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Newcastle Inner City Bypass
Rankin Park to Jesmond
Microsimulation Traffic Model
Calibration and Validation Report

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Newcastle Inner City Bypass Rankin Park to Jesmond Microsimulation Traffic Model Calibration and Validation Report

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1 Introduction

This report documents the development of microsimulation base traffic models associated with the Newcastle Inner City Bypass – Rankin Park to Jesmond project (RP2J). This report focuses on the base model development, operation, and summarises the results of the model calibration / validation against relevant modelling guidelines.

1.1 Background

The Newcastle Inner City Bypass is part of Roads and Maritime Services' long-term strategy to provide an orbital road within Newcastle's road network to connect the Pacific Highway at Bennetts Green and the Pacific Highway at Sandgate, see Figure 1-1.



Figure 1-1: Overall Newcastle Inner City Bypass

Aurecon was appointed by Roads and Maritime Services (Roads and Maritime), in a letter of acceptance dated 27 November 2014, as the Professional Services Contractor (PSC) to provide the project development services for the concept design and environmental assessment for the Newcastle Inner City Bypass – Rankin Park to Jesmond (RP2J).

The scope of work includes determining the existing traffic and transportation patterns within the study area, assessing interchange/intersection options, investigating potential impacts of the project during construction and operation, and producing a traffic and transportation assessment report as part of the environmental assessment.

An integral element of this traffic assessment relates to the development of base traffic models representing existing traffic conditions. The base traffic model will then be used to develop future year scenarios for the assessment of bypass options against retention of the existing road network configuration.

Aurecon has developed a staged approach to track progress with each element of the model and reporting development. The staged approach starts with the development of a base model with which all option testing will be undertaken.

The overall study methodology is shown in Figure 1-2.

This model calibration / validation report documents model development through Stages 3 to 5 of this methodology.

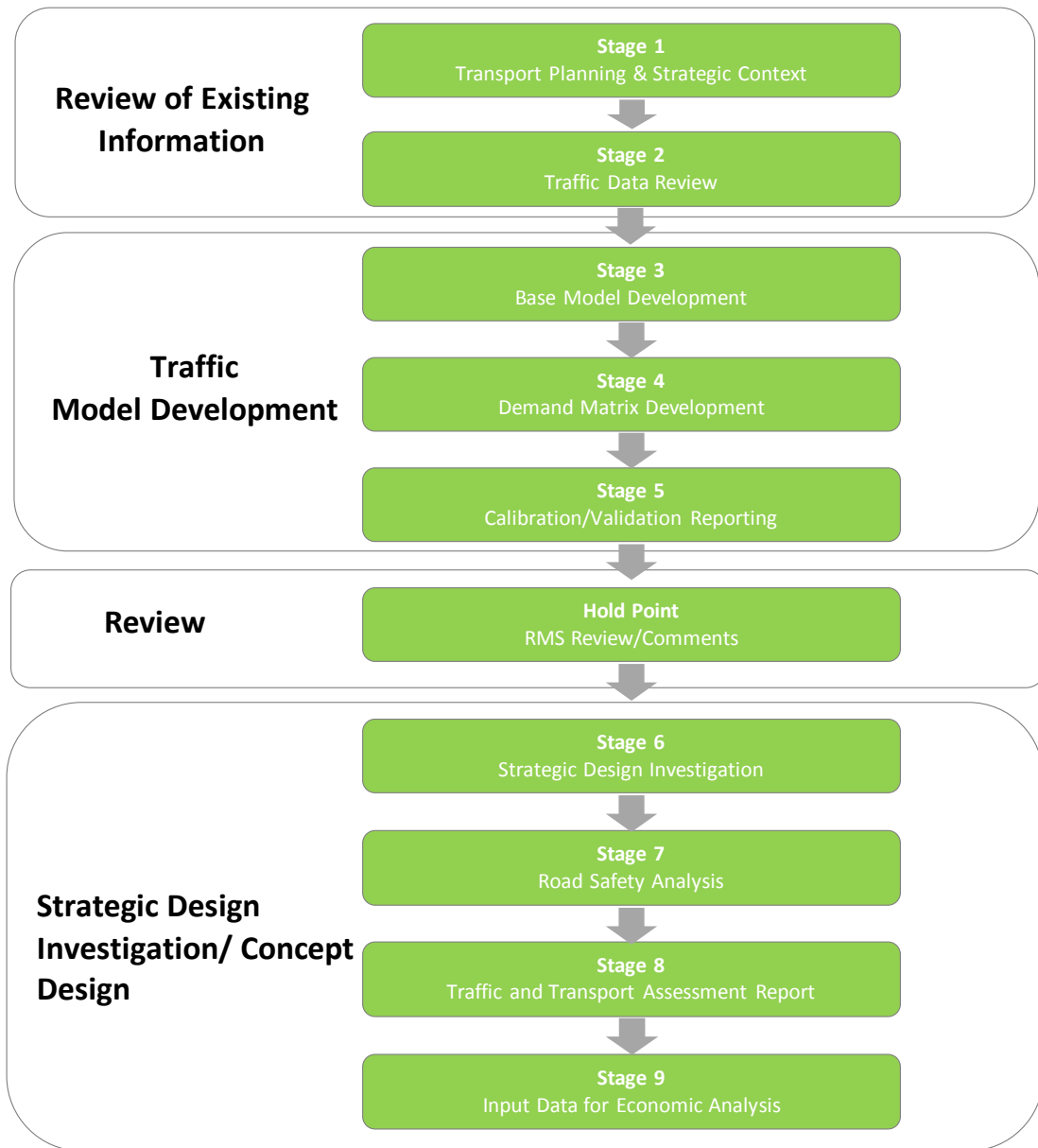


Figure 1-2: Study Methodology

2. Model Form

1.1 Paramics

The traffic model software package used for the project is Quadstone Paramics (Paramics).

Paramics represents traffic flows within a network, by simulating individual vehicles and their interactions with other vehicles and the surrounding road environment. As with real traffic conditions, these interactions can vary for each model run, resulting in unique results.

Paramics version 6.9.3 has been used in the development of this base model. All subsequent option testing should be undertaken using the same version of the software.

To obtain statistically meaningful results the average network performance is taken from multiple simulation runs. Roads and Maritime guidelines recommend a minimum of five model runs to be undertaken to obtain statistically meaningful results, and specify seed values to be used for these runs as detailed further in Section 6.2.

1.2 Base Model Network

The base model network, as shown in Figure 2-1, primarily covers the A37 route from the south via Charlestown Road, Lookout Road, Croudace Street, Newcastle Road and the existing section of the Newcastle Inner City Bypass north of Newcastle Road.

All major roads within this area have been integrated in the model. Roads carrying relatively low traffic volumes that are considered to not substantially influence traffic flow within the modelled area have not been included.

The base model was compiled using available digital aerial photography, with site visits to confirm the accuracy and operation of the modelled network. The model was constructed to a 1:1 scale, ensuring correct vehicle operation and accurate reaction to the road geometry and interaction with other vehicles.

1.3 Model Periods

The Paramics model has been developed for a morning and evening traffic periods:

- Morning period (AM) – 07:00 to 09:00
- Evening period (PM) – 16:00 to 18:00

The following peak hours have been calculated for each of the above model periods, based on observed traffic survey data.

- Morning peak hour – 07:30 to 08:30
- Evening peak hour – 16:30 to 17:30

Model durations of greater than one hour ensure the periods either side of the peak hour are adequately modelled. This allows the model to adequately accommodate peak hour spreading which could result with future growth within the study area.

1.4 Site Visits

Site visits were undertaken by Aurecon staff to assess current traffic conditions during both peak periods, confirm the model form and ensure realistic vehicle behaviour is replicated within the model.

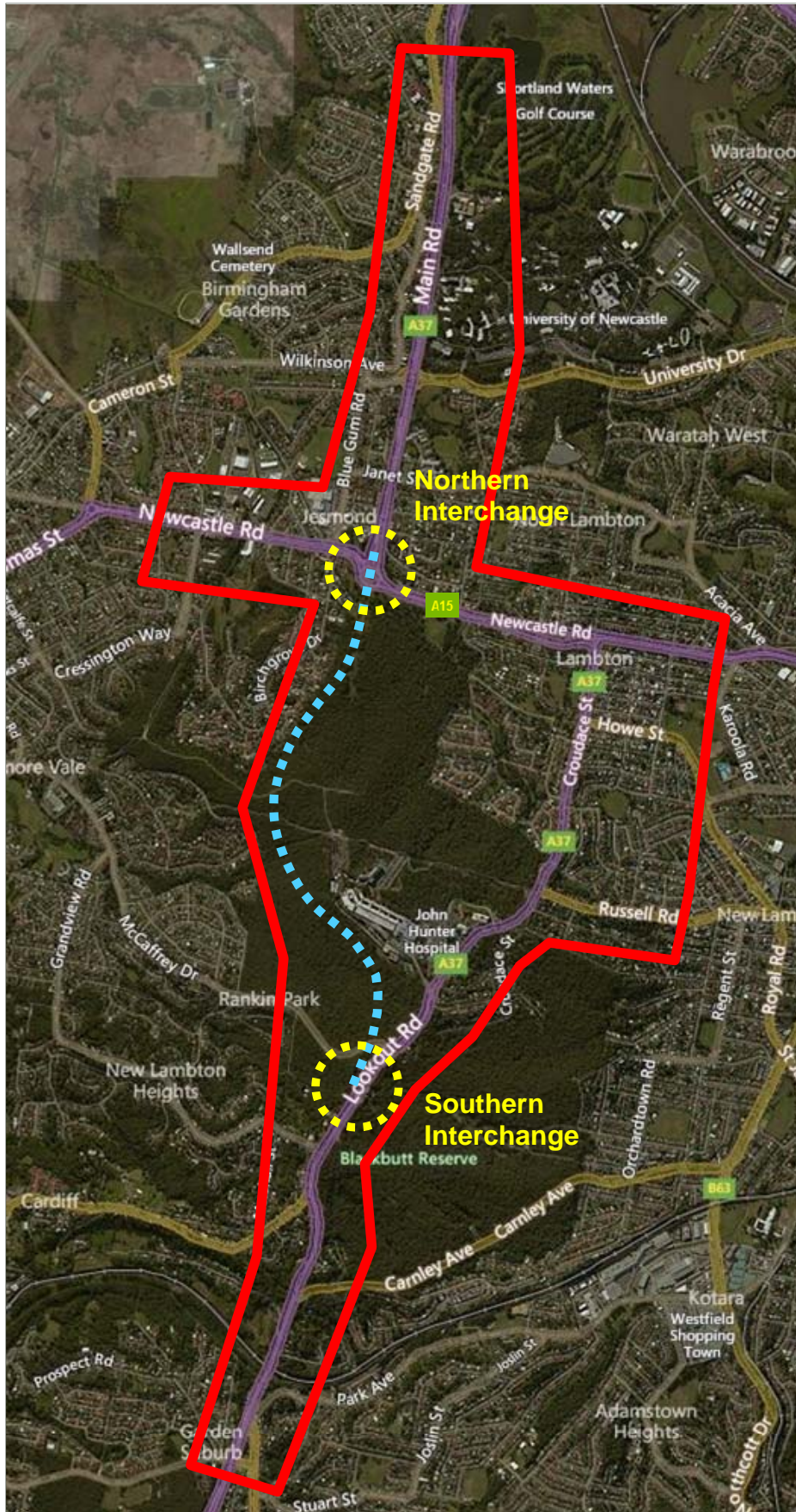


Figure 2-1: Modelled study area

3. Traffic Data Collection

3.1 Survey Data

An extensive range of traffic survey data of existing traffic conditions has been provided by Roads and Maritime to assist with the base traffic model development.

The traffic survey data provided consisted of:

- Intersection turning movement counts
- Travel time data along two routes within the study area as detailed in Section 3.1.2.
- Origin-Destination (OD) surveys to ascertain trip distribution within the study area
- Classified link counts

More information on the traffic survey data provided for the development of the Paramics traffic modelling study can be found in the related traffic modelling report titled *Newcastle Inner City Bypass, Rankin Park to Jesmond Traffic Modelling Report – Lower Hunter Traffic Model (Hyder, 2015)*

3.1.1 Intersection Turning Movements Counts

Intersection turning movement count surveys were undertaken in morning and evening peak periods.

Data has come from two sources:

- Counts undertaken on behalf of AECOM on Tuesday 24th of June 2014
- Counts undertaken on behalf of Roads and Maritime on a number of days between April and June 2014

In total 18 intersections were surveyed by vehicle type in 15 minute intervals as shown below:

- Blue Gum Road/ University Drive
- Newcastle Inner City Bypass (NICB)/ University Drive
- University Access/ University Drive
- Newcastle Inner City Bypass (NICB)/ Newcastle Road
- Blue Gum Road/ Newcastle Road
- Drury Street/ Newcastle Road/ Victory Parade
- Douglas Street/ Newcastle Road
- Croudace Street/ Dent Street/ Newcastle Road
- Morehead Street/ Newcastle Road
- Croudace Street/ Howe Street
- Croudace Street/ Mitchell Street/ Pride Avenue
- Croudace Street/ Lookout Road/ Russell Road
- Lookout Road/ Jacaranda Drive
- Lookout Road/ Hospital Access
- Lookout Road/ McCaffrey Drive
- Grandview Road/ Lookout Road
- Cardiff Road/ Lookout Road/ Charlestown Road
- Carnley Avenue/ Charlestown Road

3.1.2 Journey Time Data

Roads and Maritime have supplied travel time data collected for the following two routes for 2013 and 2014 for use in validating the base model.

Travel time data has been provided for the peak direction in each of the peak periods.

- **Route 4:** Newcastle Road from Douglas St to Morehead Street
- **Route 7:** A37 Route Charlestown Road – Lookout Road – Croudace Street – Newcastle Road – ICB – University Drive

The observed routes are illustrated Figure 3-1:

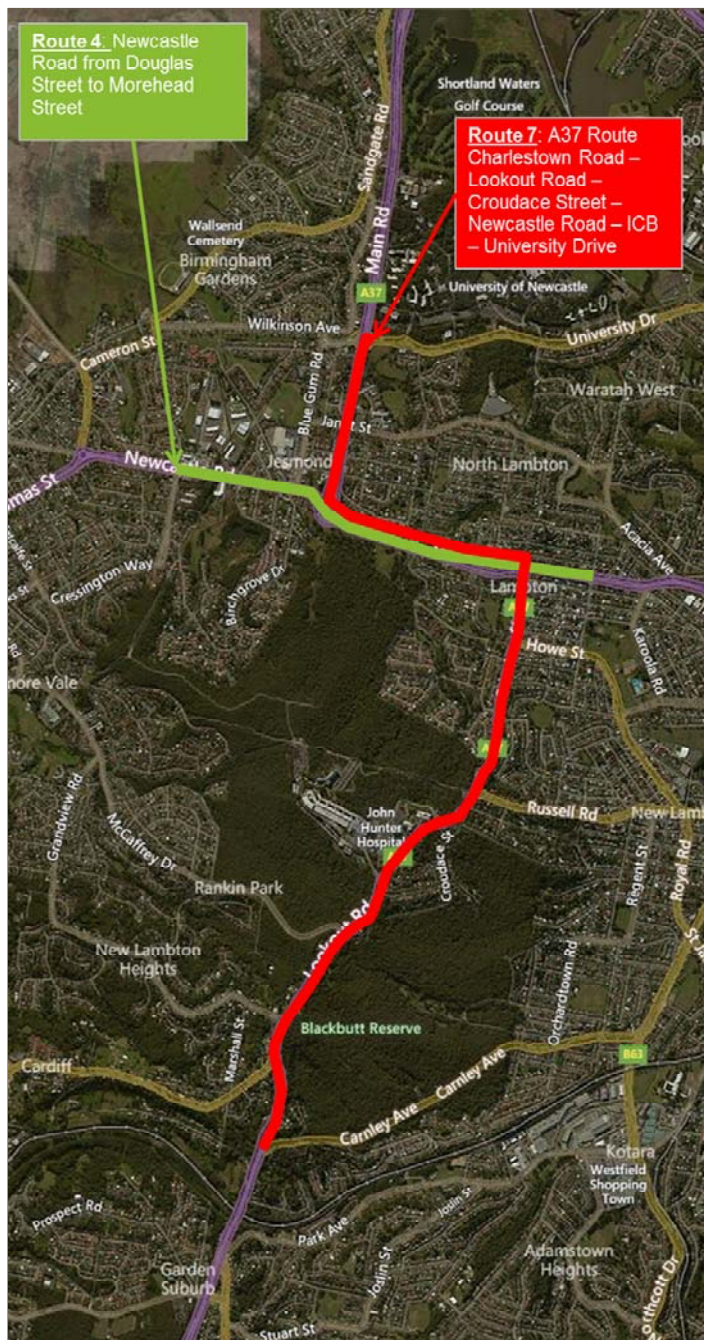


Figure 3-1: Observed journey time routes

3.1.3 Origin-Destination Surveys

Roads and Maritime commissioned two origin-destination surveys to ascertain the distribution of existing trip demand within the study area.

Stations were located at a number of points within and / or adjacent to the modelled area as shown in Figure 3-2. Video units were used to detect and match number plates over a 24 hour period in October 2014 and for a 3-hour period in the morning and evening peaks in May 2015.

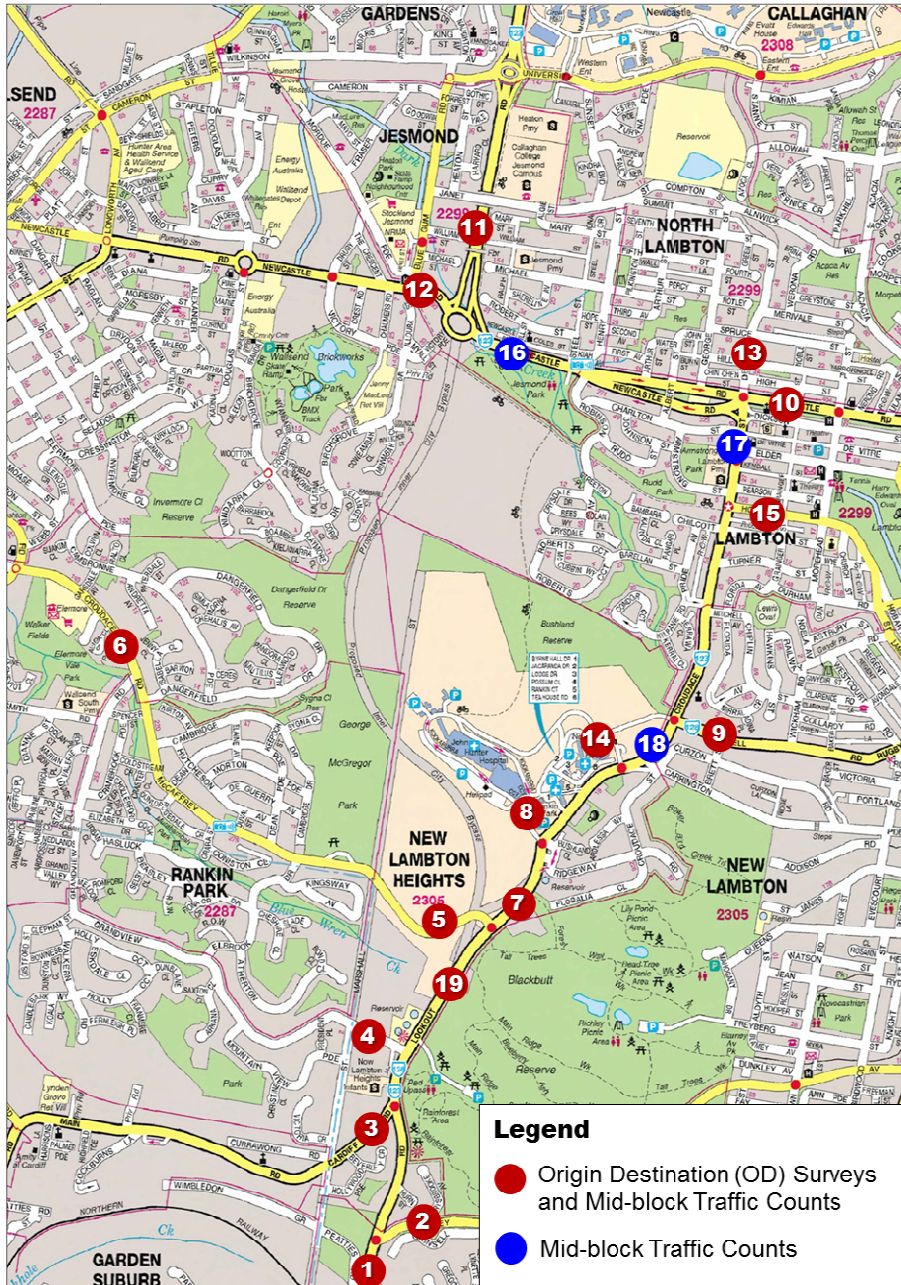


Figure 3-2: Origin-Destination and classified link count survey station locations

Outputs from these origin-destination surveys have been used in determining and reviewing the trip demand matrices for the model as further detailed in Section 4.2.

3.1.4 Classified Midblock Traffic Count Surveys

Classified midblock traffic count surveys have been undertaken at a number of locations within the study area.

The surveys were undertaken over two seven day periods, namely 7 October to 13 October 2014 and 5th May to 11th May 2015.

The locations of the surveys are listed below and are also illustrated in Figure 3-2:

- 1 Charlestown Road, south of Carnley Avenue
- 2 Carnley Avenue, east of Charlestown Road
- 3 Cardiff Road, west of Lookout Road
- 4 Grandview Road, west of Lookout Road
- 5 McCaffrey Drive, west of Lookout Road
- 6 Croudace Road, west of Grandview Road
- 7 Lookout Road, north of McCaffrey Drive
- 8 Kookaburra Circuit (John Hunter Hospital access)
- 9 Russell Road, east of Lookout Road
- 10 Newcastle Road, east of Croudace Street
- 11 Newcastle Inner City Bypass, north of Newcastle Road
- 12 Newcastle Road, west of Newcastle Inner City Bypass
- 13 Dent Street, north of Newcastle Road
- 14 Jacaranda Drive (John Hunter Hospital access)
- 15 Howe Street, east of Croudace Street
- 16 Newcastle Road, east of Newcastle Inner City Bypass
- 17 Croudace Street, north of Elder Street
- 18 Lookout Road, south of Russell Road
- 19 Lookout Road, south of McCaffrey Drive

3.1.5 Traffic Signal Data

SCATS traffic signal operation data from Intersection Diagnostic Monitor (IDM) outputs provided was obtained for 16 traffic signal installations within the study area. This data was used to develop fixed signal timings for each of the signalised intersections in the two modelled periods. Outputs from the History (HIST) file were also used to supplement this information.

The signalised intersections and pedestrian crossings are listed below:

- Douglas Street/ Newcastle Road
- Drury Street/ Newcastle Road/ Victory Parade
- Blue Gum Road/ Newcastle Road
- Main Road/ Newcastle Road
- Dent Street/ Croudace Street/ Newcastle Road
- Morehead Street/ Newcastle Road
- Howe Street/ Croudace Street
- Pride Avenue/ Mitchell Street/ Croudace Street
- Croudace Street/ Russell Road/ Lookout Road

- Jacaranda Drive/ Lookout Road
- Hospital Access/ Lookout Road
- McCaffrey Drive/ Lookout Road
- Cardiff Road/ Charlestown Road/ Lookout Road
- Carnley Avenue/ Charlestown Road
- Jesmond Park Signalised Pedestrian Crossing
- Lambton Primary School Signalised Pedestrian Crossing.

In addition, offsets between intersections (signal coordination) were determined for input to the models from the LX regional configuration file also provided by Roads and Maritime.

Roads and Maritime also provided SCATS Volume Store (VS) traffic loop count data as a further source to supplement traffic surveys.

3.1.6 Public Transport Information

Existing bus stops and services have been added to the model. Bus stop locations were derived from aerial photography, Google Transit Feed and on-site confirmation. Bus routes and timetabling have been provided by Newcastle Buses.

4. Traffic Demand and Assignment

4.1 Zone Structure

Zones are defined as areas in the model from which traffic is generated or attracted. In total 26 zones have been applied to the model.

The zone layout is shown in Figure 4-1 and Table 4-1.

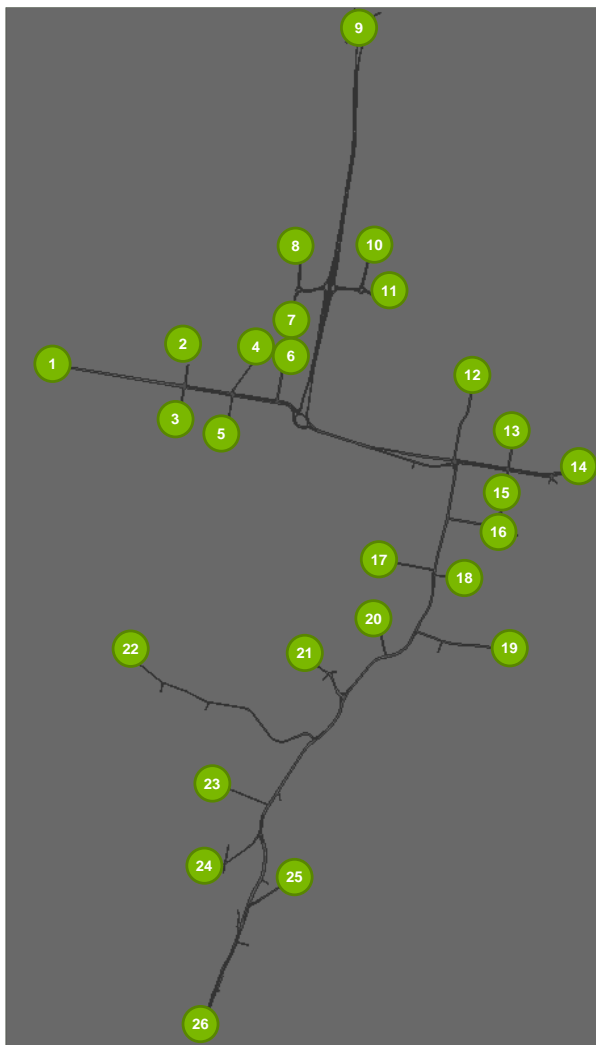


Figure 4-1: Network zone configuration

Table 4-1: Model zone system

Zone Number	Location
Zone 1	Newcastle Road (west)
Zone 2	Douglas Street (north)
Zone 3	Douglas Street (south)
Zone 4	Drury Street
Zone 5	Victory Parade
Zone 6	Blue Gum Road
Zone 7	Blue Gum Road
Zone 8	Wilkinson Avenue
Zone 9	Newcastle Inner City Bypass
Zone 10	Newcastle University Access Road
Zone 11	University Drive
Zone 12	Dent Street
Zone 13	Morehead Street (north)
Zone 14	Newcastle Road (east)
Zone 15	Morehead Street (south)
Zone 16	Howe Street
Zone 17	Pride Avenue
Zone 18	Mitchell Street
Zone 19	Russell Road
Zone 20	Jacaranda Drive
Zone 21	Kookaburra Circuit
Zone 22	McCaffrey Drive
Zone 23	Grandview Road
Zone 24	Cardiff Road
Zone 25	Carnley Avenue
Zone 26	Charlestown Road

4.2 Demand Matrix Development

The available origin-destination survey data (refer section 3.1.3) in combination with the turning movement count data has been used to develop a set of trip demand matrices for both morning and evening peak periods. This has been prepared so that the distribution of trip demand in the base model adequately replicates existing conditions.

To provide a more refined representation of the split of vehicle types and movements within the study area, separate trip demand matrices have been developed for light (cars) and heavy vehicles.

4.2.1 Paramics Matrix Development

The methodology for the development of the trip demand matrices for each of the modelled periods is detailed below.

1. Analysis of turning movement counts was undertaken on a network wide basis. Link totals between surveyed intersections were compared and where necessary minor adjustments made to balance trips totals between intersections. Classified link counts and SCATS VS data were referenced in this adjustment process.
2. Origin-destination (OD) survey data was analysed to determine the distribution of trips throughout the network for application to the Paramics model zone structure and to develop a Prior Matrix. Where possible, data from stations in the OD survey was mapped directly to a zone within the Paramics model. In some instances OD survey stations represented a number of zones within the Paramics model and some disaggregation of this data was required. Turning movement counts were used to assist this process.
3. The Prior Matrix two hour matrices were adjusted to collected survey data using the Furness method. Trip end totals for each Paramics zone were formed from turning movement survey data. Known OD movements such as trips from one external zone to another external zone were “frozen” to remain unadjusted through the Furnessing process.
4. The resulting trip demand matrices from this process were applied to the model and an iterative loop of testing and matrix refinement undertaken to achieve an appropriate level of model calibration.

4.3 Traffic demand release profiles

Traffic demand release profiles have been applied to dispense traffic demands in defined time intervals over the model periods. These profiles were developed based on the traffic survey data which was collated in 15 minute intervals.

The traffic demand release profiles, labelled as traffic flow factors, are displayed in Table 4-2 and are a percentage of the two hour trip demand matrices.

In the evening peak, an additional profile has been developed for Newcastle East (Zone 14) to better represent the release of traffic from this area of the road network.

Time	Profile		Time	General	Newcastle East
07:00	8.16%		16:00	12.18%	11.91%
07:15	9.40%		16:15	12.60%	12.91%
07:30	12.96%		16:30	12.77%	13.13%
07:45	13.80%		16:45	12.78%	13.32%
08:00	13.96%		17:00	12.86%	13.40%
08:15	14.33%		17:15	12.61%	12.79%
08:30	14.00%		17:30	12.42%	11.59%
08:45	13.39%		17:45	11.78%	10.74%

Table 4-2: Traffic Demand release profiles

4.4 Traffic assignment

The base model network being a linear network does not contain any route choice elements. However consideration of the effects of route choice forms part of option testing with the bypass route in place.

For option assessment modelling, route choice parameters were established through evaluation of parameters and outputs from the Lower Hunter Traffic Model (LTHM). Comparison was made of predicted flows on the existing and new bypass routes from the LTHM with those assigned in the Paramics model, along with observation of model operation to inform the development of appropriate values for these parameters.

4.5 Vehicle characteristics

Parameters for vehicle behaviour from the previous model have been reviewed for suitability to take forward with this model. The parameters are to be consistent with those outlined in the Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0*. These parameters were considered suitable for application in this modelling and through observation of model operation have not been adjusted as part of the calibration process.

5. Model Coding

Through the calibration process adjustments have been made to the modelling parameters to ensure the model replicates the existing observed traffic conditions. This is considered standard traffic modelling practice and forms part of the calibration process.

5.1 Behaviour

Paramics represents the behavioural characteristics of drivers by assuming a normally distributed range of values for aggression and awareness attributes. These influence aspects of model operation such as gap acceptance, lane changing and vehicle following. It is not common practice to alter these values from the software defaults unless there is a strong case for modification. Default values have been retained in the development of this model.

5.2 Configuration

The standard Roads and Maritime Paramics configuration settings as detailed in Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0* have been applied.

5.3 Road types

Road categories have been applied in accordance with Roads and Maritime standard categories.

5.4 Version

The model has been developed in Version 6.9.3 of Paramics. This was the current version at the time of model development.

5.5 Elevation

Node heights have been applied to the model to ensure the effects of gradient on traffic speed and acceleration/ deceleration are accounted for in the modelling. The TWOPAS gradient model feature of Paramics has been enabled, consistent with the guidelines described in the Roads and Maritime manual, Roads and Traffic Authority (2009) *Paramics Microsimulation Modelling – RMS Manual v1.0*.

5.6 Visibility

Visibility settings have been adjusted on links on the approaches to the Jesmond roundabout to reflect the high level of visibility available to vehicles at this roundabout and to assist with calibration of throughput and observed queues on these approaches. Similarly, visibility settings have been adjusted on the slip lane left turns from McCaffrey Drive into Lookout Road and from Croudace Street into Newcastle Road.

5.7 Gap settings

Gap settings have been adjusted for movements at the Jesmond Roundabout to improve replication of observed operation and vehicle throughput. This consisted of reducing gap acceptance parameters for the southbound movement from the stop line at Main Road (Newcastle Inner City Bypass) to circulating flow to make a subsequent right turn to Newcastle Road and the westbound movement from the stop line at Newcastle Road to circulating flow to make a subsequent right turn to Main Road.

5.8 Headway factors

Headway factors have been applied to eastbound links in advance of the Croudace Street/ Dent Street/ Newcastle Road intersection. These were applied to assist in the replication of observed queuing on this approach. This measure has been used in conjunction with adjustments to the release profile and lane choice on this approach to match observed driver behaviour.

5.9 Lane choice

Where necessary, lane choice rules have been used to make sure vehicles are in the appropriate lane in advance of decision points. Where lane choice rules have not been sufficient to adequately replicate lane choice, restrictions have been added to the model.

6. Model Calibration

6.1 Calibration/ Validation criteria

Model calibration/ validation is necessary to ensure that a model accurately represents an existing traffic situation within predetermined limits and can be used with confidence to test alternatives.

Calibration for this model has been based on the following:

- **Vehicle Behaviour:** Undertaking a visual check to confirm the observed on-street vehicle behaviour is consistent with that observed in the model
- **Turn Counts:** Comparing observed and modelled turning movements for general traffic over the modelled peak hour periods
- **Link Counts:** Comparing observed and modelled link counts for general traffic over the modelled peak hour periods
- **Journey Times:** Comparing observed and modelled journey travel times for general traffic over the modelled peak hour periods

The model has been calibrated/ validated with reference to the criteria as outlined in the Roads and Maritime document *Traffic Modelling Guidelines, Version 1.0, February 2013*. Section 11.5 details suggested calibration and validation criteria for microsimulation models and these have been applied in this assessment, as outlined in Table 6-1 and Table 6-2.

For the purposes of the calibration reporting, the core area criteria has also been applied to outputs for the modelled study area as a whole. The application of the core area criteria to the entire model network is considered very conservative and has been used for the purposes of refining the model further to ensure it provides a thorough and robust base model for options assessment.

Table 6-1 Roads and Maritime calibration and validation criteria

Topic	Network Wide	Core Area
Link or Turn	<p>Tolerance limits for network-wide area:</p> <p><i>GEH < 5 Minimum 85 per cent of observations to be within tolerance limits</i></p> <p><i>Turn or link flows with GEH > 10 require explanation in reporting</i></p>	<p>Tolerance limits for core area:</p> <p><i>Flows < 99 – to be within 10 vehicles of observed value</i></p> <p><i>Flows 100 to 999 – to be within 10 per cent of observed value</i></p> <p><i>Flows 1000 to 1999 – to be within 100 vehicles of observed value</i></p> <p><i>Flows > 2000 – to be within 5 per cent of observed value</i></p> <p><i>100 per cent of observations to be within tolerance limits</i></p>
Link or Turn	<p>Plots of observed vs modelled hourly flows required for all observations</p> <p><i>Plots to include lines showing GEH = 5 tolerance limits</i></p> <p><i>R² value to be included with plots and to be > 0.9</i></p> <p><i>Slope equation to be included with plots (intercept to be set to zero)</i></p>	<p>Plots of observed vs modelled hourly flows required for all observations</p> <p><i>Plots to include lines showing core tolerance limits</i></p> <p><i>R² value to be included with plots and to be > 0.95</i></p> <p><i>Slope equation to be included with plots (intercept to be set to zero)</i></p>

Table 6-2 Journey time criteria

Journey times	Criteria	
	Journey time average	Average modelled journey time to be within 15 per cent or one minute (whichever is greater) of average observed journey time for full length of route.
	Section time average	Average modelled journey time to be within 15 per cent of average observed journey time for individual sections.
Journey time variability	Average and 95 per cent confidence intervals to be plotted for observed and modelled travel times for each journey time route. Comparison to be to modeller and Roads and Maritime satisfaction.	

All data listed in Section 3.1 was used to calibrate the model. Detailed comparisons between observed and modelled calibration statistics are presented in the following sections for the peak hours. Where applicable the results reference the criteria as set out in the above tables.

6.2 Model runs

Five runs of each model have been undertaken. In accordance with Roads and Maritime requirements seed values 28, 560, 2849, 7771 and 86524 have been utilised throughout the calibration process.

6.3 Model stability

The coefficient of variation (COV) has been used to assess the variability between each run on the network statistics. The COV is a measure of the variation between model runs. Typically 5% is considered a good level of correlation. The coefficient of variance is calculated by dividing the mean by the standard deviation as follows:

$$COV = \frac{SD}{\mu} \times 100 \quad \text{Where: SD = Standard Deviation, } \mu = \text{Mean}$$

Table 6-3: Morning period, network statistics (5 model runs)

Statistic	Total travel time (hr)	Total vehicle km travelled	Total number of Vehicles	Mean speed (kph)
Mean	2,359	90,347	28,515	38
Std Dev	44	818	221	1
Min	2,314	88,917	28,168	37
Max	2,419	90,886	28,766	39
Range	105	1,969	598	2
CoV	1.9%	0.9%	0.8%	2.1%

Table 6-4: Evening period, network statistics (5 model runs)

Statistic	Total travel time (hr)	Total vehicle km travelled	Total number of Vehicles	Mean speed (kph)
Mean	2,758	99,119	31,964	36
Std Dev	57	219	84	1
Min	2,702	98,893	31,903	35
Max	2,825	99,467	32,104	37
Range	124	574	201	2
CoV	2.1%	0.2%	0.3%	1.9%

The general network statistics for both periods predict a CoV of less than 4%. It is considered the model is stable.

6.4 Turn count calibration

The following sections make comparisons between observed and modelled turn counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each period.

Tables of observed and modelled turn count values for individual movements are provided in Appendix A.

6.4.1 Morning peak hour turn count comparisons

Table 6-5 provides the results comparing the observed and modelled count data for each individual link with a survey target during the morning peak hour period. The links have been organised into ranges by their observed count volume.

Table 6-5: Morning peak hour observed versus modelled turn counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Turn Flows	>85% of cases	99%		
R ² value for modelled vs observed flows for all individual turns	>0.9	0.99		
Core Area				
Individual Turn Volumes				
Within 10 veh/h, for Flow<99	100% of cases	76%	35	46
Within 10%, for 100<Flow<999 veh/h	100% of cases	83%	48	58
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	72%	18	25
Within 5%, for >2000 veh/h	100% of cases	86%	6	7
R ² value for modelled vs observed flows for all individual turns	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria.

To provide further confidence in the suitability of the model for the testing of options for the Rankin Park to Jesmond project, further comparison has been undertaken against other calibration criteria as discussed in Section 6.5.3.

The following graph presents a plot of observed counts against modelled counts for the morning peak period with core area calibration tolerances.

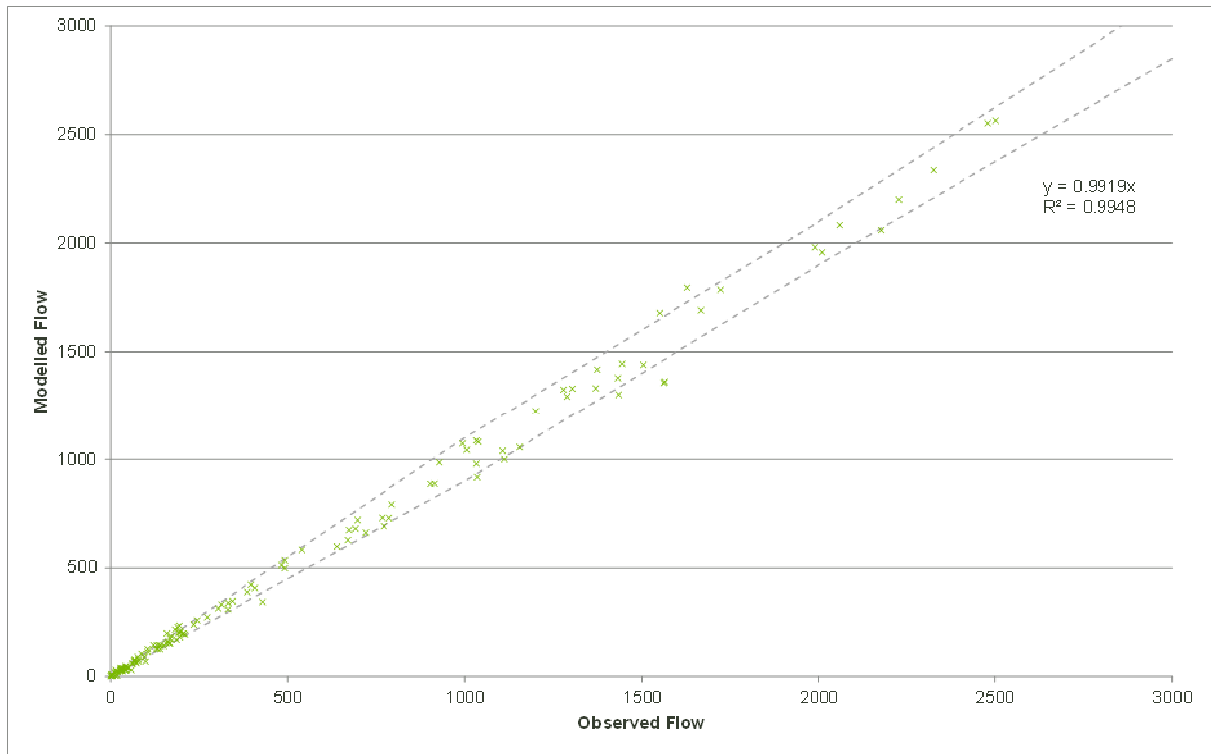


Figure 6-1 - Morning peak hour observed versus modelled turn count plot

The graph illustrates the majority of counts fall within the core calibration criteria, while those that don't meet criteria are generally on the cusp of compliance.

6.4.2 Evening peak hour turn count comparisons

Table 6-6 presents a comparison between observed and modelled count data for each individual turn with a survey target during the evening peak hour period. The turns have been organised into ranges by their observed count.

Table 6-6: Evening peak hour observed versus modelled turn counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Turn Flows	>85% of cases	99%		
R ² value for modelled vs observed flows for all individual turns	>0.9	0.99		
Core Area				
Individual Turn Volumes				
Within 10 veh/h, for Flow<99	100% of cases	71%	32	45
Within 10%, for 100<Flow<999 veh/h	100% of cases	79%	44	56
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	81%	25	31
Within 5%, for >2000 veh/h	100% of cases	100%	4	4
R ² value for modelled vs observed flows for all individual turns	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria.

The following graph shows a plot of observed counts against modelled counts for the evening peak hour period with core area calibration criteria.

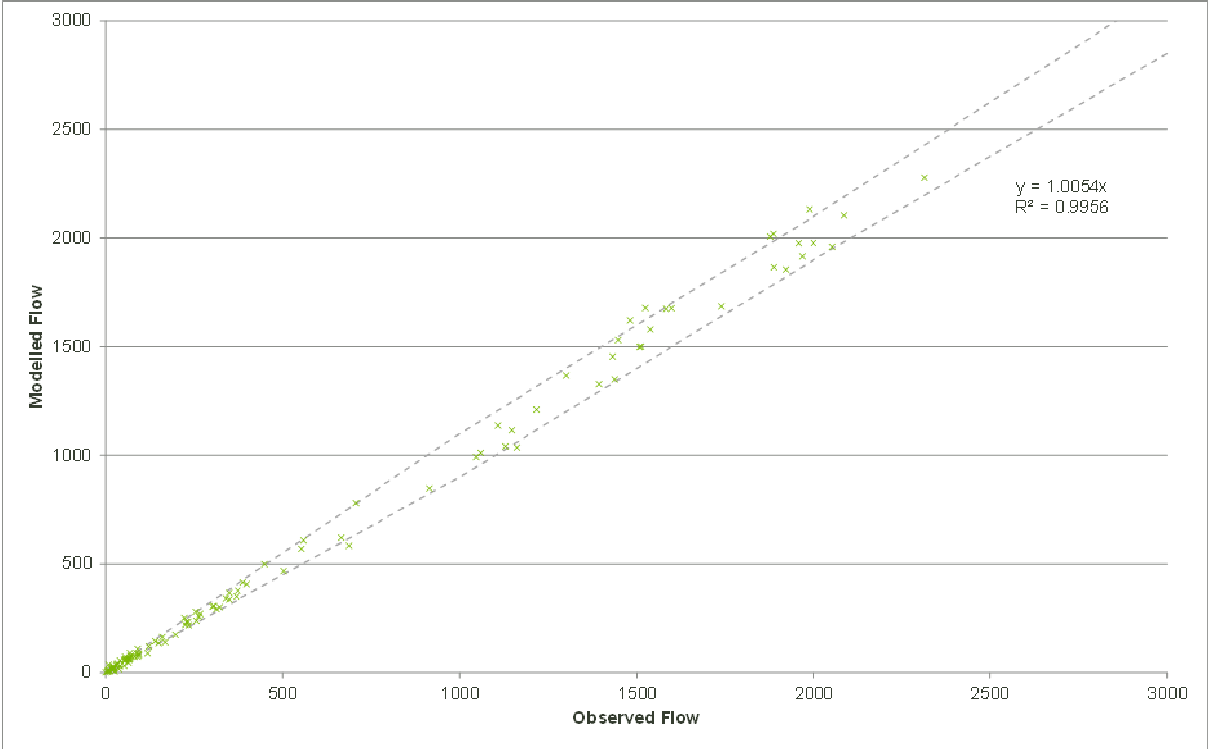


Figure 6-2: Evening peak hour observed versus modelled turn counts

The graph illustrates a strong correlation between observed and modelled counts, reinforced by the R^2 value of 0.99.

6.5 Link count calibration

Link counts have been compared based on approach and exit link flows at intersections, comprised from the same set of data used for turn count comparisons.

The following sections compare the observed and modelled link counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each period.

Roads and Maritime guidelines recommend modelled link flows to have a minimum R^2 of 0.9. The minimum R^2 value is increased to 0.95 for core areas. The network wide area needs at least 85% of cases to have a GEH < 5. For the core area all cases should fall within calibration criteria for specified flow ranges.

Tables of observed and modelled link count values for individual movements are provided in Appendix B.

6.5.1 Morning peak hour link count comparisons

Table 6-7 presents the results comparing observed and modelled count data for each individual link with a survey target during the morning peak hour period. The links have been organised into ranges by their observed count.

Table 6-7: Morning peak hour observed versus modelled link counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Link Flows	>85% of cases	98%		
R ² value for modelled versus observed flows for all individual links	>0.9	0.99		
Core Area				
Individual Link Volumes				
Within 10 veh/h, for Flow<99	100% of cases	73%	8	11
Within 10%, for 100<Flow<999 veh/h	100% of cases	85%	33	39
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	69%	34	49
Within 5%, for >2000 veh/h	100% of cases	79%	19	24
R ² value for modelled versus observed flows for all individual links	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria. The following graph presents a plot of observed counts against modelled counts for the morning peak period with core area calibration criteria.

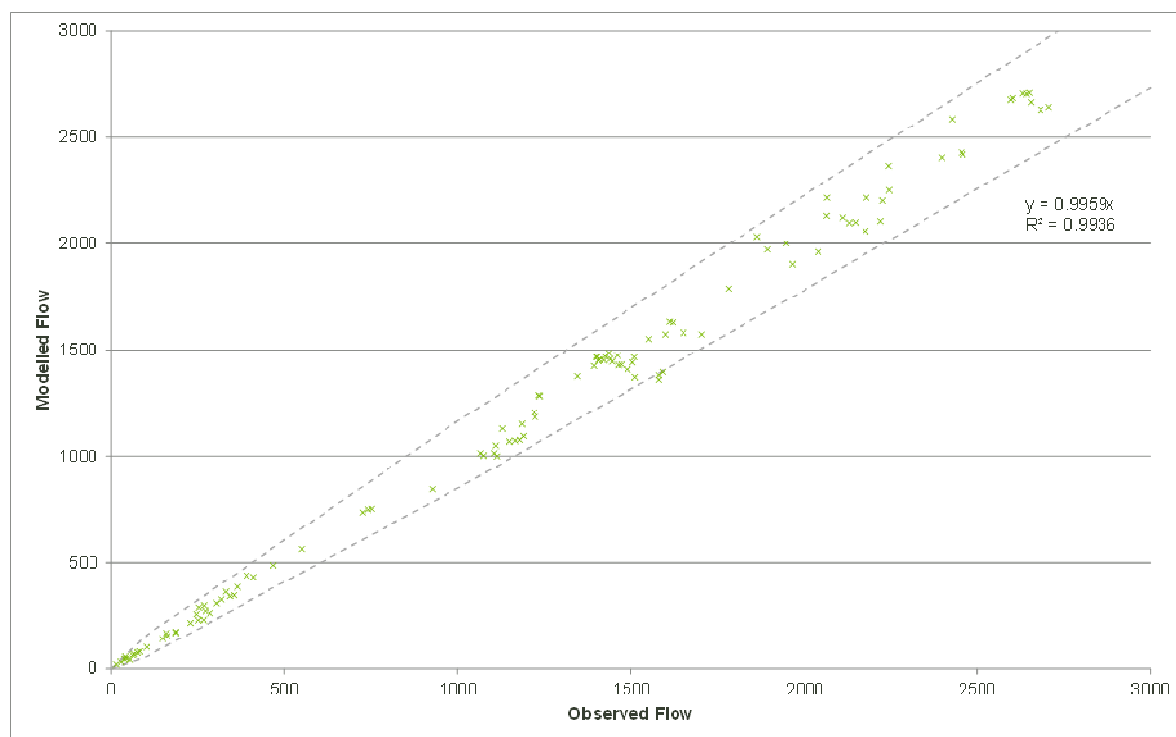


Figure 6-3: Morning peak hour observed versus modelled link counts

The graph illustrates a good correlation between observed and modelled counts, reinforced by the R2 value of 0.99.

6.5.2 Evening peak hour link count comparisons

The following table presents the results achieved comparing the observed and modelled count data for each individual link with a survey target during the Evening peak hour period. The links have been organised into ranges by their observed count.

Table 6-8: Evening Peak Hour Observed Versus Modelled Link Counts

Criteria and Measures	Calibration Targets	Result	Number meeting criteria	Total number of counts
Network Wide				
GEH Statistic < 5 for Individual Link Flows	>85% of cases	100%		
R ² value for modelled versus observed flows for all individual links	>0.9	0.99		
Core Area				
Individual Link Volumes				
Within 10 veh/h, for Flow<99	100% of cases	80%	8	10
Within 10%, for 100<Flow<999 veh/h	100% of cases	92%	34	37
Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h	100% of cases	74%	39	53
Within 5%, for >2000 veh/h	100% of cases	83%	19	23
R ² value for modelled versus observed flows for all individual links	>0.95	0.99		

The model shows a good level of calibration to the Roads and Maritime network wide performance criteria. The following graph shows a plot of observed counts against modelled counts for the Evening peak period with core area calibration criteria.

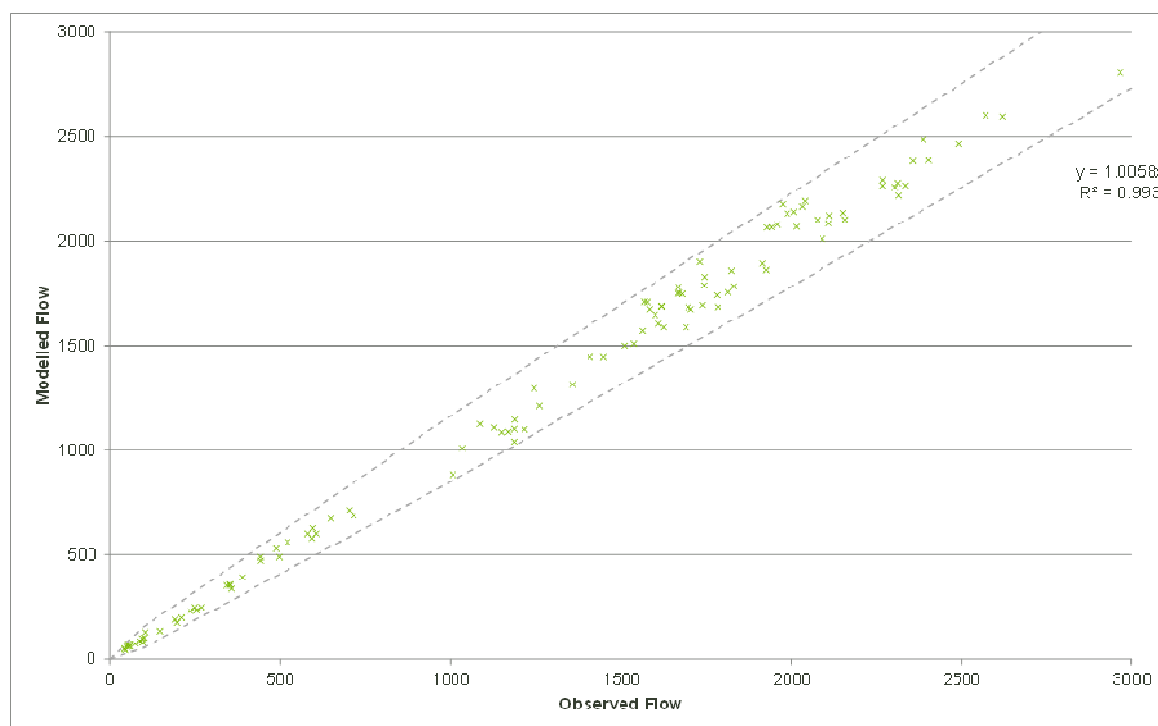


Figure 6-4: Evening peak hour observed versus modelled link counts

The graph illustrates a strong correlation between observed and modelled counts, reinforced by the R2 value of 0.99.

6.5.3 Comments on turn and link flow calibration

To provide Roads and Maritime with further confidence in the suitability of the model for undertaking the assessment of options for the Rankin Park to Jesmond project, guidelines for models of a similar size and nature from other jurisdictions have been referenced.

The two sources are the *UK Design Manual for Roads and Bridges (DMRB)* and *New Zealand Transport Agency (NZTA) Transport Model Development Guidelines*.

1.4.1.1 DRMB

DMRB Vol 12a, Chapter 4 sets out the criteria for the calibration of transport models in the UK. These are outlined in Table 6-9 along with the level of adherence achieved by the RP2J model for turn movement counts in both peak periods.

Table 6-9: DMRB, Calibration Criteria for turn movements

Criteria	Calibration Target	AM Turns	PM Turns
Within 100 veh/h, for Flow<700 veh/h	>85% of cases	100%	100%
Within 15%, for 400 veh/h<Flow<2700 veh/h	>85% of cases	98%	98%
Sum of all link flows difference	<5%	1%	0%
GEH for all individual link flows <5	>85% of cases	99%	99%

1.4.1.2 NZTA Transport Model Development Guidelines

These guidelines were developed by the New Zealand Modelling User Group (NZMUGS) and have recently been adopted by NZTA. For small corridor models, the following criteria are detailed for turn movement counts.

Table 6-10 outlines the criteria and the level of calibration achieved in both periods.

Table 6-10: NZTA Transport Model Development Guidelines, calibration criteria for turn movements

Criteria	Calibration Target	AM Turns	PM Turns
Within 50 veh/h, for Flow<400 veh/h	>85% of cases	100%	100%
Within 12.5%, for 400 veh/h<Flow<2000 veh/h	>85% of cases	93%	98%
Within 250 veh/h, for Flow>2000 veh/h	>85% of cases	100%	100%

Against both sources the model shows a high level of adherence to calibration criteria in both model periods for turning movement counts.

6.6 Journey time calibration

Journey time comparisons have been undertaken for the peak modelled hours for the routes described earlier in this report in Section 3.1.2. The comparison includes the average of the model results from all five runs.

Roads and Maritime modelling guidelines specify the average modelled journey time for the full route length and individual sections are to be within 15 per cent or one minute (whichever is greater) of average observed journey time for full length of route.

6.6.1 Morning peak hour travel time comparisons

Table 6-11 presents a comparison of observed journey times against those achieved in the model for the morning peak period. The applicable calibration criteria, either within 15% or 1 minute is highlighted in bold.

Table 6-11: Morning peak hour journey time comparison

Route Name	Observed			Modelled	Diff	Diff
	Minimum	Maximum	Average	Average		
Route 4: Newcastle EBD	00:03:00	00:08:14	00:05:09	00:04:21	00:00:48	-16%
Route 7: Lookout- Croudace NBD	00:08:43	00:18:19	00:12:48	00:10:57	00:01:51	-14%

The table illustrates a good correlation between observed and modelled journey times with the Route 4 and Route 7 routes having a difference that is within 15% or 1 minute of the observed.

Graphs of journey time against travel distance for all routes are provided in Appendix C.

6.6.2 Evening peak hour travel time comparisons

The observed and modelled journey times in minutes are presented in the following table with difference and percentages for the PM peak hour period.

Table 6-12: Evening peak hour journey time comparison

Route Name	Observed			Modelled	Diff	% Diff
	Minimum	Maximum	Average	Average		
Route 4: Newcastle WBD	00:03:32	00:10:06	00:07:08	00:06:16	00:00:53	-12%
Route 7: Lookout – Croudace SBD	00:09:15	00:23:31	00:13:49	00:12:32	00:01:17	-9%

In the evening peak period all journey times meet required calibration criteria.

6.7 Calibration results summary

The calibration summary in the table below presents the level of calibration achieved in the model against the Roads and Maritime criteria as specified in the *Traffic Modelling Guidelines, Version 1.0, February 2013*.

Table 6-13 – Calibration summary

Type	Criteria and Measures (Observed vs. Modelled)	Calibration Target	AM	PM
Model Stability	The overall network statistics such as mean flow, density, mean speed, mean travel time, mean delay, total travel distance and total travel time.	The coefficient of variation (CoV) within 5% (max)	2.1% max	2.1% max
Network Wide				
Turn counts	GEH statistic < 5.0 for individual link flows	>85% of cases	99%	99%
	R ² value for modelled versus observed flows for all individual links	0.90	0.99	0.99
Link counts	GEH statistic < 5.0 for individual link flows	>85% of cases		
	R ² value for modelled versus observed flows for all individual links	0.90		
Journey Times		Within 15% (or 1 min)	All	All
Core area				
Turn Counts	Within 10 veh/h, for Flow<99	100%	76%	71%
	Within 10%, for 100<Flow<999 veh/h		83%	79%
	Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h		72%	81%
	Within 5%, for >2000 veh/h		86%	100%
Link Counts	Within 10 veh/h, for Flow<99	100%	73%	80%
	Within 10%, for 100<Flow<999 veh/h		85%	92%
	Within 100 veh/h, for 1000 veh/h<Flow<1999 veh/h		69%	74%
	Within 5%, for >2000 veh/h		79%	83%
	R ² value for modelled versus observed flows for all individual links	>0.95	0.99	0.99

The above table demonstrates the model adheres to the calibration/ validation criteria. Both morning and evening peak models have good adherence to network wide criteria.

As demonstrated in Section 6.5.3, the model also shows good adherence to calibration guidelines of other jurisdictions (United Kingdom and New Zealand) for turn counts for models of a similar size.

With respect to journey times the model demonstrates a good level of adherence, with all journey times within calibration criteria.

7. Conclusion

A traffic simulation model for the Rankin Park to Jesmond (RP2J) project has been developed using Quadstone Paramics simulation software version 6.9.3 to replicate existing traffic conditions observed for a 2014 base year.

Statistical analysis of model runs demonstrates the modelled network and output results are stable.

Comparisons have been made between the following modelled and observed measures:

- Turn count
- Link counts
- Journey Times

Comparison results illustrate the model provides good replication of existing traffic conditions against network calibration criteria and observed journey times.

It is considered that the Paramics RP2J microsimulation base model is fit for purpose and provides a robust model for undertaking the following investigations for the project:

- Undertaking traffic analysis of interchange options
- Assessing the construction and operational impacts of the project within the study area
- Providing outputs for economic analysis

Appendix A

Observed vs Modelled Turn Counts

Morning Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Left	139	125	-14	-10%	1.3
	Douglas Street (N)	Thru	39	35	-4	-10%	0.7
	Douglas Street (N)	Right	70	68	-2	-3%	0.2
	Newcastle Road (E)	Left	78	77	-1	-1%	0.1
	Newcastle Road (E)	Thru	1,371	1,330	-41	-3%	1.1
	Newcastle Road (E)	Right	61	57	-4	-7%	0.5
	Douglas Street (S)	Left	30	31	1	3%	0.2
	Douglas Street (S)	Thru	95	89	-6	-7%	0.6
	Douglas Street (S)	Right	192	204	12	6%	0.8
	Newcastle Road (W)	Left	29	27	-2	-6%	0.3
	Newcastle Road (W)	Thru	2,325	2,336	11	0%	0.2
	Newcastle Road (W)	Right	44	40	-4	-9%	0.6
	Drury/ Newcastle/ Victory	Drury Street (N)	Left	5	5	0	0%
Drury Street (N)		Thru	4	3	-1	-15%	0.3
Drury Street (N)		Right	28	36	8	27%	1.3
Newcastle Road (E)		Left	4	7	3	75%	1.3
Newcastle Road (E)		Thru	1,375	1,418	43	3%	1.1
Newcastle Road (E)		Right	27	23	-4	-16%	0.8
Victory Parade (S)		Left	32	32	0	-1%	0.1
Victory Parade (S)		Thru	28	30	2	7%	0.4
Victory Parade (S)		Right	166	152	-14	-8%	1.1
Newcastle Road (W)		Left	104	113	9	9%	0.9
Newcastle Road (W)		Thru	2,480	2,551	71	3%	1.4
Newcastle Road (W)		Right	20	20	0	-2%	0.1
Blue Gum/ Newcastle		Blue Gum Road (N)	Left	140	141	1	1%
	Blue Gum Road (N)	Right	129	129	0	0%	0.0
	Newcastle Road (E)	Thru	1,280	1,324	44	3%	1.2
	Newcastle Road (E)	Right	120	143	23	19%	2.0
	Newcastle Road (W)	Left	130	143	13	10%	1.1
	Newcastle Road (W)	Thru	2,503	2,563	60	2%	1.2
Croudace/ Dent/ Newcastle	Dent Street (N)	Left	33	24	-9	-27%	1.6
	Dent Street (N)	Thru	203	196	-7	-3%	0.5
	Dent Street (N)	Right	48	40	-8	-16%	1.1
	Newcastle Road (E)	Left	329	308	-21	-6%	1.2
	Newcastle Road (E)	Thru	994	1,073	79	8%	2.5
Newcastle Road (E)	Right	98	69	-29	-30%	3.2	

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH	
	Croudace Street (S)	Left	904	886	-18	-2%	0.6	
	Croudace Street (S)	Thru	164	152	-12	-7%	0.9	
	Croudace Street (S)	Right	483	512	29	6%	1.3	
	Newcastle Road (W)	Left	2	9	7	330%	2.9	
	Newcastle Road (W)	Thru	1,551	1,678	127	8%	3.2	
	Newcastle Road (W)	Right	691	679	-12	-2%	0.5	
Morehead/ Newcastle	Morehead Street (N)	Left	66	70	4	6%	0.5	
	Morehead Street (N)	Thru	32	29	-3	-11%	0.6	
	Morehead Street (N)	Right	3	1	-2	-60%	1.2	
	Newcastle Road (E)	Left	42	46	4	9%	0.6	
	Newcastle Road (E)	Thru	1,305	1,329	24	2%	0.7	
	Morehead Street (S)	Left	131	126	-5	-4%	0.5	
	Morehead Street (S)	Thru	61	60	-1	-1%	0.1	
	Morehead Street (S)	Right	161	158	-3	-2%	0.3	
	Newcastle Road (W)	Left	0	1	1	0%	1.1	
	Newcastle Road (W)	Thru	2,227	2,200	-27	-1%	0.6	
	Croudace/ Howe	Croudace Street (N)	Left	188	226	38	20%	2.7
		Croudace Street (N)	Thru	1,033	979	-54	-5%	1.7
		Howe Street (E)	Left	32	35	3	8%	0.5
		Howe Street (E)	Right	271	271	0	0%	0.0
Croudace Street (S)		Thru	1,435	1,301	-134	-9%	3.6	
Croudace Street (S)		Right	77	69	-8	-11%	1.0	
Croudace/ Pride	Croudace Street (N)	Thru	1,111	1,000	-111	-10%	3.4	
	Croudace Street (S)	Thru	1,565	1,361	-204	-13%	5.3	
	Croudace Street (S)	Left	15	19	4	27%	1.0	
	Pride Avenue (W)	Left	13	3	-10	-77%	3.5	
	Pride Avenue (W)	Right	67	76	9	13%	1.0	
Croudace/ Mitchell	Croudace Street (N)	Left	11	16	5	49%	1.5	
	Croudace Street (N)	Thru	1,154	1,056	-98	-9%	3.0	
	Mitchell Street (E)	Left	35	37	2	7%	0.4	
	Mitchell Street (E)	Right	18	3	-15	-84%	4.7	
	Croudace Street (S)	Thru	1,562	1,356	-205	-13%	5.4	
	Croudace Street (S)	Right	29	39	10	33%	1.7	
Croudace/ Lookout/ Russell	Croudace Street (N)	Left	43	30	-13	-31%	2.2	
	Croudace Street (N)	Thru	1,106	1,039	-67	-6%	2.1	
	Russell Street (E)	Right	58	28	-30	-51%	4.5	
	Russell Street (E)	Left	492	534	42	8%	1.8	

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Thru	1,433	1,378	-55	-4%	1.5
	Croudace Street (S)	Right	697	719	22	3%	0.8
Jacaranda/ Lookout	Jacaranda Street (N)	Left	43	46	3	8%	0.5
	Lookout Road (E)	Right	149	141	-8	-6%	0.7
	Lookout Road (E)	Thru	1,505	1,439	-66	-4%	1.7
	Lookout Road (W)	Thru	2,178	2,059	-119	-5%	2.6
Hospital/ Lookout	Lookout Road (N)	Thru	1,033	1,086	53	5%	1.6
	Lookout Road (N)	Right	430	341	-89	-21%	4.5
	Lookout Road (S)	Left	673	673	0	0%	0.0
	Lookout Road (S)	Thru	2,011	1,957	-54	-3%	1.2
	Hospital Road (W)	Left	137	142	5	4%	0.4
	Hospital Road (W)	Right	204	196	-8	-4%	0.5
Lookout/ McCaffrey	Lookout Road (N)	Thru	1,038	1,081	43	4%	1.3
	Lookout Road (N)	Right	196	205	9	4%	0.6
	Lookout Road (S)	Left	193	233	40	21%	2.8
	Lookout Road (S)	Thru	1,988	1,981	-7	0%	0.2
	McCaffrey (W)	Left	720	661	-59	-8%	2.2
	McCaffrey (W)	Right	387	388	1	0%	0.0
Grandview/ Lookout	Lookout Road (N)	Thru	1,445	1,444	-1	0%	0.0
	Lookout Road (N)	Right	14	29	15	104%	3.2
	Lookout Road (S)	Left	50	40	-10	-20%	1.5
	Lookout Road (S)	Thru	2,061	2,082	21	1%	0.5
	Grandview Road (W)	Left	185	168	-17	-9%	1.3
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Thru	1,202	1,225	23	2%	0.7
	Charlestown Road (N)	Right	192	198	6	3%	0.5
	Charlestown Road (S)	Left	170	185	15	9%	1.1
	Charlestown Road (S)	Thru	1,724	1,786	62	4%	1.5
	Cardiff Road (W)	Left	342	345	3	1%	0.2
	Cardiff Road (W)	Right	408	407	-1	0%	0.1
Carnley/ Charlestown	Charlestown Road (N)	Left	330	337	7	2%	0.4
	Charlestown Road (N)	Thru	1,290	1,291	1	0%	0.0
	Carnley Avenue (E)	Left	492	497	5	1%	0.2
	Carnley Avenue (E)	Right	233	238	5	2%	0.3
	Charlestown Road (S)	Thru	1,631	1,795	164	10%	4.0
	Charlestown Road (S)	Right	796	791	-5	-1%	0.2
Newcastle/ NICB	Main Road (N)	Left	788	728	-60	-8%	2.2

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Main Road (N)	Right	397	422	25	6%	1.2
	Newcastle Road (E)	Thru	1,006	1,044	38	4%	1.2
	Newcastle Road (E)	Right	1,035	917	-118	-11%	3.8
	Newcastle Road (W)	Left	929	985	56	6%	1.8
	Newcastle Road (W)	Thru	1,669	1,691	22	1%	0.5
Blue Gum/ University	Blue Gum Street (N)	Left	771	691	-80	-10%	3.0
	Blue Gum Street (N)	Thru	302	312	10	3%	0.6
	University Street (E)	Left	167	173	6	4%	0.5
	University Street (E)	Right	243	257	15	6%	0.9
	Blue Gum Street (S)	Thru	87	103	16	19%	1.7
	Blue Gum Street (S)	Right	156	153	-3	-2%	0.3
NICB/ University	NICB Street (N)	Left	209	193	-16	-8%	1.1
	NICB Street (N)	Right	68	75	7	10%	0.8
	University Road (E)	Left	181	215	34	19%	2.4
	University Road (E)	Thru	311	330	19	6%	1.0
	University Road (E)	Right	104	125	21	20%	2.0
	NICB Street (S)	Left	42	27	-15	-36%	2.6
	NICB Street (S)	Right	767	729	-38	-5%	1.4
	University Road (W)	Left	72	60	-12	-16%	1.5
	University Road (W)	Thru	639	597	-42	-7%	1.7
	University Road (W)	Right	194	180	-14	-7%	1.1
University/ University Access	University Access (N)	Left	17	23	6	34%	1.3
	University Access (N)	Right	76	88	12	16%	1.4
	University Road (E)	Thru	541	582	41	8%	1.7
	University Road (E)	Right	158	197	39	25%	2.9
	University Road (W)	Left	670	627	-43	-6%	1.7
	University Road (W)	Thru	916	887	-29	-3%	1.0

Evening Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Left	69	66	-3	-5%	0.4
	Douglas Street (N)	Thru	93	87	-6	-6%	0.6
	Douglas Street (N)	Right	93	80	-13	-14%	1.4
	Newcastle Road (E)	Left	227	233	6	2%	0.4
	Newcastle Road (E)	Thru	2,000	1,977	-23	-1%	0.5
	Newcastle Road (E)	Right	40	55	15	39%	2.2
	Douglas Street (S)	Left	64	45	-19	-30%	2.6

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH	
	Douglas Street (S)	Thru	33	41	8	25%	1.3	
	Douglas Street (S)	Right	139	144	5	3%	0.4	
	Newcastle Road (W)	Left	30	32	2	6%	0.3	
	Newcastle Road (W)	Thru	1,538	1,579	41	3%	1.0	
	Newcastle Road (W)	Right	32	38	6	18%	0.9	
Drury/ Newcastle/ Victory	Drury Street (N)	Left	11	7	-4	-33%	1.2	
	Drury Street (N)	Thru	20	18	-2	-11%	0.5	
	Drury Street (N)	Right	159	163	4	3%	0.3	
	Newcastle Road (E)	Left	5	4	-1	-20%	0.5	
	Newcastle Road (E)	Thru	2,087	2,104	17	1%	0.4	
	Newcastle Road (E)	Right	21	14	-7	-31%	1.6	
	Victory Parade (S)	Left	21	26	5	22%	1.0	
	Victory Parade (S)	Thru	9	11	2	20%	0.6	
	Victory Parade (S)	Right	64	62	-2	-3%	0.3	
	Newcastle Road (W)	Left	70	77	7	10%	0.8	
	Newcastle Road (W)	Thru	1,741	1,685	-55	-3%	1.3	
	Newcastle Road (W)	Right	22	21	-1	-5%	0.3	
	Blue Gum/ Newcastle	Blue Gum Road (N)	Left	233	218	-15	-7%	1.0
		Blue Gum Road (N)	Right	265	270	5	2%	0.3
Newcastle Road (E)		Thru	1,887	1,865	-22	-1%	0.5	
Newcastle Road (E)		Right	224	219	-5	-2%	0.3	
Newcastle Road (W)		Left	221	251	30	13%	1.9	
Newcastle Road (W)		Thru	1,448	1,529	81	6%	2.1	
Croudace/ Dent/ Newcastle	Dent Street (N)	Left	22	27	5	25%	1.1	
	Dent Street (N)	Thru	311	291	-20	-6%	1.1	
	Dent Street (N)	Right	23	18	-5	-23%	1.2	
	Newcastle Road (E)	Left	559	608	49	9%	2.0	
	Newcastle Road (E)	Thru	1,302	1,367	65	5%	1.8	
	Newcastle Road (E)	Right	68	90	22	32%	2.4	
	Croudace Street (S)	Left	706	780	74	10%	2.7	
	Croudace Street (S)	Thru	167	139	-28	-17%	2.2	
	Croudace Street (S)	Right	372	376	4	1%	0.2	
	Newcastle Road (W)	Left	14	19	5	37%	1.3	
	Newcastle Road (W)	Thru	1,432	1,454	22	2%	0.6	
	Newcastle Road (W)	Right	1,046	992	-54	-5%	1.7	
	Morehead/ Newcastle	Morehead Street (N)	Left	22	22	0	1%	0.0
Morehead Street (N)		Thru	67	61	-6	-9%	0.7	

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Morehead Street (N)	Right	0	1	1	0%	1.7
	Newcastle Road (E)	Left	81	72	-9	-11%	1.0
	Newcastle Road (E)	Thru	1,877	2,006	129	7%	2.9
	Morehead Street (S)	Left	65	59	-6	-10%	0.8
	Morehead Street (S)	Thru	54	55	1	1%	0.1
	Morehead Street (S)	Right	149	135	-14	-10%	1.2
	Newcastle Road (W)	Left	6	6	0	7%	0.2
	Newcastle Road (W)	Thru	1,921	1,855	-66	-3%	1.5
Croudace/ Howe	Croudace Street (N)	Left	253	279	26	10%	1.6
	Croudace Street (N)	Thru	1,481	1,620	139	9%	3.5
	Howe Street (E)	Left	87	89	2	2%	0.2
	Howe Street (E)	Right	300	303	3	1%	0.2
	Croudace Street (S)	Thru	1,059	1,011	-48	-5%	1.5
	Croudace Street (S)	Right	90	73	-17	-18%	1.8
Croudace/ Pride	Croudace Street (N)	Thru	1,583	1,674	91	6%	2.2
	Croudace Street (S)	Thru	1,128	1,040	-88	-8%	2.7
	Croudace Street (S)	Left	57	61	4	6%	0.5
	Pride Avenue (W)	Left	8	35	27	340%	5.9
	Pride Avenue (W)	Right	37	15	-22	-58%	4.2
Croudace/ Mitchell	Croudace Street (N)	Left	19	11	-8	-43%	2.1
	Croudace Street (N)	Thru	1,601	1,677	76	5%	1.9
	Mitchell Street (E)	Left	71	75	4	5%	0.4
	Mitchell Street (E)	Right	25	5	-20	-82%	5.3
	Croudace Street (S)	Thru	1,160	1,036	-124	-11%	3.8
	Croudace Street (S)	Right	56	63	7	12%	0.9
Croudace/ Lookout/ Russell	Croudace Street (N)	Left	52	31	-21	-40%	3.3
	Croudace Street (N)	Thru	1,524	1,678	154	10%	3.8
	Russell Street (E)	Right	40	29	-11	-27%	1.8
	Russell Street (E)	Left	449	498	49	11%	2.3
	Croudace Street (S)	Thru	1,146	1,115	-31	-3%	0.9
	Croudace Street (S)	Right	553	569	16	3%	0.7
Jacaranda/ Lookout	Jacaranda Street (N)	Left	196	174	-22	-11%	1.6
	Lookout Road (E)	Right	52	59	7	14%	1.0
	Lookout Road (E)	Thru	1,987	2,132	145	7%	3.2
	Lookout Road (W)	Thru	1,512	1,500	-12	-1%	0.3
Hospital/ Lookout	Lookout Road (N)	Thru	1,886	2,019	133	7%	3.0

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Lookout Road (N)	Right	121	120	-1	0%	0.1
	Lookout Road (S)	Left	231	233	2	1%	0.1
	Lookout Road (S)	Thru	1,218	1,210	-8	-1%	0.2
	Hospital Road (W)	Left	320	300	-20	-6%	1.1
	Hospital Road (W)	Right	687	584	-103	-15%	4.1
Lookout/ McCaffrey	Lookout Road (N)	Thru	1,957	1,976	19	1%	0.4
	Lookout Road (N)	Right	665	621	-44	-7%	1.7
	Lookout Road (S)	Left	503	467	-36	-7%	1.7
	Lookout Road (S)	Thru	1,107	1,137	30	3%	0.9
	McCaffrey (W)	Left	303	306	3	1%	0.2
	McCaffrey (W)	Right	399	406	7	2%	0.4
Grandview/ Lookout	Lookout Road (N)	Thru	2,313	2,278	-35	-2%	0.7
	Lookout Road (N)	Right	90	109	19	21%	1.9
	Lookout Road (S)	Left	118	89	-29	-25%	2.9
	Lookout Road (S)	Thru	1,508	1,498	-10	-1%	0.3
	Grandview Road (W)	Left	55	72	17	32%	2.2
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Thru	1,967	1,916	-51	-3%	1.2
	Charlestown Road (N)	Right	368	350	-18	-5%	1.0
	Charlestown Road (S)	Left	347	336	-11	-3%	0.6
	Charlestown Road (S)	Thru	1,438	1,349	-89	-6%	2.4
	Cardiff Road (W)	Left	255	238	-17	-7%	1.1
	Cardiff Road (W)	Right	338	341	3	1%	0.2
Carnley/ Charlestown	Charlestown Road (N)	Left	262	258	-4	-2%	0.3
	Charlestown Road (N)	Thru	2,054	1,959	-95	-5%	2.1
	Carnley Avenue (E)	Left	915	847	-68	-7%	2.3
	Carnley Avenue (E)	Right	347	366	19	6%	1.0
	Charlestown Road (S)	Thru	1,394	1,327	-67	-5%	1.8
	Charlestown Road (S)	Right	388	414	26	7%	1.3
Newcastle/ NICB	Main Road (N)	Left	1,094	1,122	28	3%	0.8
	Main Road (N)	Right	653	706	53	8%	2.0
	Newcastle Road (E)	Thru	1,362	1,363	1	0%	0.0
	Newcastle Road (E)	Right	712	738	26	4%	1.0
	Newcastle Road (W)	Left	373	386	12	3%	0.6
	Newcastle Road (W)	Thru	1,293	1,364	71	5%	1.9
Blue Gum/ University	Blue Gum Street (N)	Left	367	376	9	3%	0.5
	Blue Gum Street (N)	Thru	214	224	10	5%	0.7

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	University Street (E)	Left	381	403	22	6%	1.1
	University Street (E)	Right	747	705	-42	-6%	1.6
	Blue Gum Street (S)	Thru	289	304	15	5%	0.9
	Blue Gum Street (S)	Right	156	183	28	18%	2.1
NICB/ University	NICB Street (N)	Left	74	65	-9	-12%	1.1
	NICB Street (N)	Right	144	136	-8	-5%	0.6
	University Road (E)	Left	550	538	-12	-2%	0.5
	University Road (E)	Thru	876	835	-41	-5%	1.4
	University Road (E)	Right	225	224	-1	0%	0.1
	NICB Street (S)	Left	104	140	36	35%	3.3
	NICB Street (S)	Right	279	258	-21	-8%	1.3
	University Road (W)	Left	55	66	11	21%	1.5
	University Road (W)	Thru	354	345	-9	-2%	0.5
	University Road (W)	Right	144	146	2	1%	0.2
University/ University Access	University Access (N)	Left	138	121	-17	-12%	1.5
	University Access (N)	Right	578	557	-21	-4%	0.9
	University Road (E)	Thru	1,079	1,041	-37	-3%	1.1
	University Road (E)	Right	48	49	1	1%	0.1
	University Road (W)	Left	226	202	-24	-10%	1.6
	University Road (W)	Thru	490	467	-23	-5%	1.1

Appendix B

Observed vs Modelled Link Counts

Morning Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Arrival	248	228	-20	8%	1.3
	Douglas Street (N)	Departure	185	173	-12	7%	0.9
	Newcastle Road (E)	Arrival	1,510	1,464	-46	3%	1.2
	Newcastle Road (E)	Departure	2,656	2,665	9	0%	0.2
	Douglas Street (S)	Arrival	317	324	7	2%	0.4
	Douglas Street (S)	Departure	161	152	-9	5%	0.7
	Newcastle Road (W)	Arrival	2,398	2,404	6	0%	0.1
	Newcastle Road (W)	Departure	1,471	1,429	-42	3%	1.1
Drury/ Newcastle/ Victory	Drury Street (N)	Arrival	37	44	7	19%	1.1
	Drury Street (N)	Departure	159	166	7	4%	0.5
	Newcastle Road (E)	Arrival	1,406	1,447	41	3%	1.1
	Newcastle Road (E)	Departure	2,651	2,709	58	2%	1.1
	Victory Parade (S)	Arrival	226	214	-12	5%	0.8
	Victory Parade (S)	Departure	28	30	2	7%	0.4
	Newcastle Road (W)	Arrival	2,604	2,684	80	3%	1.6
	Newcastle Road (W)	Departure	1,435	1,485	50	3%	1.3
Blue Gum/ Newcastle	Blue Gum Road (N)	Arrival	269	270	1	0%	0.1
	Blue Gum Road (N)	Departure	250	286	36	15%	2.2
	Newcastle Road (E)	Arrival	1,400	1,467	67	5%	1.8
	Newcastle Road (E)	Departure	2,643	2,704	61	2%	1.2
	Newcastle Road (W)	Arrival	2,633	2,706	74	3%	1.4
	Newcastle Road (W)	Departure	1,409	1,453	44	3%	1.2
Croudace/ Dent/ Newcastle	Dent Street (N)	Arrival	284	261	-23	8%	1.4
	Dent Street (N)	Departure	264	229	-35	13%	2.2
	Newcastle Road (E)	Arrival	1,421	1,450	29	2%	0.8
	Newcastle Road (E)	Departure	2,067	2,214	147	7%	3.2
	Croudace Street (S)	Arrival	1,551	1,551	0	0%	0.0
	Croudace Street (S)	Departure	1,223	1,183	-40	3%	1.1
	Newcastle Road (W)	Arrival	2,244	2,365	121	5%	2.5
	Newcastle Road (W)	Departure	1,946	2,000	54	3%	1.2
Morehead/ Newcastle	Morehead Street (N)	Arrival	101	100	-1	1%	0.1
	Morehead Street (N)	Departure	61	61	0	0%	0.0
	Newcastle Road (E)	Arrival	1,347	1,374	27	2%	0.7
	Newcastle Road (E)	Departure	2,454	2,428	-26	1%	0.5
	Morehead Street (S)	Arrival	353	344	-9	3%	0.5

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Morehead Street (S)	Departure	74	74	0	1%	0.0
	Newcastle Road (W)	Arrival	2,227	2,200	-27	1%	0.6
	Newcastle Road (W)	Departure	1,439	1,456	17	1%	0.4
Croudace/ Howe	Croudace Street (N)	Arrival	1,221	1,205	-16	1%	0.5
	Croudace Street (N)	Departure	1,706	1,572	-134	8%	3.3
	Howe Street (E)	Arrival	303	306	3	1%	0.2
	Howe Street (E)	Departure	265	295	30	11%	1.8
	Croudace Street (S)	Arrival	1,512	1,370	-142	9%	3.8
	Croudace Street (S)	Departure	1,065	1,013	-52	5%	1.6
	Croudace/ Pride	Croudace Street (N)	Arrival	1,111	1,000	-111	10%
Croudace Street (S)		Departure	1,178	1,076	-102	9%	3.0
Croudace Street (S)		Arrival	1,580	1,380	-200	13%	5.2
Pride Avenue (W)		Departure	15	19	4	27%	1.0
Pride Avenue (W)		Arrival	80	79	-1	2%	0.1
Croudace/ Mitchell	Croudace Street (N)	Departure	1,580	1,359	-220	14%	5.7
	Croudace Street (N)	Arrival	1,165	1,072	-93	8%	2.8
	Mitchell Street (E)	Departure	40	55	15	38%	2.2
	Mitchell Street (E)	Arrival	53	40	-13	24%	1.9
	Croudace Street (S)	Departure	1,189	1,093	-96	8%	2.8
	Croudace Street (S)	Arrival	1,591	1,395	-196	12%	5.1
Croudace/ Lookout/ Russell	Croudace Street (N)	Departure	1,491	1,407	-84	6%	2.2
	Croudace Street (N)	Arrival	1,149	1,068	-81	7%	2.4
	Russell Street (E)	Departure	740	749	9	1%	0.3
	Russell Street (E)	Arrival	550	562	12	2%	0.5
	Croudace Street (S)	Departure	1,598	1,572	-26	2%	0.6
	Croudace Street (S)	Arrival	2,130	2,097	-33	2%	0.7
Jacaranda/ Lookout	Jacaranda Street (N)	Departure	149	141	-8	6%	0.7
	Jacaranda Street (N)	Arrival	43	46	3	8%	0.5
	Lookout Road (E)	Departure	2,221	2,105	-116	5%	2.5
	Lookout Road (E)	Arrival	1,654	1,580	-74	4%	1.9
	Lookout Road (W)	Departure	1,505	1,439	-66	4%	1.7
	Lookout Road (W)	Arrival	2,178	2,059	-119	5%	2.6
Hospital/ Lookout	Lookout Road (N)	Departure	2,148	2,099	-49	2%	1.1
	Lookout Road (N)	Arrival	1,463	1,427	-36	2%	0.9
	Lookout Road (S)	Departure	1,237	1,283	46	4%	1.3
	Lookout Road (S)	Arrival	2,684	2,630	-54	2%	1.1

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Hospital Road (W)	Departure	1,103	1,014	-89	8%	2.7
	Hospital Road (W)	Arrival	341	338	-3	1%	0.1
Lookout/ McCaffrey	Lookout Road (N)	Departure	2,708	2,642	-66	2%	1.3
	Lookout Road (N)	Arrival	1,234	1,286	52	4%	1.5
	Lookout Road (S)	Departure	1,425	1,469	44	3%	1.1
	Lookout Road (S)	Arrival	2,181	2,214	33	2%	0.7
	McCaffrey (W)	Departure	389	438	49	13%	2.4
	McCaffrey (W)	Arrival	1,107	1,049	-58	5%	1.8
	Grandview/ Lookout	Lookout Road (N)	Departure	2,246	2,250	4	0%
Lookout Road (N)		Arrival	1,459	1,473	14	1%	0.4
Lookout Road (S)		Departure	1,445	1,444	-1	0%	0.0
Lookout Road (S)		Arrival	2,111	2,122	11	1%	0.2
Grandview Road (W)		Departure	64	69	5	7%	0.6
Grandview Road (W)		Arrival	185	168	-17	9%	1.3
Cardiff/ Charlestown/ Lookout		Charlestown Road (N)	Departure	2,066	2,131	65	3%
	Charlestown Road (N)	Arrival	1,394	1,423	29	2%	0.8
	Charlestown Road (S)	Departure	1,610	1,632	22	1%	0.5
	Charlestown Road (S)	Arrival	1,894	1,970	76	4%	1.7
	Cardiff Road (W)	Departure	362	383	21	6%	1.1
	Cardiff Road (W)	Arrival	750	752	2	0%	0.1
Carnley/ Charlestown	Charlestown Road (N)	Departure	1,864	2,033	169	9%	3.8
	Charlestown Road (N)	Arrival	1,620	1,629	9	1%	0.2
	Carnley Avenue (E)	Departure	1,126	1,128	2	0%	0.1
	Carnley Avenue (E)	Arrival	725	735	10	1%	0.4
	Charlestown Road (S)	Departure	1,782	1,788	6	0%	0.2
	Charlestown Road (S)	Arrival	2,427	2,586	159	7%	3.2
Newcastle/ NICB	Main Road (N)	Departure	1,964	1,902	-62	3%	1.4
	Main Road (N)	Arrival	1,185	1,150	-35	3%	1.0
	Newcastle Road (E)	Departure	2,457	2,419	-38	2%	0.8
	Newcastle Road (E)	Arrival	2,041	1,960	-80	4%	1.8
	Newcastle Road (W)	Departure	1,403	1,466	63	4%	1.7
	Newcastle Road (W)	Arrival	2,598	2,676	78	3%	1.5
Blue Gum/ University	Blue Gum Street (N)	Departure	330	360	31	9%	1.7
	Blue Gum Street (N)	Arrival	1,073	1,003	-70	7%	2.2
	University Street (E)	Departure	928	844	-84	9%	2.8
	University Street (E)	Arrival	410	431	21	5%	1.0

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Blue Gum Street (S)	Departure	469	485	16	3%	0.7
	Blue Gum Street (S)	Arrival	243	256	13	5%	0.8
NICB/ University	NICB Street (N)	Arrival	277	268	-9	3%	0.6
	NICB Street (N)	Departure	176	185	9	5%	0.7
	University Road (E)	Arrival	596	670	74	12%	2.9
	University Road (E)	Departure	1,615	1,519	-96	6%	2.4
	NICB Street (S)	Arrival	809	756	-53	7%	1.9
	NICB Street (S)	Departure	375	395	20	5%	1.0
	University Road (W)	Arrival	905	837	-68	8%	2.3
	University Road (W)	Departure	421	431	10	2%	0.5
University/ University Access	University Access (N)	Departure	828	824	-4	0%	0.1
	University Access (N)	Arrival	93	111	18	20%	1.8
	University Road (E)	Departure	933	910	-23	2%	0.8
	University Road (E)	Arrival	699	779	80	12%	3.0
	University Road (W)	Departure	617	671	54	9%	2.1
	University Road (W)	Arrival	1,586	1,514	-72	5%	1.8

Evening Peak Period

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
Douglas/ Newcastle	Douglas Street (N)	Arrival	255	233	-22	9%	1.4
	Douglas Street (N)	Departure	103	128	25	25%	2.4
	Newcastle Road (E)	Arrival	2,267	2,265	-2	0%	0.0
	Newcastle Road (E)	Departure	1,746	1,789	43	2%	1.0
	Douglas Street (S)	Arrival	236	230	-6	3%	0.4
	Douglas Street (S)	Departure	352	357	5	2%	0.3
	Newcastle Road (W)	Arrival	1,600	1,649	49	3%	1.2
	Newcastle Road (W)	Departure	2,157	2,102	-55	3%	1.2
Drury/ Newcastle/ Victory	Drury Street (N)	Arrival	190	188	-2	1%	0.1
	Drury Street (N)	Departure	100	102	2	2%	0.2
	Newcastle Road (E)	Arrival	2,113	2,122	9	0%	0.2
	Newcastle Road (E)	Departure	1,816	1,755	-61	3%	1.4
	Victory Parade (S)	Arrival	94	98	4	5%	0.4
	Victory Parade (S)	Departure	47	43	-4	9%	0.7
	Newcastle Road (W)	Arrival	1,833	1,783	-49	3%	1.2
	Newcastle Road (W)	Departure	2,267	2,293	26	1%	0.5
Blue Gum/ Newcastle	Blue Gum Road (N)	Arrival	498	487	-11	2%	0.5

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Blue Gum Road (N)	Departure	445	470	25	6%	1.2
	Newcastle Road (E)	Arrival	2,111	2,084	-27	1%	0.6
	Newcastle Road (E)	Departure	1,681	1,747	66	4%	1.6
	Newcastle Road (W)	Arrival	1,669	1,780	111	7%	2.7
	Newcastle Road (W)	Departure	2,152	2,135	-17	1%	0.4
Croudace/ Dent/ Newcastle	Dent Street (N)	Arrival	356	336	-20	6%	1.1
	Dent Street (N)	Departure	249	248	-1	0%	0.1
	Newcastle Road (E)	Arrival	1,929	2,065	136	7%	3.0
	Newcastle Road (E)	Departure	1,826	1,857	31	2%	0.7
	Croudace Street (S)	Arrival	1,245	1,295	50	4%	1.4
	Croudace Street (S)	Departure	1,916	1,892	-24	1%	0.6
	Newcastle Road (W)	Arrival	2,492	2,465	-27	1%	0.5
	Newcastle Road (W)	Departure	2,031	2,164	133	7%	2.9
Morehead/ Newcastle	Morehead Street (N)	Arrival	89	85	-4	5%	0.5
	Morehead Street (N)	Departure	60	61	1	2%	0.2
	Newcastle Road (E)	Arrival	1,958	2,078	120	6%	2.7
	Newcastle Road (E)	Departure	2,092	2,012	-80	4%	1.8
	Morehead Street (S)	Arrival	268	248	-20	7%	1.2
	Morehead Street (S)	Departure	148	133	-15	10%	1.2
	Newcastle Road (W)	Arrival	1,927	1,861	-66	3%	1.5
	Newcastle Road (W)	Departure	1,942	2,066	124	6%	2.8
Croudace/ Howe	Croudace Street (N)	Arrival	1,734	1,899	165	10%	3.9
	Croudace Street (N)	Departure	1,359	1,314	-45	3%	1.2
	Howe Street (E)	Arrival	387	391	4	1%	0.2
	Howe Street (E)	Departure	343	352	9	3%	0.5
	Croudace Street (S)	Arrival	1,149	1,084	-65	6%	1.9
	Croudace Street (S)	Departure	1,568	1,709	141	9%	3.5
Croudace/ Pride	Croudace Street (N)	Arrival	1,583	1,674	91	6%	2.2
	Croudace Street (S)	Departure	1,620	1,689	69	4%	1.7
	Croudace Street (S)	Arrival	1,185	1,100	-85	7%	2.5
	Pride Avenue (W)	Departure	57	61	4	6%	0.5
	Pride Avenue (W)	Arrival	45	51	6	12%	0.8
Croudace/ Mitchell	Croudace Street (N)	Departure	1,185	1,040	-145	12%	4.3
	Croudace Street (N)	Arrival	1,620	1,687	67	4%	1.7
	Mitchell Street (E)	Departure	75	73	-2	2%	0.2
	Mitchell Street (E)	Arrival	96	79	-17	18%	1.8
	Croudace Street (S)	Departure	1,672	1,751	79	5%	1.9

Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Croudace Street (S)	Arrival	1,216	1,098	-118	10%	3.5
Croudace/ Lookout/ Russell	Croudace Street (N)	Departure	1,186	1,145	-41	3%	1.2
	Croudace Street (N)	Arrival	1,576	1,709	133	8%	3.3
	Russell Street (E)	Departure	605	600	-5	1%	0.2
	Russell Street (E)	Arrival	489	528	39	8%	1.7
	Croudace Street (S)	Departure	1,973	2,176	203	10%	4.5
	Croudace Street (S)	Arrival	1,699	1,684	-15	1%	0.4
Jacaranda/ Lookout	Jacaranda Street (N)	Departure	52	59	7	14%	1.0
	Jacaranda Street (N)	Arrival	196	174	-22	11%	1.6
	Lookout Road (E)	Departure	1,708	1,674	-34	2%	0.8
	Lookout Road (E)	Arrival	2,039	2,191	152	7%	3.3
	Lookout Road (W)	Departure	1,987	2,132	145	7%	3.2
	Lookout Road (W)	Arrival	1,512	1,500	-12	1%	0.3
Hospital/ Lookout	Lookout Road (N)	Departure	1,538	1,510	-28	2%	0.7
	Lookout Road (N)	Arrival	2,007	2,139	132	7%	2.9
	Lookout Road (S)	Departure	2,573	2,603	30	1%	0.6
	Lookout Road (S)	Arrival	1,449	1,443	-6	0%	0.2
	Hospital Road (W)	Departure	352	354	2	0%	0.1
	Hospital Road (W)	Arrival	1,007	884	-123	12%	4.0
Lookout/ McCaffrey	Lookout Road (N)	Departure	1,410	1,444	34	2%	0.9
	Lookout Road (N)	Arrival	2,622	2,597	-25	1%	0.5
	Lookout Road (S)	Departure	2,356	2,382	26	1%	0.5
	Lookout Road (S)	Arrival	1,610	1,604	-6	0%	0.2
	McCaffrey (W)	Departure	1,168	1,088	-80	7%	2.4
	McCaffrey (W)	Arrival	702	713	11	2%	0.4
Grandview/ Lookout	Lookout Road (N)	Departure	1,563	1,570	7	0%	0.2
	Lookout Road (N)	Arrival	2,403	2,387	-16	1%	0.3
	Lookout Road (S)	Departure	2,313	2,278	-35	2%	0.7
	Lookout Road (S)	Arrival	1,626	1,587	-39	2%	1.0
	Grandview Road (W)	Departure	208	198	-10	5%	0.7
	Grandview Road (W)	Arrival	55	72	17	32%	2.2
Cardiff/ Charlestown/ Lookout	Charlestown Road (N)	Departure	1,693	1,587	-106	6%	2.6
	Charlestown Road (N)	Arrival	2,335	2,266	-69	3%	1.4
	Charlestown Road (S)	Departure	2,305	2,257	-48	2%	1.0
	Charlestown Road (S)	Arrival	1,785	1,685	-100	6%	2.4
	Cardiff Road (W)	Departure	715	686	-29	4%	1.1

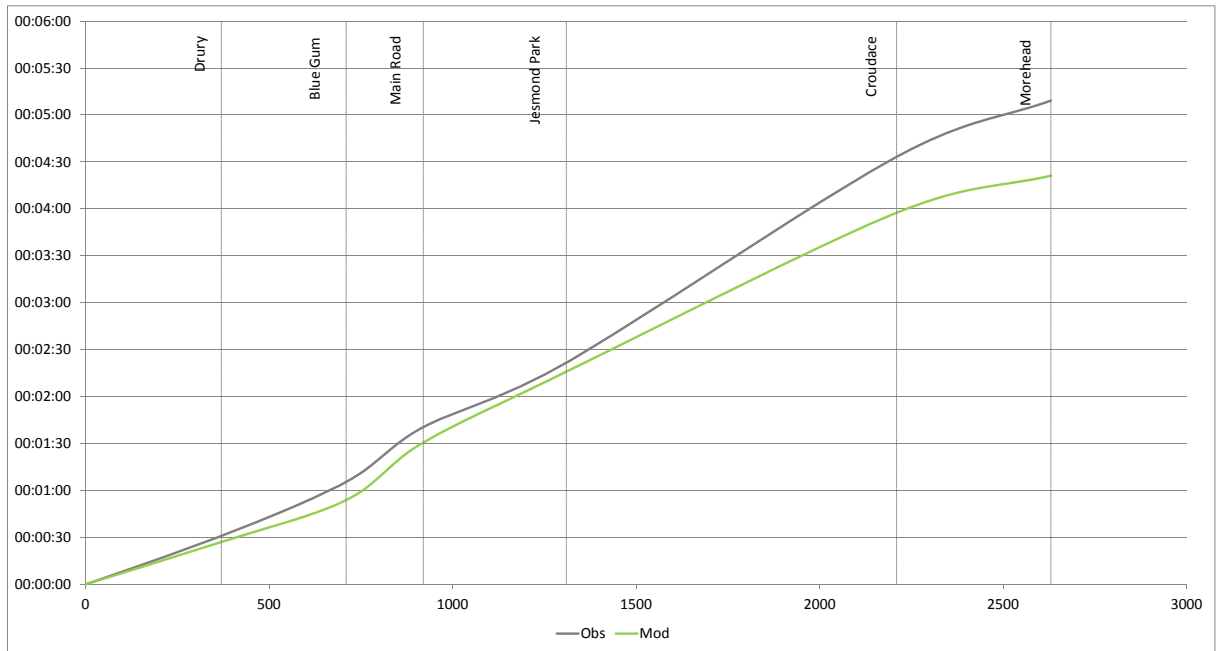
Intersection	Approach	Movement	Obs	Mod	Dif	% Dif	GEH
	Cardiff Road (W)	Arrival	593	579	-14	2%	0.6
Carnley/ Charlestown	Charlestown Road (N)	Departure	1,741	1,693	-48	3%	1.2
	Charlestown Road (N)	Arrival	2,316	2,217	-99	4%	2.1
	Carnley Avenue (E)	Departure	650	672	22	3%	0.9
	Carnley Avenue (E)	Arrival	1,262	1,213	-49	4%	1.4
	Charlestown Road (S)	Departure	2,969	2,806	-163	5%	3.0
	Charlestown Road (S)	Arrival	1,782	1,741	-41	2%	1.0
Newcastle/ NICB	Main Road (N)	Departure	1,085	1,124	39	4%	1.2
	Main Road (N)	Arrival	1,747	1,828	81	5%	1.9
	Newcastle Road (E)	Departure	2,387	2,486	99	4%	2.0
	Newcastle Road (E)	Arrival	2,074	2,101	27	1%	0.6
	Newcastle Road (W)	Departure	2,015	2,069	54	3%	1.2
	Newcastle Road (W)	Arrival	1,667	1,750	83	5%	2.0
Blue Gum/ University	Blue Gum Street (N)	Departure	1,036	1,009	-27	3%	0.8
	Blue Gum Street (N)	Arrival	581	600	19	3%	0.8
	University Street (E)	Departure	522	560	37	7%	1.6
	University Street (E)	Arrival	1,128	1,108	-20	2%	0.6
	Blue Gum Street (S)	Departure	595	627	32	5%	1.3
	Blue Gum Street (S)	Arrival	445	488	43	10%	2.0
NICB/ University	NICB Street (N)	Arrival	218	201	-17	8%	1.2
	NICB Street (N)	Departure	280	291	11	4%	0.6
	University Road (E)	Arrival	1,651	1,597	-54	3%	1.3
	University Road (E)	Departure	707	668	-39	6%	1.5
	NICB Street (S)	Arrival	383	398	15	4%	0.8
	NICB Street (S)	Departure	694	684	-10	1%	0.4
	University Road (W)	Arrival	553	558	5	1%	0.2
	University Road (W)	Departure	1,124	1,112	-12	1%	0.4
University/ University Access	University Access (N)	Departure	274	251	-23	8%	1.4
	University Access (N)	Arrival	716	678	-38	5%	1.4
	University Road (E)	Departure	628	588	-40	6%	1.6
	University Road (E)	Arrival	1,127	1,090	-37	3%	1.1
	University Road (W)	Departure	1,657	1,598	-58	4%	1.4
	University Road (W)	Arrival	716	669	-47	7%	1.8

Appendix C

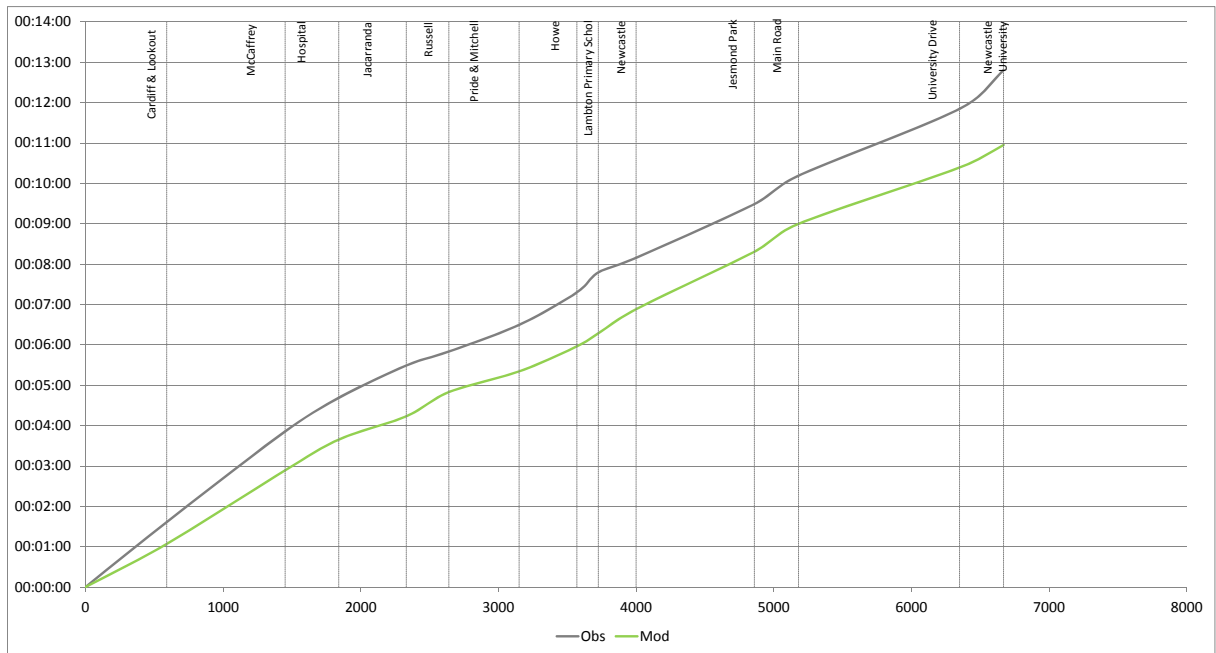
Journey Time Graphs

Morning Peak

Route 4: Newcastle EBD

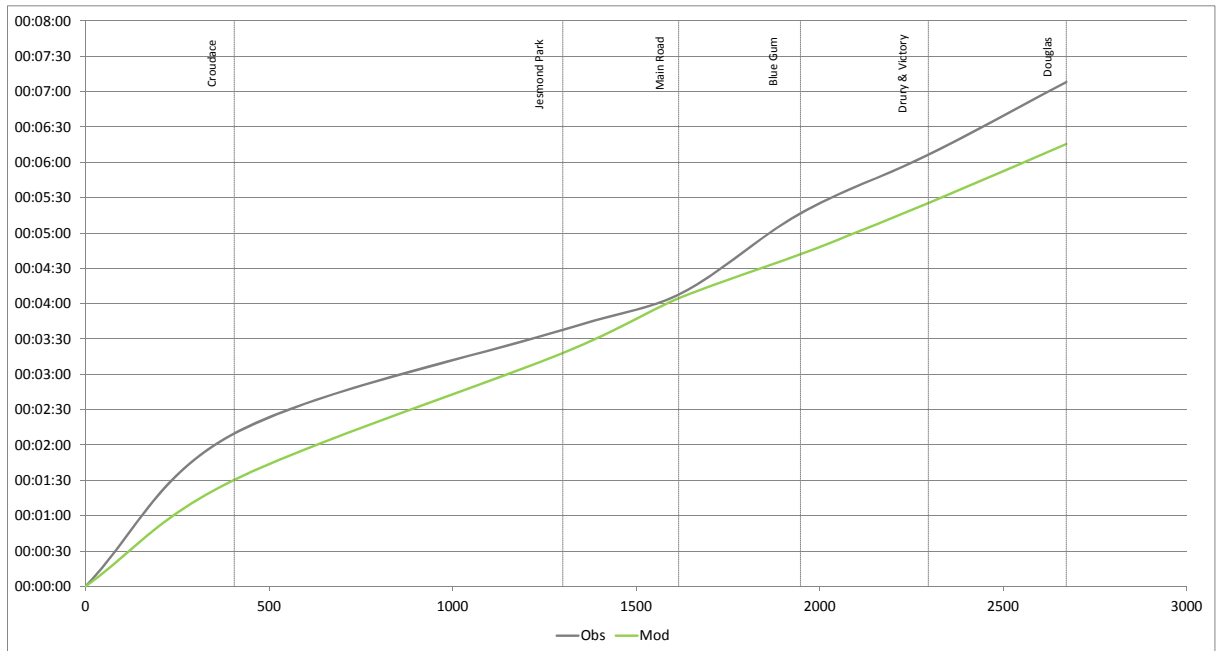


Route 7: Lookout- Croudace NBD

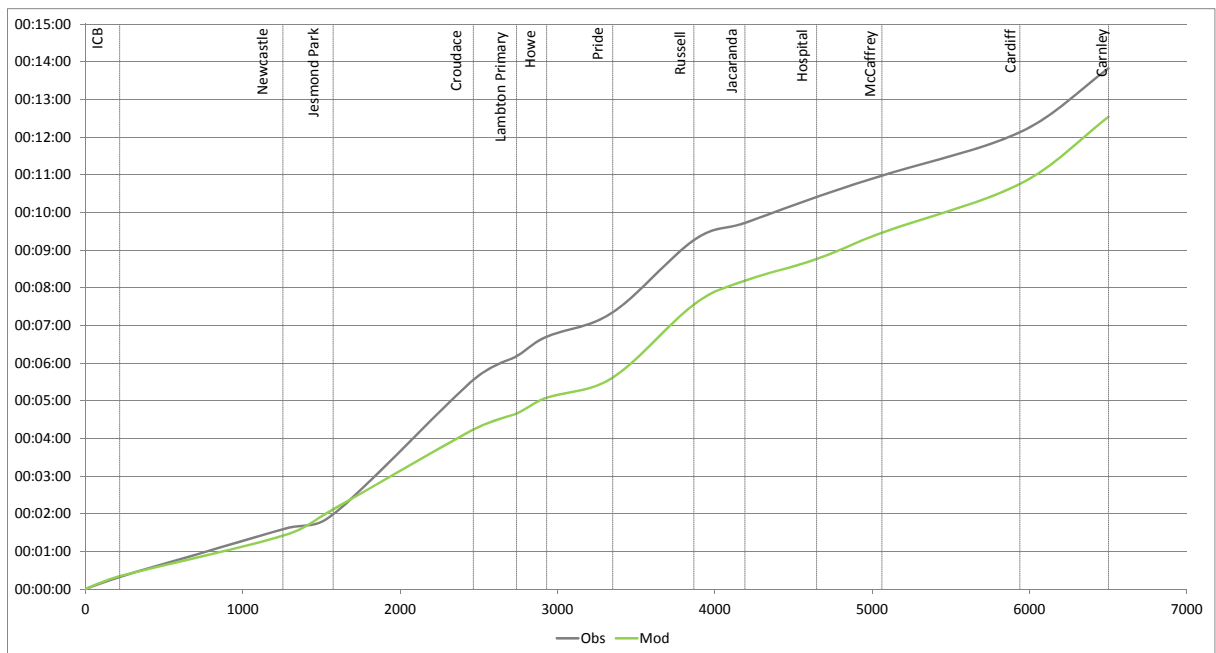


Evening Peak

Route 4: Newcastle WBD



Route 7: Lookout – Croudaice SBD





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