeting the criteria.	Section 4.3
Model Stability				
Vehicle distance travelled Number of vehicles inside the network'	✓	✓	The results produced by five seed values were plotted and compared with each other and the average. The comparison results show acceptable variability in both the AM and PM peak models.	Section 4.4

5.2 Future model application

This report has documented the steps undertaken in the model development, calibration and validation of the St Marys Development mesoscopic model for the Penrith and St Marys area. Based on the calibration and validation results, both the AM and PM models are considered ‘fit for purpose’ for use in assessing the future year traffic networks and demands associated with the proposed St Marys development site.

This draft report as well as the calibrated and validated AM and PM peak traffic models have been provided to Roads and Maritime for review and comments.