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PARAMICS MODELLING REPORT
HAROLD PARK - STAGE 1

HAROLD PARK PARAMICS MODELLING OPTIONS ASSESSMENT REPORT

FOR

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1. INTRODUCTION

1.1 BACKGROUND

Bitzios Consulting was commissioned by the City of Sydney (CoS) to develop a Paramics microsimulation model to inform the assessment of the traffic impacts of the proposed re-development of the Harold Park Paceway site. The model has also been used to assess potential improvements that could be implemented to mitigate or manage the traffic impacts of the development.

The former Harold Park trotting complex is being redeveloped by Mirvac. The development proposal includes mixed use medium density residential apartments, retail, and community facilities and open space. Specifically, the Stage 1 Development Application / Masterplan (DA D/2011/1298) states that the Stage 1 concept proposal for the former Harold Park Paceway Site includes:

- approximately 1,250 new dwellings in residential apartment buildings ranging from 3 to 8 storeys, 7565sqm non-residential floor space, 3.8ha public open space;
- restoration of heritage Tramsheds;
- dedication of 500sqm of internal space as a community facility;
- bulk excavation and infrastructure works;
- a new intersection and road widening;
- re-alignment of Ross Street; and
- car parking for the Tramsheds precinct.

The master plan of development is shown in Figure 1.1

Figure 1.1: Plan of Development

In 2009-2010 ARUP assessed the traffic needs associated with development of the Harold Park Paceway site and the former Rozelle Tram Depot for the CoS. Since then Mirvac has submitted a development application with traffic reports for the development prepared by Halcrow. An independent peer review of the Stage 1 development application has also been undertaken by GTA Consultants on behalf of the City. GTA recommended that a traffic model be developed to better assess the cumulative impacts of traffic congestion and vehicle queuing on The Crescent-Minogue Crescent corridor. Furthermore, the CoS is interested in determining what traffic improvements could be implemented to manage additional congestion created as a consequence of the traffic generated by the development.

1.2 LOCATION AND STUDY AREA

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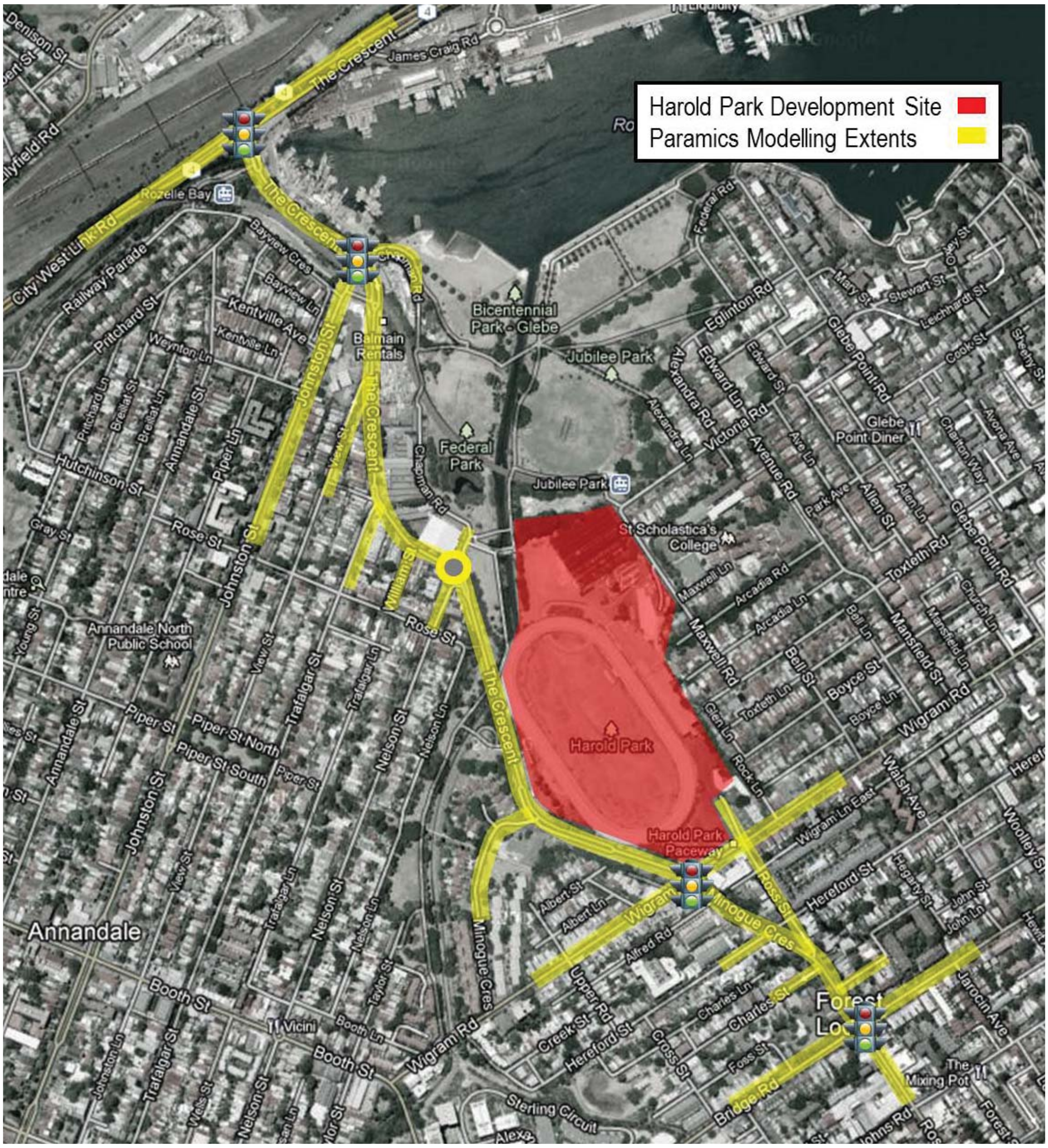
The study area is located approximately 2.5km south-west of the Sydney CBD. Figure 1.2 shows the location of the Harold Park development site and the extent of the Paramics model. The model boundary was defined by GTA initially and then through the brief provided by the CoS to Bitzios Consulting. The Paramics model area includes five key intersections:

- City West Link Road/The Crescent (signalised);
- The Crescent/Johnston Street (signalised);
- Minogue Crescent/Wigram Road (signalised);
- Ross Street/Bridge Road (signalised); and
- The Crescent/Chapman Road (roundabout).

A new four-way signalised intersection at The Crescent/Minogue Crescent is also proposed as part of the development.



Source: Google Maps Australia

Figure 1.2 Study Area and Paramics Model Extents

The selection of an appropriate area to model is a balance between the size of the development being assessed and the level of detail/certainty in the outcomes being sought. Typically, the larger the model area, the more aggregate the results and the less detailed the conclusions can be about the need for specific treatments in specific locations. For the assessment of the Harold Park development, we believe that GTA has specified an appropriate model area to simulate and investigate. The area recommended to model provides sufficient rigour in the intersection needs analysis required to manage the additional traffic generated by the development whilst still accounting for traffic developments and general traffic growth outside the immediate catchment of the corridor.

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1.3 METHODOLOGY AND SCOPE

This assessment considers the proposed development at the year of full site occupation which for modelling purposes has been assumed by the CoS to be 2019. The assessment compares the "with development" traffic conditions for a number of corridor configuration options to the "no development" conditions for the weekday afternoon peak period. The options modelled were:

- Option 1 – With development and no upgrades;
- Option 2 – With development and an internal road closure;
- Option 3 – With development and GTA-recommended improvement;
- Option 4A – With development and GTA improvement including the operation of the two northern intersections (City West and Johnston Street) as a coordinated signal group; and
- Option 4B – With Development and internal road closure including operation of the two northern intersections as a coordinated signal group.

The above options are described in more detail in Section 3 of this report.

Details of the Paramics model creation and validation are provided in the *Harold Park Paramics Modelling – Calibration and Validation* Technical Note included as Appendix A of this report. The 2012 base model along with the calibration and validation technical note was audited by an independent consultant in accordance with NSW Roads and Maritime Services (RMS) standards. This process involved the model being independently audited by an RMS-approved auditor in accordance with the "best practice" processes contained in the RMS Paramics Microsimulation Modelling Manual.

Assessment using the future year models involved comparing the traffic performance of the various corridor options (with development) against the "no development" situation. The creation of the 2019 base (i.e. no development) traffic demands and the traffic assessment methodology involved:

- calculating annual growth rates (based on RMS strategic model growth data) to determine 2019 background traffic demands in the study area;
- estimating the traffic generation of the new development, distributing this traffic to other zones in the model and adding it to the background traffic demands;
- coding each configuration option into the validated Paramics Model;
- running each option model and extracting a standard set of outputs for each option; and
- comparing the outputs of each option against the "no development" situation.

Following this process and through observation of the effects of the development traffic on The Crescent-Minogue Crescent corridor, two improvement options were identified and subsequently tested. The results of these tests lead to the conclusions and recommendations regarding improvements to the corridor that will assist in managing the additional traffic generated by the development.

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2. PARAMICS MODEL DEVELOPMENT

2.1 2019 PM BASE MODEL

Details of the base 2012 PM Paramics model development and traffic demand and assignment methodologies are discussed in the *Harold Park Paramics Modelling – Calibration and Validation* Technical Note included as Appendix A of this report.

Bitzios Consulting was provided with a 10 year forecast of traffic growth by Roads and Maritime Services (RMS). The data was provided as link volumes based on the RMS strategic transport model. This model takes into account the increases in development (reflected as population and employment changes) in the entire Sydney Metropolitan Area. From this data Bitzios Consulting calculated the percentage growth for 10 years (i.e. 2009-2019) by link for the PM peak.

The growth southbound on The Crescent over 10 years was less than 1% while the northbound growth was between 3% and 5% over this period. On a conservative basis, all origin destination (OD) pairs in the traffic demand matrix contributing to the northbound right turn from the Crescent to the Crescent at City West Link were increased by 5%. Some localised turns were also factored based on the data from the strategic model. This process of review, adjustment and refinement of growth rates was done in close consultation with the RMS and the final growth rates used in the model were endorsed by the RMS.

2.2 2019 PM WITH DEVELOPMENT MODELS

"With development" model networks were created by adding the Harold Park development's internal network (links and intersections). Figure 2.1 shows the base Paramics model network with additional links coded for the development area.

Figure 2.1 Paramics Network including Harold Park Development Area

Additional zones were added to the base model to represent various components and access points for the development. Figure 2.2 shows the new zones added to the model to represent the proposed development, along with the connection points of each zone.

Figure 2.2 Zones Representing the Harold Park Development Area

Zone 5 was present in the base model as well, but in the "with development" future year model additional development traffic was added to this zone. Zones 21, 22 and Zone 23 were new zones added to the zones in the base model.

2.3 DEVELOPMENT-GENERATED TRAFFIC

The development's traffic generation was calculated as 650 vehicles per hour in the PM peak hour. This total is slightly different to the Halcrow estimates for the "Proposed Masterplan" and "Rezoning Study" due to slightly different assumptions regarding land uses on the site but is consistent with the GTA land use assumptions.

The traffic generation for the assessment in this report was derived from RTA's *Guide to Traffic Generating Developments* assuming 4.1 trips per 100m^2 GFA for retail (reflecting constrained parking provisions) and 0.29 trips per dwelling for residential, and based on the following development yield:

- 7,565m^2 GFA of retail; and
- 1,250 residential units.

It has subsequently been recognised that some of the retail area may in fact be developed as commercial area with a traffic generation rate approximately half of the retail rate. However, in the critical PM peak, almost 80% of commercial use (e.g. office space) movements would be exiting the site which would have similar effects to the volume of traffic exiting the same retail area. Notwithstanding this, the retail rate has been used as the basis for a conservative assessment of traffic management needs.

The *In:Out* directional splits assumed in the PM peak were:

- Retail 50:50; and

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- Residential 80:20

The assumed development trip distribution is shown in Figure 2.3. This distribution has been derived from the November 2010 Arup report: *Harold Park Paceway Transport, Traffic and Access "Addendum" Study*.

This shows that around 40% of the development-generated traffic will use The Crescent north of the site, while around 24%-25% of the development traffic will travel to/from the south on Minogue Crescent and Ross Street.

Figure 2.3: Development Trip Distribution

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3. FUTURE YEAR OPTION MODELLING

3.1 2019 PM (WITHOUT DEVELOPMENT)

3.1.1 Option Description

The 2019 PM “without development” model was run to determine the base network operation assuming only background traffic growth (as advised by RMS) and no network upgrades.

A total of 10 model runs were conducted for the base case and for each option using different seeds. Seed values provide “random” vehicle release profiles of vehicles from the traffic zones. It is important to run simulation models for multiple seeds to develop an understanding of the potential variability in results and hence potential variability in day-to-day travel times and queuing. The need to run the models using 10 different seed values (instead of the typical convention of 5) was established during the model calibration and validation process.

Results for the 2019 Base Case and options were extracted for the runs that corresponded to the “maximum”, “median” and “minimum” travel times in The Crescent-Minogue Crescent corridor.

3.1.2 Base 2019 Model Queuing Assessment

Given that the intersections of The Crescent with City West and with Johnston Street are near/at capacity in 2012, the analysis showed that additional demand up to 2019 results in lengthening of northbound queues on The Crescent.

The maximum “back of queue” on The Crescent northbound did vary significantly between different model seed runs showing the sensitivity of northbound conditions to minor changes in demand when near/at capacity. Back of queue lengths for the maximum, median and minimum seed runs are presented in Appendix B.

Figure 3.1 shows the typical intersection queuing at City West Link Road, Johnston Street and Chapman Road intersections. Most evident is the northbound approach queue at Johnston Street/The Crescent intersection which extends back towards the Chapman Road roundabout. Another noticeable observation from this model is the long vehicle queues associated with the southbound right turn movements into Johnston Street. These are observed to queue back to the City West Link Road and this in turn influences the flow of left turning movements from City West Link Road into The Crescent. These queues, however, still remain within the available left turn pocket area.

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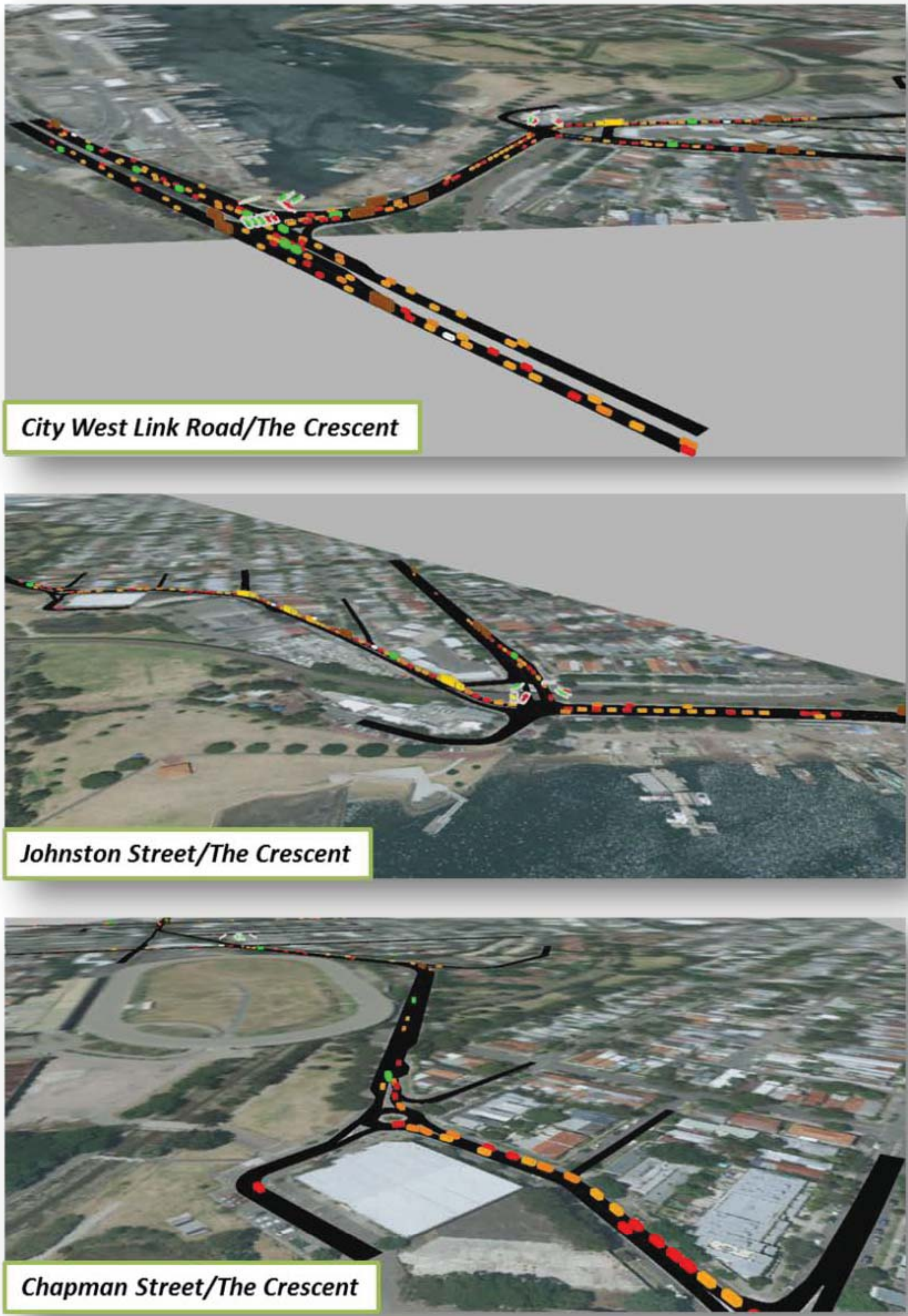

Figure 3.1: Base 2019 PM Model Typical Intersection Queues

3.1.3 Travel Times

Table 3.1 compares the maximum, median and minimum median seeds run results for the 2012 and 2019 travel times on The Crescent – Minogue Crescent – Ross Street corridor between City West Link and Bridge Street. The results show an increase in northbound travel time of around 60 seconds from Bridge

Street to City West Link Road between 2012 and 2019. By comparison the southbound direction shows only a marginal increase in travel time of up to 19 seconds. This reinforces the general observations that northbound in this corridor is the critical direction in the PM peak.

Table 3.1: 2012/2019 Travel Time Comparison (Minutes)

Model Run Result	2012 PM Base		2019 PM Base		Increase	
	NBD	SBD	NBD	SBD	NBD	SBD
Maximum	5:56	3:13	7:01	03:32	1:05	0:19
Median	4:26	2:55	5:28	02:55	1:02	0:00
Minimum	3:34	2:46	4:25	02:46	0:51	0:00

3.2 OPTION 1

3.2.1 Option Description

Option 1 adds the proposed development and its road connections/intersections to the network including a new fourth leg added to the Minogue Crescent/The Crescent intersection, and converting this intersection from priority control to traffic signal control. The fourth leg to the intersection is Road MC02 (the main site access).

Figure 3.2 below shows the additional network links added to incorporate the new development and connection to the base network.

Figure 3.2: With Development – Option 1 Network

3.2.2 Option 1 Network Performance

Figure 3.3 shows typical vehicle queuing observed in the Option 1 models at the City West Link Road, Johnston Street and The Crescent intersections. Key observations include:

- vehicle queues on City West Link Road turning into The Crescent extend beyond the right turn pocket blocking north-eastbound through movements on City West Link Road. This is due to the downstream queues associated with the right turn movement from The Crescent into Johnston Street;
- the northbound queues on The Crescent extend back from Johnston Street and through the Chapman Road roundabout, and almost extend as far as the Minogue Crescent intersection;
- the model shows some vehicles rat-running through the development in a northbound direction exiting The Crescent at Minogue Crescent and re-entering via the Chapman Road roundabout due to congestion o the Crescent and the fact that the Chapman Road roundabout provides right turners from the development access right of way over northbound through traffic; and
- southbound queues on The Crescent extend from Chapman Road to the Johnston Street/The Crescent intersection due to the heavy opposing right turn movement for vehicles entering the development from the south at the Chapman Road roundabout;

Figure 3.3: Option 1 – Typical Intersection Queues

Table 3.2 compares the maximum, minimum and median seeds run travel time results for Option 1 compared to the 2019 PM base model for The Crescent – Minogue Crescent – Ross Street corridor between City West Link and Bridge. The results show that, on average, the northbound travel time increases by around 30 seconds compared to the 2019 base model while the southbound travel time increases by approximately 60 seconds. The major increase in the southbound travel times is a results of congestion at the Chapman Road/The Crescent intersection, with right turning movements (into the development) having priority over southbound through movements.

Table 3.2: Option 1 Travel Time Comparison

Model Run Result	2019 PM Base		Option 1		Increase	
	NBD	SBD	NBD	SBD	NBD	SBD
Maximum	7:01	3:32	6:58	4:42	-0:02	1:00
Median	4:59	2:55	5:28	3:52	0:29	0:57
Minimum	4:25	2:48	4:36	3:16	0:09	0:28

3.3 OPTION 2

3.3.1 Option Description

Option 2 maintains the same external road network as Option 1, but the development's internal road network is modified to remove the link connecting the "Tramshed" retail/commercial development from accessing the Minogue Crescent/The Crescent signalised intersection. Subsequently all development traffic associated with the "Tramsheds" would be required to use the Chapman Road/The Crescent roundabout.

3.3.2 Option 2 Network Performance

Figure 3.4 shows the typical vehicle queue lengths at the City West Link Road, Johnston Street and The Crescent intersection for Option 2. The model shows that that were no discernible queue length differences compared to Option 1. A number of seed runs resulted in blocking of the Chapman Road roundabout caused by a combination of northbound queues extending through the roundabout and relatively high right turn volumes turning out of Chapman Road, with these having priority over the northbound movements on The Crescent.

Whilst the level of blocking that occurs in Paramics at roundabouts is not necessarily reflective of reality (where conventional priorities are often disbanded and drivers give way on a "one-for-one" basis), it does demonstrate the continuously heavy over-capacity conditions at the Chapman Road roundabout in this option. That is, development traffic coming into and out of the development access with right of way over through movements at this location will generate queues back into Johnston Street and back down The Crescent which will then adversely affect the corridor's operations.

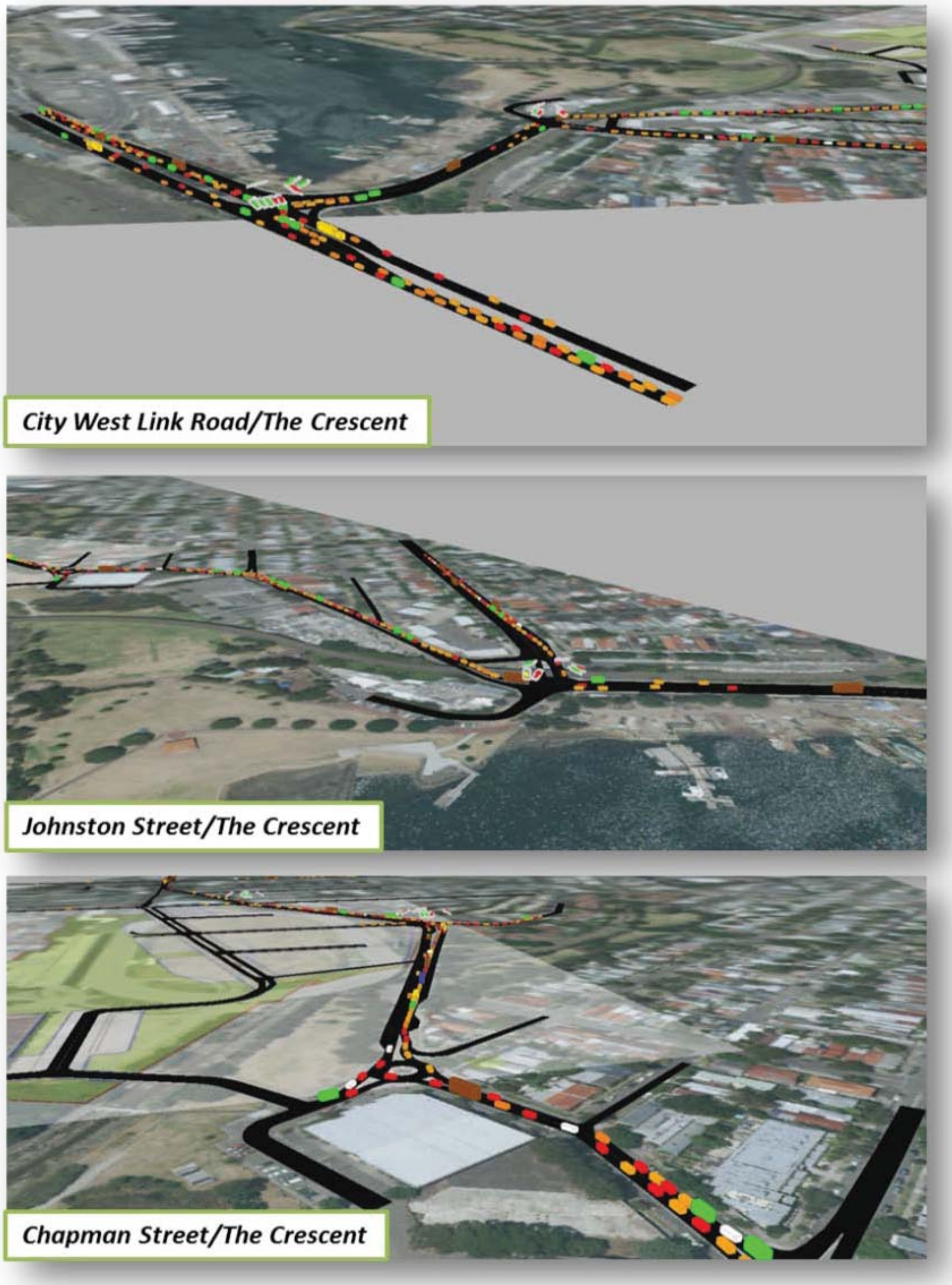

Figure 3.4: Option 2 – Typical Intersection Queues

Table 3.2 compares the maximum, minimum and median seeds run results for Option 2 to the 2019 PM "without development" base model travel times on The Crescent – Minogue Crescent – Ross Street corridor between City West Link and Bridge Street. As with the assessment of queue lengths, the travel times modelled for Option 2 were virtually the same as with Option 1 with about 30 seconds additional delay compared to the base case.

Table 3.3: Option 2 Travel Time Comparison

Item	2019 PM Base		Option 2		Increase	
	NBD	SBD	NBD	SBD	NBD	SBD
Maximum	7:01	3:32	7:09	4:44	0:08	1:12
Median	4:59	2:55	5:28	3:51	0:29	0:56
Minimum	4:25	2:48	4:32	3:18	0:07	0

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3.4 OPTION 3

3.4.1 Option Description

This option introduces a double right turn into Johnston Street from The Crescent. By increasing the capacity of right turning traffic into Johnston Street less green time is needed for this movement and more green time can be allocated to the heavy opposing northbound through movement.

However, given road reserve width constraints in this location, the northbound through traffic lane in The Crescent is limited to a single lane for the length of the adjacent dual right turn lanes. Figure 3.5 below shows the new intersection layout with double right turn into Johnston Street and a single northbound lane.

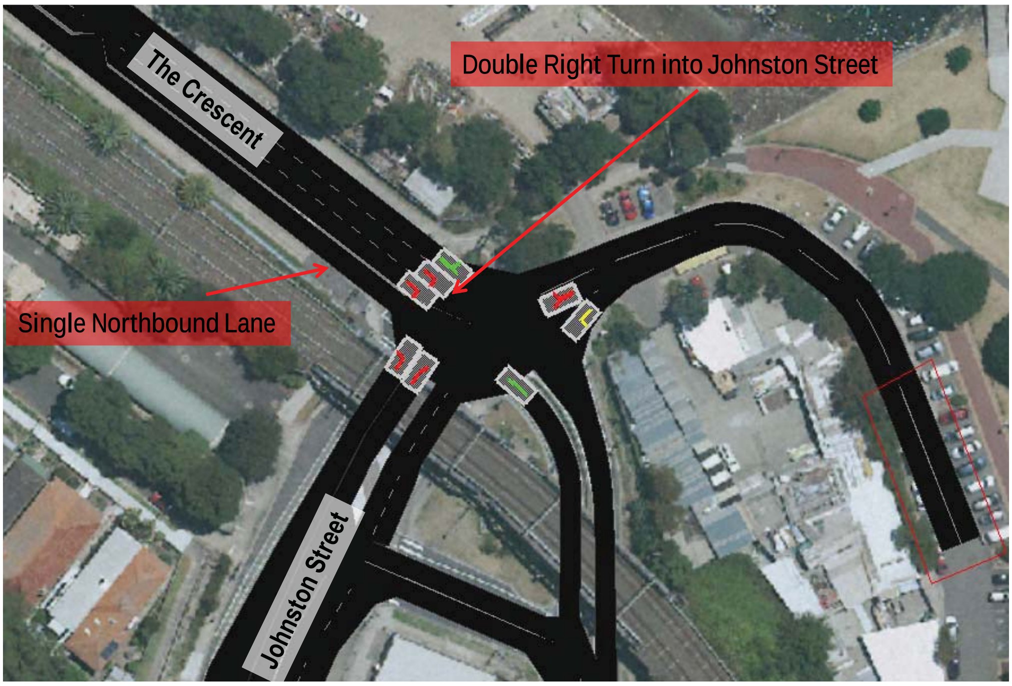

Figure 3.5: Johnston Street/The Crescent Intersection Modification

3.4.2 Option 3 Network Performance

Of the ten seed runs modelled for this option, nine of them resulted in blocking back through the Chapman Road/The Crescent roundabout. This occurred as a result of the reduced northbound queue space available (due to the modifications under this option). The northbound queues then extend back from City West Link and Johnston Street intersections through to the Chapman Road roundabout. This extended queue combined with a large volume of right turn movements from the development's Chapman Road approach to the roundabout blocks the roundabout and southbound traffic can't get through. This leads to some "circular congestion".

These findings highlight that whilst the changes under this option provide more northbound green time at Johnston Street, the reduced queuing space on approach to the City West Link intersection works against this and simply forces the back of queue further south, rendering the additional green time as ineffective.

Figure 3.6 shows the typical vehicle queue lengths at the City West Link Road, Johnston Street and The Crescent intersection for this option. Southbound queues on The Crescent at Johnston Street were substantially reduced (due to the dual right turns), as were the consequential left turn and right turn queues on City West Link Road. However, the northbound queues on The Crescent are significantly increased, and were observed (in a number of seed runs) to extend to through to the Wigram Road intersection.

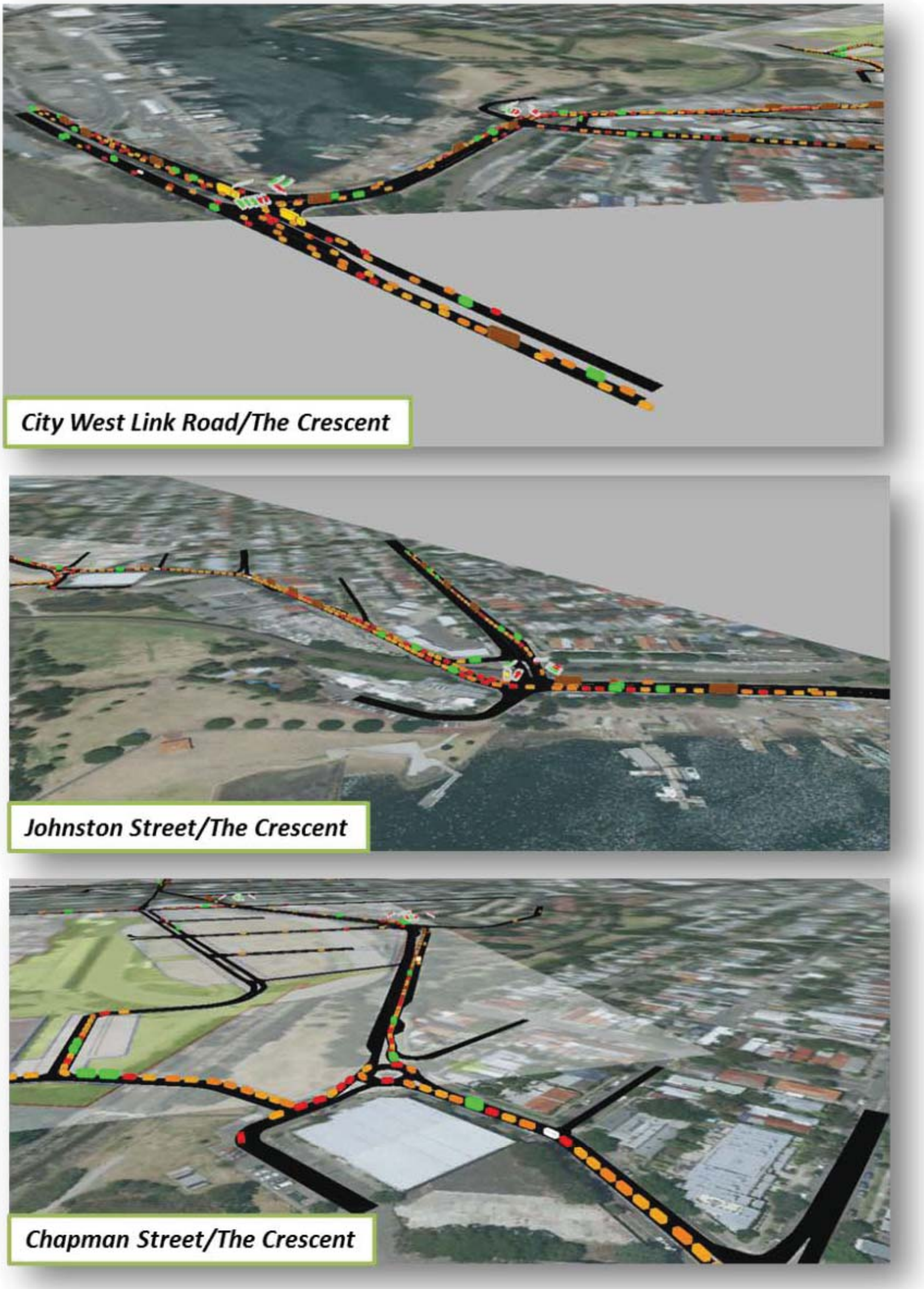

Figure 3.6: Option 3 Typical Intersection Queues

The assessment of corridor travel times was limited to only one seed run, as the blocking of the Chapman Road roundabout occurred on the other nine seed runs, resulting in unreasonable results. Given the limited observed benefit of this option there is therefore little benefit in assessing the model results for this option further.

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3.5 OPTION 4A AND OPTION 4B

3.5.1 Options Description

Options 4a and 4b were developed as extensions of Options 3 and 2 respectively. For both options the two northern signalised intersections (i.e. City West Link Road/The Crescent and The Crescent/Johnston Street) were grouped together and coordinated for northbound traffic movement along The Crescent. The objective of these options was to test whether improved coordination of the two northern intersections would provide more consistent and settled northbound flow and reduce northbound queuing in this area.

3.5.2 Option 4a & 4b Network Performance

The Option 4a model runs show similar unstable results to Option 3. That is, the signal coordination improvements were insufficient to overcome the reduction in northbound queuing space under this option. Five out of the ten seed runs resulted in blocking at the Chapman Road/The Crescent roundabout. Furthermore, the average travel time for the corridor between Bridge Street and City West Link for the runs which were completed was 9:31 minutes in the northbound direction which is significantly higher than Option 1 or 2 at approximately 5:00 minutes.

Option 4b corridor average travel time results were around 30 seconds longer than Option 2 which initially contradicted expectations of the results of this run. When observing the model operations, however, it was clear that there is a key constraint on the capacity of City West Link and that trying to “push” more traffic into this link (though better coordination on The Crescent) simply generates a queue back down The Crescent. That is, there is little benefit of improved coordination until downstream issues on City West Link are improved.

3.6 OPTIONS COMPARISON

3.6.1 Level of Service (LOS)

The Level of Service (LOS) plots based on link intersection delays for the maximum, median and minimum seed values are detailed in Appendix C. It is evident that the addition of the development traffic into the network reduces LOS all along The Crescent-Minogue Crescent corridor. These reductions are particularly noticeable at intersections, with the most noticeable LOS impact occurring in Option 3.

3.6.2 Vehicle Hours Travelled (VHT)

Vehicle Hours Travelled (VHT) for all vehicle trips within the model gives an overall indication of the how the traffic network is performing under each option. VHT is an accumulation of all vehicles travel times in the model within the peak hour period. Generally, lower the VHT result, the lower the delays to vehicles, and hence the better the traffic network is performing. Table 3.4 below summarises the VHT for all the options for all model runs under each seed value.

Table 3.4: 2019 PM Vehicle Hours Travelled

Seed Value	2019 Do Nothing	With Development				
		Option 1	Option 2	Option 3	Option 4A	Option 4B
560	299	438	420	466	429	536
28	311	591	571	605	595	603
7771	297	570	540	656	667	572
86524	301	469	475	545	663	497
2849	257	540	542	568	819	521
5321	284	471	459	602	556	535
137	298	603	596	594	541	603
98812	311	436	407	525	607	513
601027	281	536	557	614	560	588
559	252	478	486	556	564	532
Average	289	513	505	573	600	550

** Represents value as there are ten sets of data*

The VHT results shown that all of the “with development” options have higher VHT values compared to the “no development” options. This is partly due to more vehicles in the network in the “with development” options but is also a consequence of increased queuing with the development traffic added to the network.

When comparing the “with development” options they indicate that Option 2 performs the best of the options in terms of minimising network travel time impacts. Whilst Option 3 provides some benefit to The Crescent southbound north of Johnston and City West Link, it worsens conditions northbound in the critical direction at the critical location.

3.6.3 Travel Times

Table 3.5 summarises the median corridor travel time results from the 10 seed runs undertaken for each option. These travel times are from The Crescent – Minogue Crescent – Ross Street corridor between City West Link and Bridge Street.

Table 3.5: Median Corridor Travel Times - Option Summary

Scenario	Northbound	Southbound
2019 Base	04:59	02:55
2019 Option 1	05:28	03:52
2019 Option 2	05:28	03:51
2019 Option 3	08:49	03:57
2019 Option 4A	08:13	04:36
2019 Option 4B	06:01	03:55

Table 3.5 highlights that Options 1 and 2 have similar impacts on northbound travel times in the corridor whilst Option 3 has far greater impacts. Attempts at signal coordination improvements in Options 4A and 4B actually worsen conditions.

Southbound travel times also increase primarily due to the need to give way to opposing right turning traffic at Chapman Road.

4. ADDITIONAL OPTIONS ASSESSMENT

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4.1 LESSONS FROM INITIAL OPTIONS MODELLING

Observing the running of the Paramics models for each option provided by CoS clearly identified that the key traffic constraints in the area relate to a finite capacity northbound on The Crescent due to its intersections with City West Link and Johnston Street. Unless there are upgrade works to overcome these issues these locations will continue to be the critical pinch points in the corridor and any traffic growth in The Crescent northbound in the PM peak (i.e. independent of the development) will simply add to the back of the queue leading it back to the Chapman Road roundabout.

Similarly, the Harold Park development will also add traffic to the back of this queue. In addition, however, its connection into Chapman Road means that its traffic exiting to the north will have priority over northbound through traffic in The Crescent hence making conditions worse for this movement. Similarly, traffic turning right into Chapman at the roundabout and associated with the development will have priority over southbound through traffic on The Crescent, generating long queues.

Whilst there are no reasonable solutions to improving conditions on The Crescent between Johnston Street and City West Link associated with background traffic growth generally or the incremental impacts of the development, considerations should move towards the best way to manage the traffic generated by the development, given these constraints.

This means, identifying ways to ensure that the priority for entry and exit to the development is consistent with the need to keep through traffic moving on The Crescent. Additional options to achieve this have been identified as:

- Option 5: Removing the access to the development from Chapman Road; and
- Option 6: Signalising the intersection of The Crescent and Chapman Road.

4.2 ADDITIONAL OPTIONS DESCRIPTION

Option 5 involves closing the link between the development and Chapman Road such that no development traffic would access and egress the external road network via the Chapman Road roundabout. This closure removes the priority movement provided to the development at this intersection and eliminates the potential for rat-running through the development (northbound) to “jump” the queues on The Crescent.

Option 6 replaces the Chapman Road/The Crescent Avenue roundabout with traffic signals and maintains the connection to the development from Chapman Road. This option reduces the level of priority for development traffic through using signal control and reduces the attractiveness of using the development roads as a rat-run. It also provides improved pedestrian accessibility to the commercial/retail components of the development from the areas west of The Crescent.

4.3 ADDITIONAL OPTIONS ASSESSMENT AND COMPARISON TO INITIAL OPTIONS

4.3.1 Travel Times

The model runs for Options 5 and 6 show better results compared to Options 1, 2, 3, 4A and 4B, as shown in Table 4.1.

Table 4.1: Median Corridor Travel Times - Option Summary with Additional Options

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Scenario	Northbound	Southbound
2019 Base	04:59	02:55
2019 Option 1	05:28	03:52
2019 Option 2	05:28	03:51
2019 Option 3	08:49	03:57
2019 Option 4A	08:13	04:36
2019 Option 4B	06:01	03:55
2019 Option 5	05:05	04:18
2019 Option 6	05:04	04:13

Whilst the travel time results for Option 2 showed a reasonable traffic performance of this option, observation of the models running for various seed values revealed that this option could be susceptible to high levels of congestion at the Chapman Road/The Crescent roundabout. This has the potential to generate long queues in a southbound direction back up The Crescent towards Johnston Street. The modelling simply highlights the susceptibility of this option to increased queuing and delays with minor changes in development traffic levels or traffic release profiles.

Options 5 and 6 do have lower travel times northbound than other options and almost return conditions back to the "base case". A disadvantage of the closure (in Option 5) and the signalisation of the Chapman/The Crescent intersection (in Option 6) is that southbound vehicles are affected by either traffic travelling further down The Crescent before entering the site (option 5) or stopping at the traffic signals (Option 6).

4.3.2 Queue Lengths

Options 5 and 6 generally provide more stable traffic conditions than options 1, 2 and 3 (or 4A/4B) with improved traffic flow and reduced queuing generally on The Crescent northbound, as shown in Figure 4.1.

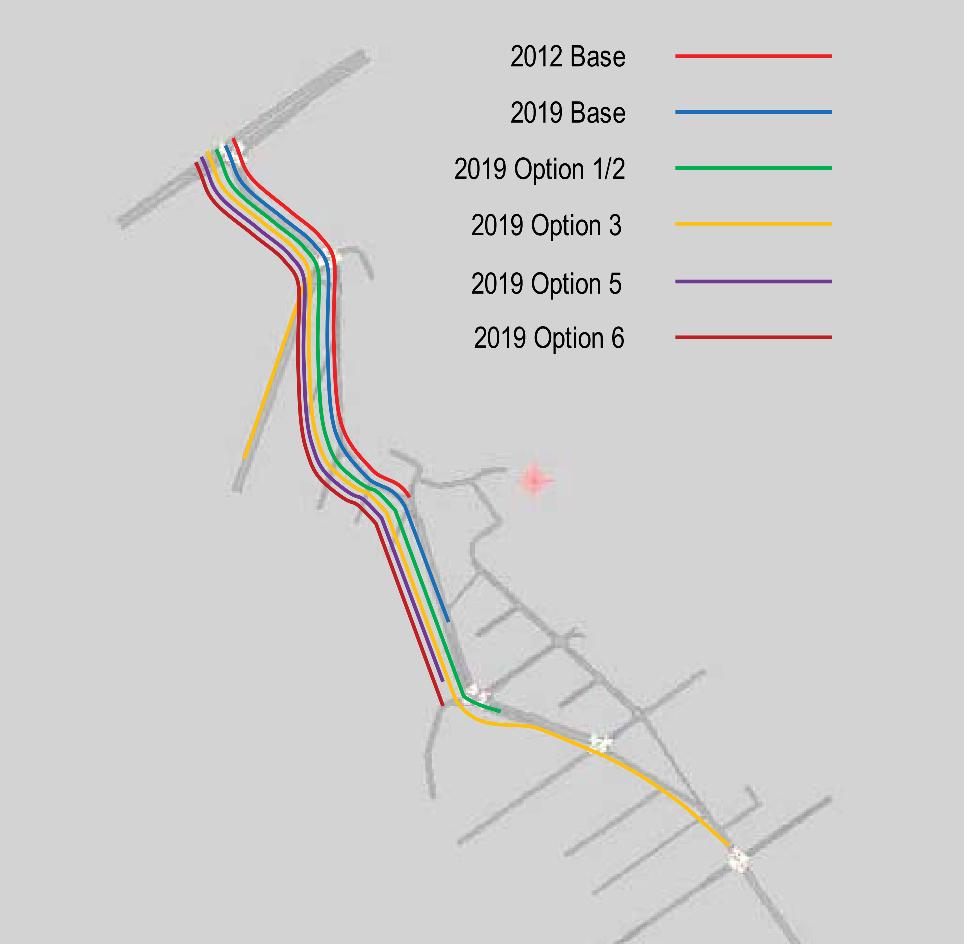


Figure 4.1: Northbound Queuing by Option

The modelling of the additional options shows clear benefits for associated with Options 5 and 6 for effectively managing the additional traffic generated by the development within the adjacent road network.

4.3.3 Option 5 v Option 6 – Advantages and Disadvantages

The advantages of Option 5 over Option 6 include:

- Option 5 does not involve the construction costs associated with signalisation of the Chapman/The Crescent intersection;
- Option 5 has less risk of traffic queuing back from the signals into the development; and
- Option 5 has less of an impact to through traffic in off peak periods (i.e. not having to stop at signals).

The advantages of Option 6 over Option 5 include:

- Option 6 provides a northern point of access for the development, thereby reducing the length of The Crescent that development traffic needs to use;
- Option 6 gives RMS/Council the ability to manage (through signal timings) the relative priority of development (turning) traffic over through traffic on The Crescent; and
- Option 6 provides a controlled pedestrian crossing opportunity at the northern end of the site to access nearby bus stops.

5. CONCLUSIONS

ATTACHMENT G

The Crescent-Minogue Crescent-Ross Street corridor is a highly constrained corridor that experiences afternoon peak hour traffic congestion. Long (but variable) northbound queues occur on The Crescent at City West Link and at Johnston Street, which are a consequence of high traffic volumes and a constrained single northbound traffic lane between Chapman Road and Johnston Street. By 2019 these queues are likely to extend to Chapman Road regardless of the Harold Park development and assuming additional traffic can bed fed into the corridor as background traffic growth.

The Harold Park Development will add up to 650 vehicles into the network in the PM peak hour. Of these, approximately 90 vehicles per hour would join the northbound queues on The Crescent.

In the context of managing development traffic impacts, it is the Chapman Road roundabout which generates some of the issues in this area due to:

- The priority that right turning traffic from Chapman has over northbound through traffic;
- The priority that right turning traffic from The Crescent northbound into Chapman has over southbound through traffic on The Crescent; and
- The attractiveness of the route through the development as a rat run.

Unless targeted traffic management measures are put in place, the resultant impact is the potential extension of northbound queues through the Chapman Road roundabout and back to the Minogue Crescent intersection.

Options to better manage development traffic and its impacts on The Crescent include removing its access to the Chapman Road roundabout or signalising the Chapman Road/The Crescent intersection.

Both options have similar effects on external traffic conditions (queuing and travel times) in The Crescent and the selection of the preferred option is essentially a trade-off between construction cost and accessibility. That is, the signalisation of the intersection of Chapman/The Crescent is more expensive than a closure of the connection between the development and Chapman but the traffic signals provide the benefit of a controlled pedestrian crossing opportunity between the retail/commercial development and the bus stops on The Crescent. Similarly, the signals introduce a risk of queuing back into the development but the closure option reduces the accessibility to the retail/commercial components of the development.

There is the potential, however, to consider the implementation of these options in stages. For example, a partial closure of the development access road south of the retail/commercial development could be converted to a full closure as turning volumes at the Chapman/The Crescent roundabout increase. Once the development has been substantially completed there may be benefits in then opening up this closure to improve the access between the retail/commercial and residential components and introducing the traffic signals at Chapman/The Crescent at that time.

ATTACHMENT G

APPENDIX A

HAROLD PARK PARAMICS MODELLING

CALIBRATION AND VALIDATION TECHNICAL NOTE

Issue History

File Name	Prepared by	Reviewed by	Issued by	Date	Issued to
P0997.001T Harold Park Paramics Modelling – Calibration and Validation	M.Kimmins	D.Bitzios	A.Finlay	19th April, 2012	Mitchell Lee (City of Sydney)
P0997.002T Harold Park Paramics Modelling – Calibration and Validation	M.Kimmins / I. Pais	D.Bitzios	A.Finlay	25h May, 2012	Mitchell Lee (City of Sydney)

Harold Park Paramics Modelling – Validation and Calibration

1. INTRODUCTION

1.1 BACKGROUND

Bitzios Consulting was commissioned by the City of Sydney to develop a Paramics microsimulation model to assist in the assessment of traffic impacts as a result of the proposed re-development of the Harold Park Paceway site. The model will also be used to identify potential improvements that could be implemented in the corridor to mitigate the effects of future development in the area.

The purpose of this Model Calibration and Validation Technical Note is to demonstrate the base model validity in accordance with RMS guidelines. Many of the roads in the network surrounding the development are under state control.

1.2 METHODOLOGY

The Paramics modelling was undertaken in accordance with the RMS's Paramics Microsimulation Modelling Manual. The processes involved in validating and calibrating the Harold Park models included:

- data collection and analysis for the PM peak period;
- model traffic network coding;
- estimation of traffic demands; and
- model calibration and validation.

This technical note describes the processes used and results achieved in developing the base model.

1.3 STUDY AREA

The study area shown in Figure 1.1 shows the location of the Harold Park development site and the extent of the Paramics model for assessment of potential traffic impacts and needs. The model boundary has been defined by the City of Sydney and includes four signalised intersections on "The Crescent" - Minogue Crescent – Ross Street corridor between City West Link and Bridge Road.

Source: Google Maps Australia

Figure 1.1: Study Area and Paramics Model Extents

2. DATA COLLECTION AND ANALYSIS

A variety of data sets have been sourced, analysed and used for model development, as follows:

- 2009 and 2011 Intersection Traffic Counts (City of Sydney and Halcrow Report);
- 2012 Intersection Back of Queue Observations (Bitzios Consulting); and
- 2012 The Crescent - Minogue Crescent – Ross Street Corridor Travel Time Surveys (Bitzios Consulting).

Intersection Counts were available at seven locations within the Harold Park area including:

- The Crescent/City West Link;
- The Crescent/Johnston Street / Chapman Road;
- The Crescent/Chapman Road / Nelson Street;
- The Crescent/Minogue Crescent;
- Minogue Crescent/Wigram Road;
- Wigram Road/Ross Street; and
- Ross Street/Bridge Road.

The intersection counts refer to 2009 and were used in the traffic demands estimation and turning counts validation processes (provided in Attachment A).

3. NETWORK CODING

3.1 LINK CATEGORIES AND SPEEDS

The link categories used in the base model coding are taken from RMS's standard category file. Link categories have been created for links with a higher number of lanes than those included in RMS's standard file.

The posted speed limits coded in to the model are detailed in Figure 3.1 below. Although there are 40 km/h school zones in the study area the modelled peak hour period is outside of these times.

Figure 3.1: Posted Speed Limits

3.2 ZONE SYSTEM

The zone system used for the base model is detailed in Figure 3.2 below.

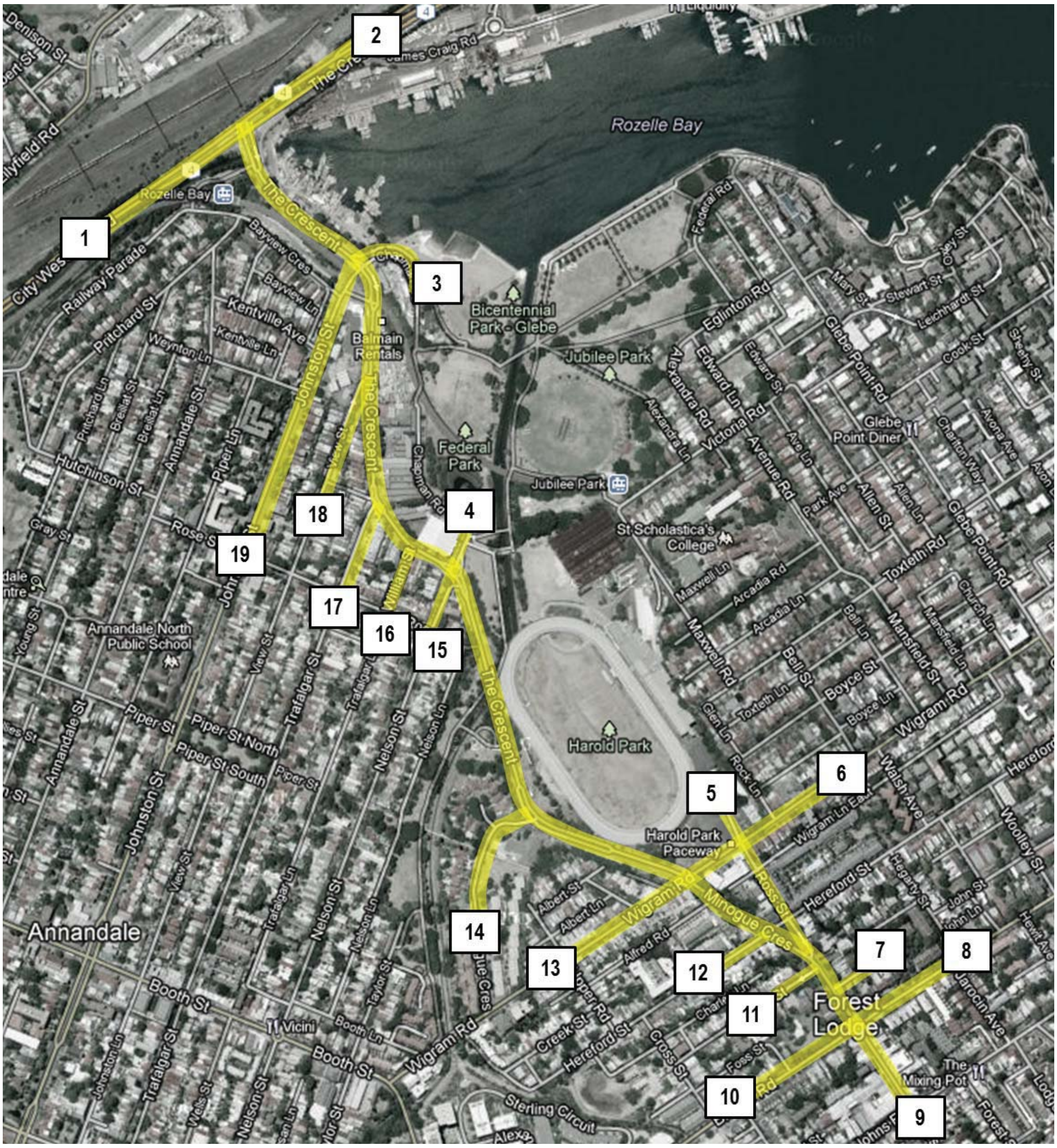


Figure 3.2: Zone System

3.3 TRAFFIC SIGNALS AND KEY ASSUMPTIONS

The traffic signals have been coded using the average cycle times for the peak period taken from SCATS data collected on the 28th of March 2012 for each of the signalised intersections in the study area. Pedestrian crossing influences on traffic delays have been included in the model using "dummy" phases where the SCATS data suggest these as being required.

3.4 BUS ROUTES AND STOPS

The Bus routes and stops in the base model are detailed in Figure 3.3 below. The timetables have been obtained from the TransportInfo website. As the model is for the PM peak period the majority of buses are heading northbound or westbound away from the Sydney CBD.

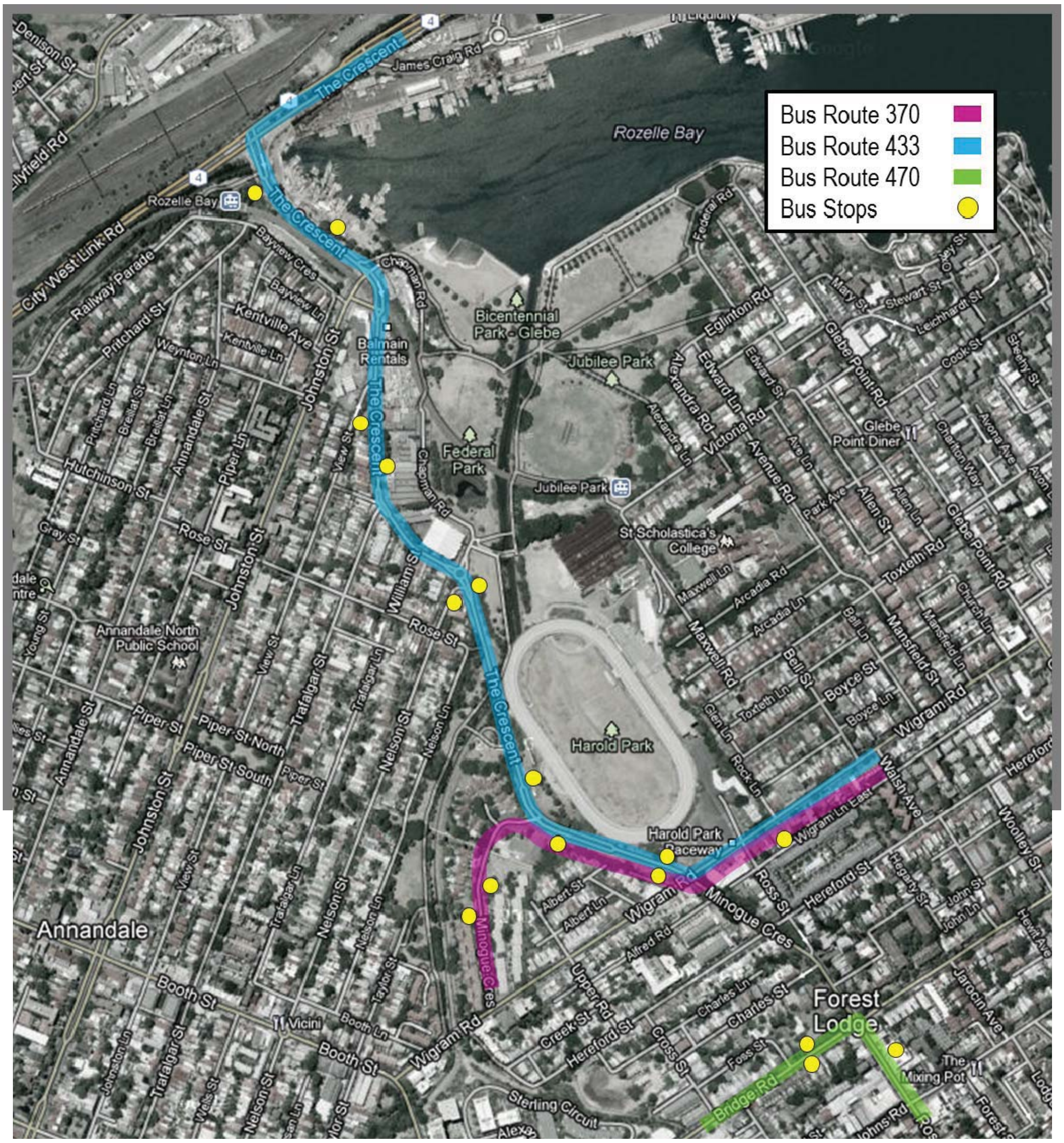


Figure 3.4: Bus Routes and Stops

4. TRAFFIC DEMANDS AND ASSIGNMENT METHODOLOGIES

4.1 PATTERN MATRIX AND DEVELOPMENT

As the model is relatively small with minimal route choice, Paramics Estimator was not required to be used in the development of the demand matrix. The demand matrix was developed using the 2009 count data and assumptions for the expected distribution of vehicles within the network considering the relative volume of entering and exiting traffic at each location. An iterative process was used to check that the demands when assigned to the network and represented as turning volumes at intersections were appropriately validated to the intersection count volumes.

4.2 "WARM-UP" AND "COOL-DOWN" PERIODS

The model has been developed for a 4:30 PM to 5:30 PM peak hour period including a 30 minute warm up and 30 minute cool down period before and after the peak hour. The warm up and cool down demands are 80% of the peak 30 minute demands.

4.3 DEMAND PROFILES AND VEHICLE CATEGORIES

The intersection count data used for the calibration and validation of the base model were one hour counts with no more detailed information available. As a result, the demands could not be accurately profiled in to smaller intervals and a flat demand profile was adopted. This was also justified on the capacity-constrained nature of the corridor and the fact that volumes are somewhat controlled by signal timings which are relatively consistent through the modelled peak hour. With the models "warm-up" and "cool-down" periods before and after the peak hour period the model will reflect a peak hour profile similar to what would be expected in the actual traffic network, as show in Figure 4.1.

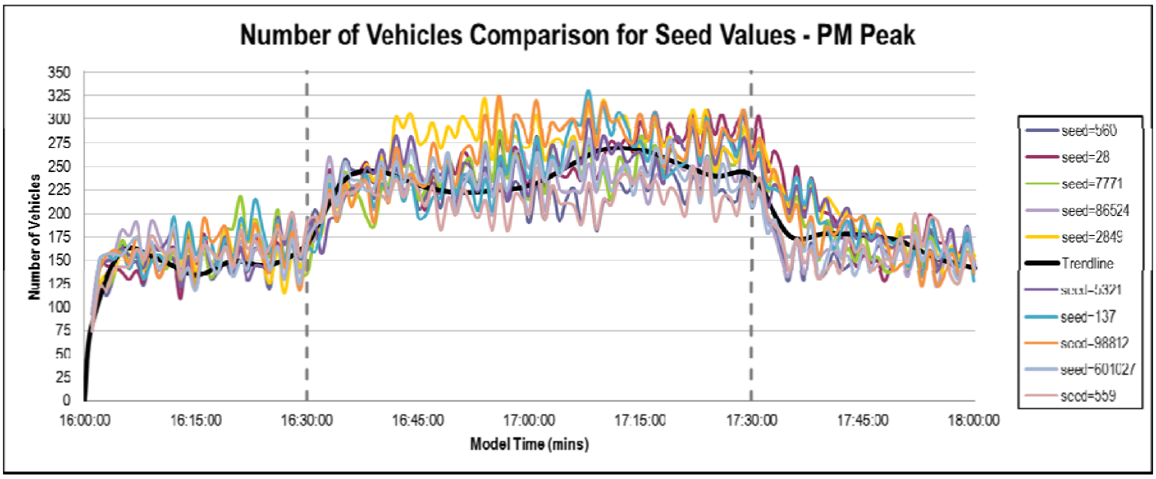


Figure 4.1: Profile of Vehicles on the Network

4.4 TRAFFIC ASSIGNMENT METHOD

As the model is simplistic with minimal route choice available, an "all-or-nothing" traffic assignment methodology has been used with no feedback or perturbation.

5. MODEL CALIBRATION AND VALIDATION

5.1 CALIBRATION AND VALIDATION PROCESSES

The base model validation process involved comparisons between the following observed and modelled attributes:

- traffic volume turning movement data;
- queue lengths; and
- travel time.

All count data available refers to 2009 and as such the calibration to turning volume data was carried out using a "2009 model". However, queue lengths and travel times were validated against current (2012) observations. As such, an additional model was created to replicate 2012 network operation. Since no current turning volumes are available for the study area, this process involved the estimation of annual growth factors for the main zones in the model using 10 year forecast traffic growths provided by RMS. The RMS-provided growth rates were for the ten years 2011 to 2021 but only for east-west traffic volumes on City West Link and on Bridge Road. We used these figures to derive 10 year growth factors on the north-south corridor, but some interpretation was necessary at the southern end (Ross Street) because there was an illogical change in eastbound growth factors across the Ross Street intersection. Agreement was reached with RMS and City of Sydney to adopt an overall 10 year northbound growth figure of 3% northbound and a southbound figure of 0.5%.

Overall, the increase in traffic volumes was relatively minor and the models show very similar results. Table 5.1 documents the annual growth rates applied (by O-D combination).

Table 5.1: Annual Growth Rates Applied (2009 to 2012)

Growth Rates (% per annum)																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
from	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	2	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0.05	0
from	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	9	0	0.2	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
from	10	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	19	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
from	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The comparison between the modelled and observed traffic count data was undertaken using the commonly used GEH statistic, which measures the degree of divergence of the modelled value from the observed value whilst accounting for the relative scale of each movement-volume (i.e. the higher volume movements are more important to match than the lower volume movements). GEH results less than 5 indicated acceptable comparisons between observed and modelled counts. GEH statistics were used to assist in validating traffic volumes for each of the RMS seed value model runs.

5.2 MODEL ROBUSTNESS

In accordance with RMS modelling guidelines, the base models were run with five different seed values to demonstrate the robustness of the model under slight variations of vehicle release rates. More specifically, the seed values used were:

- Seed = 560;
- Seed = 28;
- Seed = 7771;
- Seed = 86524; and
- Seed = 2849.

After running the above seed runs a high level of travel time variability was noticed. It was then decided to run a further 5 seeds to provide a larger sample size to be able to determine if the model was suitably robust for its intended purpose. The additional five seed values used were:

- Seed = 5321;
- Seed = 137;
- Seed = 98812;
- Seed = 601027; and
- Seed = 559.

Following the additional model runs, the mean and median travel times in the model converged sufficiently to provide confidence in the model robustness, as shown in the sections below.

5.3 TRAFFIC VOLUMES AND GEH STATISTIC

The main criterion to validate the 2009 base model is the GEH statistic which compares modelled traffic volumes with actual turn counts. The turn volumes used to undertake this comparison and the results for the base model are shown in Table 5.2 below. More detailed GEH tables are attached in Attachment B.

Table 5.2: GEH Results

RTA Seeds	Average GEH	% of counts under a GEH of 5
Seed = 560	0.89	100%
Seed = 28	0.82	100%
Seed = 7771	1.15	100%
Seed = 86524	0.87	100%
Seed = 2849	0.91	100%
Seed = 5321	0.95	100%
Seed = 137	0.82	100%
Seed = 98812	1.03	100%
Seed = 601027	1.06	100%
Seed = 559	0.98	100%

The criteria used for simulation model validation in the RMS manual is based on achieving a GEH value of less than 5 for more than 85% of the observed count data at recorded locations. The results shown above demonstrate that the model satisfies this criterion.

5.4 QUEUE LENGTHS

Attachment C illustrates the modelled maximum queue lengths for all seed runs in the 2012 PM base model. The figures show a long queue on The Crescent's northbound approach to the Johnston Street intersection. The maximum queue on this approach varies significantly between the seed runs and has a significant impact on the northbound travel times for the study area. This queue variation is evident in the field when observing a range of queue lengths at this approach through the peak hour.

Overall, the queuing behaviour in the 2012 base model reasonably reflects the observed queuing patterns on site.

5.5 TRAVEL TIMES

The travel time surveys involved 4 runs in each direction on the Crescent – Minogue Crescent – Ross Street corridor between City West Link and Bridge Road. Comparisons between the 2012 modelled and surveyed travel times are shown in Table 5.3.

Table 5.3: Travel Time Comparison (The Crescent - Minogue Crescent - Ross Street)

		Northbound	Southbound
Surveyed	Minimum	4:22	2:30
	Average Surveyed	5:16	3:15
	Maximum	6:12	4:00
Modelled	Seed = 560	4:08	3:02
	Seed = 28	4:21	3:13
	Seed = 7771	5:56	2:51
	Seed = 86524	5:40	2:54
	Seed = 2849	4:37	2:55
	Seed = 5321	4:30	2:46
	Seed = 137	4:20	2:51
	Seed = 98812	5:02	3:03
	Seed = 601027	3:42	3:04
	Seed = 559	3:34	2:47
	Average Modelled	4:35	2:57
	Median	4:26	2:55
	Max	5:56	3:13
	Min	3:34	2:46
	Standard Deviation	0:46	0:09

The high level of travel time variability in the surveys and the model is consistent with the significant level of queue variation observed on site. The degree of variation can be attributed to the capacity of the northbound approach to the Johnston Street intersection. The approach is over capacity as observed and experienced in the field. This is also evident by the deviation from the mean as shown in the table above. The below-capacity southbound travel times have a low standard deviation when compared to the over capacity (larger standard deviation) for the northbound travel times. Figures 5.1 and 5.2 illustrate these deviations of the travel times in both the northbound and southbound directions.

Figure 5.1: Northbound Travel Time Graph

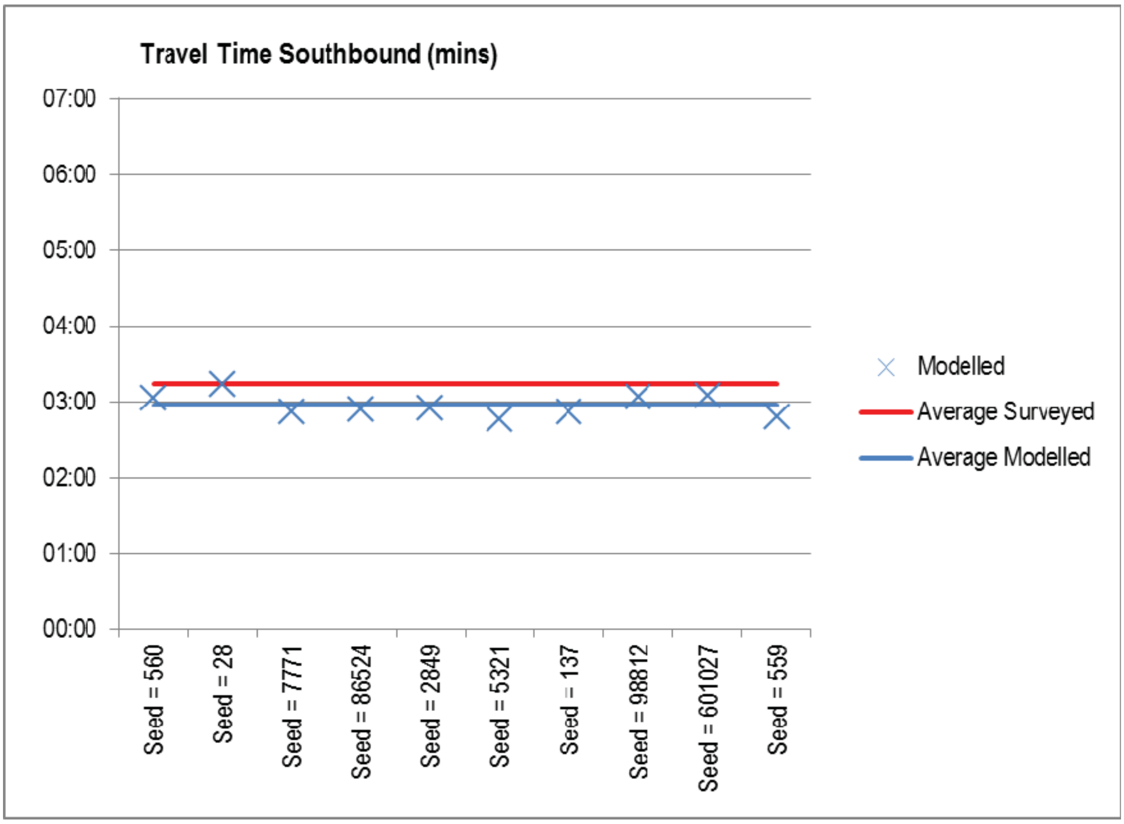


Figure 5.2: Southbound Travel Time Graph

5.6 MODEL CALIBRATION DECLARATION

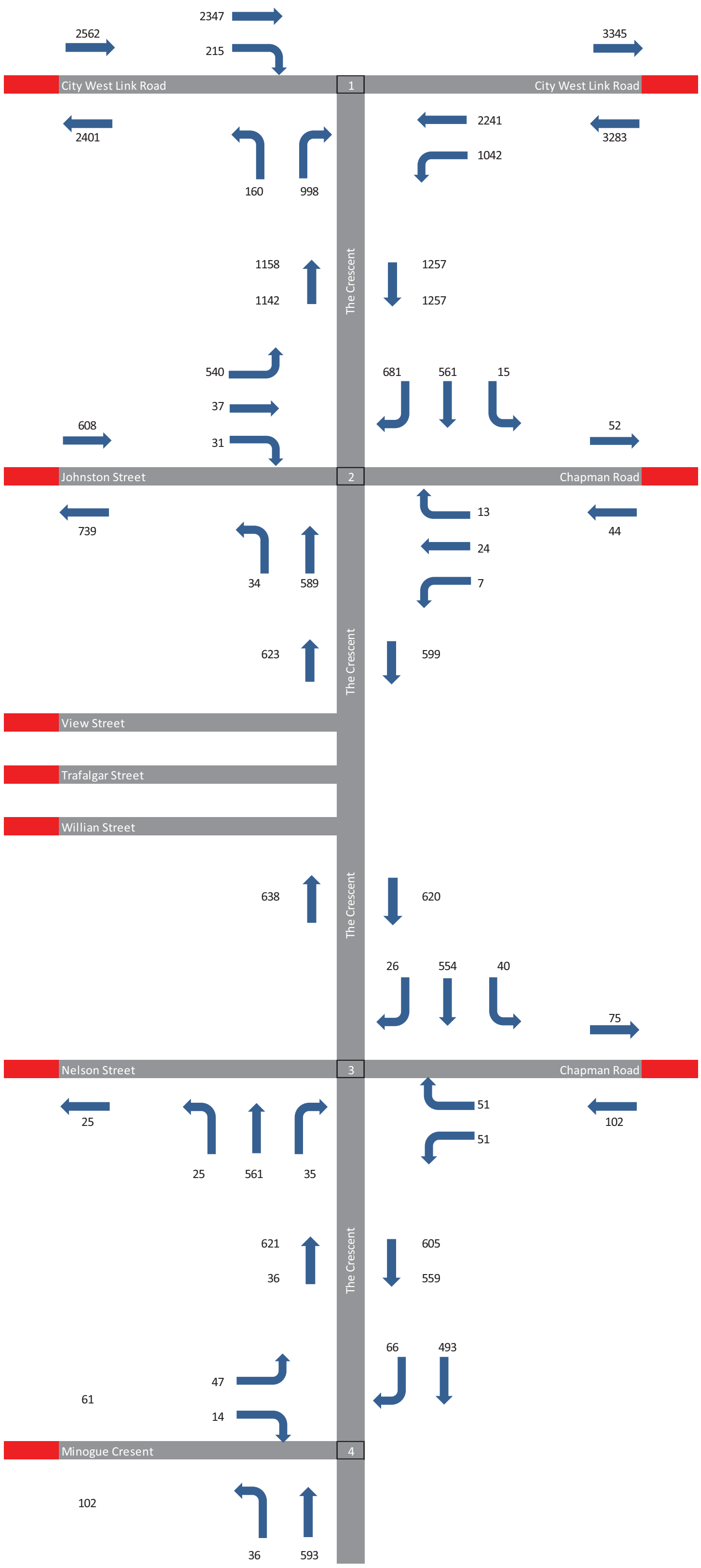
The Paramics model for the PM peak hour period has been validated and calibrated to meet the requirements as per the RMS's Microsimulation Modelling Manual.

ATTACHMENT A

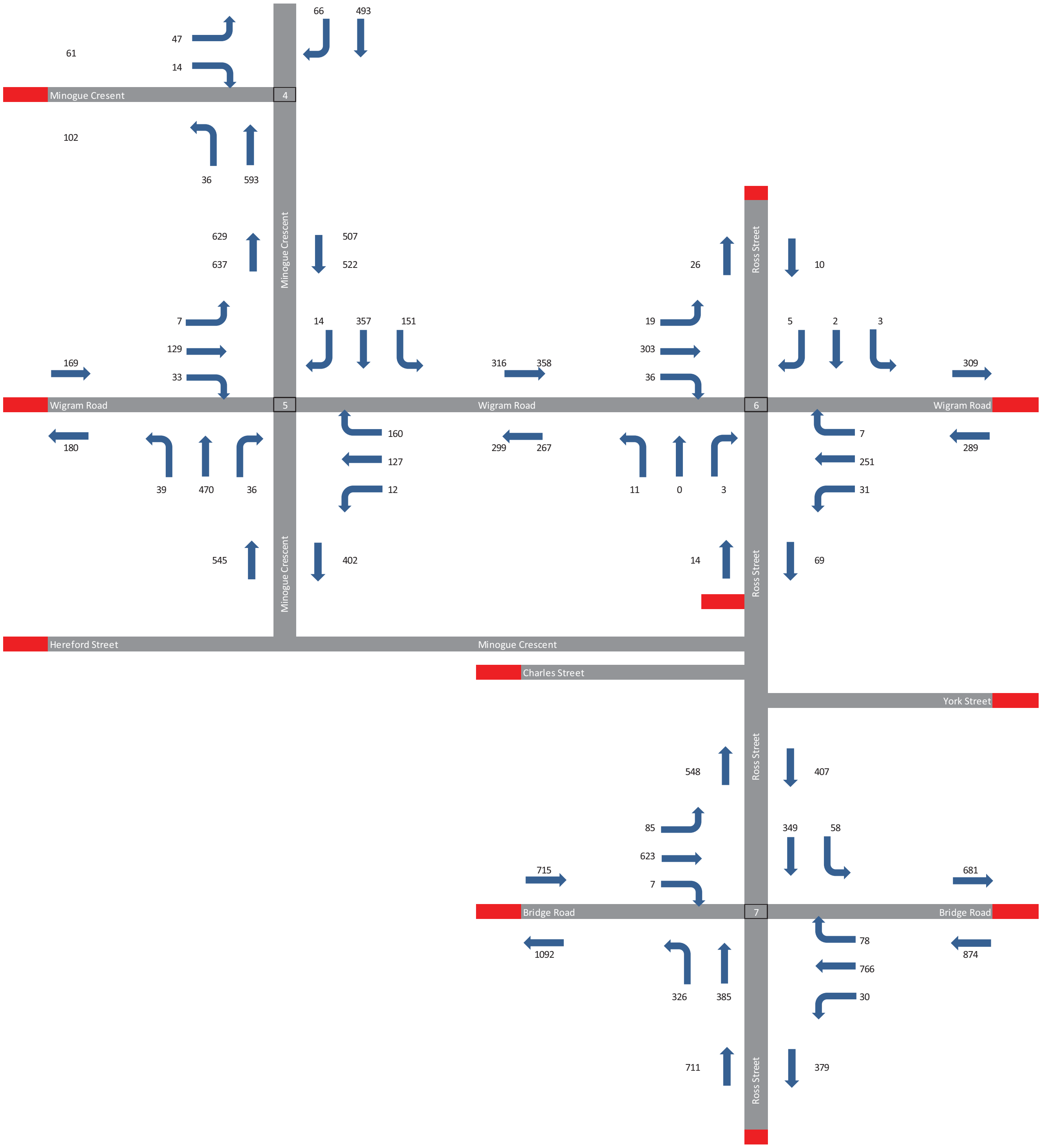
INTERSECTION VOLUMES

ATTACHMENT G

PM PEAK PERIOD: 16:30 to 17:30



ATTACHMENT G



ATTACHMENT B

GEH VALIDATION TABLE

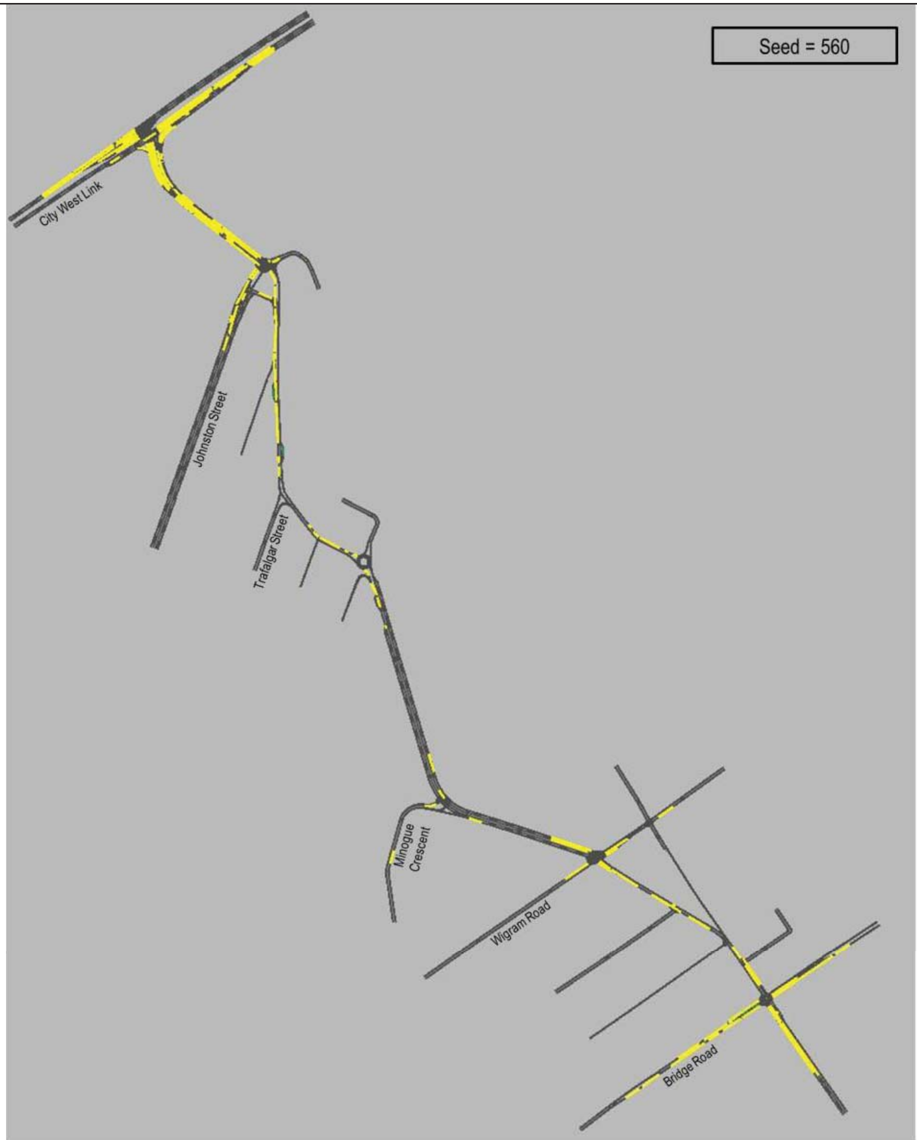
Site	Approach	Movement	Count	Seed = 560		Seed = 28		Seed = 7771		Seed = 86524		Seed = 2849	
				Modelled	GEH	Modelled	GEH	Modelled	GEH	Modelled	GEH	Modelled	GEH
1	WB	Left	1042	974	2.14	1009	1.03	986	1.76	1045	0.09	1045	0.09
	City West Link	Through	2241	2300	1.24	2216	0.53	2230	0.23	2242	0.02	2220	0.44
	NB	Left	160	134	2.14	136	1.97	124	3.02	129	2.58	174	1.08
	The Crescent	Right	998	961	1.18	974	0.76	980	0.57	1002	0.13	946	1.67
	EB	Through	2347	2279	1.41	2364	0.35	2391	0.90	2302	0.93	2344	0.06
	City West Link	Right	215	208	0.48	199	1.11	190	1.76	195	1.40	201	0.97
2	SB	Left	15	13	0.53	11	1.11	8	2.06	13	0.53	10	1.41
	The Crescent	Through	561	537	1.02	535	1.11	508	2.29	561	0.00	543	0.77
		Right	681	623	2.27	655	1.01	659	0.85	670	0.42	693	0.46
	WB	Left	7	8	0.37	7	0.00	9	0.71	7	0.00	2	2.36
	Chapman	Through	24	27	0.59	28	0.78	26	0.40	31	1.33	24	0.00
		Right	13	11	0.58	19	1.50	15	0.53	21	1.94	15	0.53
	NB	Left	34	26	1.46	30	0.71	28	1.08	27	1.27	36	0.34
	The Crescent	Through	589	583	0.25	599	0.41	586	0.12	609	0.82	605	0.65
	EB	Left	540	524	0.69	519	0.91	548	0.34	527	0.56	548	0.34
	Johnston	Through	37	35	0.33	38	0.16	41	0.64	33	0.68	34	0.50
		Right	31	42	1.82	34	0.53	31	0.00	38	1.19	38	1.19
3	SB	Left	40	44	0.62	56	2.31	51	1.63	54	2.04	37	0.48
	The Crescent	Through	554	517	1.60	499	2.40	465	3.94	516	1.64	522	1.38
		U	26	28	0.38	24	0.40	27	0.19	37	1.96	22	0.82
	WB	Left	51	47	0.57	53	0.28	46	0.72	52	0.14	54	0.41
	Chapman	Right	51	60	1.21	64	1.71	69	2.32	57	0.82	64	1.71
	NB	Left	25	22	0.62	24	0.20	30	0.95	20	1.05	28	0.58
	The Crescent	Through	561	551	0.42	600	1.62	567	0.25	583	0.92	603	1.74
		Right	35	40	0.82	50	2.30	39	0.66	35	0.00	29	1.06
4	SB	Through	493	494	0.05	481	0.54	448	2.07	489	0.18	505	0.54
	The Crescent	Right	66	71	0.60	68	0.24	59	0.89	79	1.53	72	0.72
	NB	Left	36	35	0.17	28	1.41	30	1.04	29	1.23	33	0.51
	Minogue	Through	593	571	0.91	630	1.50	593	0.00	599	0.25	618	1.02
	EB	Left	47	44	0.44	46	0.15	46	0.15	43	0.60	45	0.29
	Minogue	Right	14	23	2.09	17	0.76	24	2.29	15	0.26	23	2.09
5	SB	Left	151	174	1.80	147	0.33	156	0.40	146	0.41	168	1.35
	Minogue	Through	357	321	1.96	326	1.68	291	3.67	331	1.40	326	1.68
		Right	14	11	0.85	16	0.52	13	0.27	19	1.23	22	1.89
	WB	Left	12	8	1.26	13	0.28	4	2.83	4	2.83	9	0.93
	Wigram	Through	127	123	0.36	135	0.70	131	0.35	127	0.00	101	2.44
		Right	160	148	0.97	144	1.30	138	1.80	144	1.30	156	0.32
	NB	Left	39	32	1.17	38	0.16	41	0.32	23	2.87	44	0.78
	Minogue	Through	470	453	0.79	506	1.63	477	0.32	471	0.05	485	0.69
		Right	36	43	1.11	51	2.27	45	1.41	43	1.11	44	1.26
	EB	Left	7	2	2.36	3	1.79	1	3.00	7	0.00	4	1.28
	Wigram	Through	129	127	0.18	137	0.69	134	0.44	138	0.78	137	0.69
		Right	33	30	0.53	34	0.17	31	0.35	38	0.84	44	1.77
6	SB	Left	3	1	1.41	5	1.00	2	0.63	3	0.00	2	0.63
	Ross	Through	2	5	1.60	2	0.00	3	0.63	7	2.36	3	0.63
		Right	5	4	0.47	4	0.47	1	2.31	2	1.60	0	3.16
	WB	Left	31	33	0.35	33	0.35	24	1.33	32	0.18	28	0.55
	Wigram	Through	251	260	0.56	275	1.48	261	0.63	255	0.25	245	0.38
		Right	7	10	1.03	4	1.28	7	0.00	9	0.71	6	0.39
	NB	Left	11	15	1.11	15	1.11	9	0.63	12	0.29	17	1.60
	Ross	Through	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
		Right	3	2	0.63	5	1.00	3	0.00	2	0.63	4	0.53
	EB	Left	19	20	0.23	24	1.08	12	1.78	17	0.47	23	0.87
	Wigram	Through	303	288	0.87	272	1.83	277	1.53	288	0.87	291	0.70
		Right	36	38	0.33	40	0.65	47	1.71	23	2.39	36	0.00
7	SB	Left	58	56	0.26	68	1.26	51	0.95	55	0.40	62	0.52
	Ross	Through	349	337	0.65	329	1.09	296	2.95	341	0.43	340	0.48
	WB	Left	30	37	1.21	20	2.00	30	0.00	20	2.00	34	0.71
	Wigram	Through	766	775	0.32	753	0.47	719	1.72	757	0.33	731	1.28
		Right	78	85	0.78	86	0.88	84	0.67	67	1.29	84	0.67
	NB	Left	326	334	0.44	342	0.88	332	0.33	351	1.36	325	0.06
	Ross	Through	385	391	0.30	432	2.33	427	2.08	405	1.01	430	2.23
	EB	Left	85	61	2.81	79	0.66	54	3.72	77	0.89	64	2.43
	Wigram	Through	623	638	0.60	642	0.76	652	1.15	629	0.24	589	1.38
		Right	7	4	1.28	4	1.28	4	1.28	4	1.28	4	1.28
Average GEH					0.92		0.97		1.16		0.90		0.95
% under 5					100%		100%		100%		100%		100%

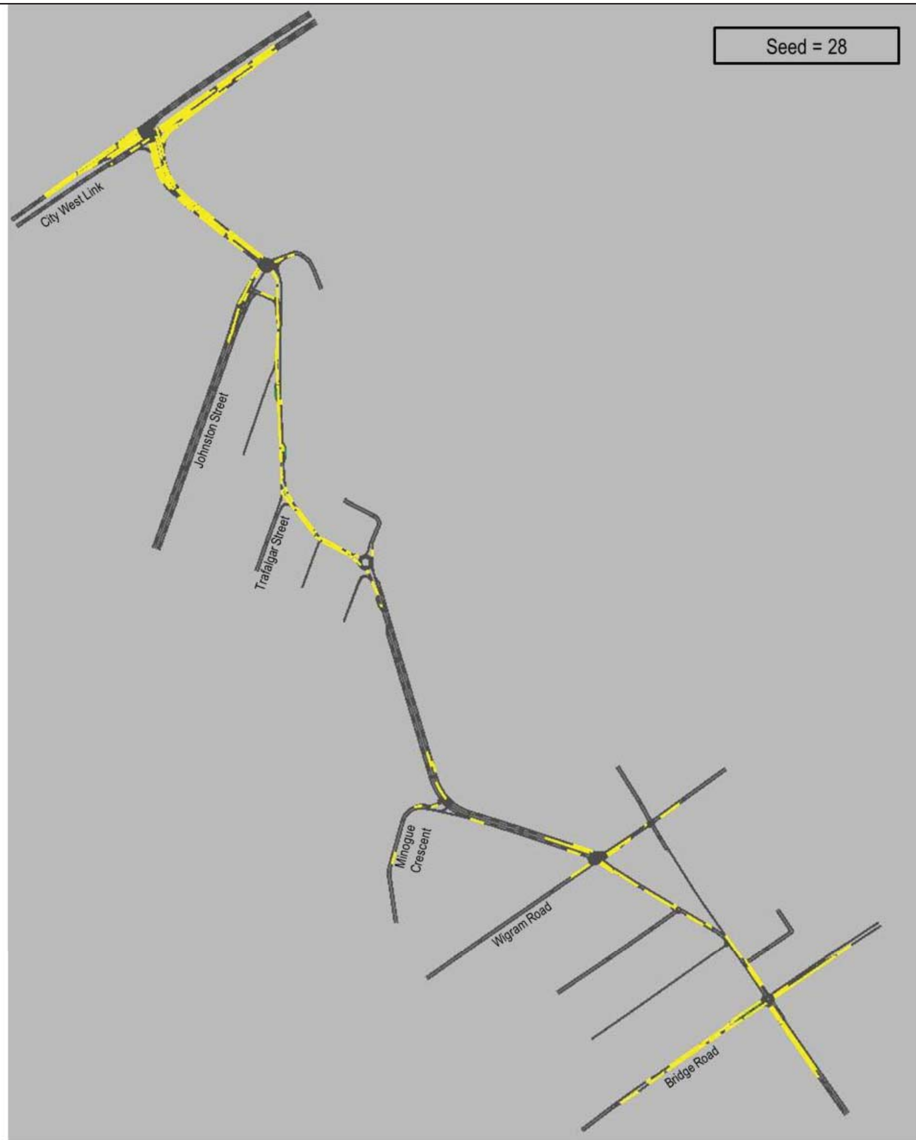
Site	Approach	Movement	Count	Seed = 5321		Seed = 137		Seed = 98812		Seed = 601027		Seed = 559	
				Modelled	GEH	Modelled	GEH	Modelled	GEH	Modelled	GEH	Modelled	GEH
1	WB	Left	1042	1046	0.12	1054	0.37	1040	0.06	1014	0.87	1042	0.00
	City West Link	Through	2241	2191	1.06	2176	1.38	2257	0.34	2241	0.00	2213	0.59
	NB	Left	160	130	2.49	138	1.80	123	3.11	134	2.14	148	0.97
	The Crescent	Right	998	977	0.67	949	1.57	937	1.96	949	1.57	930	2.19
	EB	Through	2347	2379	0.66	2376	0.60	2343	0.08	2369	0.45	2356	0.19
	City West Link	Right	215	194	1.47	192	1.61	185	2.12	227	0.81	186	2.05
2	SB	Left	15	14	0.26	15	0.00	11	1.11	18	0.74	15	0.00
	The Crescent	Through	561	562	0.04	561	0.00	516	1.94	579	0.75	545	0.68
		Right	681	650	1.20	667	0.54	691	0.38	644	1.44	664	0.66
	WB	Left	7	9	0.71	11	1.33	6	0.39	9	0.71	9	0.71
	Chapman	Through	24	31	1.33	30	1.15	30	1.15	32	1.51	22	0.42
		Right	13	10	0.88	11	0.58	11	0.58	7	1.90	11	0.58
	NB	Left	34	30	0.71	17	3.37	31	0.53	25	1.66	28	1.08
	The Crescent	Through	589	560	1.21	564	1.04	565	1.00	598	0.37	568	0.87
	EB	Left	540	559	0.81	543	0.13	524	0.69	509	1.35	513	1.18
	Johnston	Through	37	41	0.64	30	1.21	36	0.17	28	1.58	44	1.10
		Right	31	30	0.18	29	0.37	42	1.82	42	1.82	41	1.67
3	SB	Left	40	40	0.00	47	1.06	42	0.31	35	0.82	31	1.51
	The Crescent	Through	554	537	0.73	530	1.03	493	2.67	574	0.84	541	0.56
		U	26	28	0.38	23	0.61	29	0.57	21	1.03	23	0.61
	WB	Left	51	32	2.95	55	0.55	52	0.14	51	0.00	42	1.32
	Chapman	Right	51	57	0.82	48	0.43	61	1.34	51	0.00	43	1.17
	NB	Left	25	22	0.62	26	0.20	38	2.32	24	0.20	27	0.39
	The Crescent	Through	561	574	0.55	543	0.77	576	0.63	573	0.50	539	0.94
		Right	35	34	0.17	31	0.70	30	0.88	30	0.88	45	1.58
4	SB	Through	493	492	0.05	522	1.29	467	1.19	558	2.84	508	0.67
	The Crescent	Right	66	79	1.53	66	0.00	81	1.75	68	0.24	75	1.07
	NB	Left	36	26	1.80	35	0.17	32	0.69	26	1.80	31	0.86
	Minogue	Through	593	594	0.04	561	1.33	612	0.77	587	0.25	574	0.79
	EB	Left	47	40	1.06	40	1.06	37	1.54	43	0.60	40	1.06
	Minogue	Right	14	18	1.00	14	0.00	14	0.00	23	2.09	21	1.67
5	SB	Left	151	191	3.06	157	0.48	161	0.80	188	2.84	164	1.04
	Minogue	Through	357	290	3.73	353	0.21	303	2.97	364	0.37	344	0.69
		Right	14	18	1.00	16	0.52	15	0.26	18	1.00	12	0.55
	WB	Left	12	7	1.62	6	2.00	9	0.93	7	1.62	6	2.00
	Wigram	Through	127	131	0.35	133	0.53	116	1.00	125	0.18	112	1.37
		Right	160	166	0.47	136	1.97	150	0.80	149	0.88	138	1.80
	NB	Left	39	23	2.87	43	0.62	28	1.90	30	1.53	28	1.90
	Minogue	Through	470	442	1.31	450	0.93	480	0.46	460	0.46	456	0.65
		Right	36	36	0.00	42	0.96	45	1.41	49	1.99	30	1.04
	EB	Left	7	6	0.39	3	1.79	5	0.82	2	2.36	3	1.79
	Wigram	Through	129	139	0.86	143	1.20	158	2.42	129	0.00	145	1.37
		Right	33	36	0.51	36	0.51	29	0.72	34	0.17	45	1.92
6	SB	Left	3	3	0.00	4	0.53	1	1.41	0	2.45	3	0.00
	Ross	Through	2	2	0.00	5	1.60	2	0.00	4	1.15	5	1.60
		Right	5	3	1.00	5	0.00	2	1.60	0	3.16	4	0.47
	WB	Left	31	32	0.18	33	0.35	44	2.12	21	1.96	32	0.18
	Wigram	Through	251	291	2.43	257	0.38	254	0.19	264	0.81	237	0.90
		Right	7	9	0.71	3	1.79	6	0.39	3	1.79	4	1.28
	NB	Left	11	11	0.00	13	0.58	15	1.11	13	0.58	11	0.00
	Ross	Through	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
		Right	3	1	1.41	1	1.41	6	1.41	3	0.00	4	0.53
	EB	Left	19	20	0.23	22	0.66	19	0.00	25	1.28	15	0.97
	Wigram	Through	303	309	0.34	282	1.23	301	0.12	301	0.12	295	0.46
		Right	36	38	0.33	38	0.33	43	1.11	40	0.65	28	1.41
7	SB	Left	58	48	1.37	57	0.13	55	0.40	57	0.13	68	1.26
	Ross	Through	349	323	1.42	363	0.74	323	1.42	355	0.32	352	0.16
	WB	Left	30	41	1.85	32	0.36	34	0.71	38	1.37	34	0.71
	Wigram	Through	766	777	0.40	755	0.40	783	0.61	790	0.86	741	0.91
		Right	78	73	0.58	79	0.11	93	1.62	71	0.81	84	0.67
	NB	Left	326	329	0.17	316	0.56	335	0.50	343	0.93	351	1.36
	Ross	Through	385	401	0.81	388	0.15	406	1.06	406	1.06	386	0.05
	EB	Left	85	50	4.26	73	1.35	62	2.68	68	1.94	53	3.85
	Wigram	Through	623	632	0.36	665	1.66	640	0.68	647	0.95	620	0.12
		Right	7	4	1.28	4	1.28	4	1.28	4	1.28	4	1.28
Average GEH					0.95		0.82		1.03		1.06		0.98
% under 5					100%		100%		100%		100%		100%

ATTACHMENT C

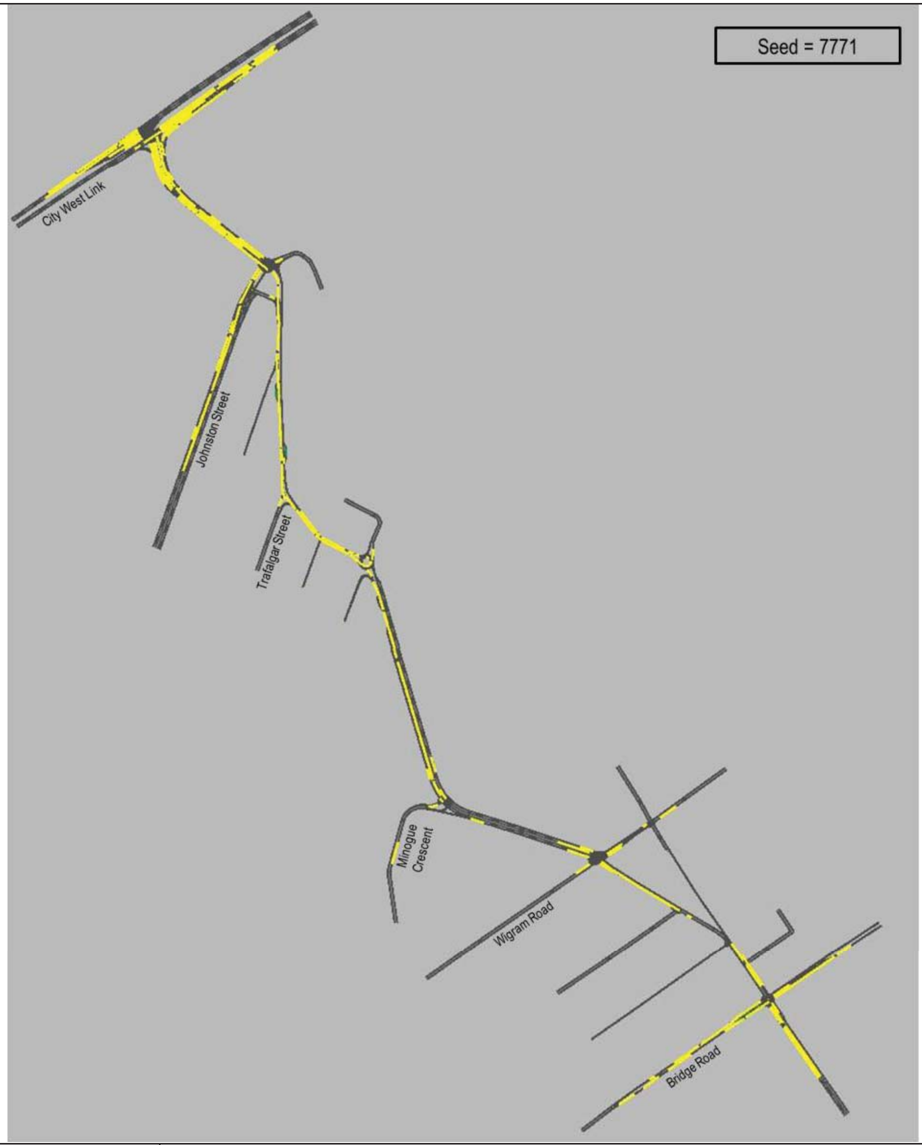
MAXIMUM QUEUE FIGURES

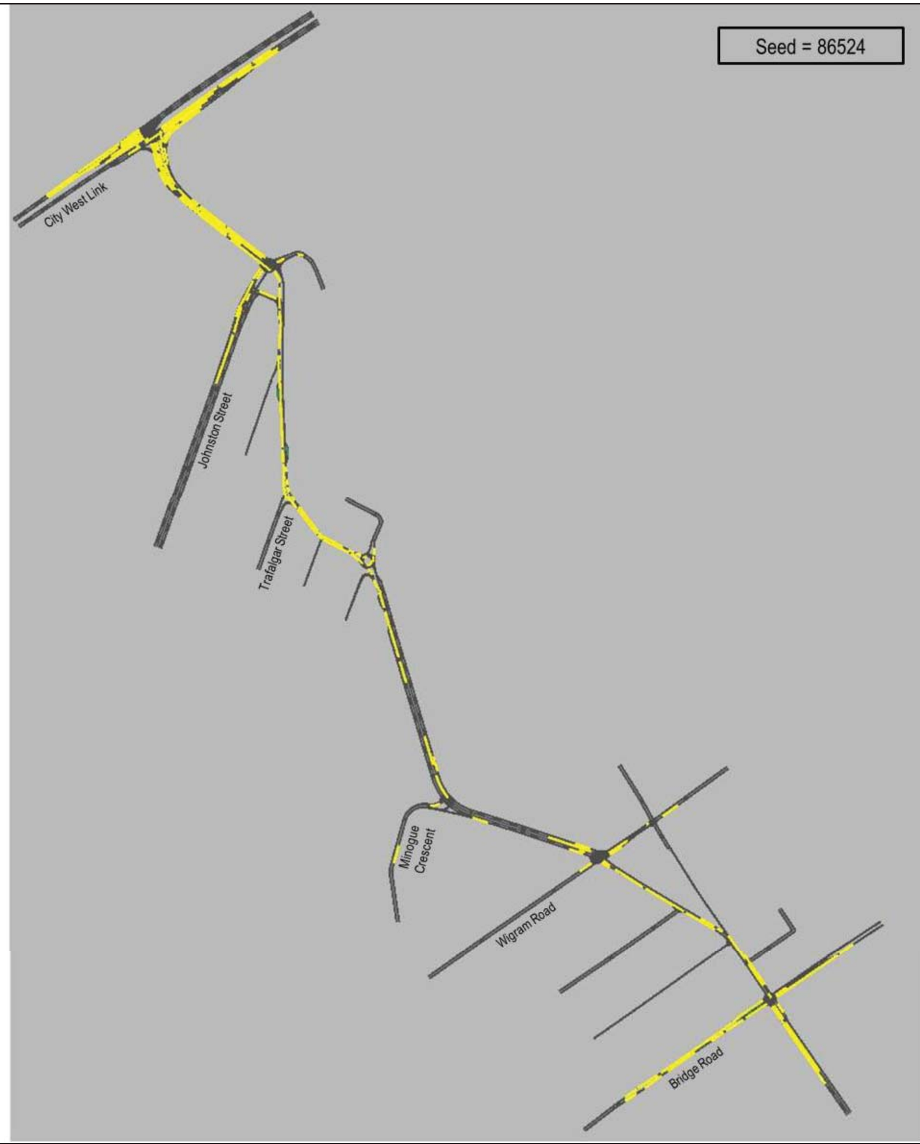
ATTACHMENT G



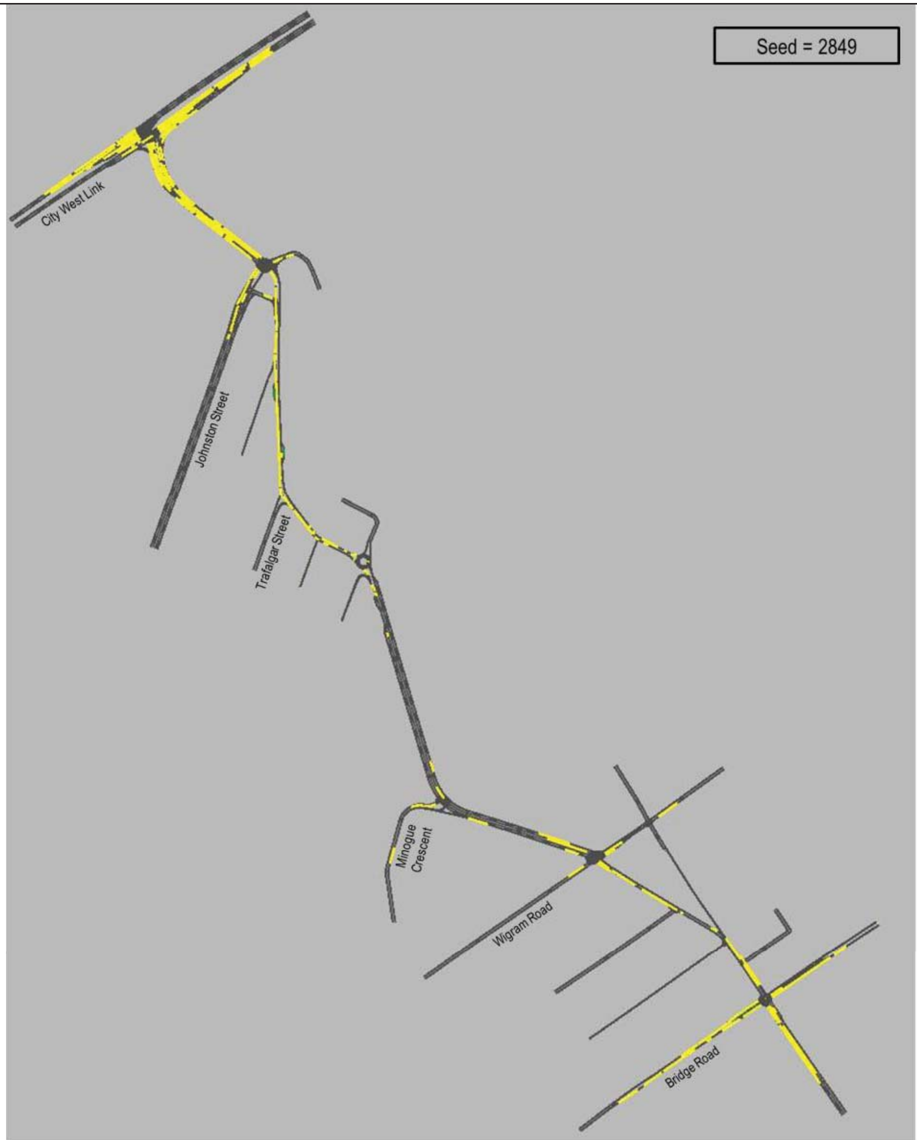


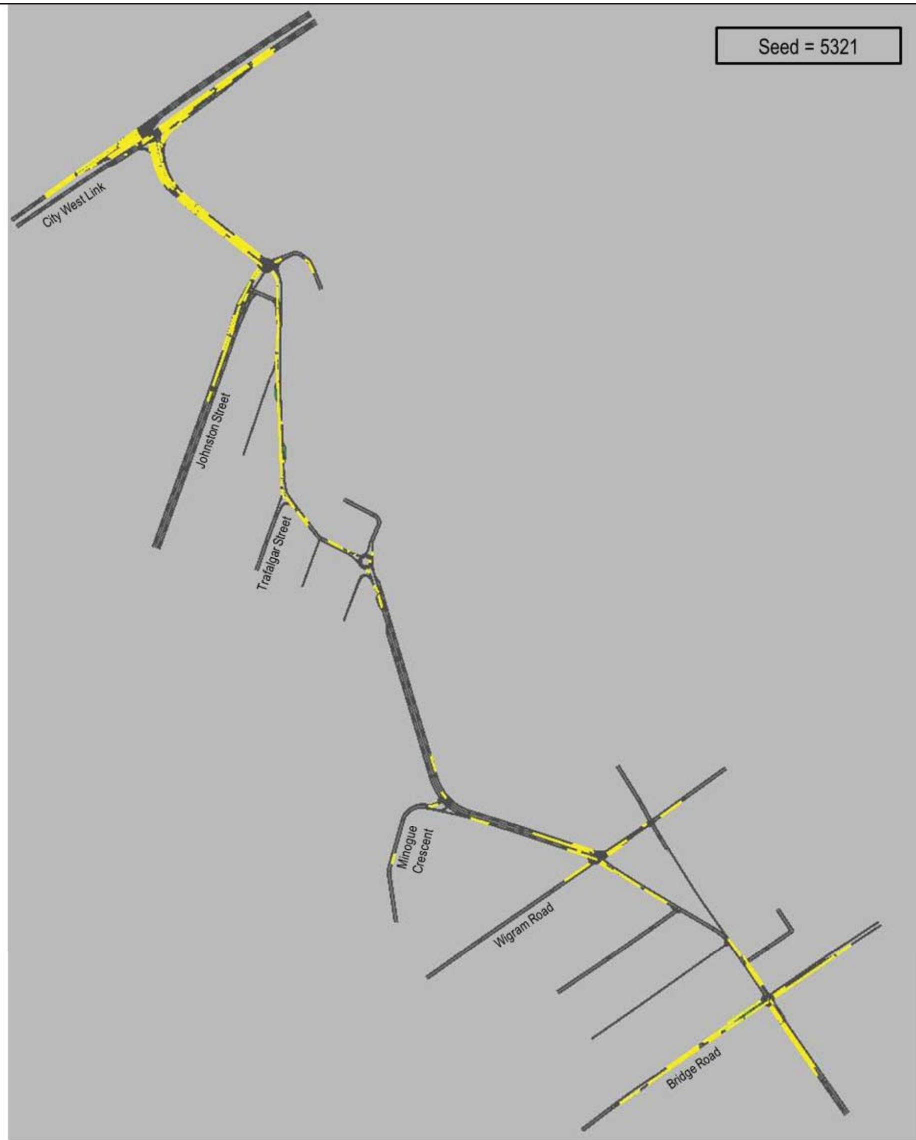
Date: May 2012	**Figure Title:** Maximum Queue Lengths	N W E S	BITZIOS consulting
Project No.: P0997	**Project Name:** Harold Park Paramics Modelling – Validation and Calibration		**Figure No.:** C.1



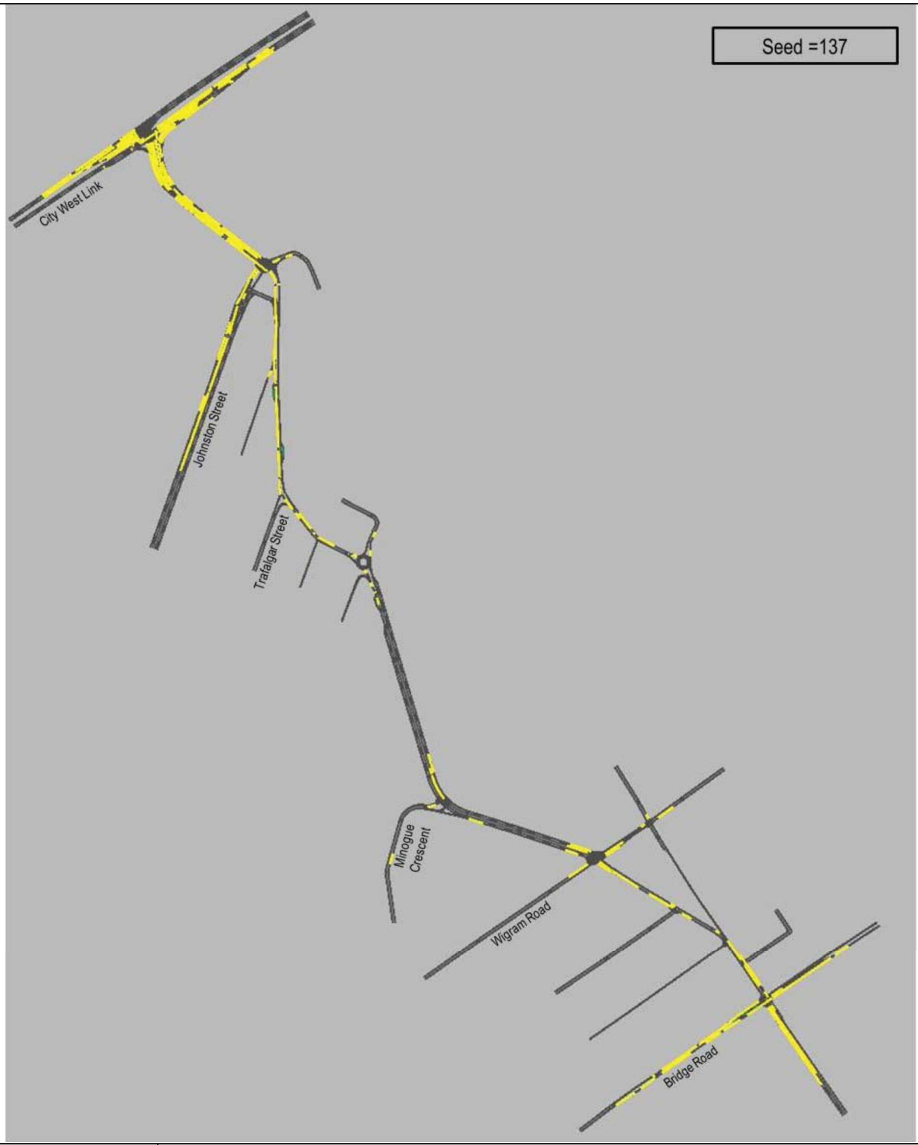


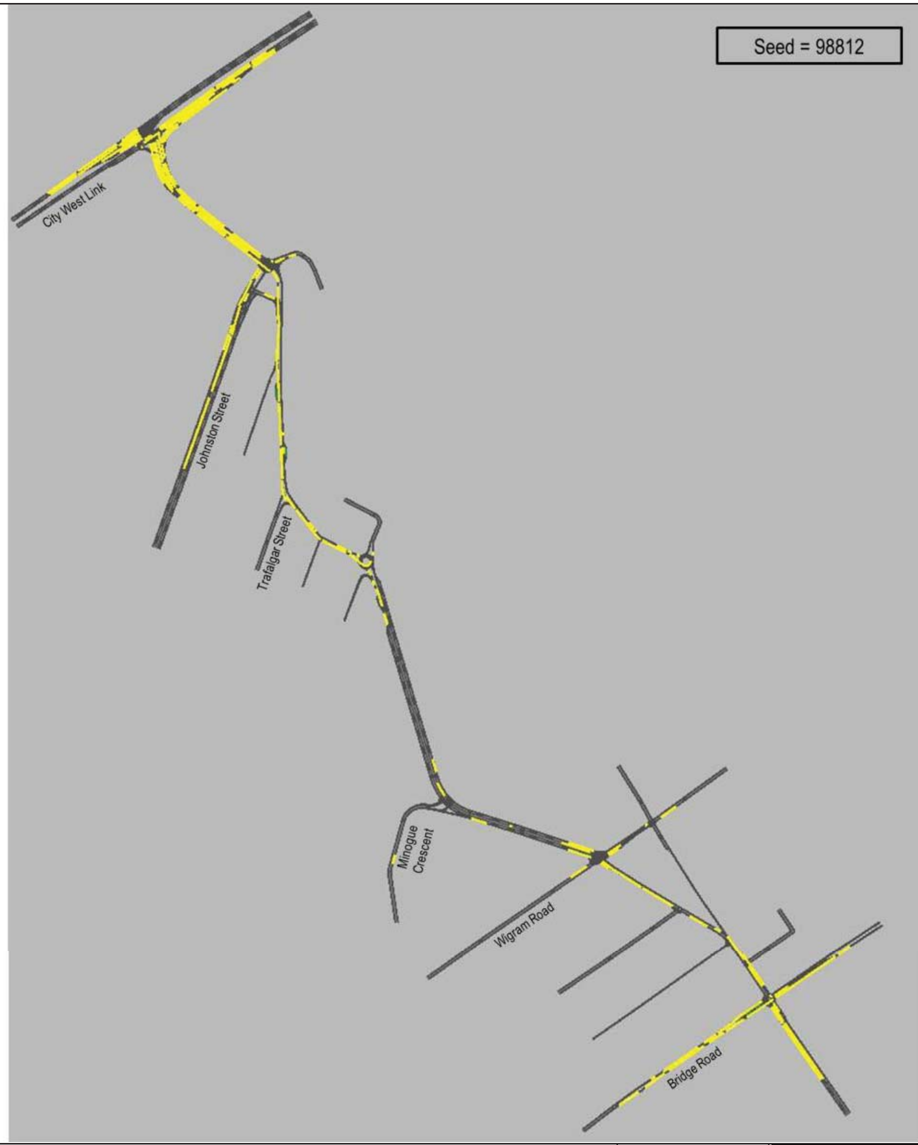
Date: May 2012	**Figure Title:** Maximum Queue Lengths	N W E S	BITZIOS consulting
Project No.: P0997	**Project Name:** Harold Park Paramics Modelling – Validation and Calibration		**Figure No.:** C.2



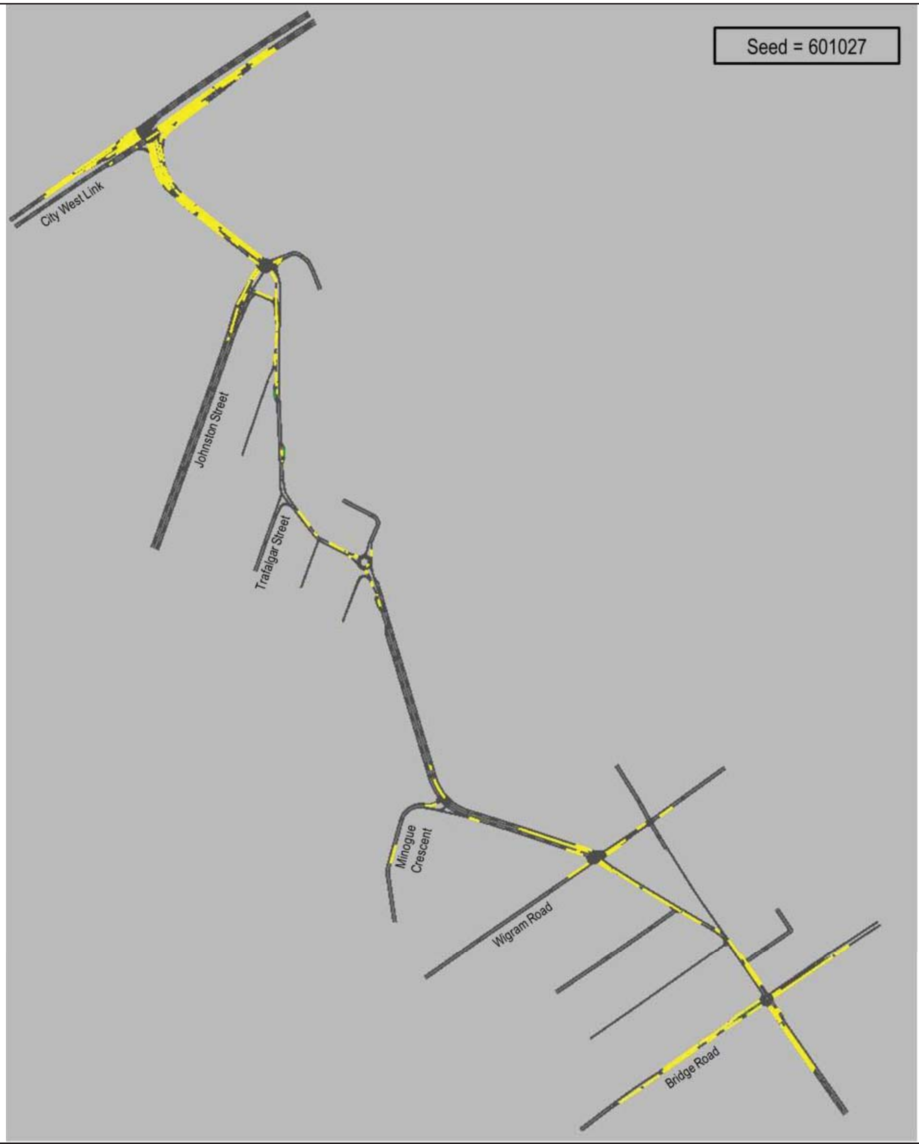


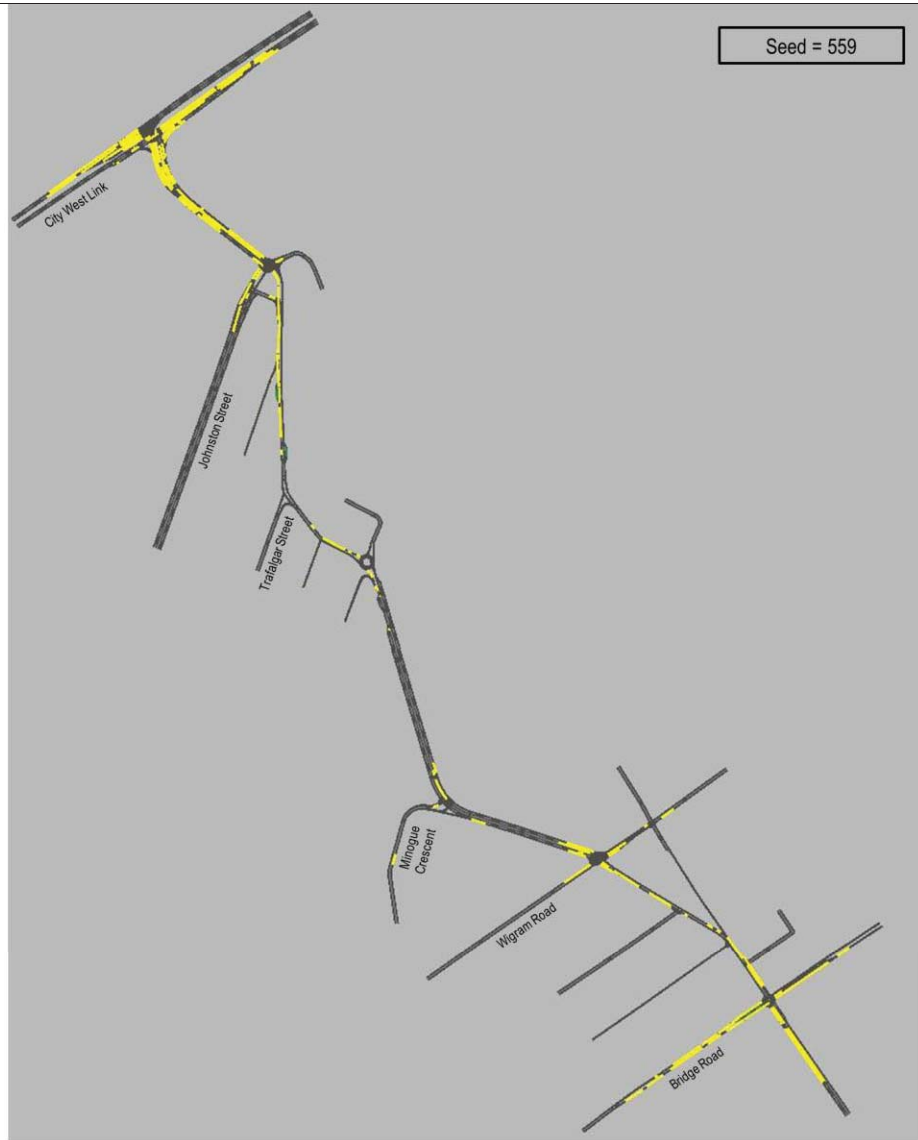
Date: May 2012	**Figure Title:** Maximum Queue Lengths	N W E S	BITZIOS consulting
Project No.: P0997	**Project Name:** Harold Park Paramics Modelling – Validation and Calibration		**Figure No.:** C.3





Date: May 2012	**Figure Title:** **Maximum Queue Lengths**	N W E S	BITZIOS consulting
Project No.: P0997	**Project Name:** **Harold Park Paramics Modelling – Validation and Calibration**		**Figure No.:** C.4





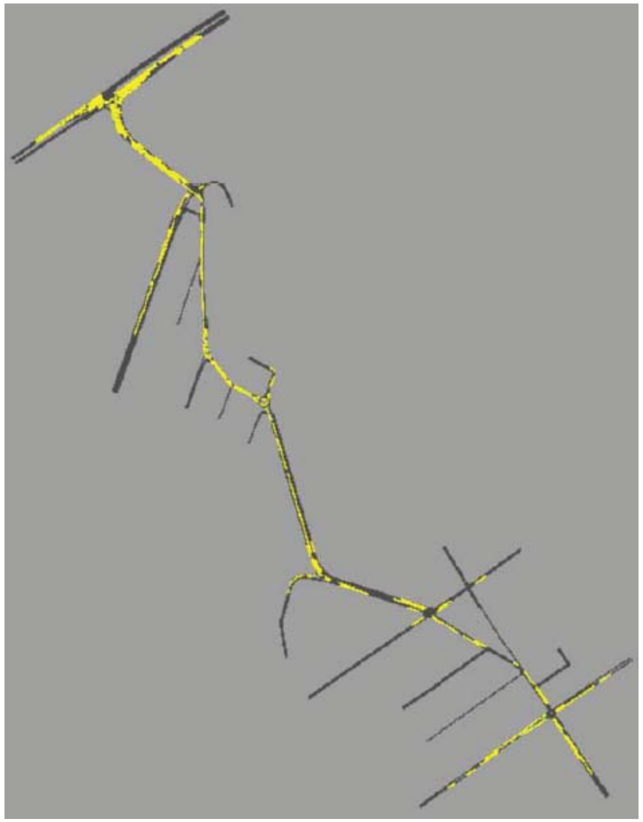
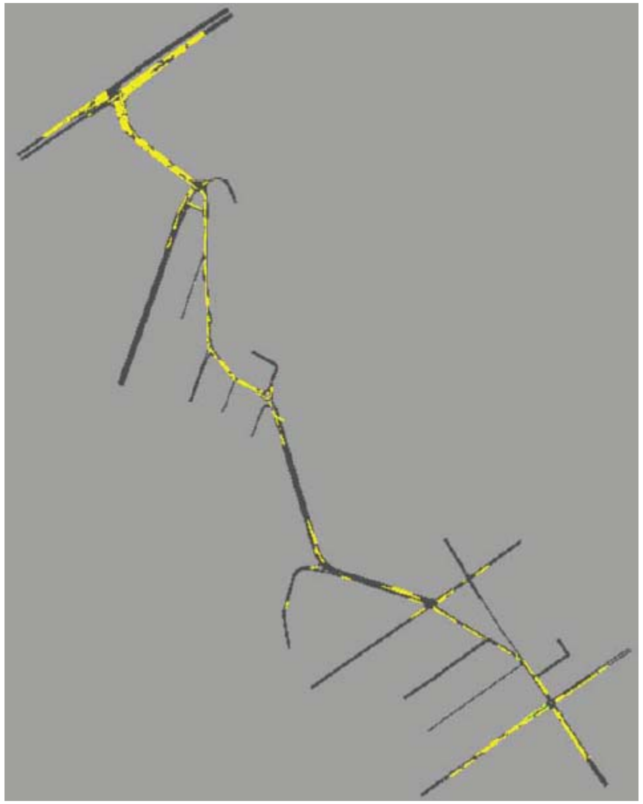
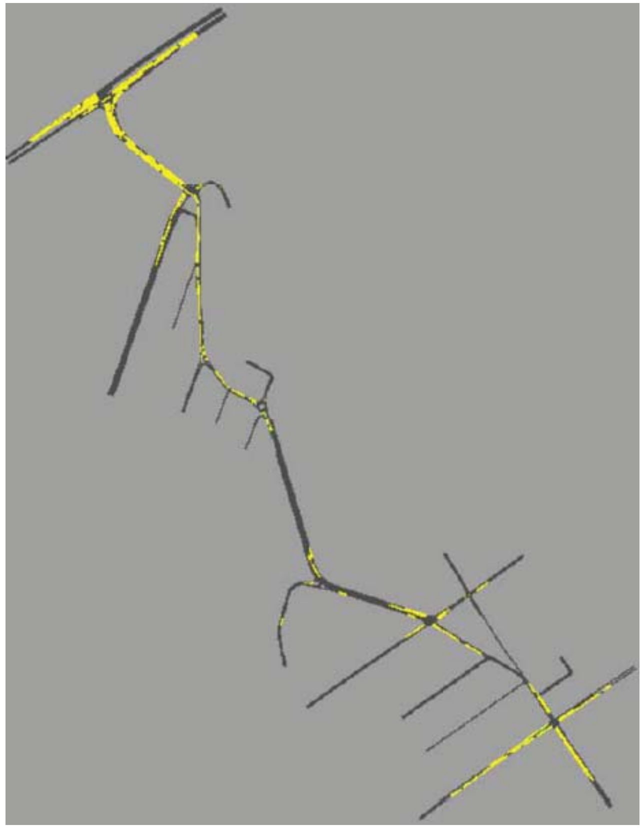
Date: May 2012	**Figure Title:** Maximum Queue Lengths	N W E S	BITZIOS consulting
Project No.: P0997	**Project Name:** Harold Park Paramics Modelling – Validation and Calibration		**Figure No.:** C.5

ATTACHMENT G

APPENDIX B

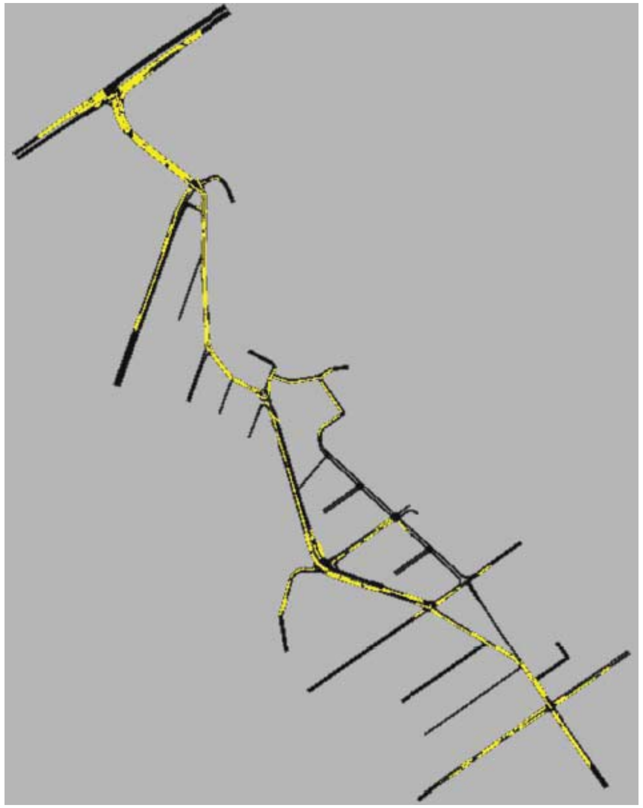
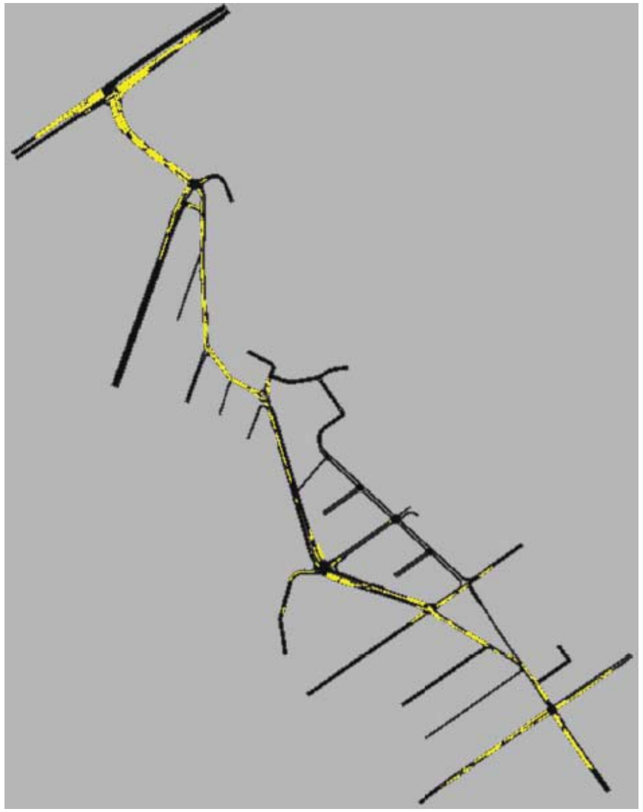
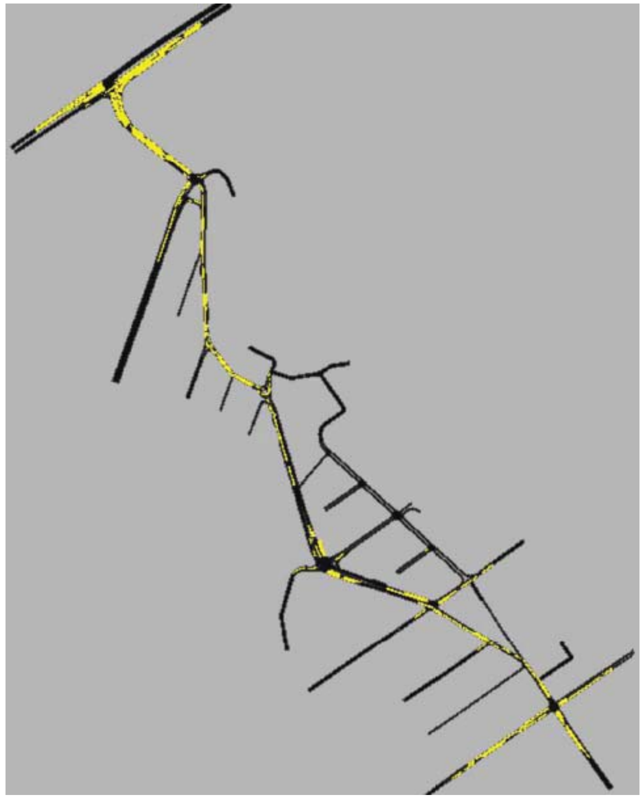
MAXIMUM QUEUE LENGTH FIGURES

ATTACHMENT G

Seed = 7771	Seed = 98812	Seed = 560
		

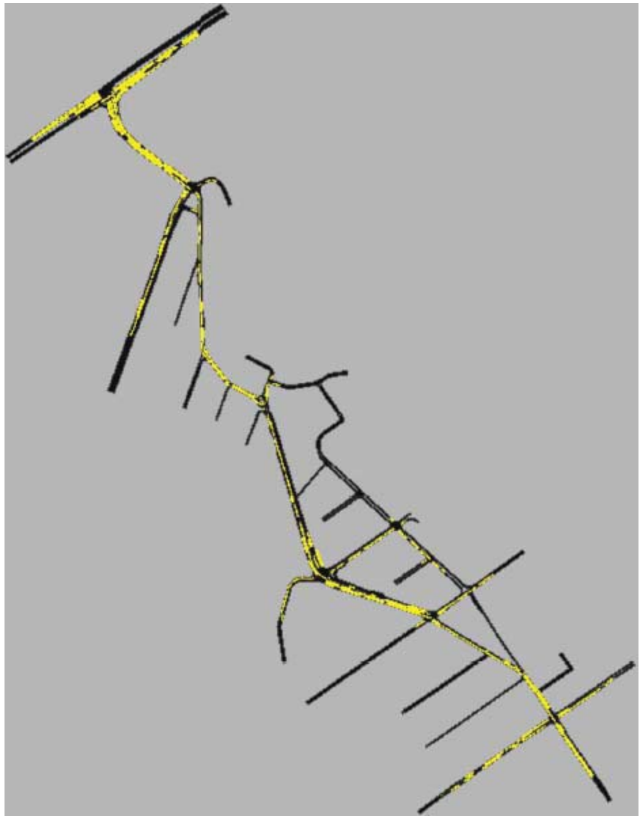
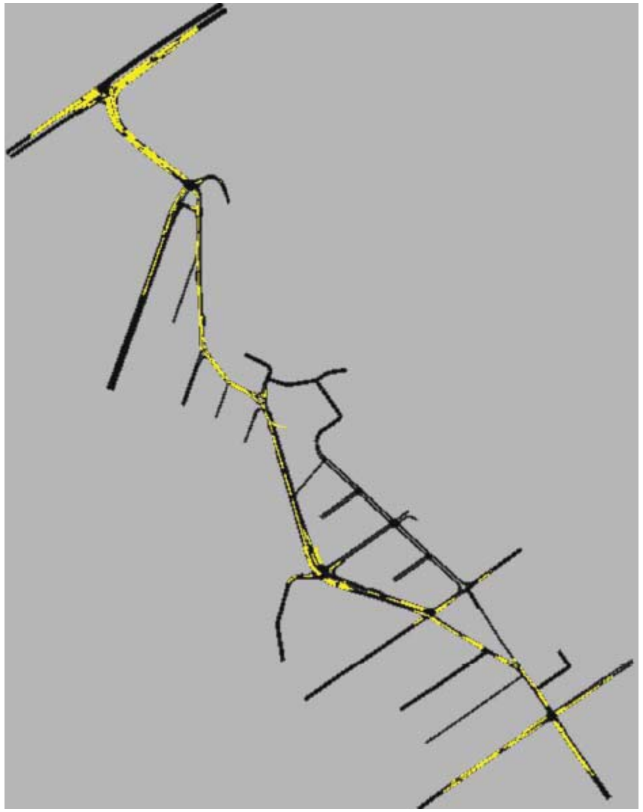
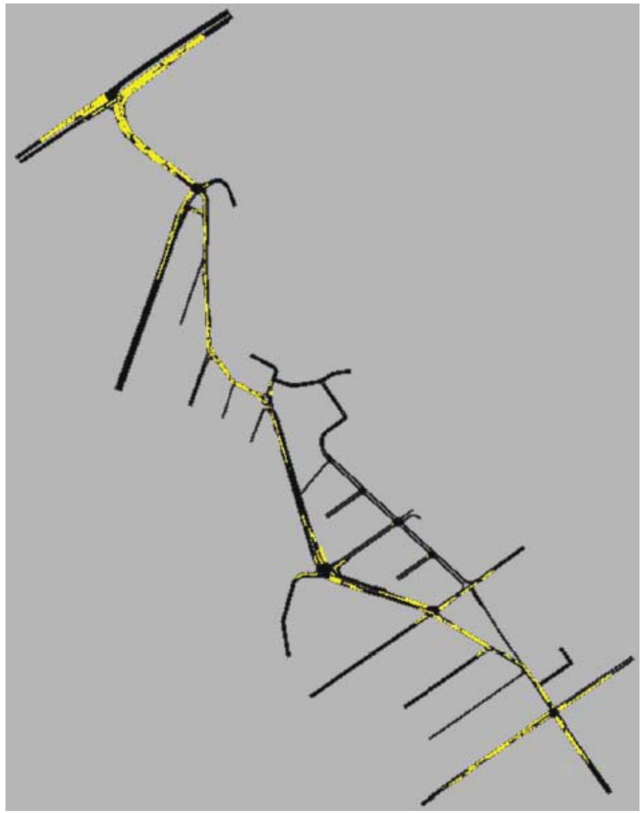
Date: July 2012	Figure Title: 2019 Do Nothing – Maximum Queue Length	Figure No.: B.1
Project No.: P0997	Project Name: Harold Park Paramics Modelling	

ATTACHMENT G

Seed = 601027	Seed = 7771	Seed = 560
		

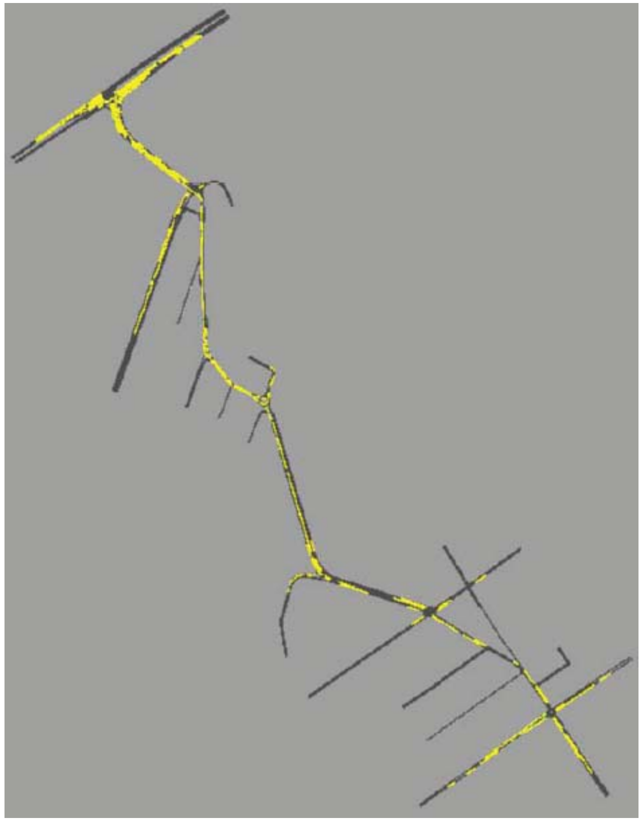
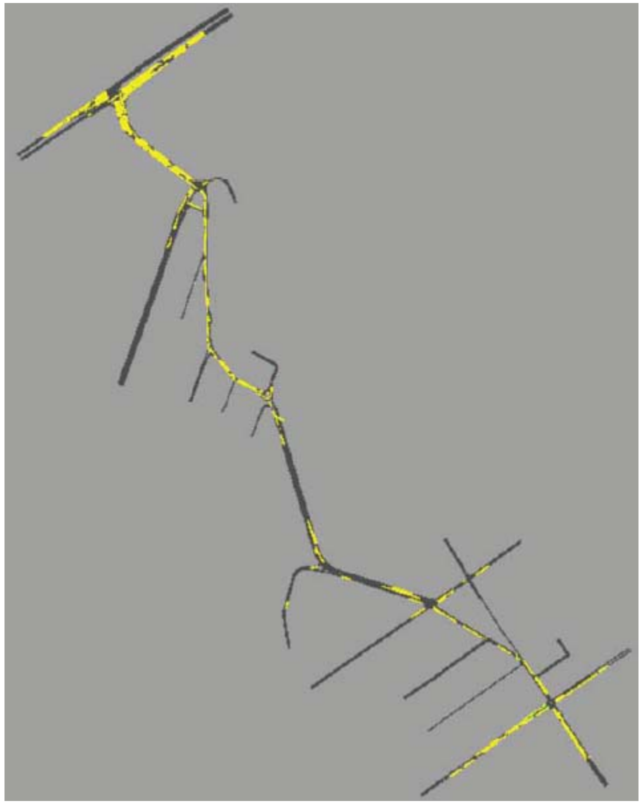
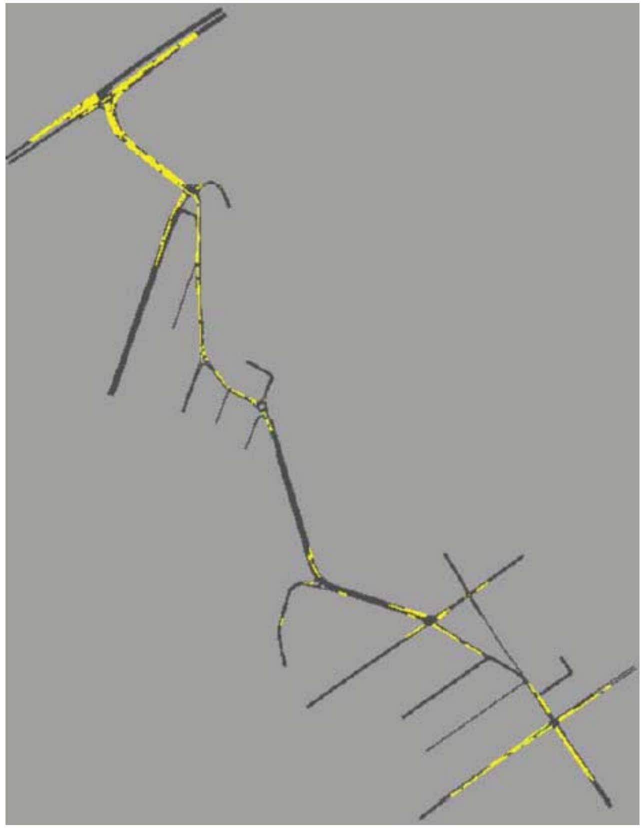
Date: July 2012	Figure Title: 2019 With Development Option 1 - Maximum Queue Length	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: B.2

ATTACHMENT G

Seed = 601027	Seed = 559	Seed = 560
		

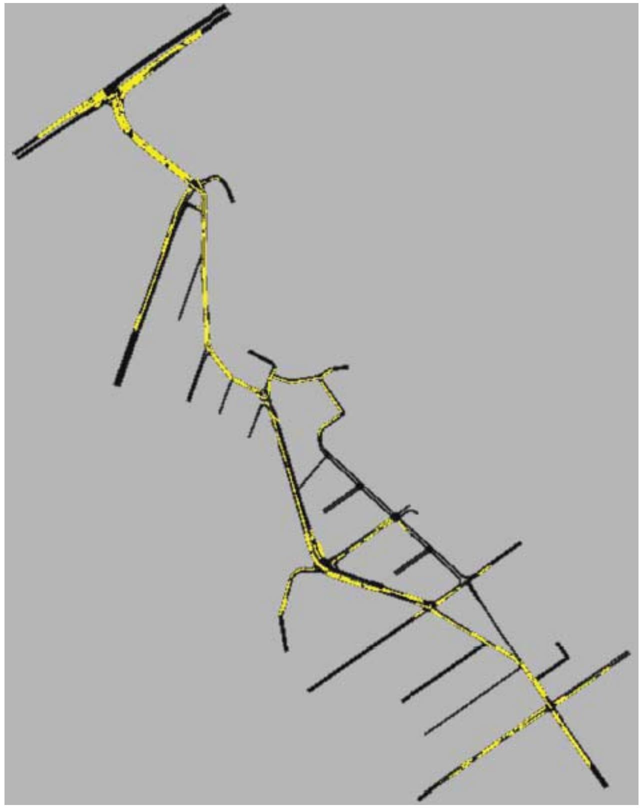
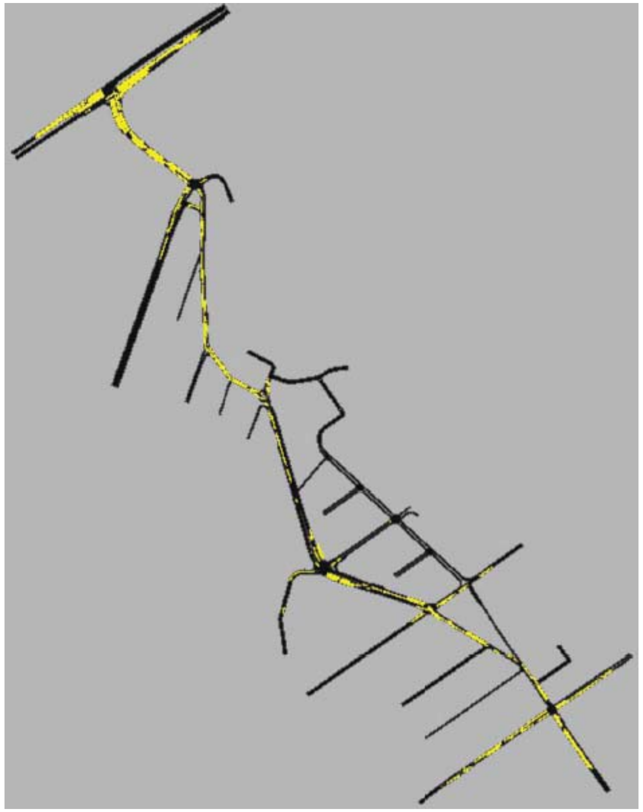
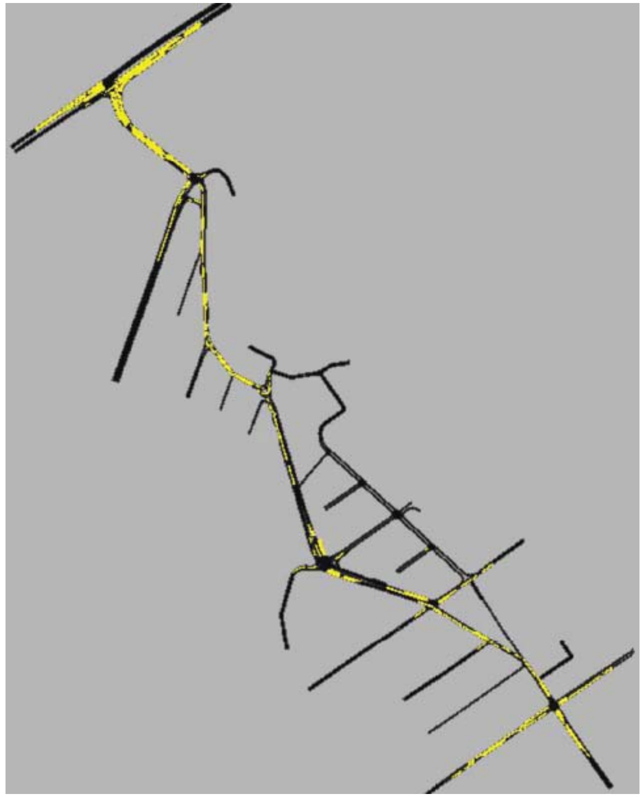
Date: July 2012	Figure Title: 2019 With Development Option 2 - Maximum Queue Length	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: B.3

ATTACHMENT G

Seed = 7771	Seed = 98812	Seed = 560
		

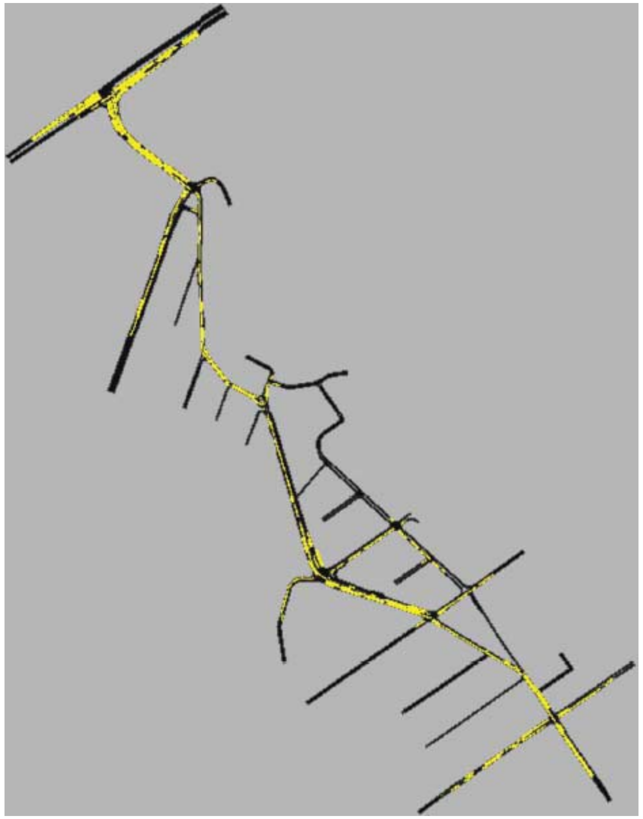
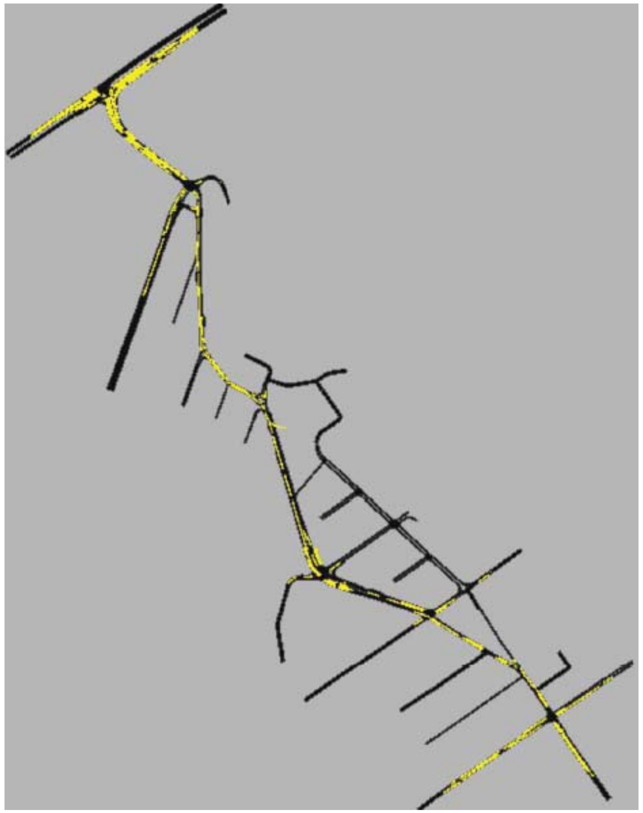
Date: July 2012	Figure Title: 2019 Do Nothing – Maximum Queue Length	N W E S	BITZIOS consulting
Pro ect No.: P0997	Pro ect Name: Harold Park Paramics Modelling		Figure No.: B.1

ATTACHMENT G

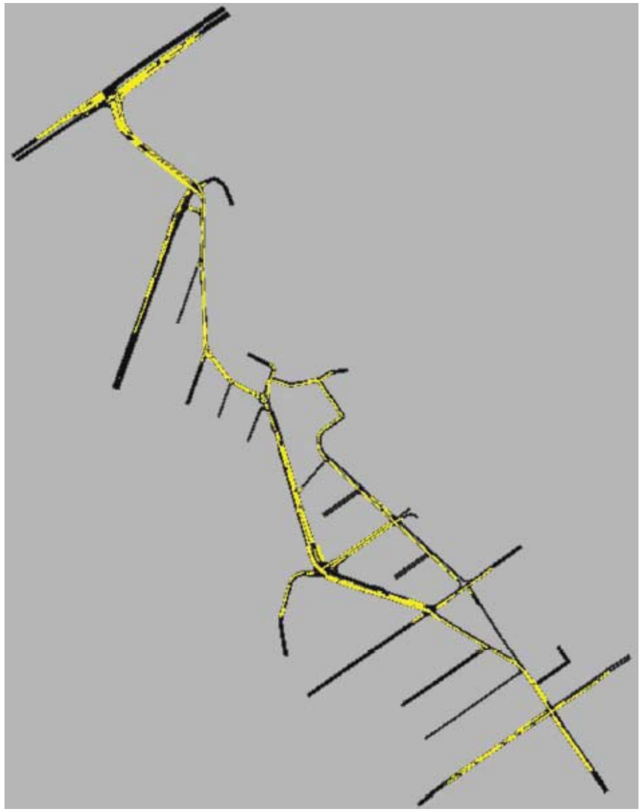
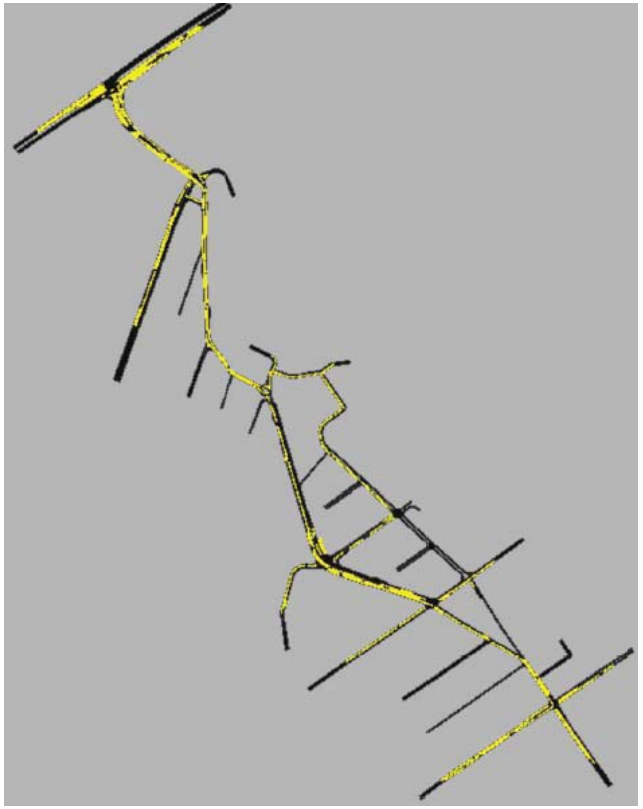
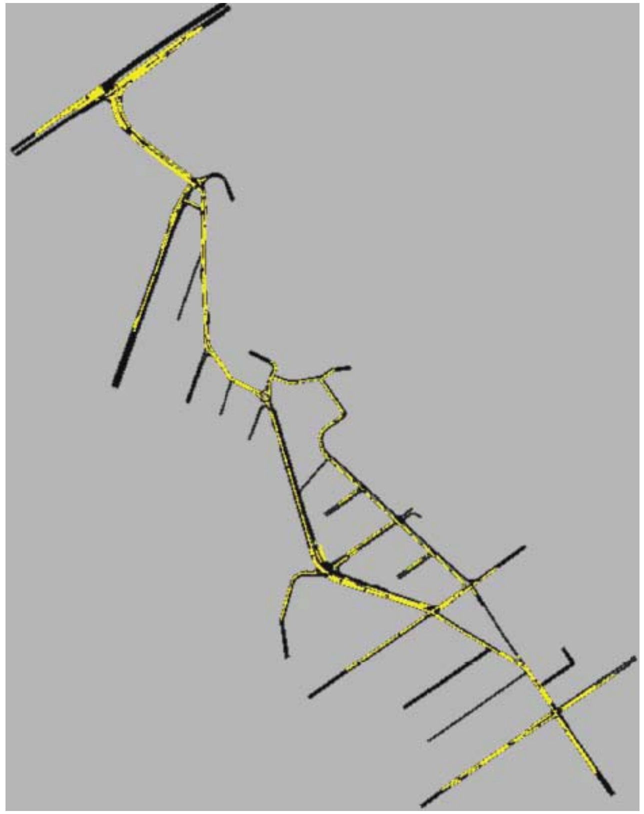
Seed = 601027	Seed = 7771	Seed = 560
		

Date: July 2012	Figure Title: 2019 With Development Option 1 - Maximum Queue Length	N W E S	BITZIOS consulting
Pro ect No.: P0997	Pro ect Name: Harold Park Paramics Modelling		Figure No.: B.2

ATTACHMENT G

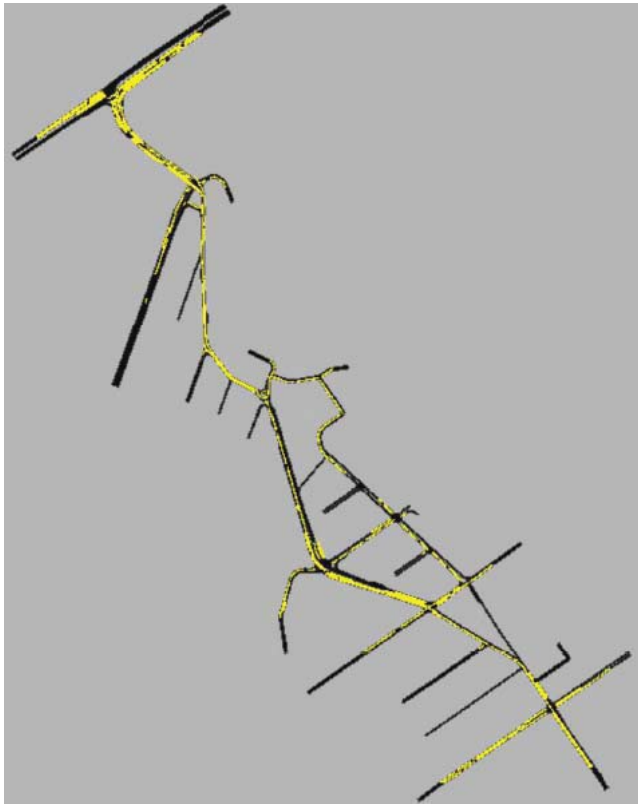
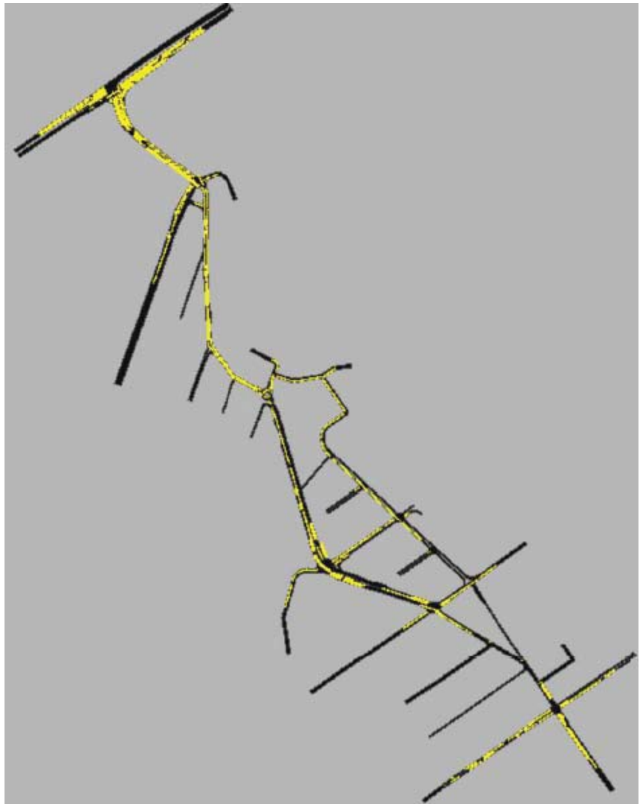
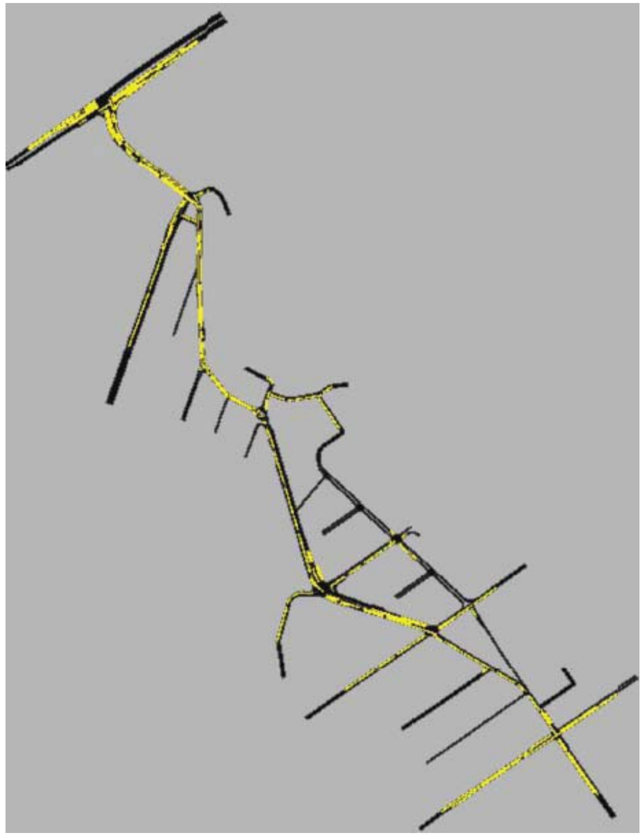
Seed = 601027	Seed = 559	Seed = 560
		

Date: July 2012	Figure Title: 2019 With Development Option 2 - Maximum Queue Length	N W E S	BITZIOS consulting
Pro ect No.: P0997	Pro ect Name: Harold Park Paramics Modelling		Figure No.: B.3

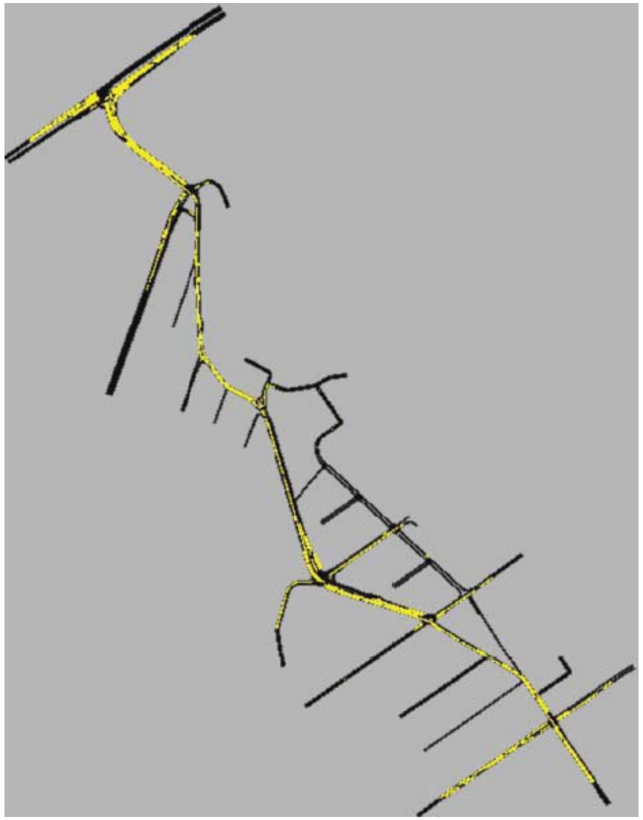
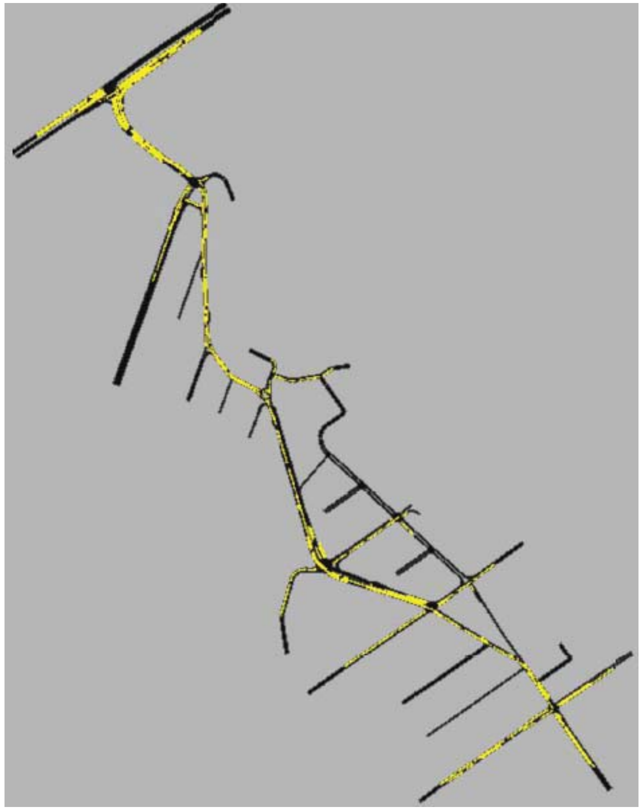
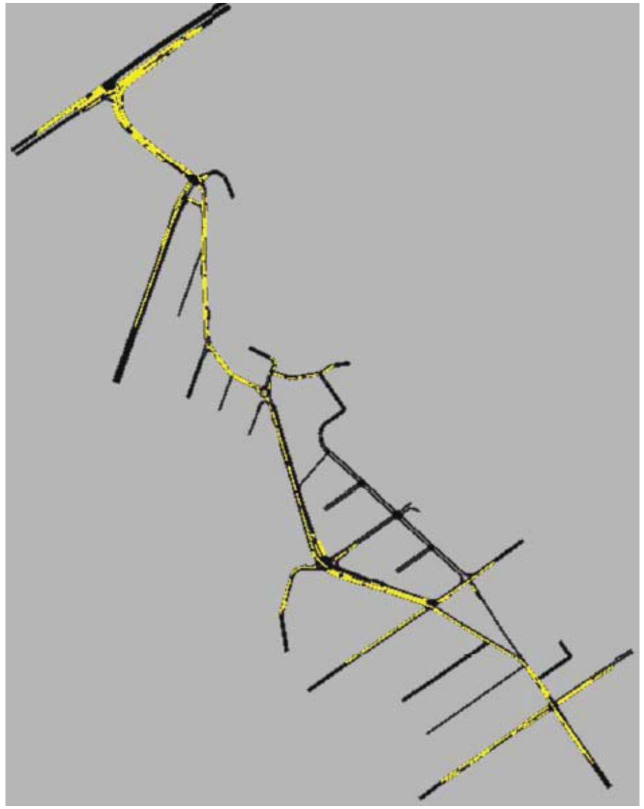
Seed = 2849	Seed = 7771	Seed = 28
		

Date: July 2012	Figure Title: 2019 With Development Option 3 - Maximum Queue Length	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: B.4

ATTACHMENT G

Seed = 2849	Seed = 560	Seed = 28
		

Date: July 2012	Figure Title: 2019 With Development Option 4A - Maximum Queue Length	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: B.5

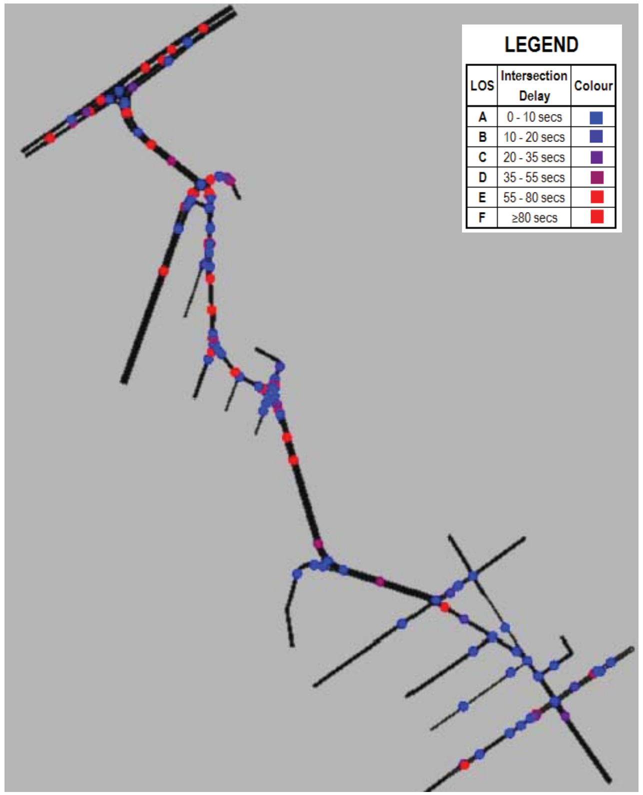
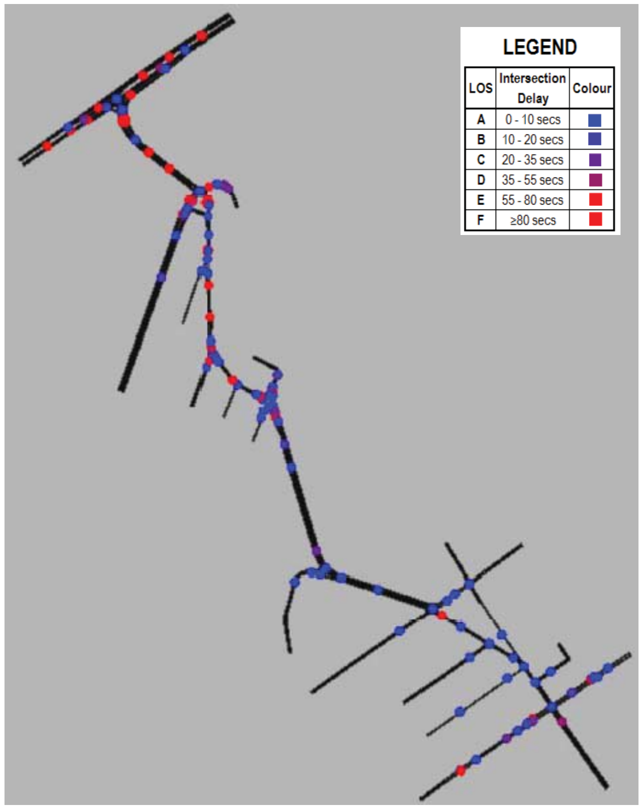
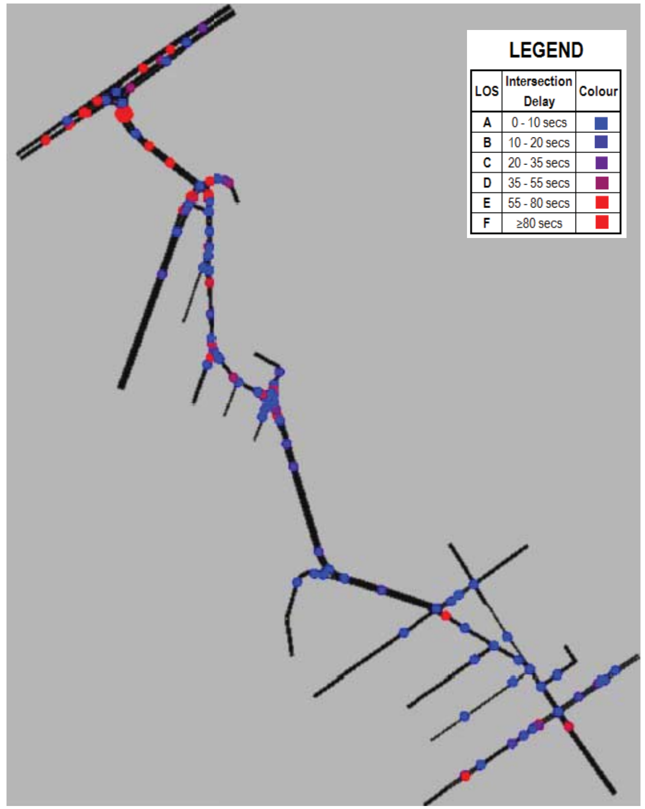
Seed = 601027	Seed = 28	Seed = 7771
		

Date: July 2012	Figure Title: 2019 With Development Option 4B - Maximum Queue Length	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling	Figure No.: B.6

ATTACHMENT G

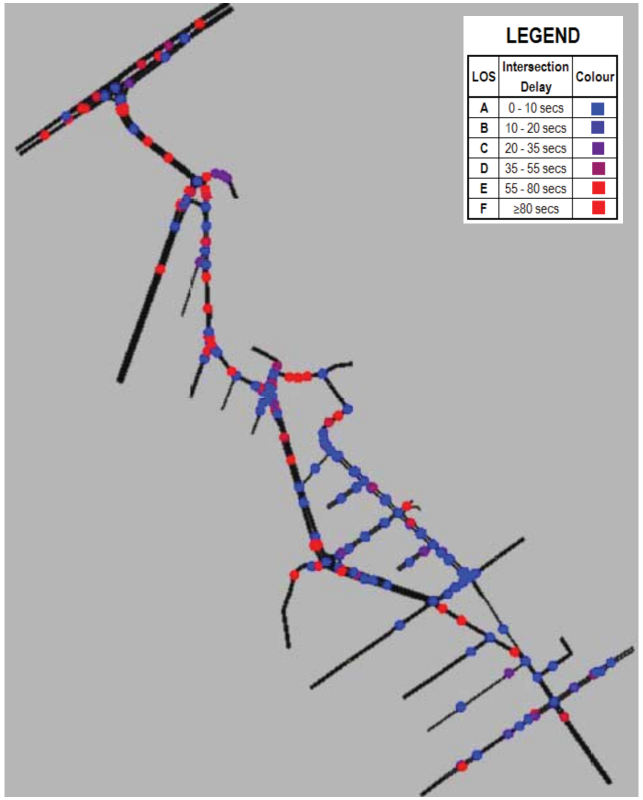
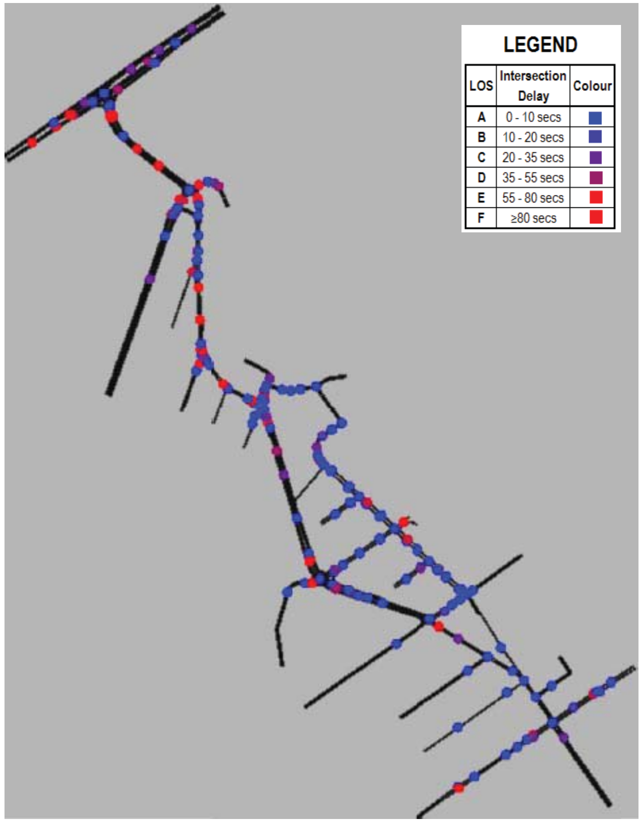
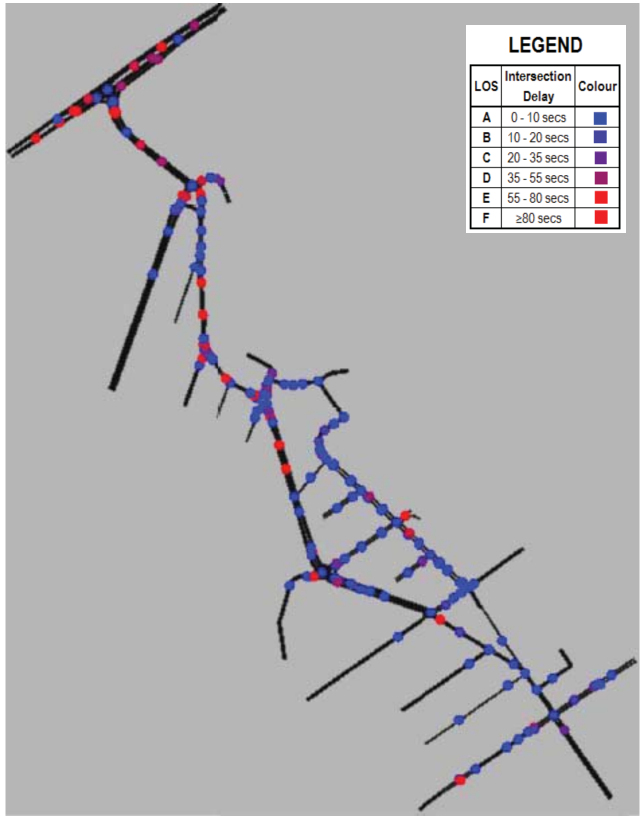
APPENDIX C

LEVEL OF SERVICE (LOS) FIGURES

Maximum	Median	Minimum
		

Date: July 2012	Figure Title: 2019 Do Nothing – Intersection Level of Service	N W E S	BITZIOS consulting
Pro ect No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.1

ATTACHMENT G

Maximum	Median	Minimum
		

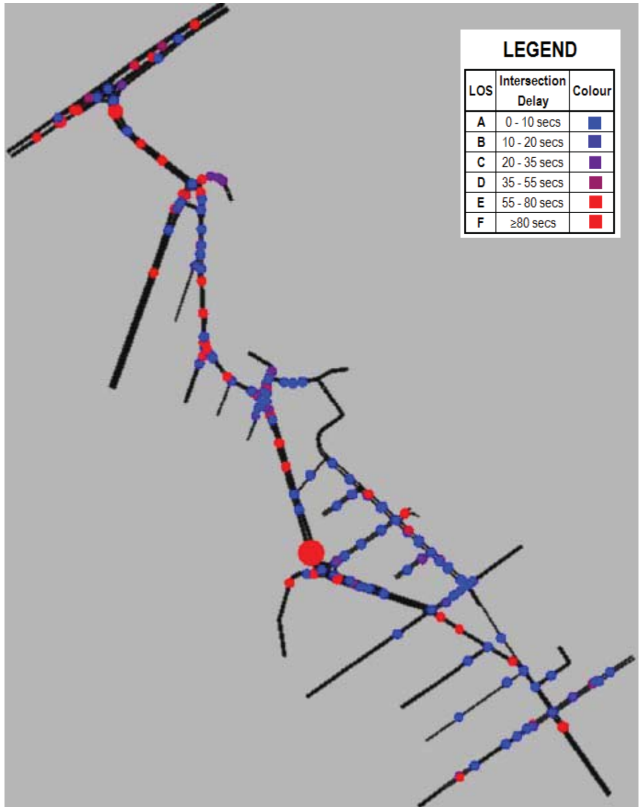
LEGEND

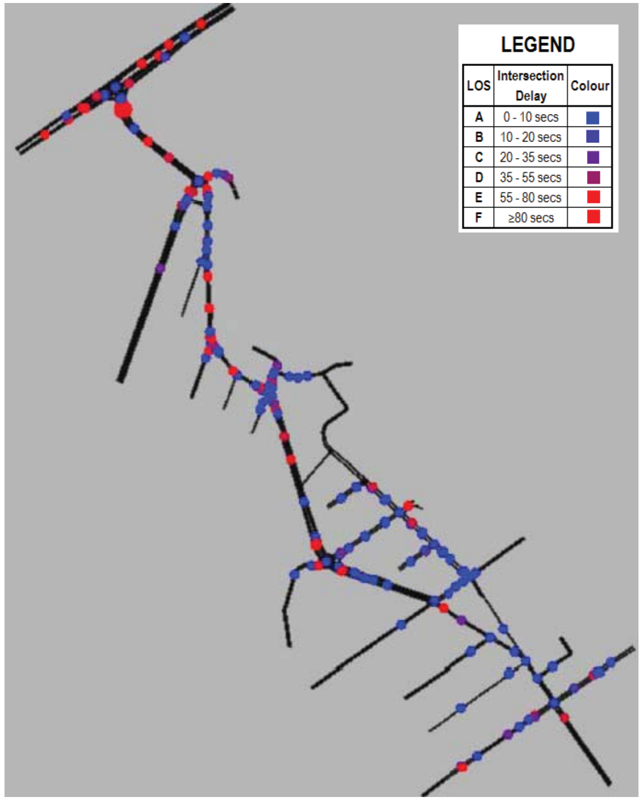
LOS	Intersection Delay	Colour
A	0 - 10 secs	Blue
B	10 - 20 secs	Blue
C	20 - 35 secs	Purple
D	35 - 55 secs	Magenta
E	55 - 80 secs	Red
F	≥80 secs	Red

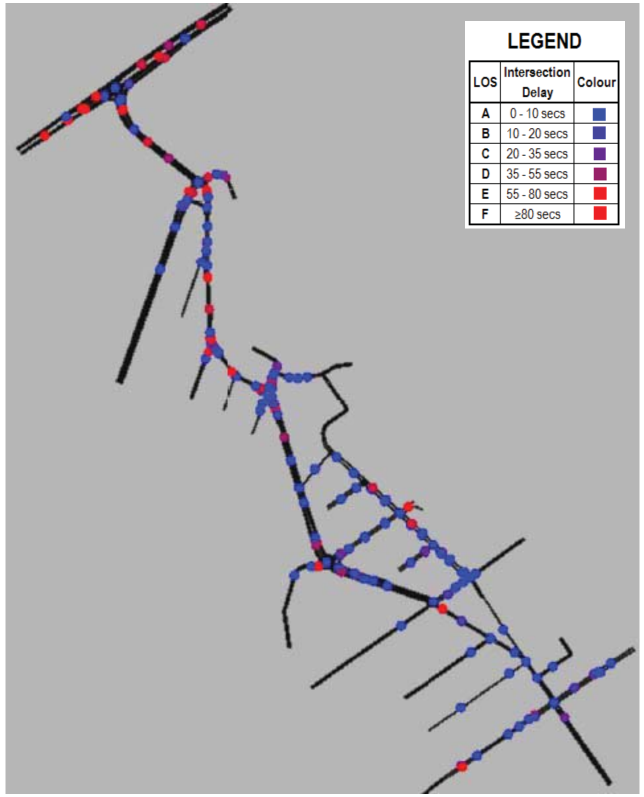
Date: July 2012	Figure Title: 2019 With Development Option 1 - Intersection Level of Service	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.2

ATTACHMENT G

Maximum	Median	Minimum

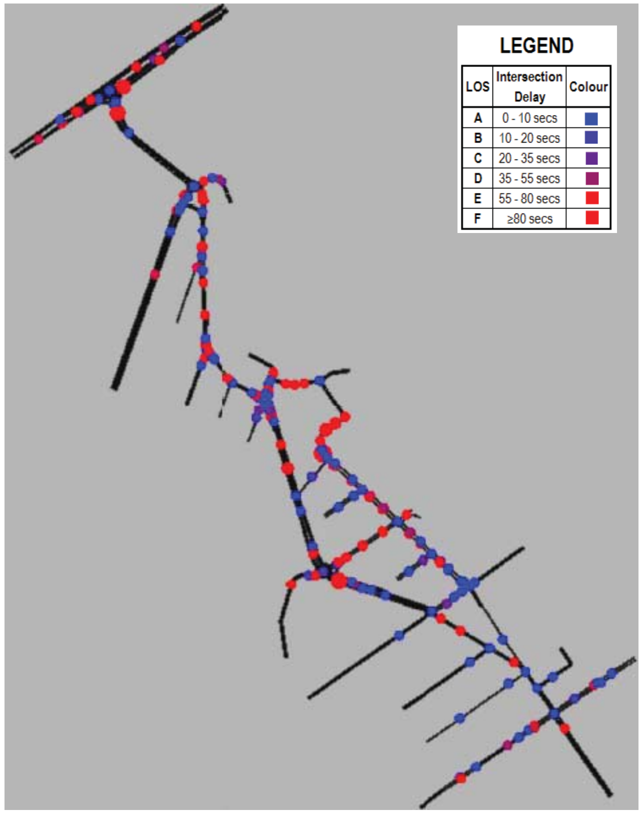
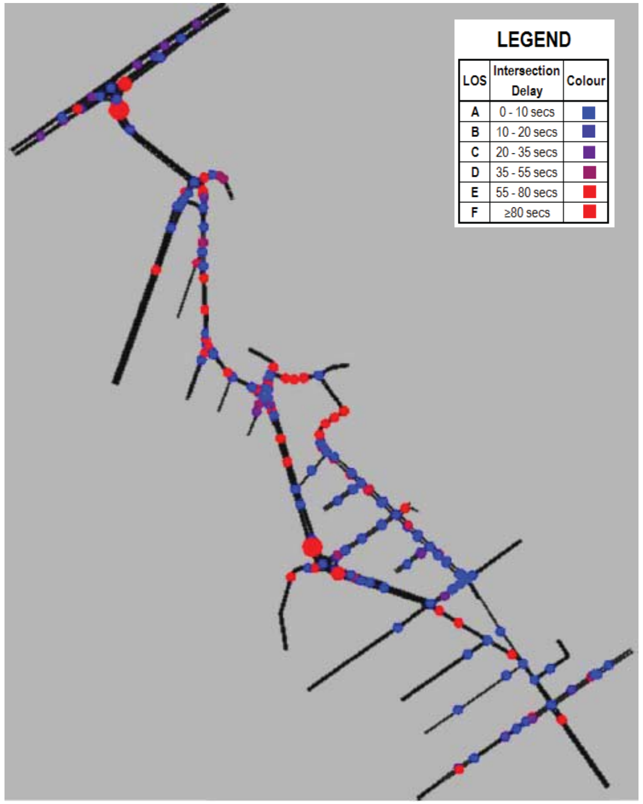
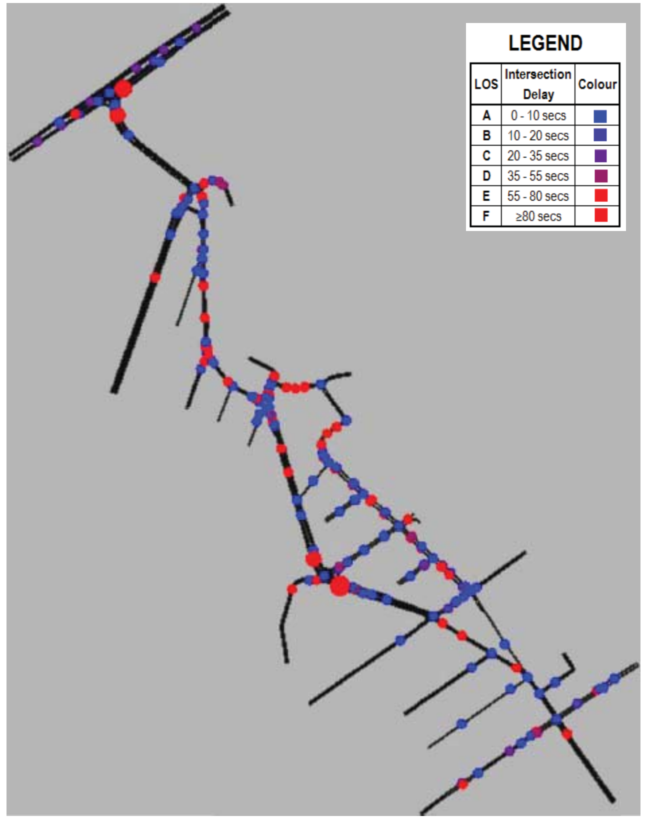






Date: July 2012	Figure Title: 2019 With Development Option 2 - Intersection Level of Service	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.3

ATTACHMENT G

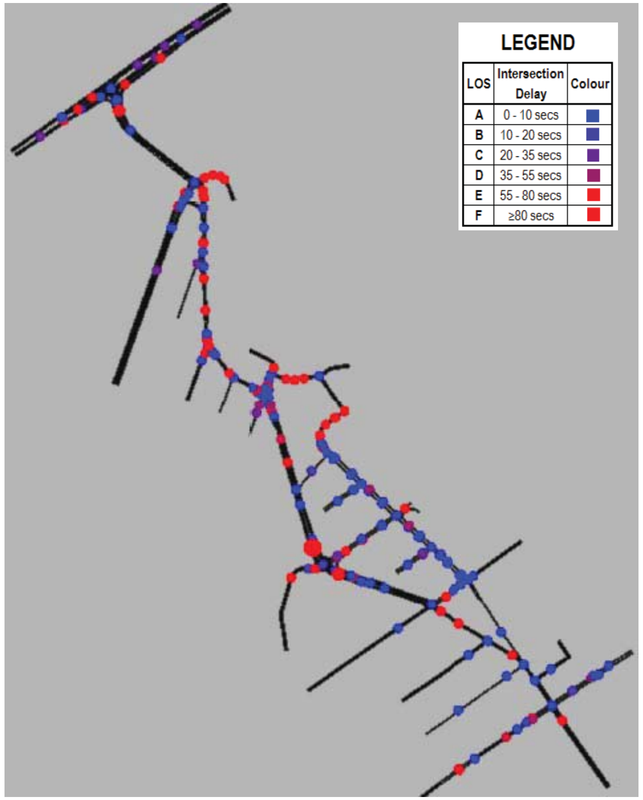
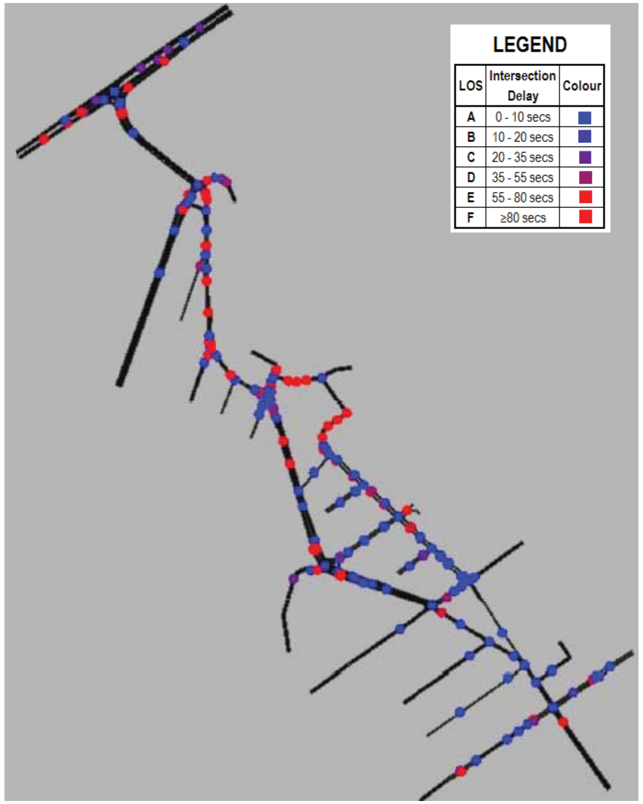
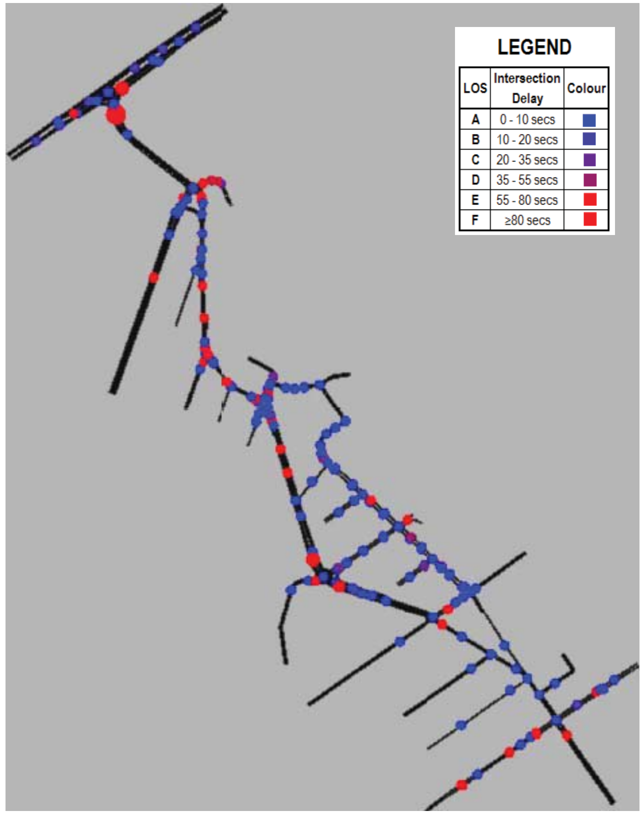
Maximum	Median	Minimum
		

LEGEND
LOS | Intersection Delay | Colour
A | 0 - 10 secs
B | 10 - 20 secs
C | 20 - 35 secs
D | 35 - 55 secs
E | 55 - 80 secs
F | ≥80 secs

LEGEND
LOS | Intersection Delay | Colour
A | 0 - 10 secs
B | 10 - 20 secs
C | 20 - 35 secs
D | 35 - 55 secs
E | 55 - 80 secs
F | ≥80 secs

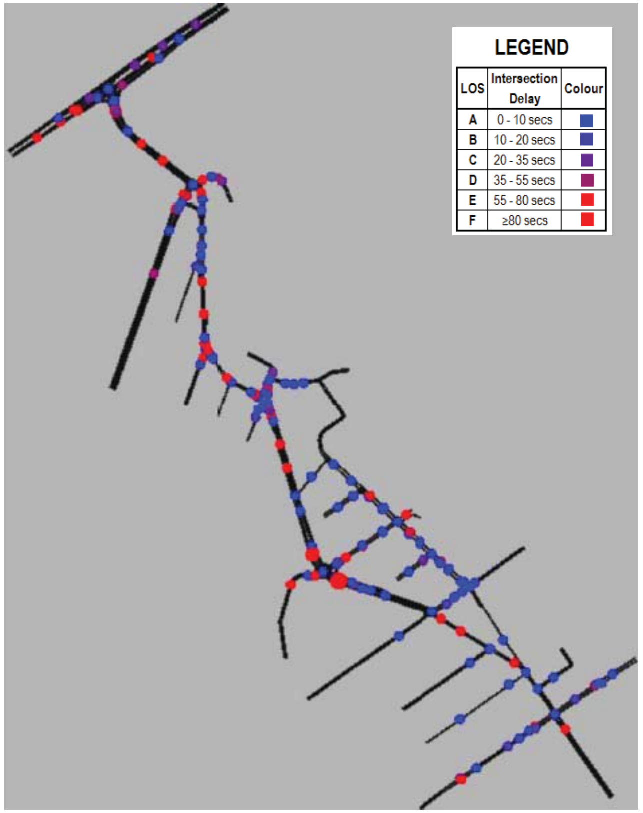
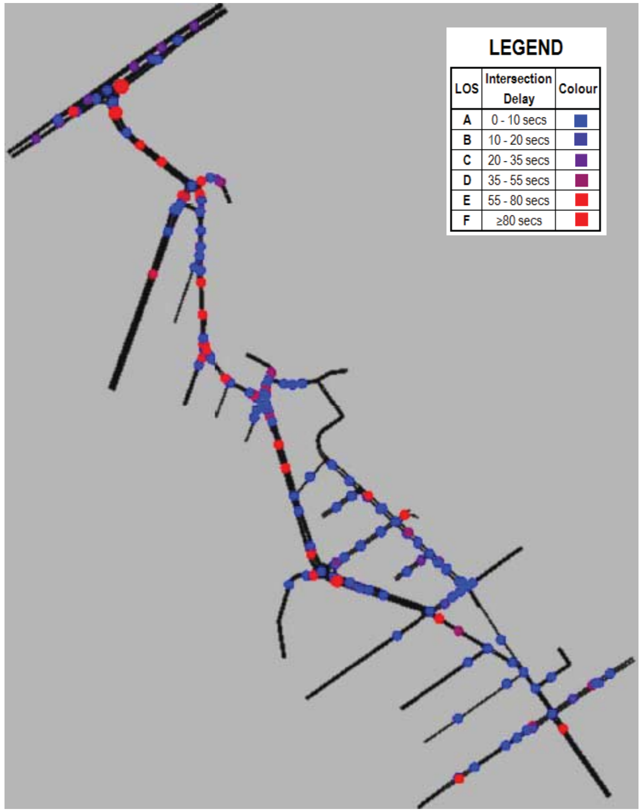
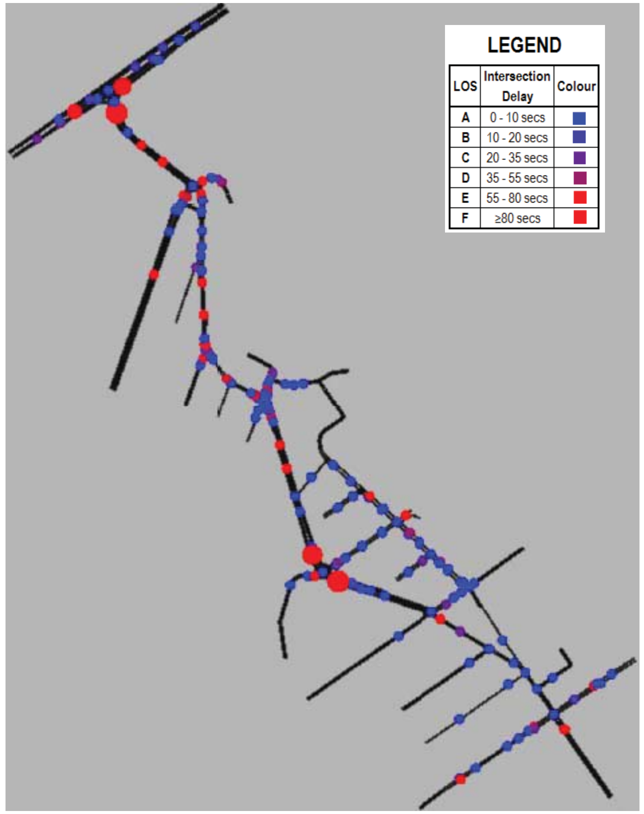
Date: July 2012	Figure Title: 2019 With Development Option 3 - Intersection Level of Service	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.4

ATTACHMENT G

Maximum	Median	Minimum
		

Date: July 2012	Figure Title: 2019 With Development Option 4A - Intersection Level of Service	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.5

ATTACHMENT G

Maximum	Median	Minimum
		

Date: July 2012	Figure Title: 2019 With Development Option 4B - Intersection Level of Service	N W E S	BITZIOS consulting
Project No.: P0997	Project Name: Harold Park Paramics Modelling		Figure No.: C.6