Technical Note

Project:	**Cardiff City Centre Transportation**	Job No:	**60197354**
Subject:	**Waun Gron Modelling – Two Way Bus Hub Modelling Update V2**		
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1. Introduction

AECOM was approached by Cardiff Council to undertake a modeling assessment of the latest highway and development proposals at the Waun Gron Road household waste and re-cycling centre.

Current proposals for the site include private development and bus interchange facilities which will directly help deliver the Cardiff Local Development Plan (LDP) 2006 – 2026. The plan is to create a key bus interchange next to the Waun Gron Park station and move towards achieving the goal of having a 50:50 split of people using sustainable modes of travel as set out in the LDP, '*Deposit Plan, Section 4, KP8 Sustainable Transport'*.

The principal area of concern is the potential impact of proposed signalised bus interchange access and egress points on key junctions in the study area, in particular the A48 Western Avenue / Waun Gron Road junction, and the impact of possible development traffic.

AECOM's work to date includes:

Title	Description
Waun Gron Option Feasibility Assessment 20.04.2015	Engineering assessment of three potential bus hub options.
Waun Gron Modelling ECR_Issue	Waun Gron Existing Conditions Report (ECR) providing a detailed traffic review of the 'core area'.
Waun Gron Modelling - LMVR	Local Model Validation Report (LMVR) which sets out the construction of AM and PM base VISSIM models and the level of calibration and validation achieved.
Powerpoint Presentation (Preliminary Results)	Initial modelling results, outlining the potential highway impacts of the initial two way circulatory bus hub design. Presented to Cardiff Council on 15/09/15.
Feasibility Modelling Assessment (Nov 15) *'Waun Gron Modelling - Option Modelling Report'*	AM and PM peak modeling of a two way circulatory bus hub under increased bus flow scenarios.

Following the November 2015 feasibility modelling the bus hub scheme was further developed by Cardiff Council with refinements to the layout of the bus hub, development area and signalised junctions. A meeting was held between AECOM and Cardiff Council to discuss the new design and the requirement for updated VISSIM modelling of the latest design proposals.

The remainder of this technical note acts as an addendum to the feasibility modelling assessment and provides an updated model specification and results that reflect the latest bus hub design.

2. Summary Conclusions

A summary of the key conclusions arising from the modeling of the updated bus hub are:

- In the AM peak period, the two way bus hub and surrounding highway network operates without significant additional congestion with 39 bus services per hour using the bus hub (20 existing services and an additional 19 buses per hour diverted from Cowbridge Road East/West
- In the PM peak period, the two way bus hub and surrounding highway network operates without significant additional congestion with 40 bus services per hour (20 existing services and an additional 20 buses per hour diverted from Cowbridge Road East/West
- The operation was assessed with a greater number of bus services diverting from Cowbridge Road, and whilst the operation of the bus hub and it's junctions with the highway network were maintained, notable additional delays were indicated on St Fagans Road in the AM peak and the A48 Northbound and Cowbridge Road East and West in the PM peak.
- In both the AM and PM periods, modelling indicates peak hour queuing southbound on Fairwater Grove. The increased delay is associated with the new signalised junction between Fairwater Grove, Waun Gron Road and the bus hub, and signal timings which were optimised to mitigate the impact of the bus hub on the A48 Western Avenue and Waun Gron Road.
- The modelling assessment has not considered in detail the internal operation and capacity of the interchange.

3. Two Way Circulatory Bus Hub Layout

Figure 1 illustrates the latest two way bus hub layout on which the modelling assessment detailed in this technical note was undertaken.

Figure 1 - Two Way Circulatory Bus Hub

4. Two Way Circulatory Bus Hub Modelling updates:

AM and PM peak VISSIM models were updated to reflect the latest bus hub design as detailed below:

- VISSIM network updated to replicate the new design, including relocation of signal heads, bus stops, pedestrian crossings and development access arrangements.
- VISSIM and LinSig phase intergreens recalculated to reflect the updated design and location of on street signal heads. (10s -Waun Gron Ped, 17s -Bus hub/Waun Gron Rd, 18s -Bus Hub/A48)
- Pedestrian crossings across the South and North of the bus hub are assumed to be called every cycle to replicate a worst case scenario in both peak hours.
- The new design also features 10 undercroft parking spaces within the development; for the purpose of this assessment it is assumed that in the AM and PM peak hours each parking space is utilised three times during each peak hour resulting in traffic flows of 30 vehicles per hour in and out of the development area.

A preliminary LinSig model was developed with updated intergreens at all junctions and updated staging on the A48/Bus hub junction. This was used to provide indicative signal timings which were entered into VISSIM and visually optimised to ensure there is minimal wasted green time.

5. Modelling Scenarios

General traffic is unchanged from the base models except for access and egress from the proposed bus hub development where 30 vph were allocated to movements in and out of the bus hub.

Bus demand scenarios are retained from previous feasibility modelling. Bus 'stress test' scenarios in which the number of bus services diverted in to the bus hub are incrementally increased to assess the operation of the surrounding highway network. Scenario 2 and 3 below were seen to provide sufficient bus demand in the AM and PM peaks respectively after which any additional bus demand caused the network to 'breakdown'.

Table 1 - Bus Service Routing Scenarios

Scenario	Description	AM Buses Per Hour	PM Buses Per Hour
2	Scenario 1 + Service 17/18 diverted from Cowbridge Road East/West	39	40
3	Scenario 2 + Service X1 & X2 diverted from Cowbridge Road East/West	51	53

A full list of bus routeing assumptions within each scenario is included in the 'Waun Gron Modelling - Option Modelling Report'.

The latest Waun Gron bus hub layout in **Figure 1** has been initially assessed with' Scenario 2' bus demand in both the AM and PM peaks, and if this is seen to operate effectively 'Scenario 3' demand also.

6. Updated Two Way Hub Option Results

5.1 Average Speeds - AM Peak

Average modelled speeds of all vehicles in the Base and Scenario 2 (39 buses) AM peak models are indicated in **Figure 2** and **Figure 3** below. Pink indicates an average speed of below 5mph, whilst yellow/green indicates near free flowing speeds.

Figure 2 - Average Speeds - Base - AM Peak Hour

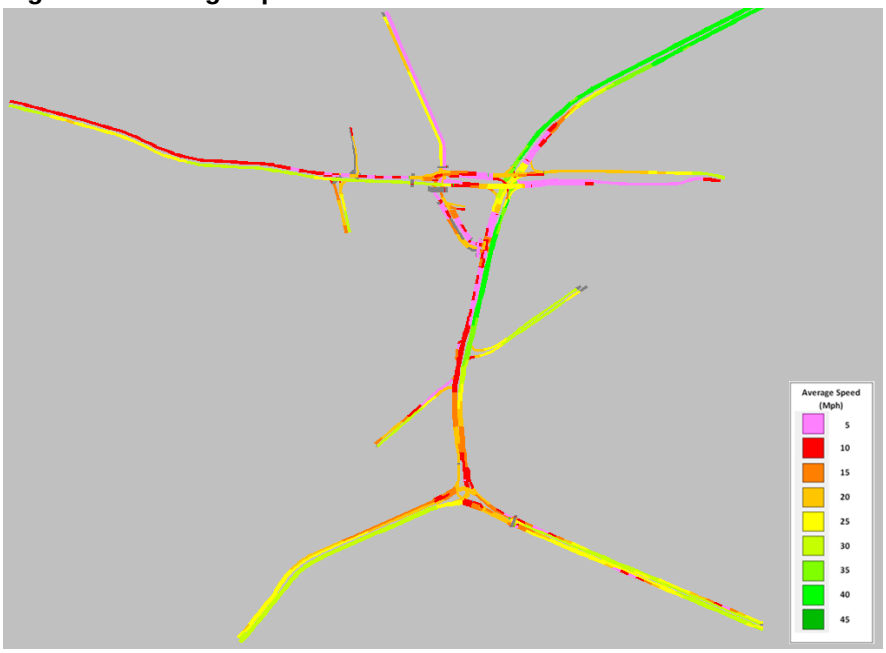


Figure 3 - Average Speeds - Scenario 2 (39 buses) - AM Peak Hour

Figure 3 indicates that in Scenario 2 average speeds on the A48 Western Avenue and Cowbridge Road corridors are maintained at speeds near those recorded in the base situation.

Average speeds on Fairwater Grove and Waun Gron Road westbound approach to the A48 decrease with the bus hub in place as the signals have been optimised to ensure St Fagans Road Eastbound continues to operate without additional congestion.

Peak hour queuing occurs southbound on Fairwater Grove with over 100 vehicles not entering the model due to congestion. The increased queueing is associated with the new signalised junction between Fairwater Grove, Waun Gron Road and the bus hub, and signal timings which were optimised to mitigate the impact of the bus hub on the A48 Western Avenue and Waun Gron Road. The 'trade off' of increasing the amount of green time on Fairwater Grove approach directly impacts on the level of congestion, and the number of cars not entering the model, from St Fagans Road.

In AM peak scenarios with more than 39 buses per hour (Scenarios 3), the average speed of vehicles on the Cowbridge Road West approach to Ely bridge roundabout fall below 10 mph. St Fagans Road Eastbound also falls below 5 mph with queues extending off the modelled network.

5.2 Average Speeds - PM Peak

Average modelled speeds of all vehicles in the Base and Scenario 2 (40 buses) PM peak models are indicated in **Figure 4** and **Figure 5** below

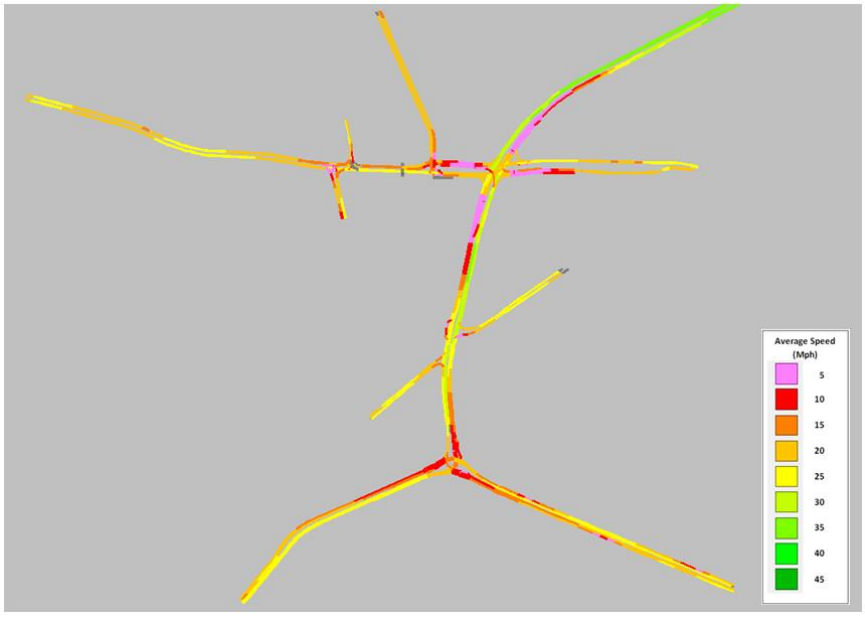


Figure 4 - Average Speeds - Base - PM Peak Hour

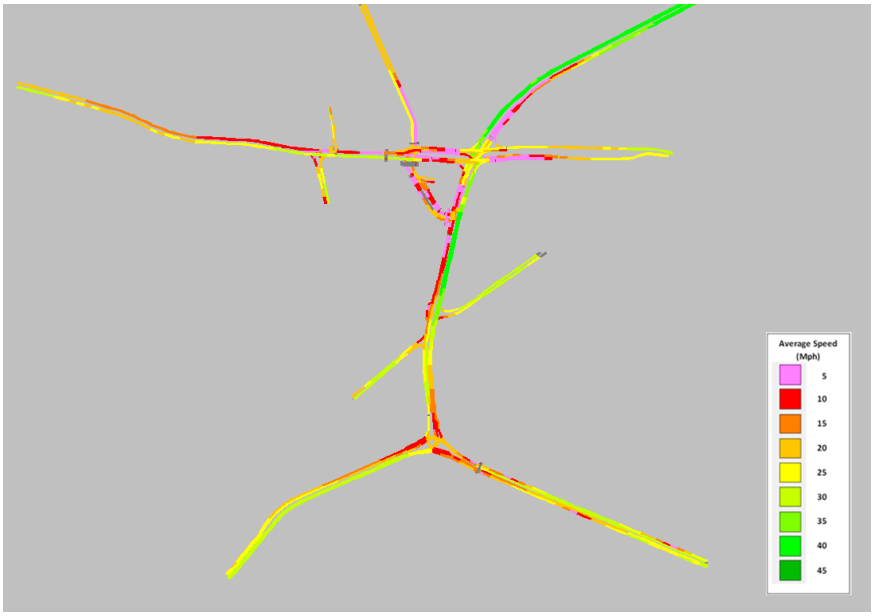


Figure 5 - Average Speeds - Scenario 2 (40 buses) - PM Peak Hour

Figure 5 indicates that average speeds on the A48 Western Avenue and Cowbridge Road corridors are maintained at speeds near those recorded in the base situation. Average speeds on Fairwater Grove decrease on the approach to the new signalised junction.

Average speeds on the Waun Gron Road westbound approach to the A48 decrease with the bus hub in place.

In modelled PM peak scenarios with bus volumes above 40 buses per hour (Scenarios 3) the average speed of vehicles on the Cowbridge Road West approach to Ely bridge roundabout fall to below 10 mph with peak hour delays extending off the modelled network.

5.3 General Traffic Journey Times

AM and PM peak, base and two way hub modelled journey time comparisons (over the routes indicated in **Figure 6**), are shown in **Table 2** and **Table 3**.

Figure 6 - General Traffic Journey Time Routes

Table 2 – AM Journey Times – All Traffic excluding Buses

From	To	Modelled - All Traffic (Seconds)				
		AM Base	Scenario 2 (39 buses)	Difference	Scenario 3 (51 buses)	Difference
Cowbridge Rd E	A48	132	146	14	144	12
A48	Cowbridge Rd E	116	119	3	120	4
St Fagans Rd W	Waun Gron Rd E	180	165	-15	169	-11
Waun Gron Rd E	St Fagans Rd W	127	267	140	260	132
St Fagans Rd W	Cowbridge Rd E	262	232	-30	235	-27
Cowbridge Rd E	St Fagans Rd W	162	202	39	203	41

Table 3 – PM Journey Times – All Traffic excluding Buses

From	To	Modelled - All Traffic (Seconds)				
		PM Base	Scenario 2 (40 buses)	Difference	Scenario 3 (53 buses)	Difference
Cowbridge Rd E	A48	136	142	6	148	12
A48	Cowbridge Rd E	125	124	-1	125	0
St Fagans Rd W	Waun Gron Rd E	89	153	64	171	82
Waun Gron Rd E	St Fagans Rd W	119	133	14	133	14
St Fagans Rd W	Cowbridge Rd E	152	237	85	262	110
Cowbridge Rd E	St Fagans Rd W	173	231	58	236	63

In the AM peak, the most notable increase in journey times is from Waun Gron Road East heading west where average journey times increase by 140 seconds in Scenario 2. This increase is a result of vehicles passing through one additional set of signals and signal timings adjustments made to facilitate the bus hub operation. Similarly travel times between Cowbridge Road East and St Fagans Road increase due to the additional signalised junctions this movement must pass through.

AM peak journey times from St Fagans Road reduce in the bus hub option scenarios as signal timings adjustments assist with vehicles making these movements.

PM peak journey times increase on all but one movements but most noticeably on movements from St Fagans Road due to signal timing adjustments made to facilitate the bus hub operation.

Whilst Scenario 3 journey times appear comparable to Scenario 2 the additional bus demand causes vehicles to queue off the modelled network, and hence the full extent of the journey is not reflected in the journey time values.

5.4 Bus Journey Times

AM and PM peak, modelled bus journey time comparisons are shown in **Table 4** and **Table 5**.

Table 4 – AM Journey Times – Buses only

Route	From	To	Modelled – Buses (Seconds)				
			AM Base	Scenario 2 (39 buses)	Diff	Scenario 3 (51 buses)	Diff
Cardiff Bus 1 - Clockwise	Cowbridge Rd E	A48	278	418	140	436	158
Cardiff Bus 2 – Anti Clockwise	A48	Cowbridge Rd E	172	297	126	300	129
Cardiff Bus 61 - Inbound	St Fagans Rd W	Waun Gron Rd E	169	346	177	361	192
Cardiff Bus 61 - Outbound	Waun Gron Rd E	St Fagans Rd W	143	506	363	485	342
Cardiff Bus 64/65 - Inbound	St Fagans Rd W	Cowbridge Rd E	334	333	0	345	11
Cardiff Bus 64/65 - Outbound	Cowbridge Rd E	St Fagans Rd W	289	326	37	327	38

Table 5 – PM Journey Times – Buses only

Route	From	To	Modelled – Buses (Seconds)				
			PM Base	Scenario 2 (40 buses)	Diff	Scenario 3 (53 buses)	Diff
Cardiff Bus 1 - Clockwise	Cowbridge Rd E	A48	228	432	204	432	204
Cardiff Bus 2 - Anti Clockwise	A48	Cowbridge Rd E	203	403	200	430	228
Cardiff Bus 61 - Inbound	St Fagans Rd W	Waun Gron Rd E	114	282	168	322	208
Cardiff Bus 61 - Outbound	Waun Gron Rd E	St Fagans Rd W	150	348	199	405	255
Cardiff Bus 64/65 - Inbound	St Fagans Rd W	Cowbridge Rd E	230	327	97	383	153
Cardiff Bus 64/65 - Outbound	Cowbridge Rd E	St Fagans Rd W	252	363	112	358	106

Large increases in bus journey times are recorded throughout the AM and PM peak as a direct result of the rerouting of bus services to pass through the hub, and in some cases, to and from Cowbridge Road to the bus hub.

In the AM and PM peak the smallest changes are seen on the 64 and 65 routes, which both now bypass the A48/Waun Gron signals by travelling through the bus hub.

5.5 Queue Comparison

AM and PM peak base and two way option modelled queue comparisons are provided in **Figure 7** and **Figure 8** for Scenario 2 (39 Buses) in the AM peak, and for Scenario 2 (40 Buses) in the PM peak. Modelled queues are provided for the following two junctions:

- A48 Western Avenue / Waun Gron Road; and
- A48 Western Avenue / Cowbridge Road East and West

A visual 'snapshot' of the AM and PM network each 15 minutes is provided in **Appendix A**

5.5.1 A48 Western Avenue / Waun Gron Road

Queues in the AM peak on the Waun Gron Road Westbound approach to the A48 increase with the bus hub due to signal timing adjustments made to facilitate the bus hub operation, whilst in the PM queues are maintained at levels similar to that shown in the base models.

In the AM peak St Fagans Road Eastbound has similar levels of queuing to the base model (with all vehicles entering the network). In the PM peak queues on St Fagans Road Eastbound increase due to signal timing adjustments made to facilitate the bus hub junctions and maintain the operation of the surrounding highway network.

In the AM and PM peak, Scenario 2 queues on the A48 southbound are maintained at a similar level to the base models.

AM and PM peak queuing on the A48 Northbound increase due to the 3 stage signalised bus hub junction which was not present in the base, and a pedestrian stage which is called every cycle. In Scenario 2 queues are maintained on the A48 and do not impact on the operation of Ely Bridge roundabout. PM peak queuing on the A48 Northbound also increase due to blocking back from the left turn onto Waun Gron Road. The signals were optimised in such a way that left turners from the A48 Northbound turn onto a red signal by the northern entry to the bus hub.

In Scenario 3 queuing extends beyond the modelled highway network.

5.5.2 A48 Western Avenue / Cowbridge Road East and West (Ely Bridge Roundabout)

AM and PM (Scenario 2) peak average queues at the Ely bridge roundabout are maintained at levels close to those recorded in base modelling.

Figure 7 - AM Scenario 2 Queues

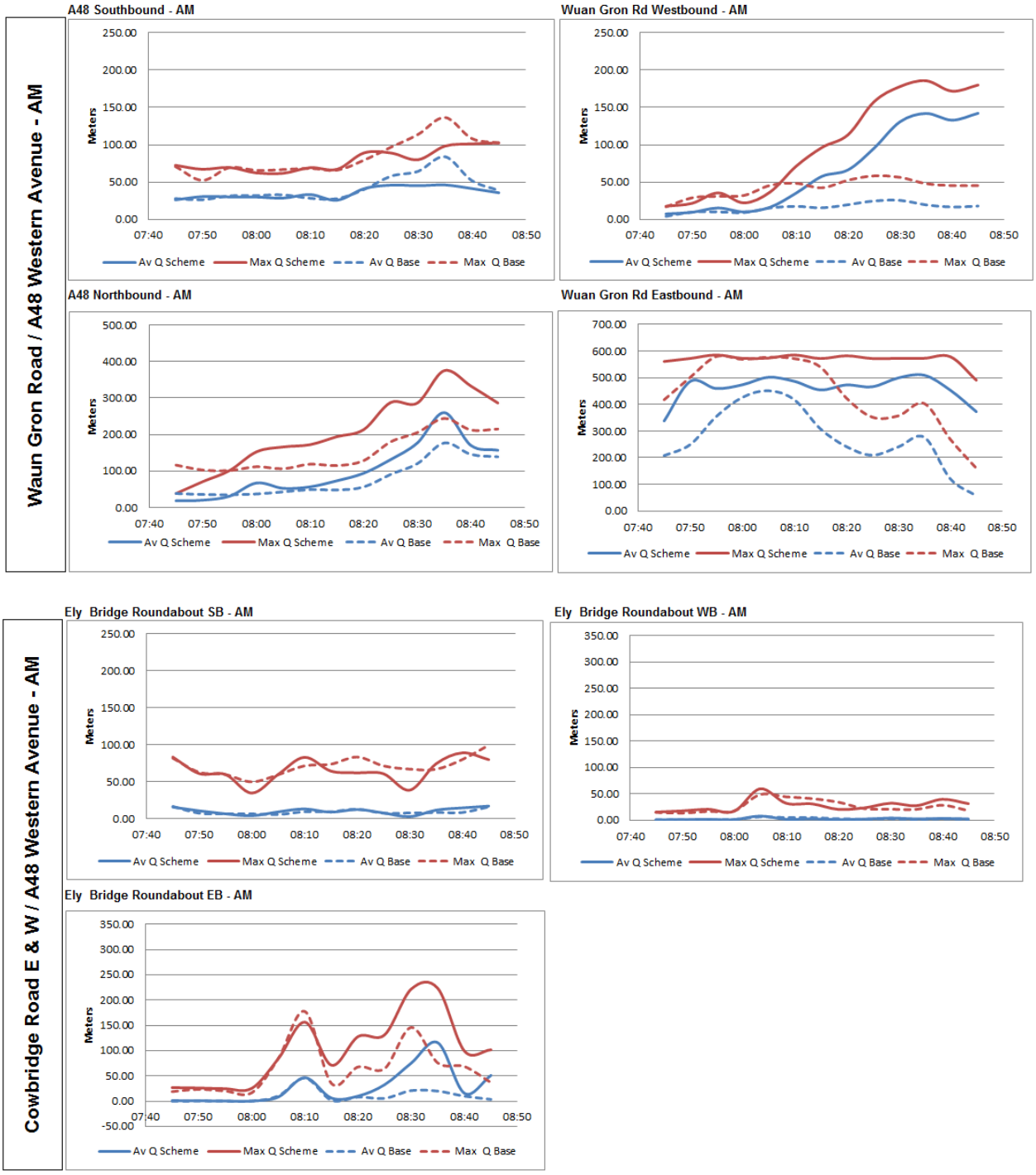
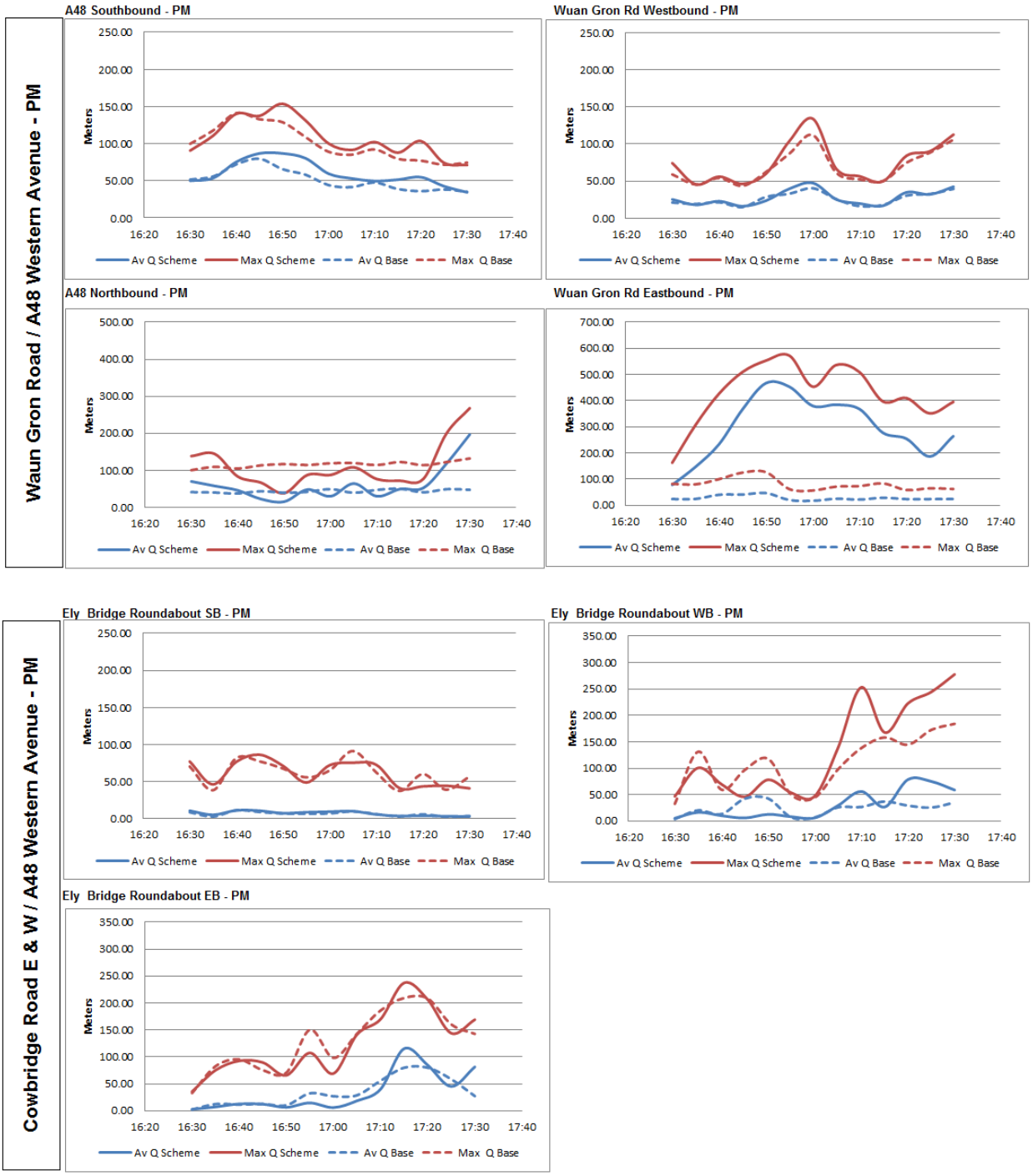


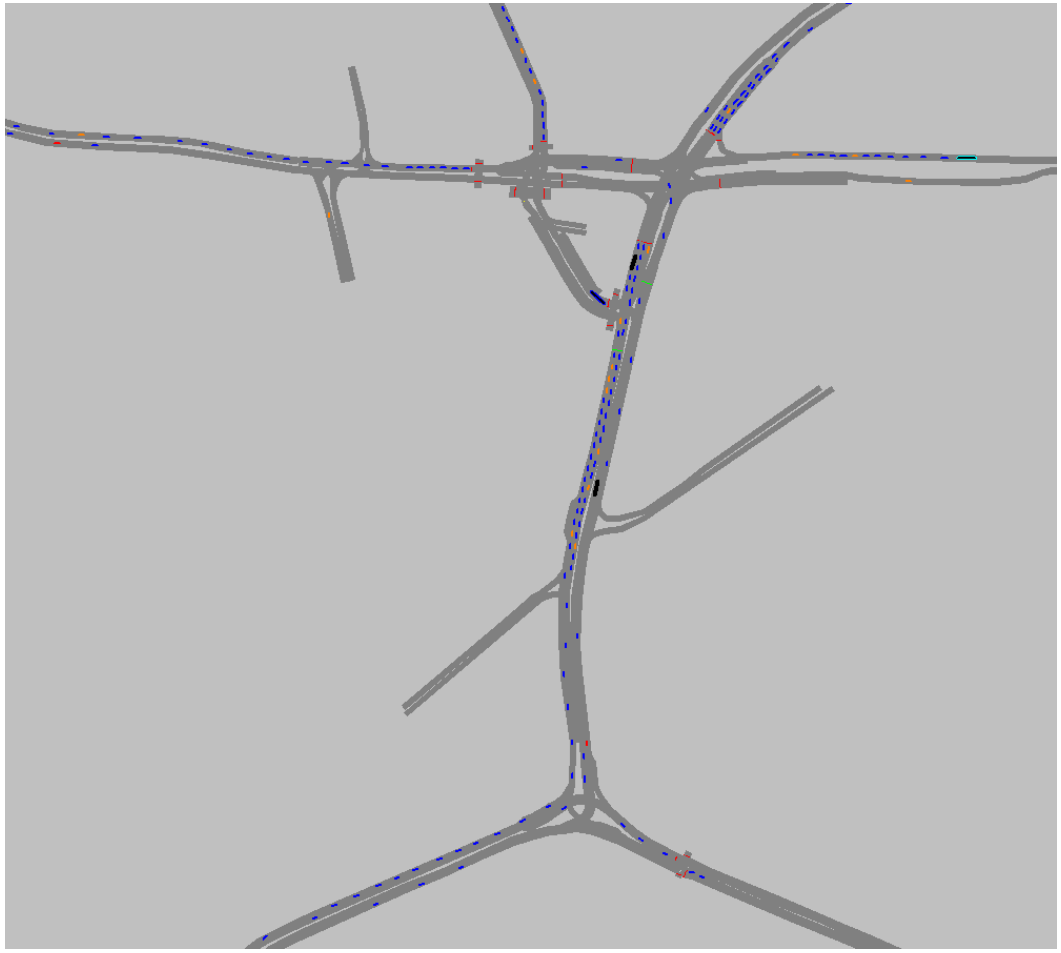
Figure 8 - PM Scenario 2 Queues



Appendix A – Network Plots

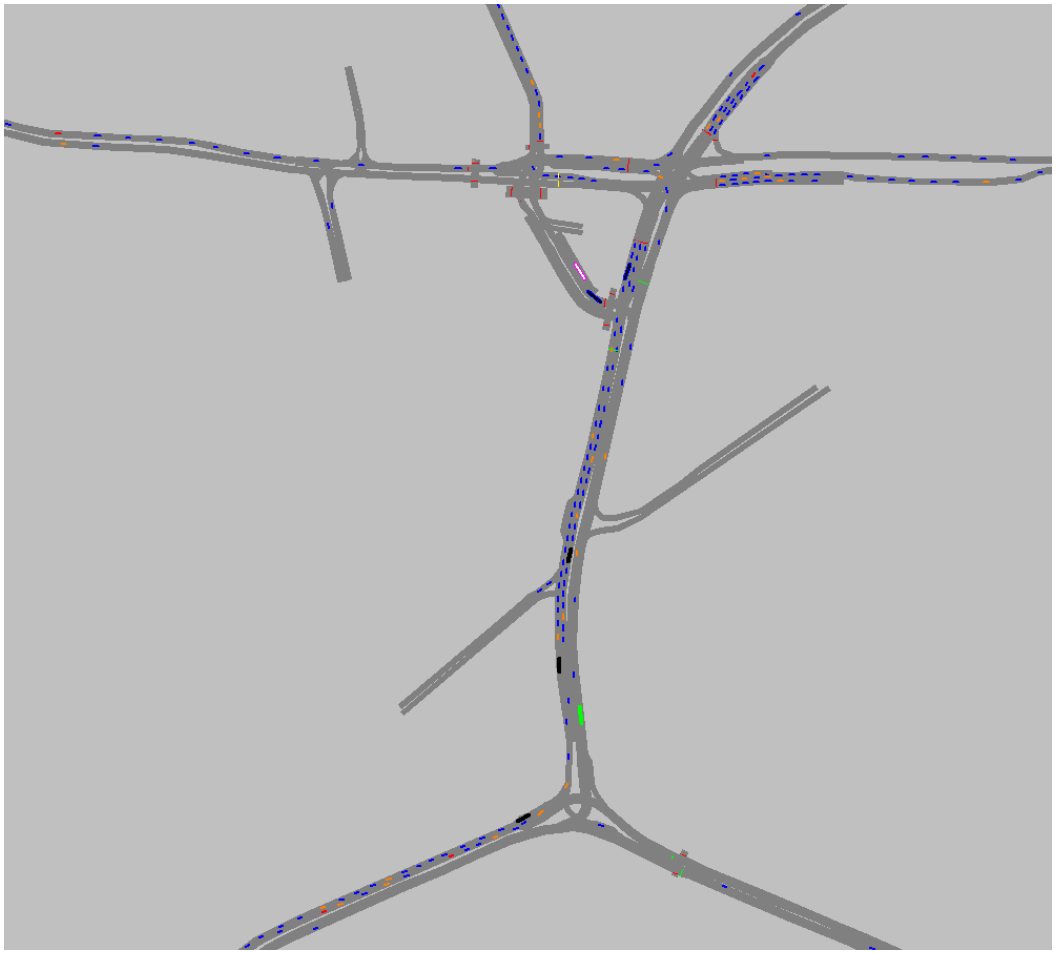
AM peak - 07:45

AM peak - 08:00



AM peak - 08:15

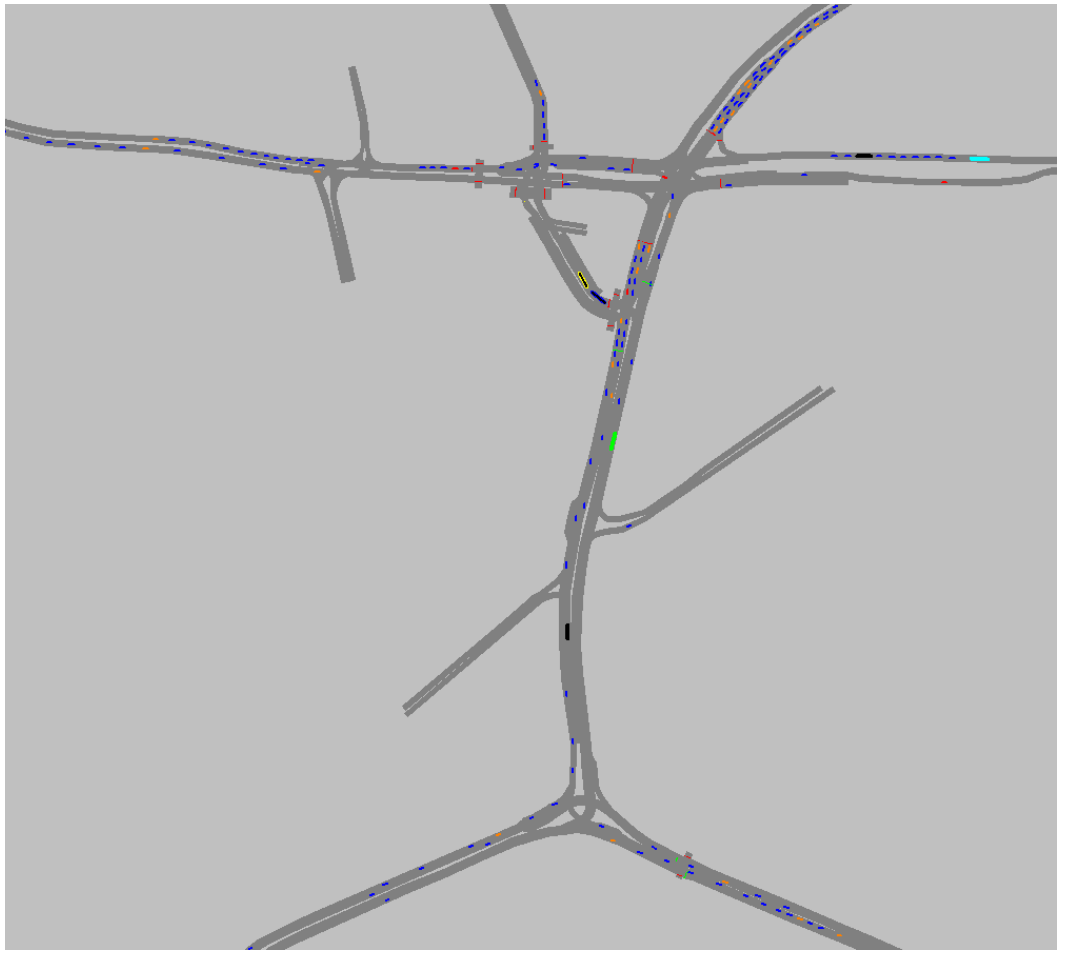
AM peak - 08:30



AM peak - 08:45

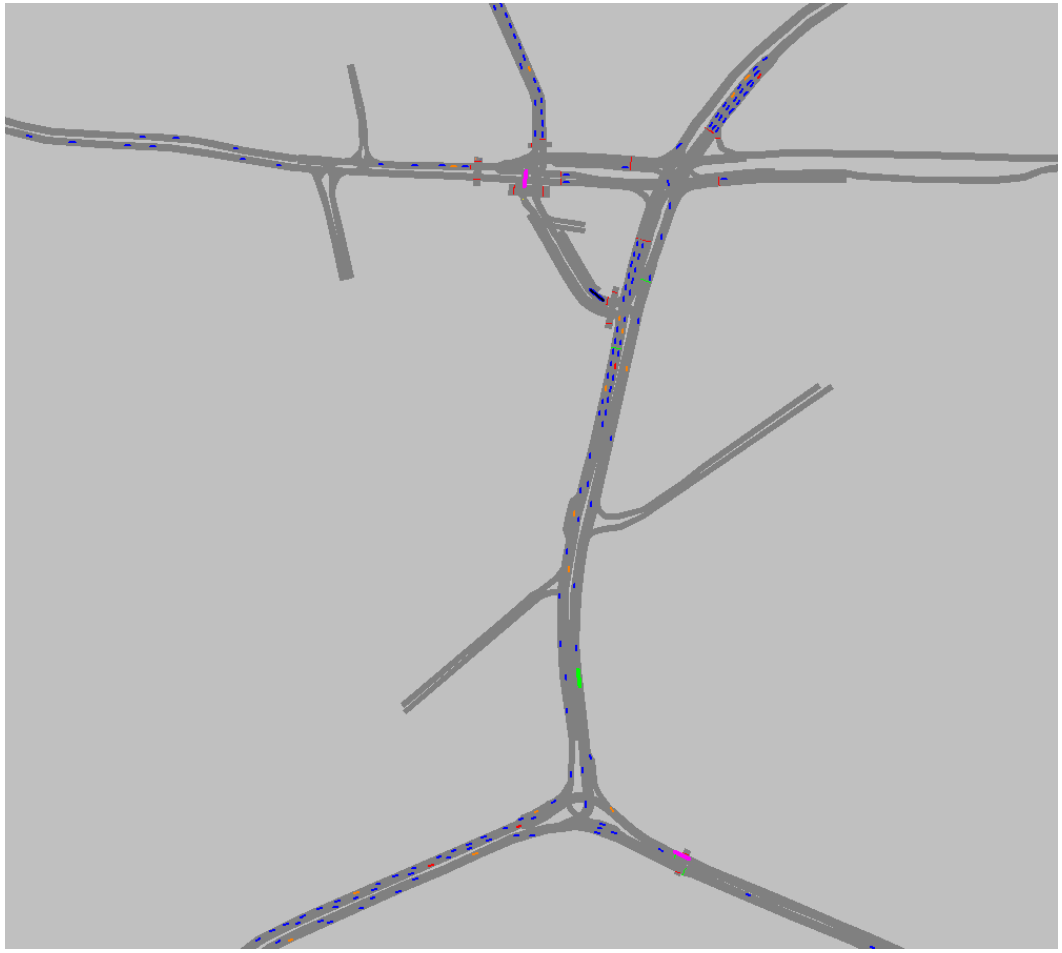
PM peak - 16:30

PM peak - 16:45



PM peak -17:00

PM peak - 17:15



PM peak - 17:30