Option Testing Report
The Warehouse Balmoral Plan Change
Flow Transportation Specialists Ltd

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1. Executive Summary

This report outlines the development and option testing of a calibrated S-Paramics (Paramics) model built for the redevelopment of The Warehouse Balmoral off Balmoral Road, Balmoral built by Aurecon New Zealand Limited (Aurecon) on behalf of Flow Transportation Specialists Ltd (Flow).

The primary objective of the Paramics models is to provide and use a calibrated base to assess two options and their expected traffic effects from a proposed development within 200 metres of the corner of Balmoral Road and Dominion Road, Balmoral.

Two peak period models have been developed to replicate observed 2009 traffic conditions for the following periods:

- Evening Peak Period (16:00 – 19:00)
- Saturday Peak Period (11:00 – 14:00)

The road network was constructed and calibrated utilising the Paramics suite of microscopic traffic simulation software. From the statistical analysis, The Warehouse Balmoral models were appropriately calibrated for the peak hours and the full model periods. The models are deemed to replicate existing conditions to an acceptable level of accuracy and are an appropriate tool for future option testing.

Two option models were developed. Option 1 model comprises of approximately 7,000 sqm gross floor area (GFA) of retail. Trip generation is predicted to be 560 vehicles per hour (vph) and 700 vph in the Evening and Saturday peak hours respectively. Option 2 model shows reduced GFA to 6,280 sqm with a corresponding trip generation of 502 vph in the Evening period and 628 vph in the Saturday period.

The site is shown to have two access points, one connecting with Balmoral Road with the other connecting to Rocklands Avenue. Both enable vehicle movements to and from the site. There are no network differences between Option 1 and Option 2.

The Evening development model predicts noticeable increases in journey times and queue lengths on Dominion Road northbound and Balmoral Road westbound, when compared to the base models for each respective period. The Saturday development model predicts increased delays and queues on Dominion Road northbound building back from the Dominion Road/ Balmoral intersection, an existing area of congestion in the base model. The intersection of Dominion Road/ Rocklands Avenue is proposed to be signalised for the option models and for both shows an increase in delay.

With marginally less traffic being generated from the proposed development in the Option 2 model, delays and queues are only slightly reduced when compared to Option 1 model outputs.

2. Introduction

Aurecon were commissioned to develop a Paramics microscopic traffic simulation model for the proposed plan change for The Warehouse situated on the corner of Dominion and Balmoral Roads, Balmoral. This report details options modelled and results.

2.1 Background

The proposed development is situated within 200 metres of the south-eastern corner of Dominion Road and Balmoral Road. It comprises of approximately 7,000 sqm GFA of retail in Option 1 and 6,280 sqm GFA in Option 2. Proposed vehicle access to the site would be via a left-in / left-out onto Balmoral Road in addition to a priority controlled intersection connecting to Rocklands Avenue.

As part of this assessment, base Paramics models for the surrounding area were built to assess the impacts of the proposed traffic generation.

The base models make use of traffic count data undertaken by Team Traffic on 29 August 2009 and 3 September 2009.

2.2 Purpose

The purpose of this report is to present the modelling work undertaken to assess the traffic impacts of the proposed development. This includes details of the traffic models, traffic generation assumed with the models, assumptions regarding traffic distribution, and outputs of the traffic modelling.

3. Microsimulation Modelling

3.1 Paramics

The model suite used for this project is Paramics, version 2008.1, the latest version of the software developed by SIAS. Paramics represents traffic flow within a network by simulating individual vehicles and their interactions with other vehicles and the surrounding road environment. As with real traffic conditions, these interactions can vary for each model run, resulting in unique results. Furthermore, the inclusion of adaptive signals, as described in the following section, assists in randomising operation and hence varying results.

To obtain statistically meaningful results the average network performance is taken from multiple simulation runs. Previous experience indicates that ten model runs are sufficient to obtain stable results for a network of this size, nature and purpose.

3.2 baseplusFUSE

Within the option model network there are two signalised intersections as well as signalised pedestrian crossings. These intersections are controlled by the computer signals management system SCATS (Sydney Co-ordinated Adaptive Traffic System).

The adaptive nature of SCATS means that throughout the peak traffic periods the signal operation adjusts according to the traffic flows detected. As a result, the signal cycle times and phase splits can vary over time. SCATS reacts and adjusts to the current traffic conditions by varying the signal operation constantly. This can result in the peak traffic demands producing a unique signal operation on a day to day basis. For this reason, “baseplusFUSE” has been incorporated into the modelling.

baseplusFUSE, is the interface that allows Paramics to replicate the actual on-street operation of SCATS. The operation and connectivity between the Paramics model and SCATS is shown in Figure 1. It shows baseplusFUSE as the link between the Paramics model and WinTraff, an RTA product that simulates multiple traffic signal controllers. These simulated controllers use the same personality as the on-street intersection does, thereby replicating the same on-street operation. The SCATS Region and Central Manager software is the same software that is used to control the signalised intersections on street.

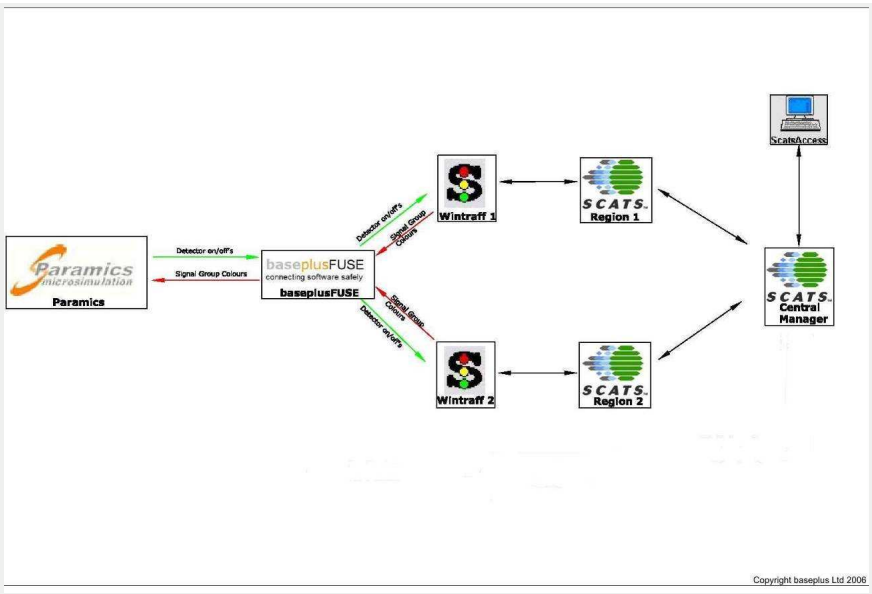

Figure 1 - baseplusFUSE connection to Paramics and SCATS

Incorporating baseplusFUSE into the model ensures realistic operational boundaries are set and a greater level of confidence can be achieved in regard to the representation of the existing situation and the confidence in the option tests.

4. Model Form

4.1 Model Network

The model network, as shown in Figure 2 is the area surrounding the intersection of the Dominion Road/ Balmoral Road intersection. All major roads within this boundary have been included in the model. Driveways and roads carrying low traffic volumes that do not significantly affect the traffic flow within the model have not been included.

The model network extends from King Edward Street in the north, to Telford Avenue/ Marsden Avenue in the south, from Goring Road in the west and Henley Road in the east.

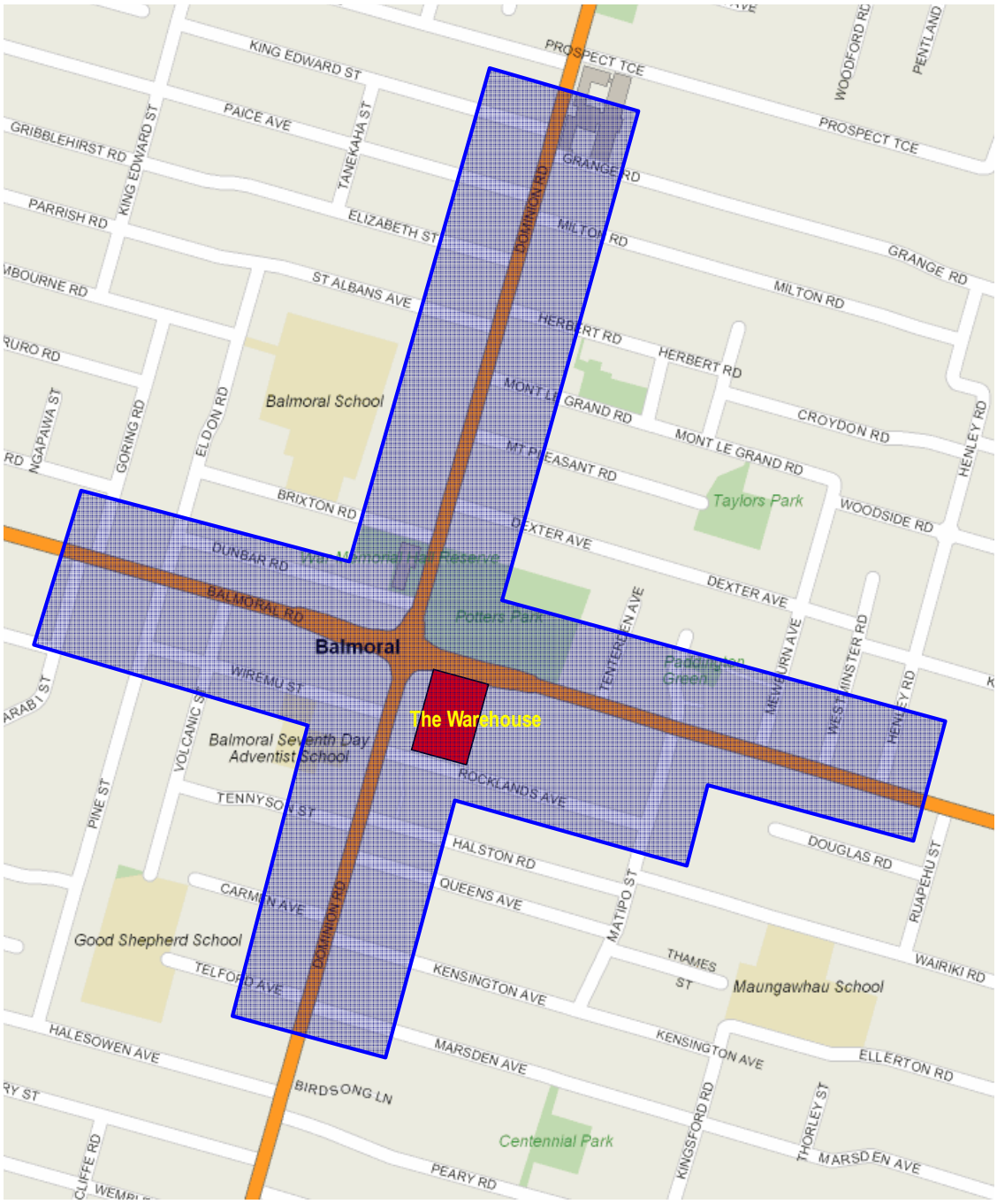

Figure 2 - Study Area

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

Model network differences between the Evening and Saturday base models relate to bus lanes on Dominion Road, which are not in operation on Saturday.

4.2 Model Periods

Paramics models have been developed for the following two peak traffic periods:-

- Evening Peak Period (PM) – 16:00 to 19:00
- Saturday Peak Period (SAT) – 11:00 to 14:00

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

- Evening Peak Hour (PM) – 17:00 to 18:00
- Saturday Peak Hour (SAT) – 12:00 to 13:00

Model duration of three hours ensures the shoulders to the peaks of the background traffic and development traffic are adequately modelled. This allows for the model to adequately accommodate peak hour spreading which may result from future growth within the network.

5. Model Option Testing

5.1 Proposed Development

The site is proposed to gain access via two points, one connecting with Balmoral Road with the other accessing Rockwell Avenue. Both accesses enable vehicle movements to and from the site. The development is comprised solely of retail activities and has a planned GFA of approximately 7,000 sqm in Option test 1 and 6,280 sqm in Option test 2. The GFA and hence the trip generation from the development is the only difference between Option 1 and Option 2 models.

5.2 Development Trip Generation

The Warehouse trip generation was provided by Flow for input to the modelling. The predicted traffic generated by the development totals 560 vehicles per hour (vph) in the Evening period and 700 vph during the Saturday peak period for Option 1 and 502 vph and 628 vph, respectively, for Option 2.

Table 1 below summarises the total predicted traffic generation for the site.

Model Option	GFA (m^2)	Evening Peak Hour		Saturday Peak Hour	
		Trip Rate	Total Vehicle Trips	Trip Rate	Total Vehicle Trips
Option 1	7,000	8.0	560	10.0	700
Option 2	6,280	8.0	502	10.0	628

Table 1 – Peak Hour Trips generated from The Warehouse development

Estimated of pass-by trips was provided by Flow for input to this assessment. The pass-by trip proportions were estimated as 20% for the Evening period and 30% in the Saturday period for the retail trips.

The Paramics models developed reflect three hour periods and as such the predicted traffic volumes presented in Table 1 above have been factored accordingly to reflect three hour traffic generation.

Peak hour factors have been derived to convert one hour traffic volumes to three hours traffic volumes for this modelling exercise. Survey counts from the existing Warehouse entry points were used to obtain the factors for the retail peak.

The following table presents the predicted factors for each respective activity for the Evening and Saturday periods.

Activity	PM	Saturday
Retail	2.55	2.76

Table 2 – Peak hour to three hour factor for the proposed development

No growth in background traffic has been assumed. The development option demands are as per the calibrated base model.

The existing Warehouse and BP petrol station on Balmoral Road have however been removed from the matrices. Their associated pass-by trips with these sites have also been taken into account in this process.

The total volume of traffic added to the model for each of the three periods is presented in Table 3 below. The differences in background traffic between Option 1 and Option 2 is related to the change in the number of pass-by trips.

	Option 1		Option 2	
	PM	Saturday	PM	Saturday
Background traffic	12,154	12,015	12,170	12,045
Development traffic	1,429	1,935	1,282	1,736
Total	**13,583**	**13,950**	**13,452**	**13,781**

Table 3 – Total development traffic added to the models

Note that the background traffic varies from Option 1 and Option 2 given the reduction in pass-by trips with the lower GFA proposed with the Option 2 model.

5.3 Development Trip Distribution

The traffic distribution for trips associated with the development is presented in Table 4 below. This data was provided by Flow. It has been assumed that trip distribution for the Evening and Saturday peak periods are the same.

Zone location	From the development	To the development
Dominion North	13%	13%
Balmoral East	14%	14%
Dominion South	42%	42%
Balmoral West	21%	21%
Matipo	10%	10%

Table 4 – Distribution for the proposed development

Table 5 below presents the distribution in the final Option 1 matrices as vehicles per hour in the peak hour for both of the modelled periods once pass-by trips have been accounted for.

Zone location	Evening		Saturday	
	To the development	From the development	To the development	From the development
Dominion North	40	38	54	45
Balmoral East	52	45	74	61
Dominion South	104	110	140	113
Balmoral West	58	65	85	73
Matipo	23	24	30	24

Table 5 – Distribution for the proposed development in vehicles per hour for all land use activities

Similarly for Option 2, Table 6 below presents the distribution in the final Option 2 matrices as vehicles per hour in the peak hour for both of the modelled periods once pass-by trips have been accounted for.

Zone location	Evening		Saturday	
	To the development	From the development	To the development	From the development
Dominion North	36	34	48	40
Balmoral East	46	40	66	55
Dominion South	93	99	126	101
Balmoral West	52	59	76	65
Matipo	21	22	27	22

Table 6 – Distribution for the proposed development in vehicles per hour for all land use activities

5.4 Development Traffic Release Profiling

Traffic demand release profiles are applied to assign different traffic demands in defined time intervals over the model period.

A retail demand release profile has been assigned to the development and this profiling utilises observed outbound profile data for the two existing Warehouse Balmoral access ways. The development release profiles applied to the modelling is presented in Figure 3 and Figure 4 below.

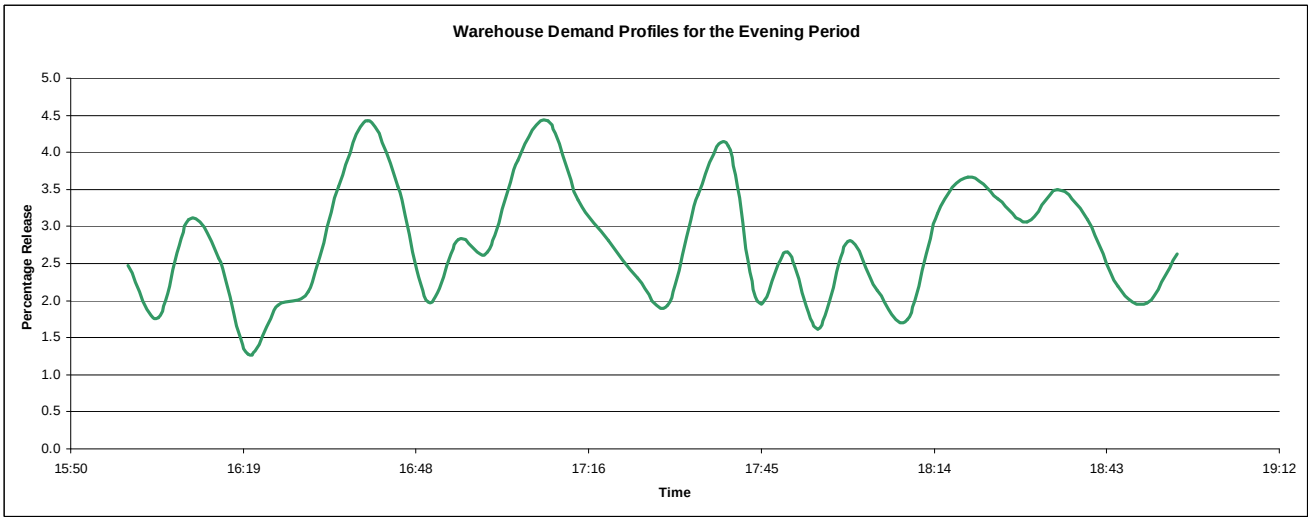

Figure 3 – Demand release profiles for development trips for the Evening Period

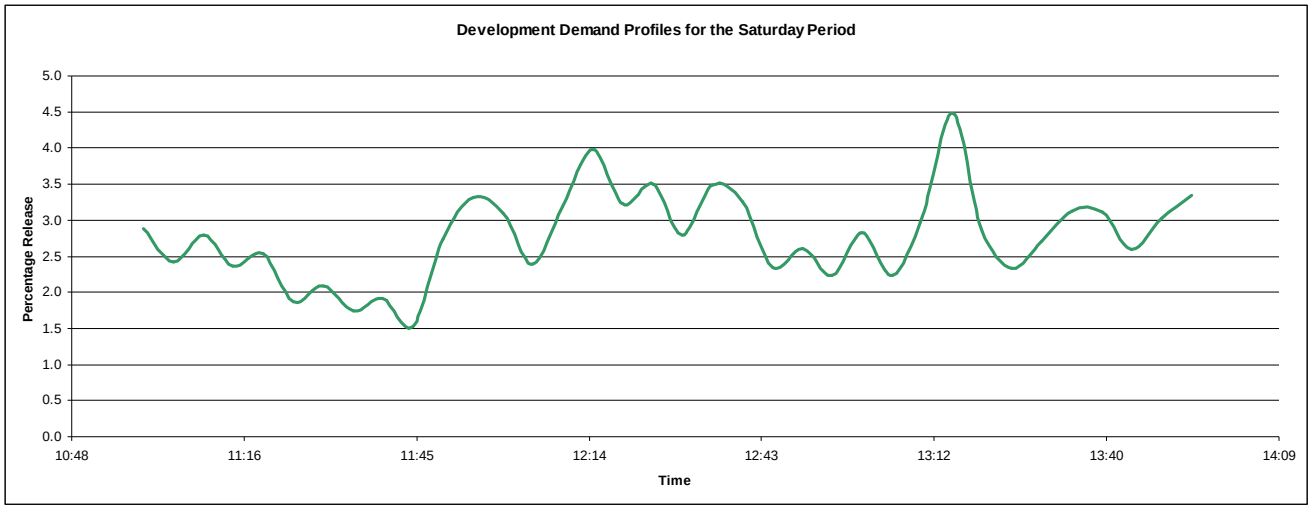

Figure 4 - Demand release profiles for development trips for the Saturday Period

5.5 Development Network Changes

Changes to the modelled network have been applied to the models reflecting the access points and intersections to cater for the predicted traffic generation of the proposed development. There are no network differences between Option 1 and Option 2.

5.5.1 Development coding

Coding of the internal carpark operation was compiled to allow vehicles to load onto the model network appropriately.

The site proposes two access points, one from Balmoral Road and one from Rocklands Avenue, with both links allowing vehicle movements to and from the site.

The proposed Balmoral Road entrance way is shown to be a priority intersection with left in / left out access to the development. The Rocklands Avenue access is priority controlled with all movements allowed. No traffic was permitted to “rat run” through the site.

The coding of the development site is shown in Figure 5 below.

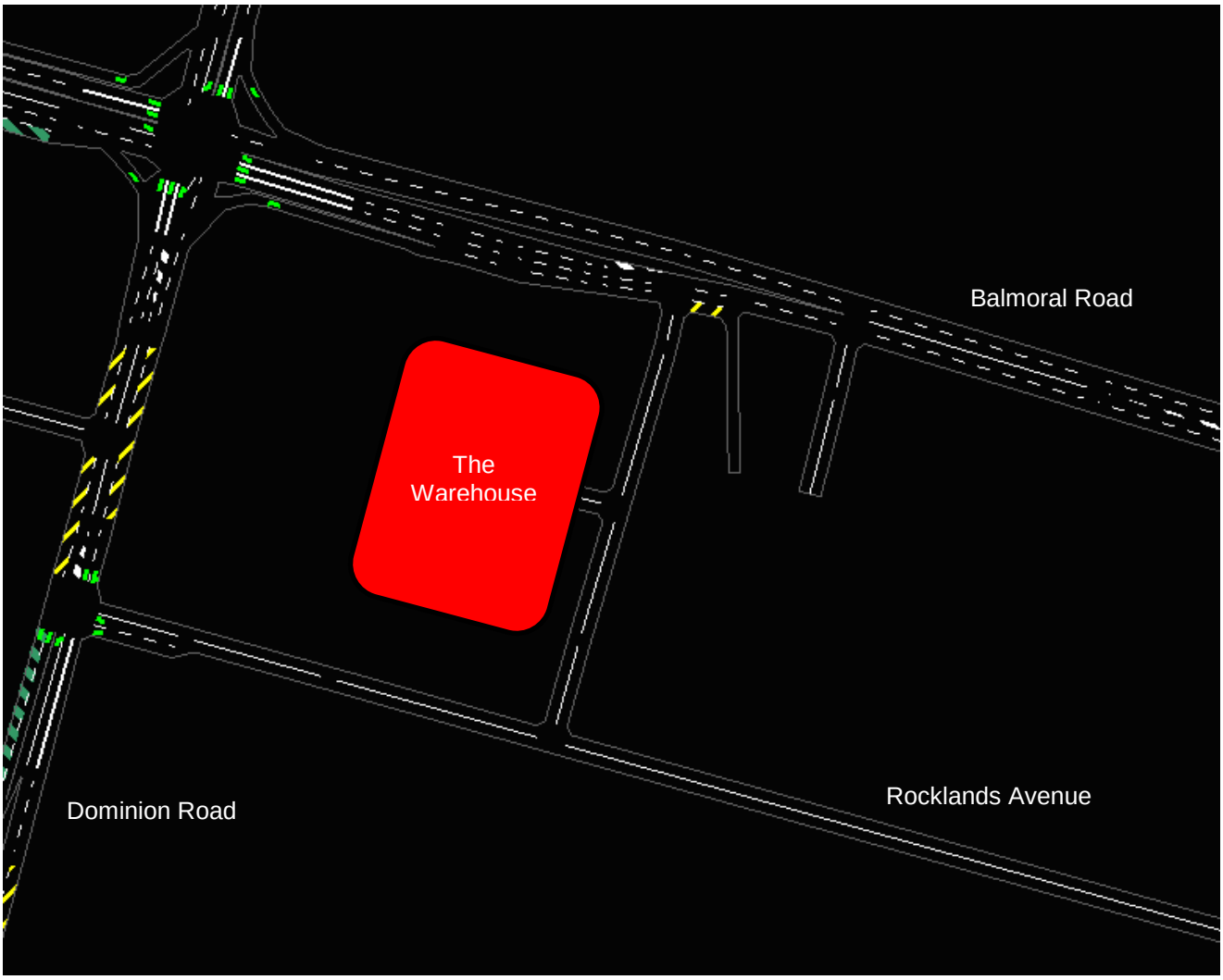

Figure 5 – Development coding with indications of zone placement

5.5.2 Intersection changes

The intersection of Dominion Road and Rocklands Avenue has been assumed to operate as a signalised 'T' intersection. It is controlled through the model via SCATS. This intersection, through SCATS is linked to the intersection of Dominion Road and Balmoral Road. The coding of this intersection is shown in Figure 6. Pedestrian demands consistent with those used in the base models were applied to replicate the introduction of the pedestrian crossings at this signalised intersection.

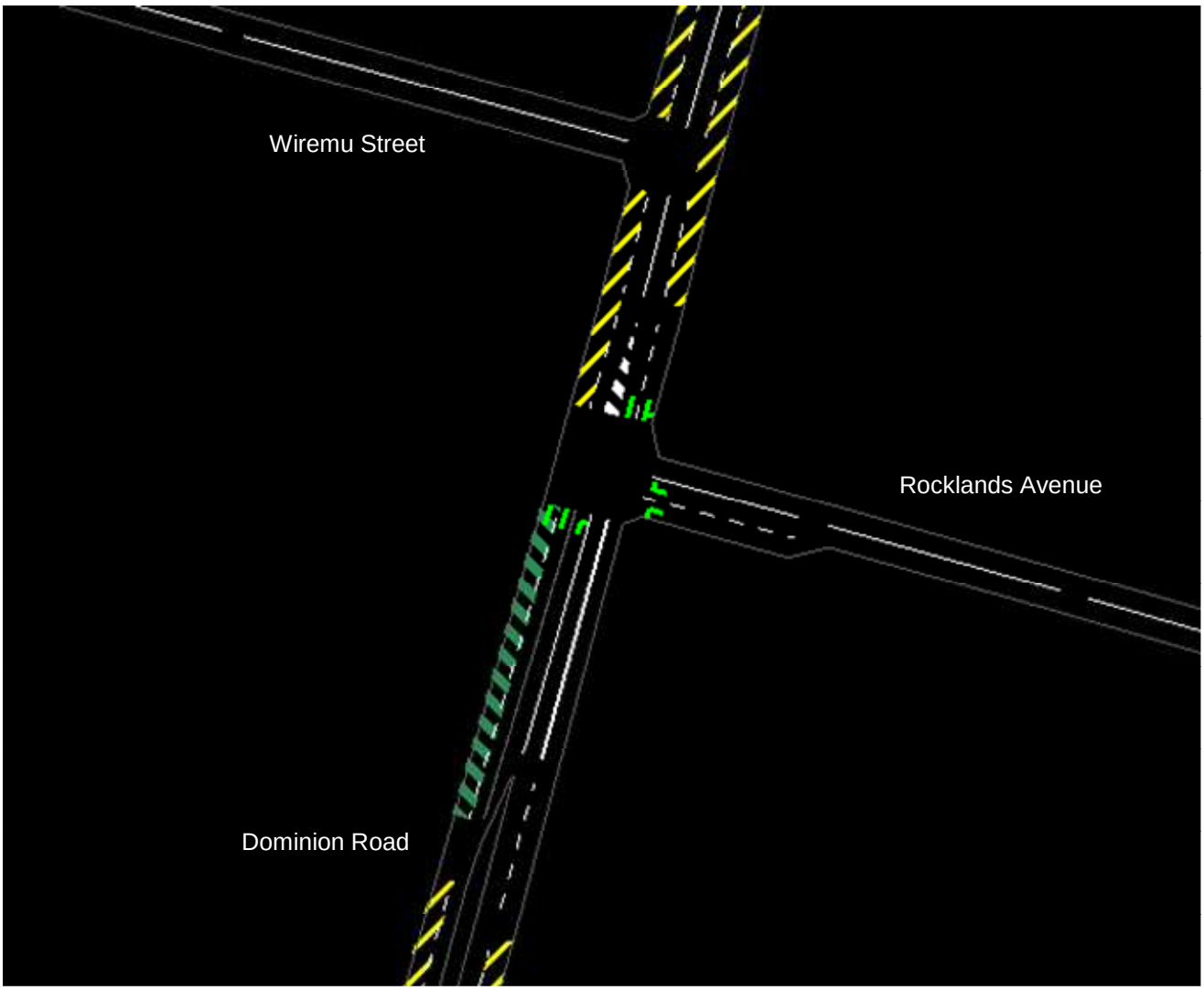

Figure 6 – Coding of the signalised Dominion Road / Rocklands Avenue intersection

5.5.3 Other changes

Other network changes were made to ensure that the modelled traffic behaved realistically with the proposed traffic generation applied to the model. These changes consisted of the extension of the Dominion Road South arm. The extension of this point enables better replication of queued vehicles within the network and enables a better comparison of statistics. The extension of the zone connection points is considered acceptable in this instance as it not considered to adversely affect the base model calibration.

6. Development Network Operation

6.1 Introduction

The assessment of the traffic effects associated with the proposed development compares the outputs from the development models to that of the corresponding base models.

All models have been run ten times with Paramics to achieve a robust assessment. Results are presented for the modelled peak hour of 17:00 – 18:00 for the Evening period and 12:00 – 13:00 for the Saturday period with averages calculated unless stated.

6.2 Network Observations

As a first point of reference for the assessment of the network operation, the models were run with observations of model conditions being noted. The only difference of significance observed from the addition of the development and network changes was additional queuing at the Dominion Road / Balmoral Road intersection stemming from the Dominion Road south approach in the Saturday model. This queuing is shown in the model snapshot in Figure 7 below.

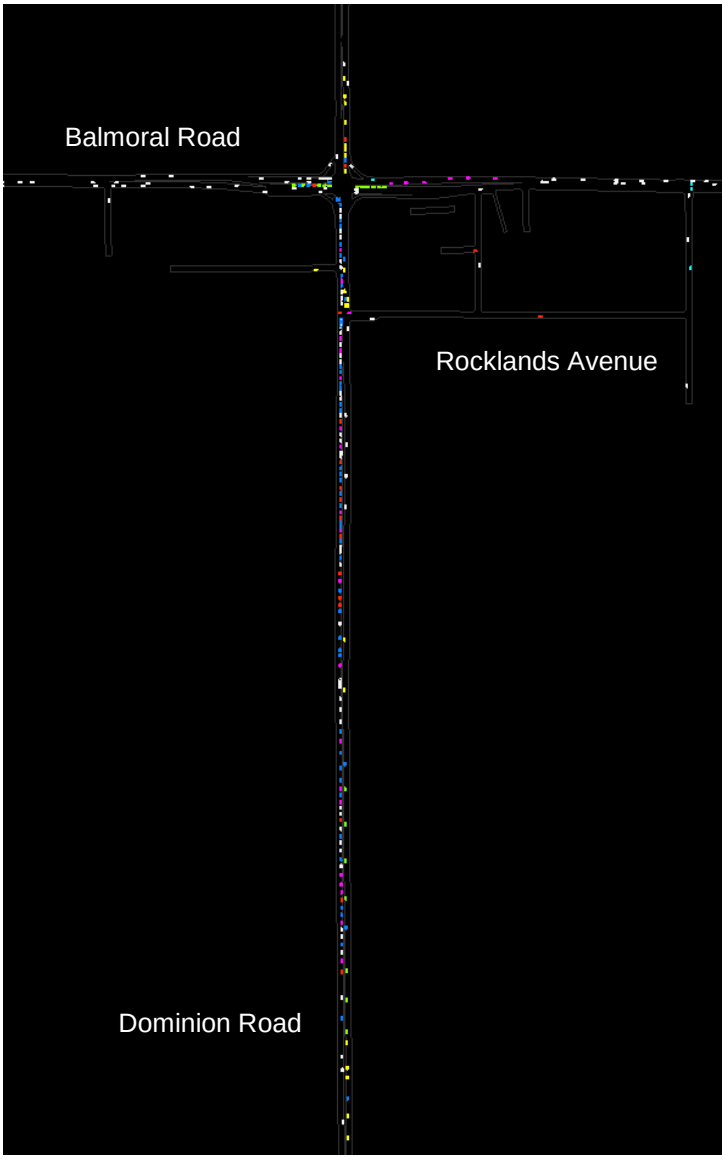

Figure 7 – Snapshot of the Dominion Road northbound queue from the Saturday model at 12:00pm.

6.3 Network Operation Performance Criteria

The criteria adopted to compare the performance of the models are:

- ***Network statistics (time and distance);*** as indicators of network wide consequences;
- ***Journey times;*** giving an indication of the overall effects on through traffic;
- ***Queue lengths;*** showing the changes in queued congestion;
- ***Signal phasing;*** Effects on the phasing at signals and their cycle lengths;
- ***Level of Service;*** a comparative tool to assess the differences between intersection operation;

Note: these statistics are for comparative purposes only and should not be compared with other modelling packages as the results may vary depending upon the modelling suite used.

6.3.1 Network Statistics

Extracting the overall network statistics from each model reveals the overall network performance variation between the base and option models.

Activity	Base	Option 1	Option 2
Mean Delay	235	258	258
Total Distance (km)	32,033	35,954	35,767
Total Number of Vehicles	14,599	14,988	14,847
Mean Speed (kph)	34	33	34
Total Network Travel Time (hrs)	953	1,075	1,064

Table 7 – Evening Network Statistics

The overall results suggest that with the predicted traffic generation for the proposed the following would occur with Option 1:

- 10% increase in mean delay
- 13% increase in total network travel time.

The difference between Option 1 and Option 2 is minimal.

Activity	Base	Option 1	Option 2
Mean Delay	239	263	264
Total Distance (km)	31,556	35,656	35,402
Total Number of Vehicles	14,481	15,111	14,927
Mean Speed (kph)	33	32	32
Total Network Travel Time (hrs)	960	1105	1093

Table 8 – Saturday Network Statistics

The overall results suggest that with the predicted traffic generation for the proposed the following would occur in the Saturday period:

- 10% increase in mean delay
- 15% increase in total network travel time.

Presented in the following tables is the model run summaries for comparison and the COV for each statistic.

	Mean Delay	Total Distance (km)	Total Number of Vehicles	Mean Speed (kph)	Total Network Travel Time (hrs)
run-001	259	35,946	14,992	33	1079
run-002	255	35,967	14,991	34	1064
run-003	252	35,949	14,984	34	1050
run-004	266	35,935	14,991	32	1108
run-005	257	35,958	14,990	34	1070
run-006	262	36,027	14,989	33	1093
run-007	257	35,900	14,980	34	1070
run-008	253	35,997	14,992	34	1053
run-009	263	35,969	14,991	33	1095
run-010	258	35,895	14,978	33	1073
CoV	1.73%	0.11%	0.03%	1.72%	1.73%

Table 9 – Option 1 Network Statistics for each Evening model run

	Mean Delay	Total Distance (km)	Total Number of Vehicles	Mean Speed (kph)	Total Network Travel Time (hrs)
run-001	257	35,763	14,839	34	1061
run-002	253	35,776	14,846	34	1041
run-003	257	35,754	14,844	34	1058
run-004	252	35,770	14,851	34	1039
run-005	255	35,746	14,846	34	1053
run-006	260	35,751	14,836	33	1072

	Mean Delay	Total Distance (km)	Total Number of Vehicles	Mean Speed (kph)	Total Network Travel Time (hrs)
run-007	260	35,814	14,856	33	1073
run-008	267	35,708	14,850	32	1101
run-009	260	35,813	14,851	33	1074
run-010	260	35,778	14,849	33	1070
CoV	1.70%	0.09%	0.04%	1.72%	1.70%

Table 10 – Option 2 Network Statistics for each Evening model run

	Mean Delay	Total Distance (km)	Total Number of Vehicles	Mean Speed (kph)	Total Network Travel Time (hrs)
run-001	259	35,641	15,108	33	1088
run-002	267	35,670	15,113	32	1122
run-003	259	35,657	15,112	33	1088
run-004	268	35,650	15,107	32	1123
run-005	270	35,657	15,109	31	1132
run-006	257	35,667	15,117	33	1080
run-007	251	35,656	15,115	34	1053
run-008	260	35,636	15,103	33	1091
run-009	272	35,654	15,107	31	1141
run-010	269	35,673	15,116	32	1129
CoV	2.60%	0.03%	0.03%	2.61%	2.59%

Table 11 – Option 1 Network Statistics for each Saturday model run

	Mean Delay	Total Distance (km)	Total Number of Vehicles	Mean Speed (kph)	Total Network Travel Time (hrs)
run-001	281	35,401	14,926	30	1165
run-002	277	35,414	14,927	31	1148
run-003	259	35,410	14,932	33	1074
run-004	262	35,420	14,929	33	1088
run-005	262	35,376	14,911	33	1085
run-006	250	35,392	14,929	34	1036
run-007	254	35,383	14,919	34	1054
run-008	259	35,408	14,932	33	1073
run-009	272	35,410	14,934	31	1129
run-010	260	35,410	14,932	33	1078
CoV	3.79%	0.04%	0.05%	3.71%	3.79%

Table 12 – Option 2 Network Statistics for each Saturday model run

With a CoV of less than 5%, the Evening and Saturday period models are, in our opinion, considered stable.

6.3.2 Journey Time Comparison

Journey time statistics have been extracted for both the base and development option models to compare the predicted impact of the proposed. Four journey routes were considered:

- Dominion Road; Northbound
- Dominion Road; Southbound
- Balmoral Road; Eastbound
- Balmoral Road; Westbound

The journey routes are presented in Figure 8 below.

Figure 8 – Map of the journey routes

The following tables present the journey time comparisons for the Evening and Saturday peak hour periods. Appendices A to D contain comparisons of the base and both development option journey routes in the form of cumulative journey time graphs.

Journey Route	Base			Option 1			Diff (sec)	% Diff
	-95% Conf Int.	Average	+95% Conf Int.	-95% Conf Int.	Average	+95% Conf Int.		
Dominion Road Northbound	4.15	4.74	5.32	4.52	5.29	6.05	33	12%
Dominion Road Southbound	4.21	4.83	5.46	4.56	5.17	5.78	20	7%
Balmoral Road Eastbound	3.17	3.65	4.14	3.28	3.63	3.97	-1	-1%
Balmoral Road Westbound	2.99	3.47	3.95	3.39	3.80	4.21	20	10%

Table 13 – Evening peak hour Journey times for Option 1 (minutes)

The Evening period journey times predicts the largest increase in journey times would be on the route Dominion Road Northbound with a 33 second increase. Also the Balmoral Road Westbound had a noticeable increase in journey times and would be due to this route being the only Balmoral Road journey time with direct access to and from the development site.

Journey Route	Base			Option 2			Diff (sec)	% Diff
	-95% Conf Int.	Average	+95% Conf Int.	-95% Conf Int.	Average	+95% Conf Int.		
Dominion Road Northbound	4.15	4.74	5.32	4.35	5.17	5.99	26	9%
Dominion Road Southbound	4.21	4.83	5.46	4.45	5.04	5.63	12	4%
Balmoral Road Eastbound	3.17	3.65	4.14	3.30	3.65	3.99	0	0%
Balmoral Road Westbound	2.99	3.47	3.95	3.29	3.78	4.27	18	9%

Table 14 – Evening peak hour Journey times for Option 2 (minutes)

Option 2 showed an increase of only 26 second for the Dominion Road Northbound journey time. This is less than the Option 1 increase due to the reduction traffic destined for the development.

Table 15 and Table 16 below present the same information for the Saturday peak period.

Journey Route	Base			Option 1			Diff (sec)	% Diff
	-95% Conf Int.	Average	+95% Conf Int.	-95% Conf Int.	Average	+95% Conf Int.		
Dominion Road Northbound	5.08	6.58	8.08	6.22	7.71	9.21	68	17%
Dominion Road Southbound	4.04	4.54	5.03	4.26	4.83	5.40	18	6%
Balmoral Road Eastbound	3.15	3.62	4.09	3.29	3.61	3.94	0	0%
Balmoral Road Westbound	2.98	3.45	3.93	3.22	3.54	3.87	6	3%

Table 15 – Saturday peak hour Journey times for Option 1 (minutes)

Journey Route	Base			Option 2			Diff (sec)	% Diff
	-95% Conf Int.	Average	+95% Conf Int.	-95% Conf Int.	Average	+95% Conf Int.		
Dominion Road Northbound	5.08	6.58	8.08	5.84	7.46	9.08	53	13%
Dominion Road Southbound	4.04	4.54	5.03	4.21	4.70	5.20	10	4%
Balmoral Road Eastbound	3.15	3.62	4.09	3.27	3.60	3.94	-1	0%
Balmoral Road Westbound	2.98	3.45	3.93	3.16	3.51	3.87	4	2%

Table 16 – Saturday peak hour Journey times for Option 2 (minutes)

As shown in the Evening period, the Dominion Road Northbound route had the largest increase in journey times but this increase was less in Option 2 than Option 1.

It is noted that the journey time increases are for the small model area and should be considered as part of the full journey of each vehicle from their origin to final destination.

6.3.3 Queue Length Comparison

The maximum queue over the average model run is used in the queue length comparison between the base model and the development option models at the intersection Dominion Road / Balmoral Road. Queuing is an inherently unstable phenomenon and hence variation in results is always present however every attempt has been made to reduce the variation to give queue outputs for the average run.

These comparisons are presented in Appendices E to H but in summary in the Evening period both option tests predicted an increase in queue length on the Dominion North and Balmoral East approaches. The Dominion North approach displayed longer queues particularly at the start of the model period and between 18:00 and 18:30 whereas the longer queues were exhibited in the peak hour for the Balmoral East approach.

The largest queue in the Saturday period at several hundred metres was on the Dominion Road South approach. These queues were longer queues than that seen in the base model for the majority of the option model periods, more so with Option 1 than Option 2. The Option 1 queue has been graphed against the base model outputs in Figure 9 below and shows this increase in queue length. The Dominion Road North approach displayed an increase in queue length over the second half of the Saturday model period.

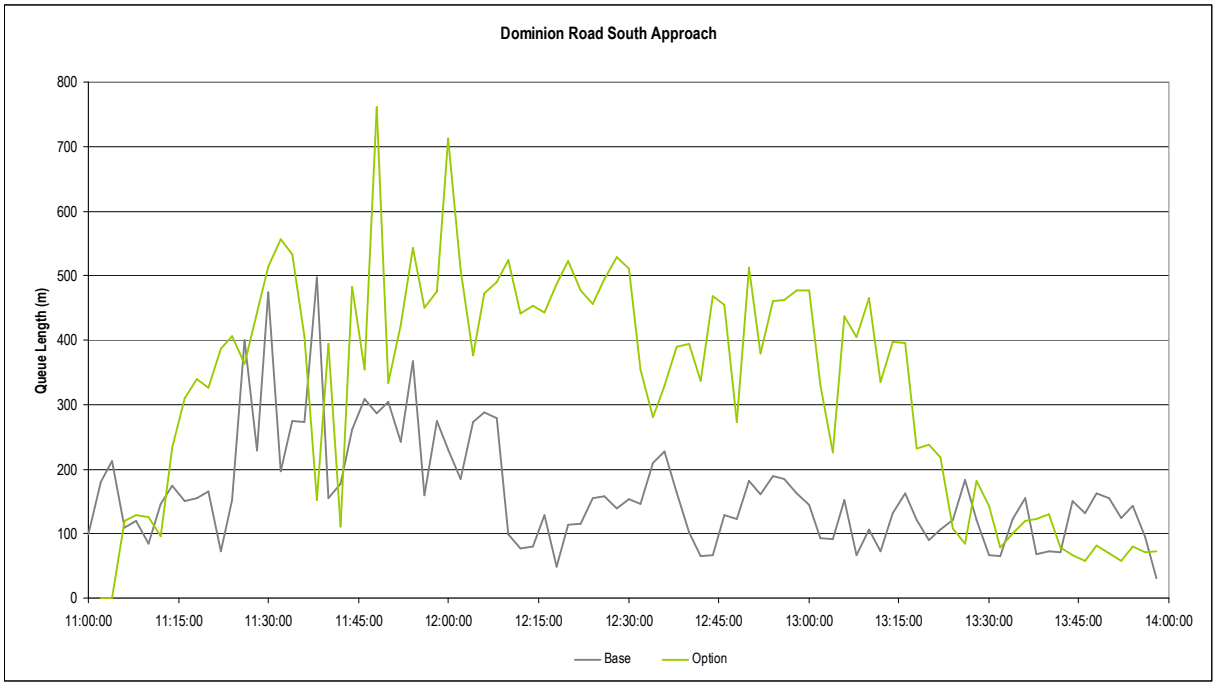

Figure 9 – Queue graph of Dominion Road South approach to Dominion Road/ Balmoral Road in the Saturday period of Option 1

In both the Evening and Saturday models the maximum Rocklands Avenue approach queue at Dominion Road/ Rocklands Avenue was 60 metres. To give an idea of relative distance, the current Warehouse driveway on Rocklands Avenue is 75 metres from the Dominion Road/ Rocklands Avenue intersection.

6.3.4 Signal Phasing

The following sections present the base modelled cycle length/phase splits and compare these with the development model cycle length/phase split for the Dominion Road/ Balmoral Road intersection. The average model run from each model was selected for assessing the model stability results. Both sets of data are for the peak hour and have been extracted from the SCATS SM data.

Model	Phase (%)				Cycle Length
	A	D	E	G	
Base	38	13	29	20	120
Option 1	32	13	31	24	120
Option 2	33	14	29	24	120

Table 17 – Evening peak hour signal phase splits for Dominion Road/ Balmoral Road, TCS 2201

Model	Phase (%)				Cycle Length
	A	D	E	G	
Base	36	15	27	22	120
Option 1	32	14	27	27	120
Option 2	32	14	26	28	120

Table 18 – Saturday peak hour signal phase splits for Dominion Road/ Balmoral Road, TCS 2201

For both model periods moving from the base model to the option models has resulted in green time being taken from phase A, the eastbound/ westbound through movements, and given to phase G, the eastbound/ westbound right turn movements. With the increased volumes making these right turns, SCATS has adapted the phase splits according to the volumes passing over the stop lines for each movement.

6.3.5 Level of Service

The level of service (LOS) for the three major modelled intersections have been analysed with a comparative summary for the base and development model provided in the tables below.

The full intersection LOS diagrams with levels of service for approaches and individual movements are provided in Appendices I to N.

Intersection	Approach	Mvt	Base			Option 1			Option 2		
			Movement			Movement			Movement		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
Dominion Balmoral	Dominion Road North	L	243	28	C	247	34	C	248	30	C
		T	668	64	E	651	84	F	657	79	E
		R	138	73	E	145	86	F	147	83	F
	Balmoral Road East	L	219	17	B	216	25	C	211	24	C
		T	1036	30	C	1054	52	D	1042	48	D
		R	238	50	D	258	48	D	253	51	D
	Dominion Road South	L	110	17	B	118	18	B	122	16	B
		T	483	44	D	494	52	D	501	50	D
		R	91	66	E	113	69	E	115	67	E
	Balmoral Road West	L	102	4	A	105	4	A	105	4	A
		T	619	30	C	627	30	C	625	30	C
		R	221	53	D	265	66	E	259	65	E
Balmoral Matipo	Balmoral Road East	L	63	9	A	70	9	A	75	10	B
	Matipo Street	L	62	13	B	57	13	B	57	13	B
		R	53	24	C	73	34	C	68	30	C
	Balmoral Road West	R	92	18	B	90	19	B	93	20	C
Rocklands Dominion	Dominion Road North	L	77	3	A	95	4	A	85	3	A
		T				1013	6	A	1014	5	A
	Rocklands	L	74	11	B	117	38	D	108	45	D
		R	20	65	E	25	97	F	30	105	F
	Dominion Road South	T				706	52	D	713	51	D
		R	87	30	C	120	73	E	111	77	E

Table 19 – Evening peak hour Level of Service

The Evening peak period levels of service predict that several movements show increases in delay. The movements that increased as a result of vehicles originating or destined for The Warehouse include the Dominion Road South right turn into Rocklands, all of the Rocklands movements onto Dominion Road, the Balmoral Road West right turn into Dominion Road, and the Balmoral Road East through movement at Dominion Road. The Rocklands movements also have the added delay of the new set of signals at Dominion Road in the option models.

The Dominion Road / Balmoral Road north approach has a predicted increase in delay as a result of the queue from Dominion Road/ Rocklands Avenue intermittently spilling back to Balmoral Road. The volume of traffic in this queue increases in the option models and the majority of this additional traffic originates from Balmoral Road West. Any other changes in the levels of service are only from marginal changes in the average delay.

Intersection	Approach	Mvt	Base Movement			Option 1 Movement			Option 2 Movement		
			Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS	Volume	Average Delay (s/veh)	LOS
Dominion Balmoral	Dominion Road North	L	241	19	B	244	16	B	244	15	B
		T	491	50	D	492	63	E	487	59	E
		R	179	62	E	176	66	E	177	63	E
	Balmoral Road East	L	189	17	B	187	28	C	197	21	C
		T	797	35	D	805	42	D	803	41	D
		R	304	47	D	328	45	D	323	51	D
	Dominion Road South	L	138	20	C	141	19	B	142	19	B
		T	472	55	E	466	57	E	465	57	E
		R	120	74	E	133	68	E	135	68	E
	Balmoral Road West	L	148	4	A	146	4	A	146	4	A
		T	665	33	C	665	31	C	666	32	C
		R	240	56	E	293	70	E	290	62	E
Balmoral Matipo	Balmoral Road East	L	40	7	A	42	7	A	32	7	A
	Matipo Street	L	59	13	B	58	13	B	57	14	B
		R	126	30	C	147	32	C	141	33	C
	Balmoral Road West	R	75	16	B	79	17	B	78	15	B
Rocklands Dominion	Dominion Road North	L	75	4	A	128	3	A	119	4	A
		T				824	7	A	836	6	A
	Rocklands	L	82	4	A	128	35	D	106	36	D
		R	26	78	E	17	118	F	19	115	F
	Dominion Road South	T				726	206	F	726	188	F
		R	147	127	F	186	217	F	169	197	F

Table 20 – Saturday peak hour Level of Service

As with the Evening period, the movements from Rocklands Avenue at Dominion Road have increased in actual average delay along with the right turn from the south approach at the same intersection, this is not shown clearly by the levels in the table as the LOS is already an 'F'. With the introduction of a reduced development GFA in Option 2 the large delay drops for the south approach through and right turn movements by 18 and 20 s/veh respectively.

The only other movement in the Saturday network that shows an increase in delay is the Dominion Road/ Balmoral Road North through movement with an increase in level of service from a 'D' in the base model to an 'E' in both option tests. As with the Evening model a small amount of spill back from the Dominion Road/ Rocklands Avenue queue causes this increase in delay with higher volumes turning right at Dominion Road/ Balmoral Road from Balmoral Road West.

7. Summary and Conclusions

Using the calibrated Balmoral Warehouse base traffic model, Aurecon has carried out testing of two options with existing year background traffic demands and the proposed development traffic generation. For Option 1 the proposed development comprises of approximately 7,000 sqm GFA of retail. Trip generation is expected to be 560 vph and 700 vph in the Evening and Saturday peak hours respectively. Option 2 has a reduced GFA of 6,280 sqm and has generates 502 vph in the Evening period and 628 vph in the Saturday period. The site has two access points, one connecting with Balmoral Road with another connecting to Rocklands Avenue. Both enable vehicle movements to and from the site.

Outputs from the model option tests were evaluated and compared to the calibrated base model using network operation performance criteria consisting of network statistics, journey times, queue lengths, signal phasing, and level of service.

Comparisons between the base model, built from 2009 survey data, and both of the proposed development option models predicted an increase in journey times and queue lengths on Dominion Road Northbound in all of the model periods with the Balmoral westbound movement also showing an increase in journey times and queue lengths in the Evening period.

With the introduction of traffic signals at the Dominion Road/ Rocklands Avenue intersection and the increased volumes the LOS increases for the south approach right turn for both periods, moving from a ‘C’ to an ‘E’ in the Evening period. This is similar for the left and right turn movements out of Rocklands Avenue.

Across all model performance criteria, Option 2 performed marginally better compared to Option 1 through having less development trips.

With the development generated trips in the Evening period model the network operates at a reduced level of performance for both options. Further delay occurs for the already congested Dominion Road northbound movement in the Saturday model stemming from the Dominion Road/ Balmoral Road intersection.

Appendix A
Option 1 Evening Journey Time Graphs

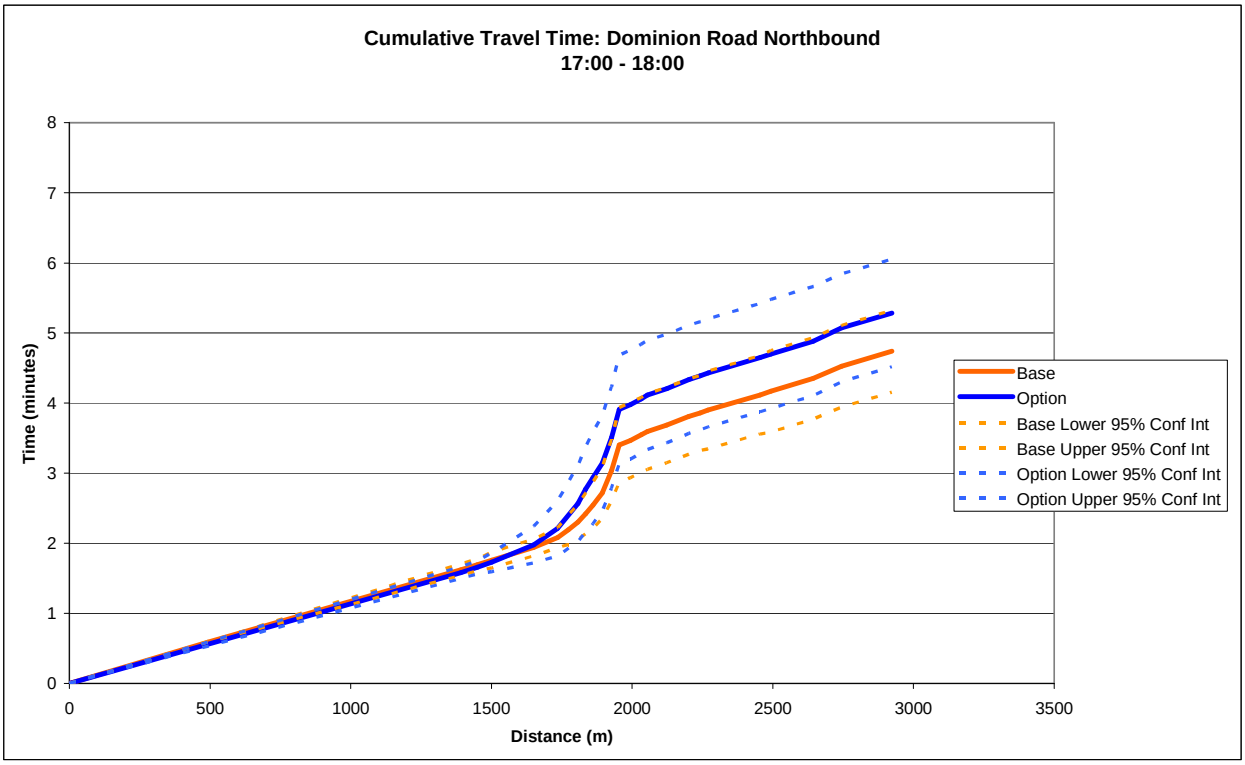

Figure 10 – Journey time graph of Dominion Road Northbound in the Evening peak hour of Option 1

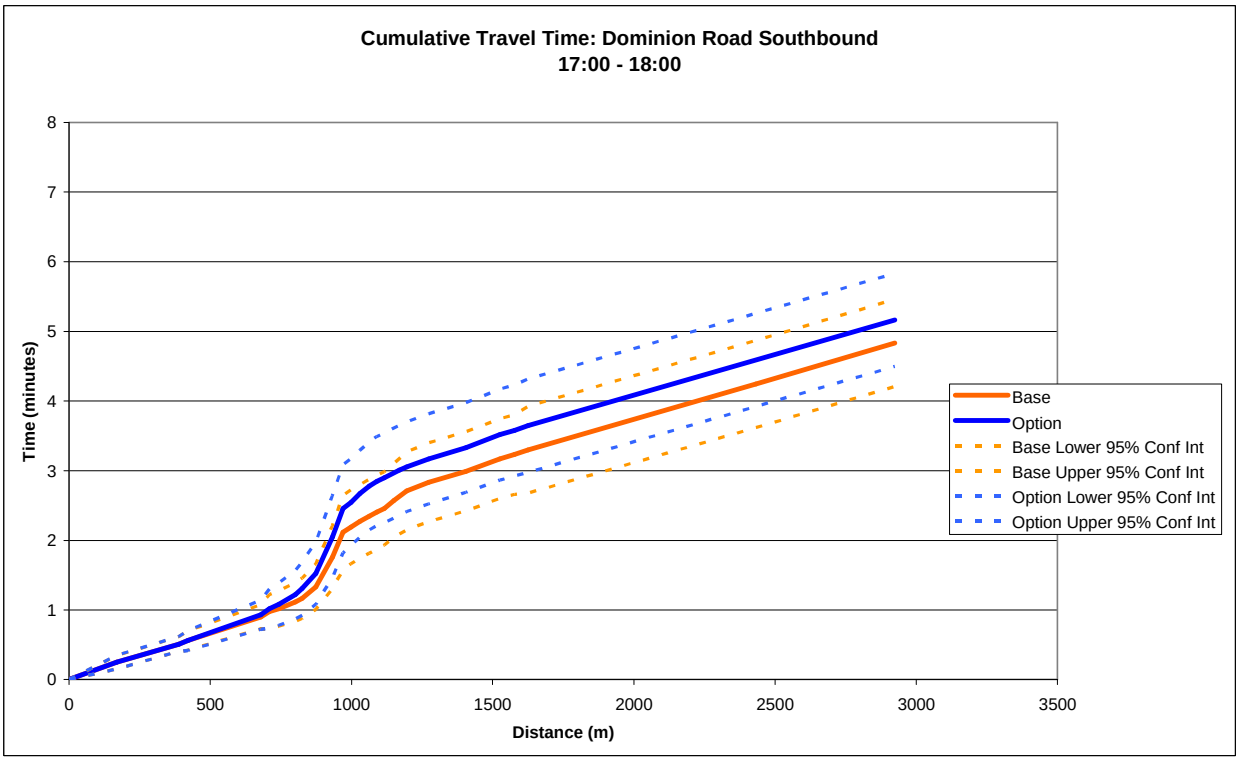

Figure 11 – Journey time graph of Dominion Road Southbound in the Evening peak hour of Option 1

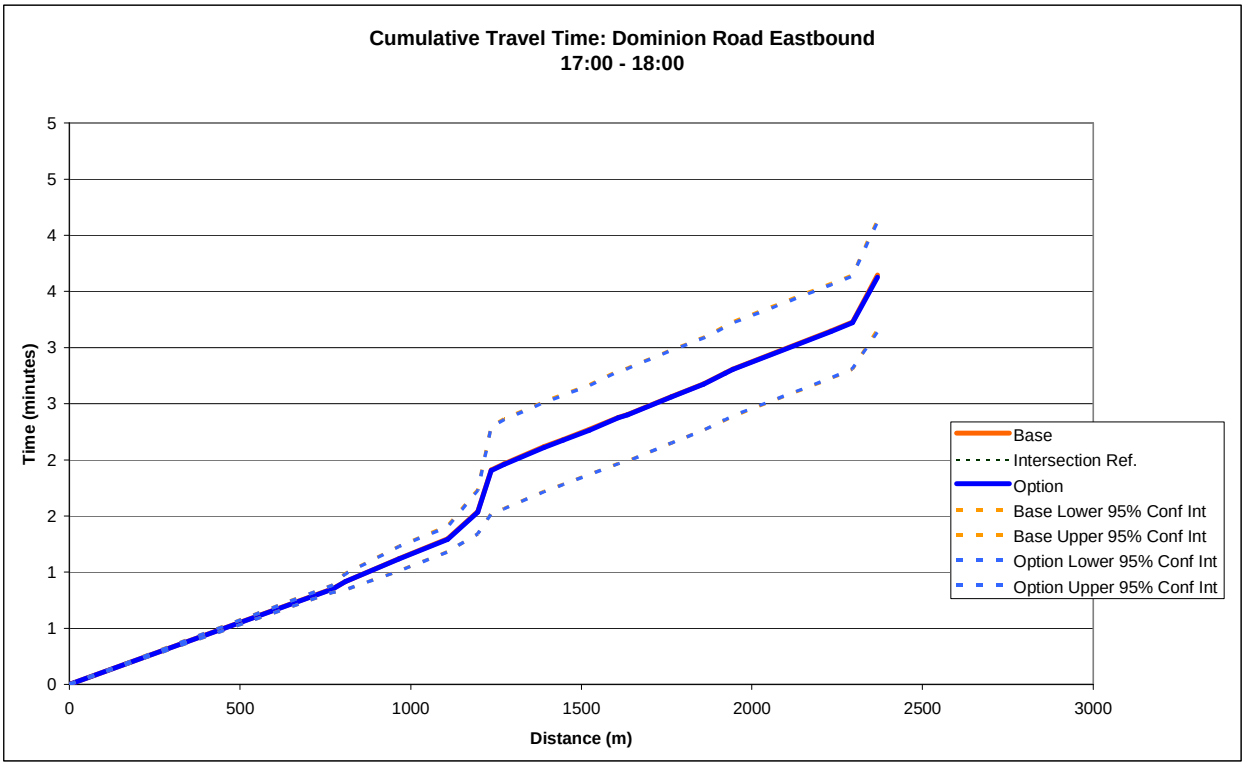

Figure 12 – Journey time graph of Balmoral Road Eastbound in the Evening peak hour of Option 1

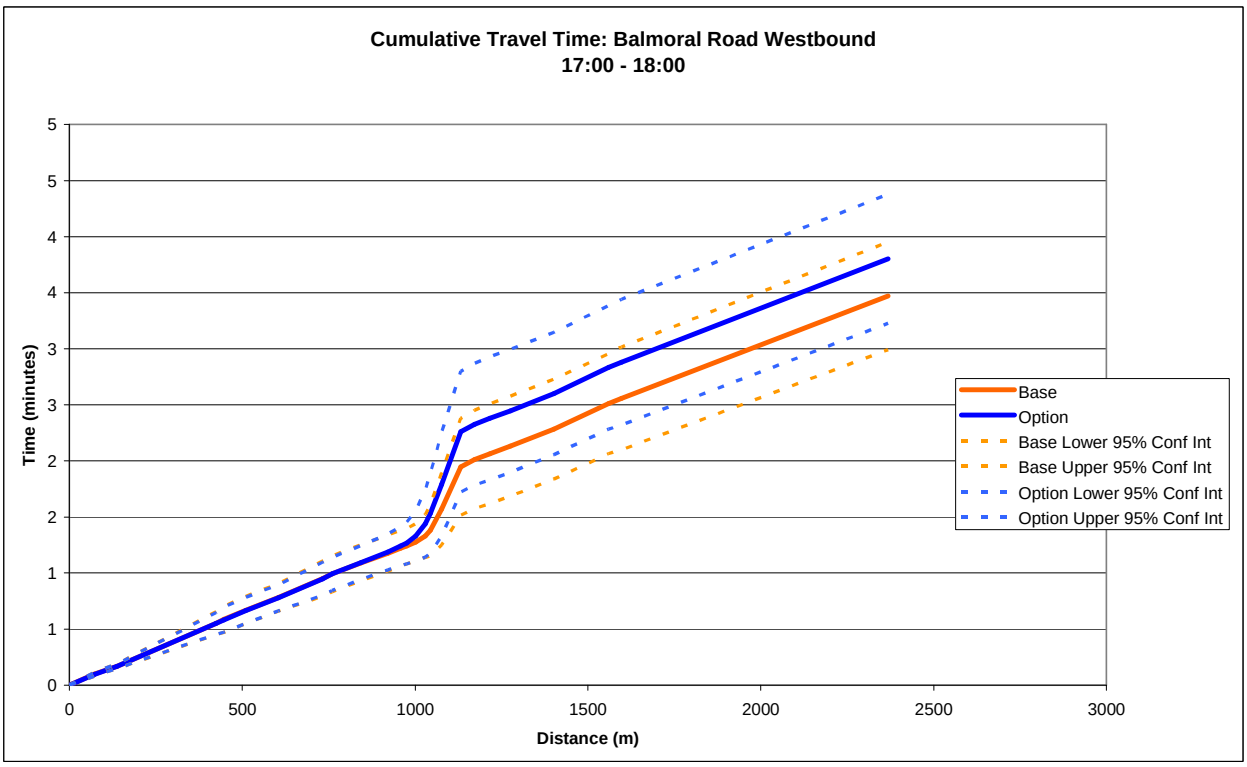

Figure 13 – Journey time graph of Balmoral Road Westbound in the Evening peak hour of Option 1

Appendix B
Option 1 Saturday Journey Time Graphs

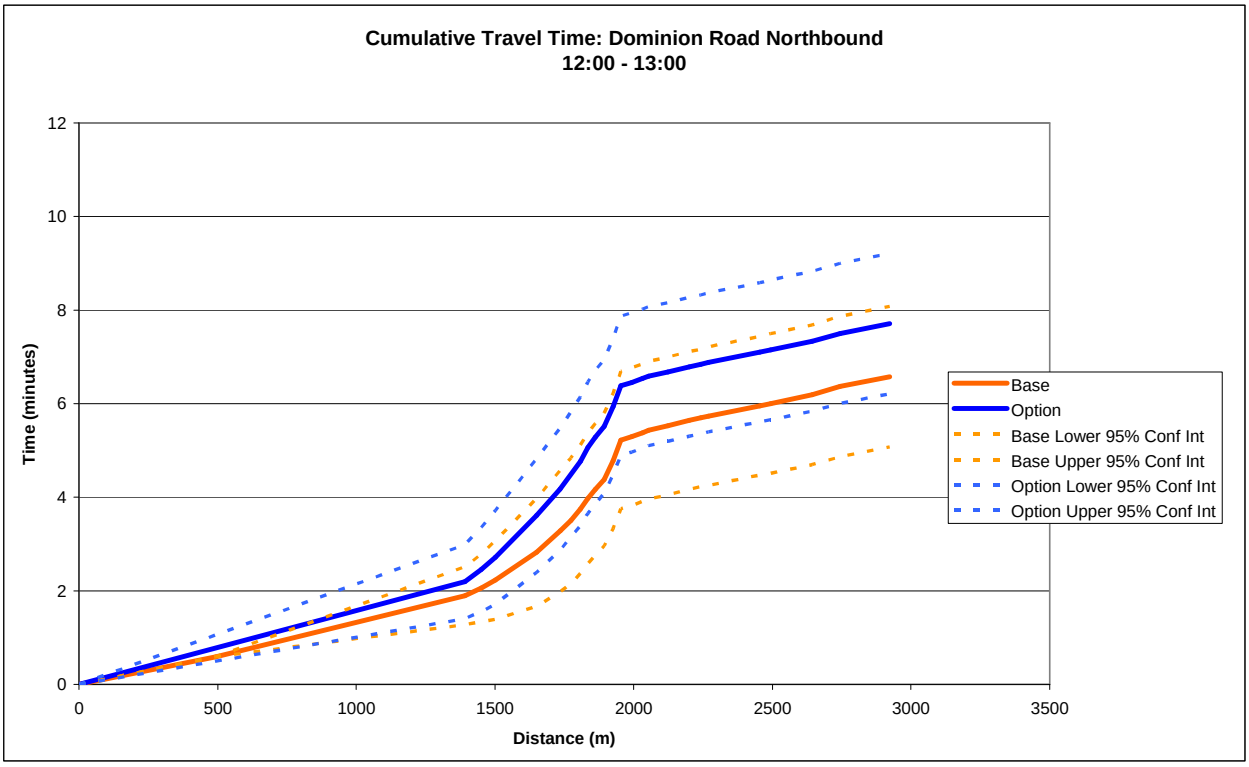

Figure 14 – Journey time graph of Dominion Road Northbound in the Saturday peak hour of Option 1

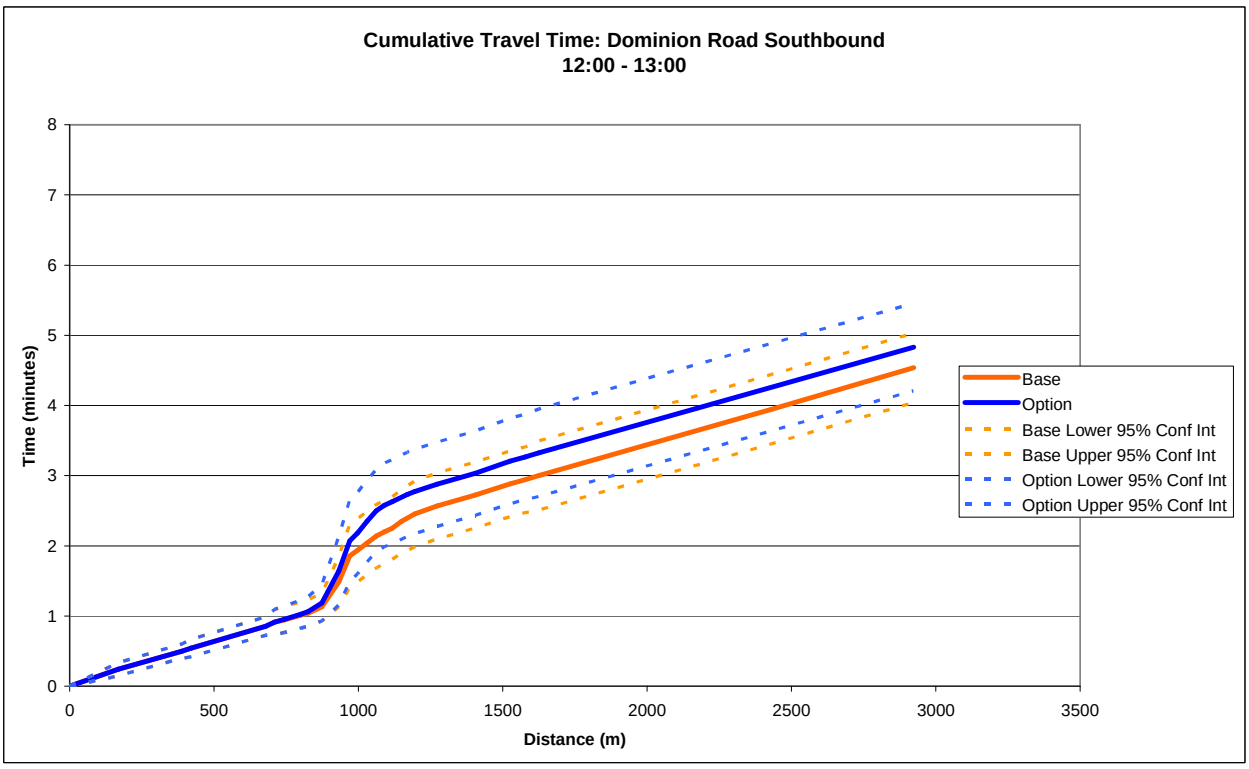

Figure 15 – Journey time graph of Dominion Road Southbound in the Saturday peak hour of Option 1

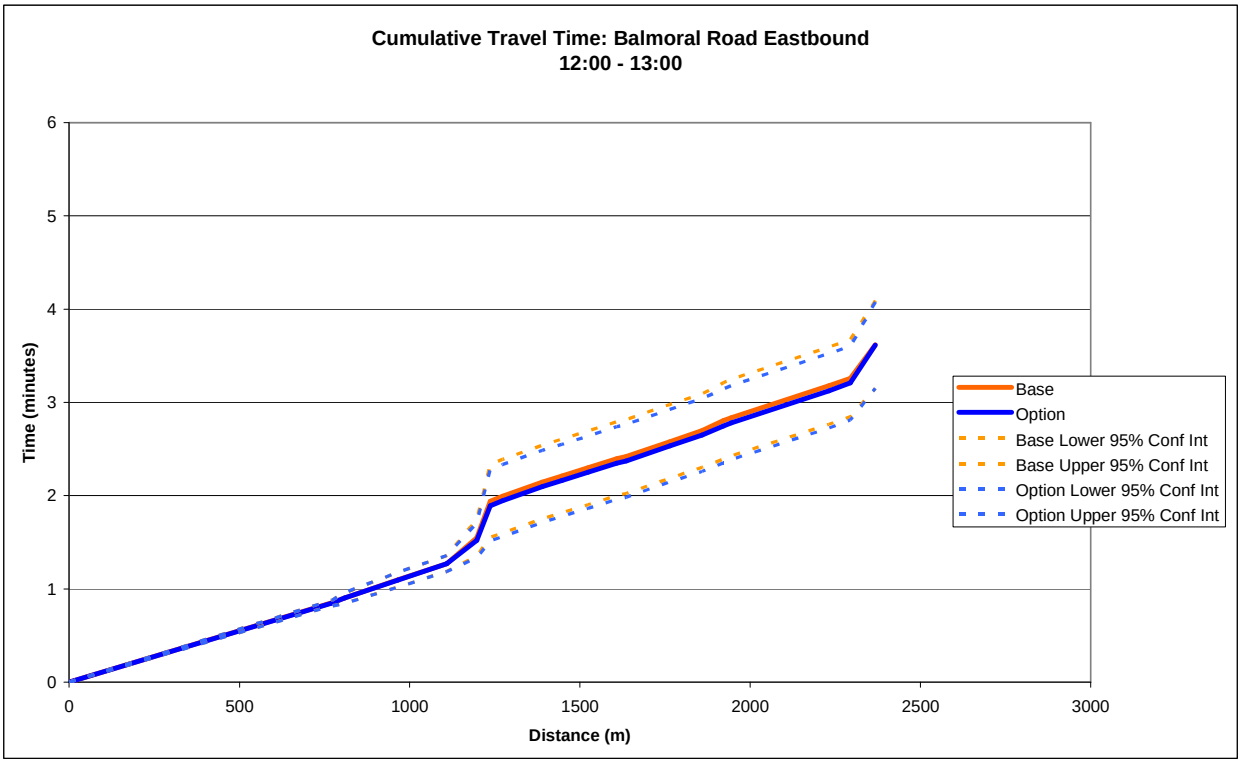

Figure 16 – Journey time graph of Balmoral Road Eastbound in the Saturday peak hour of Option 1

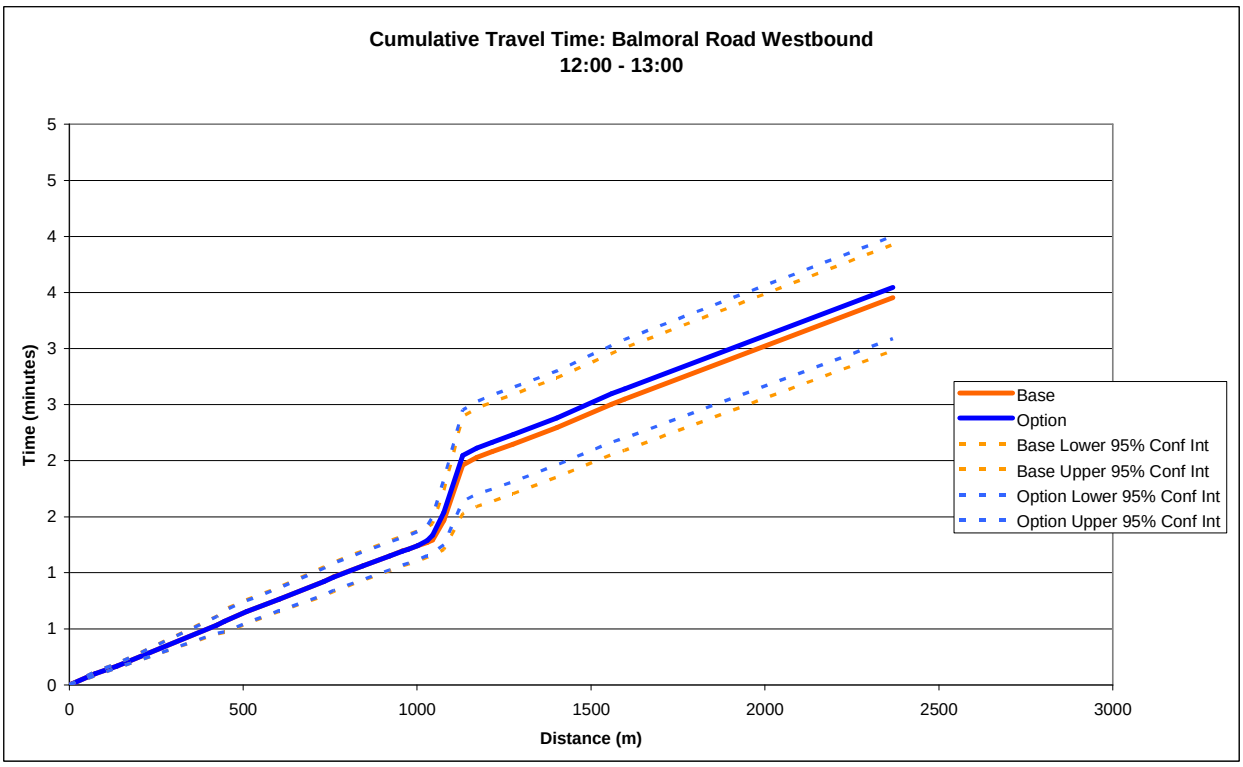

Figure 17 – Journey time graph of Balmoral Road Westbound in the Saturday peak hour of Option 1

Appendix C
Option 2 Evening Journey Time Graphs

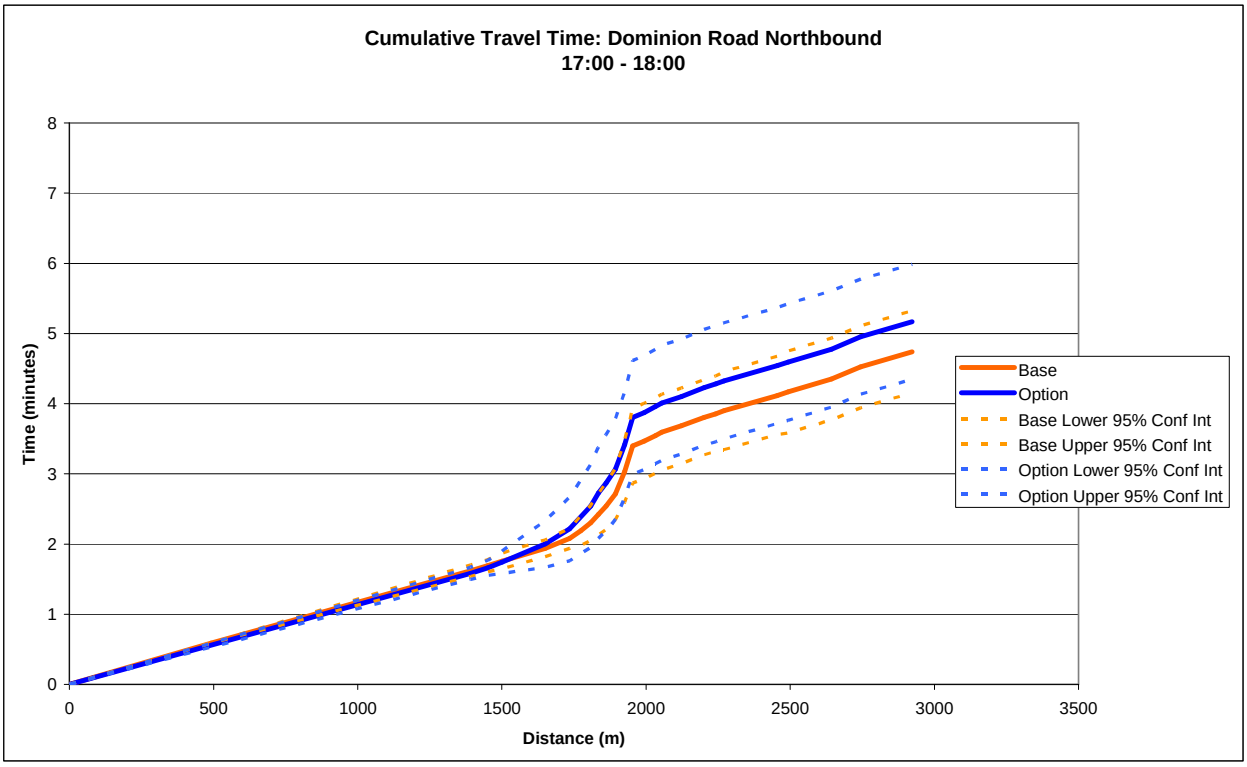

Figure 18 – Journey time graph of Dominion Road Northbound in the Evening peak hour of Option 2

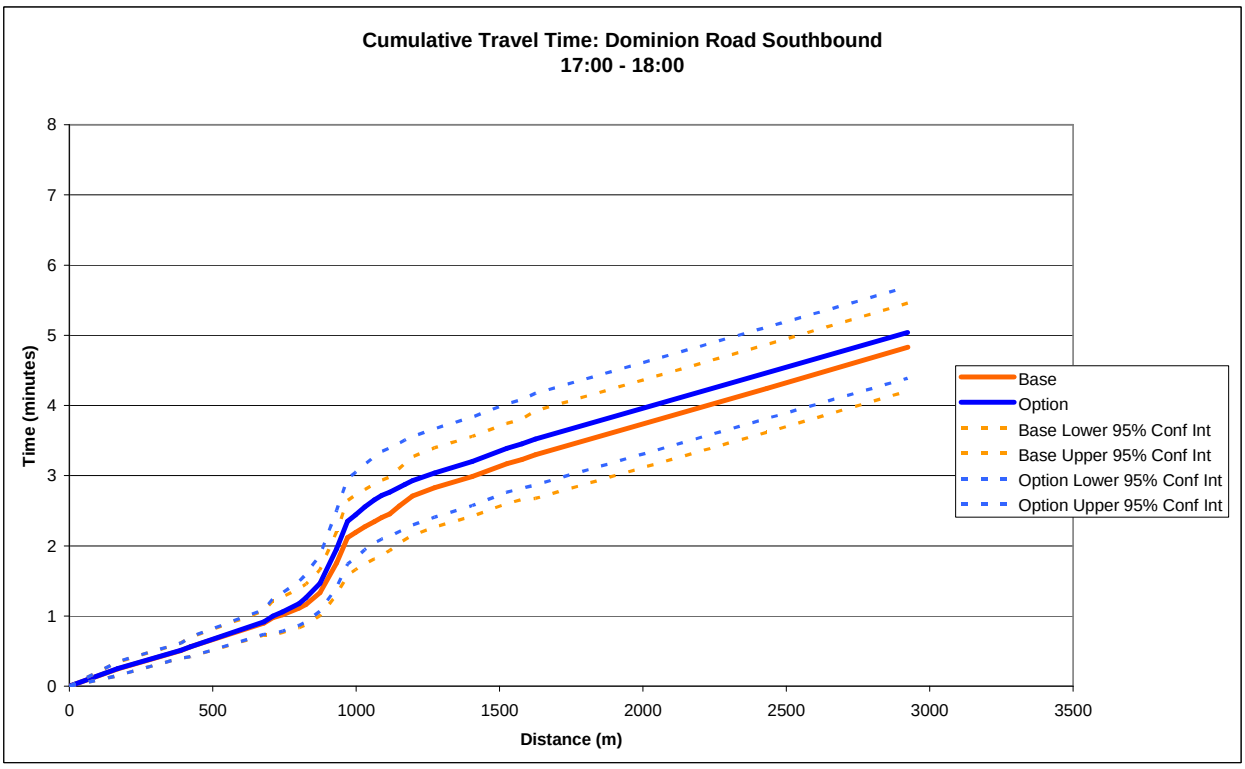

Figure 19 – Journey time graph of Dominion Road Southbound in the Evening peak hour of Option 2

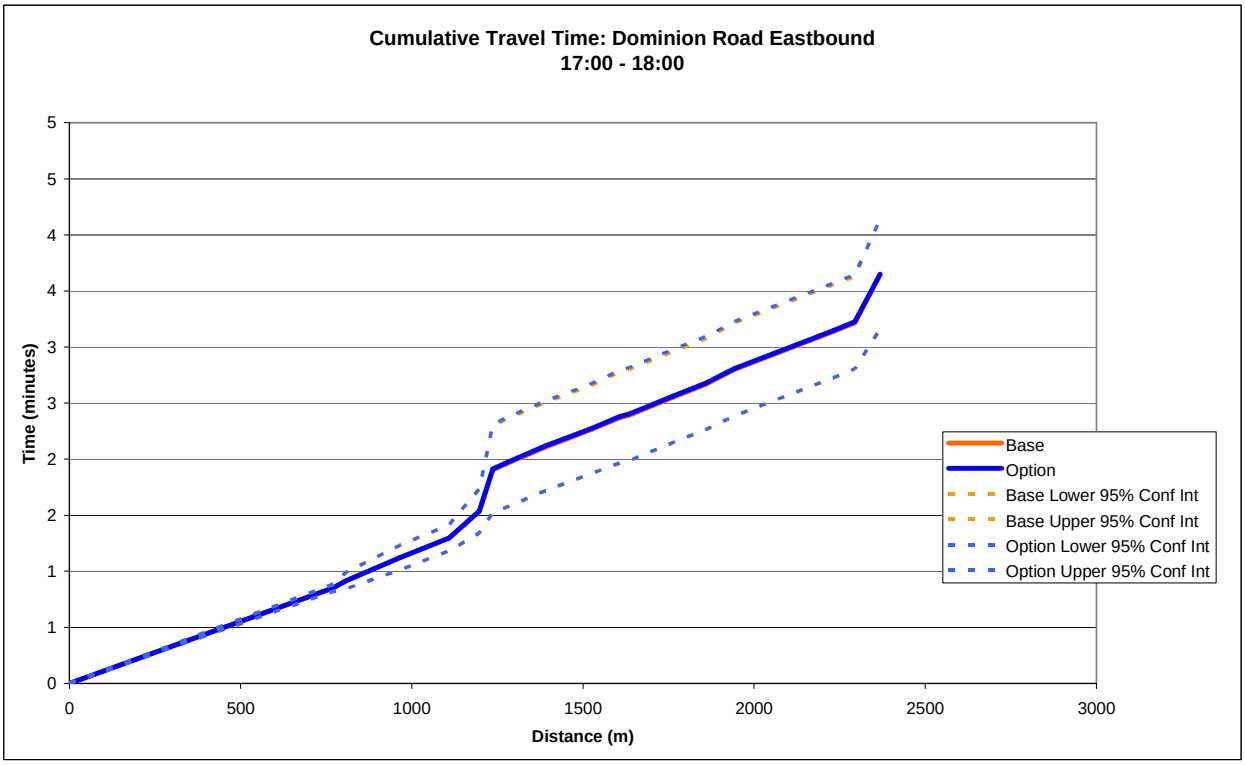

Figure 20 – Journey time graph of Balmoral Road Eastbound in the Evening peak hour of Option 2

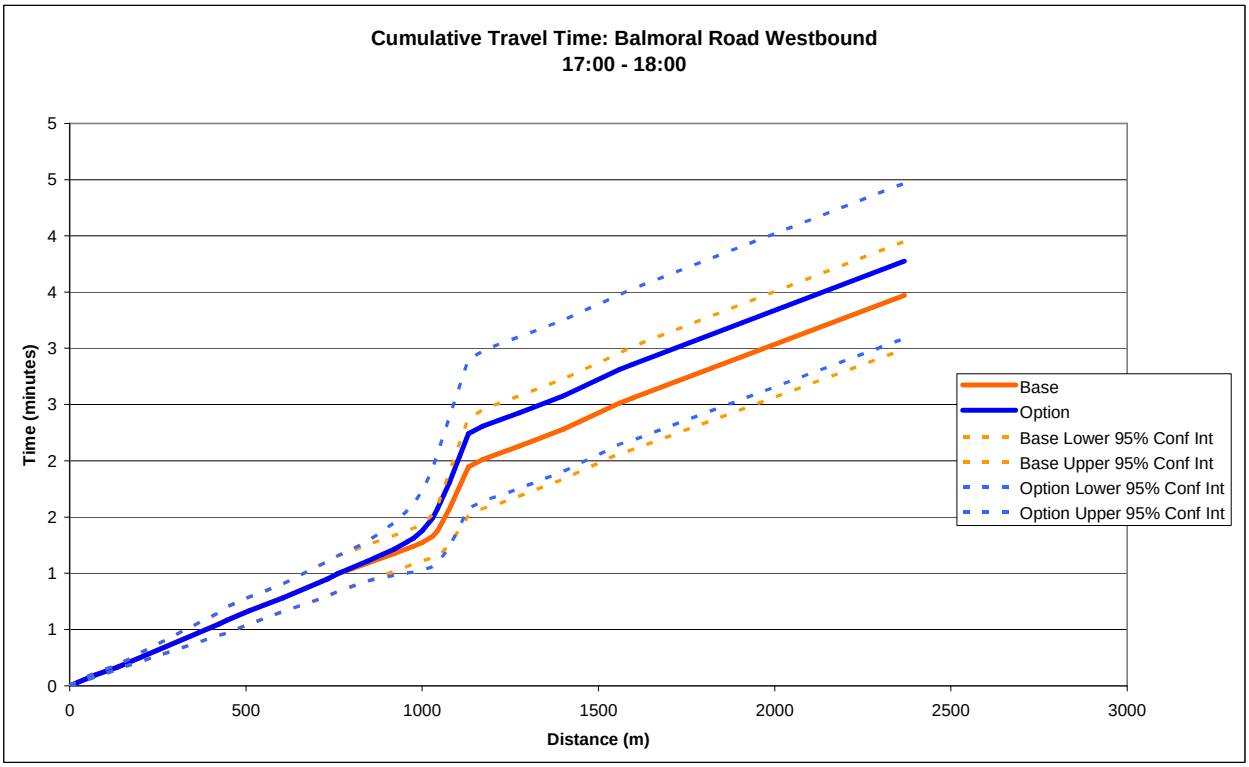

Figure 21 – Journey time graph of Balmoral Road Eastbound in the Evening peak hour of Option 2

Appendix D
Option 2 Saturday Journey Time Graphs

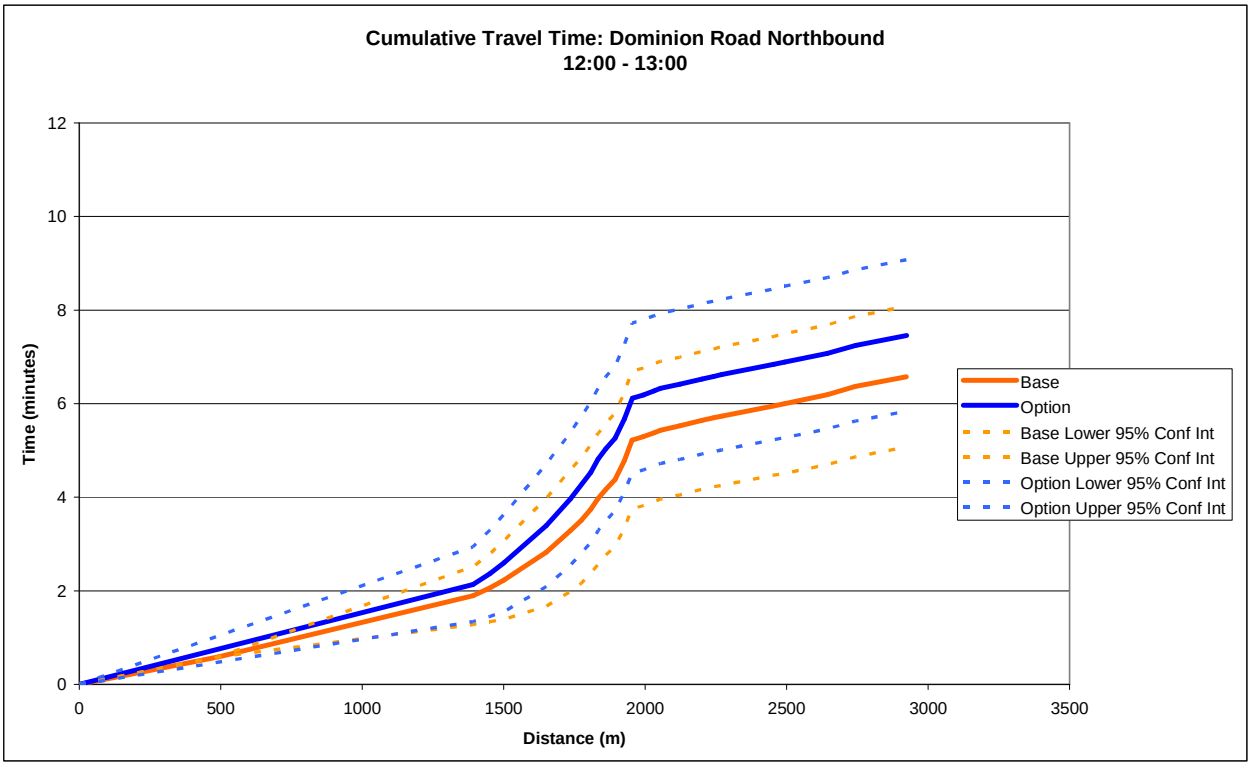

Figure 22 – Journey time graph of Dominion Road Northbound in the Saturday peak hour of Option 2

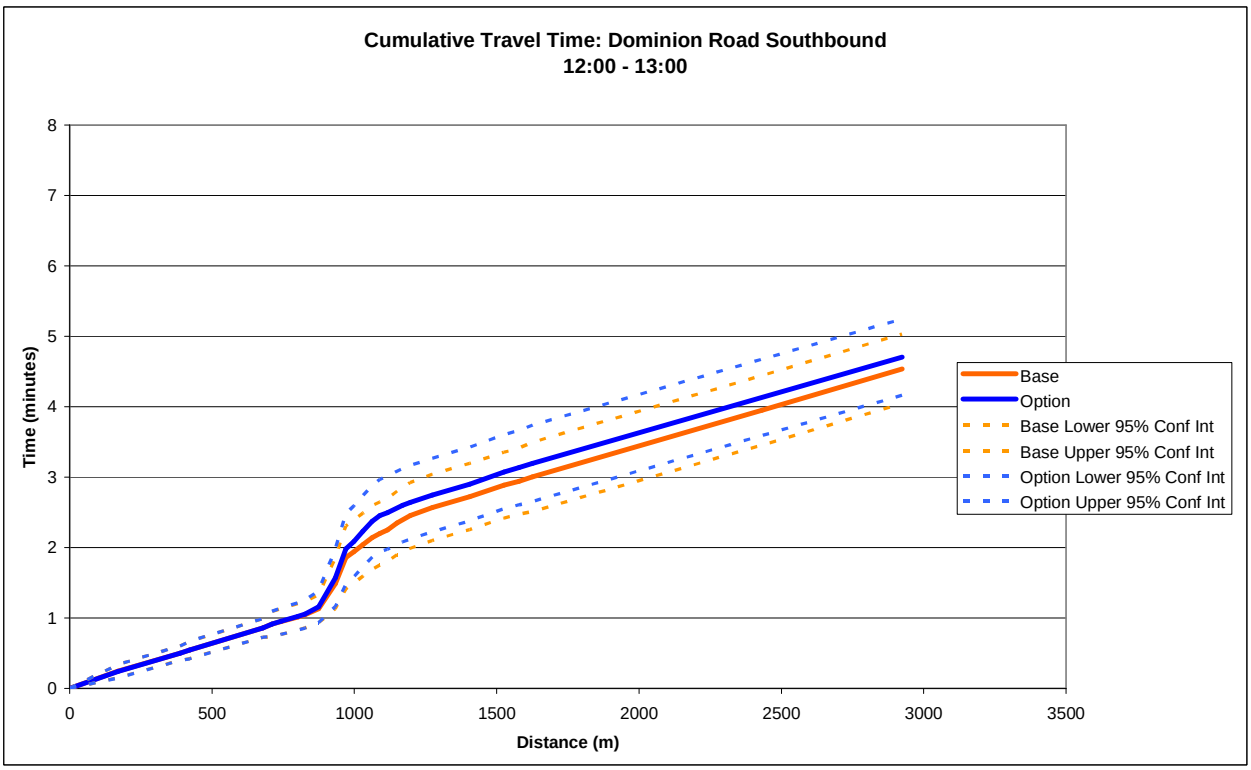

Figure 23 – Journey time graph of Dominion Road Southbound in the Saturday peak hour of Option 2

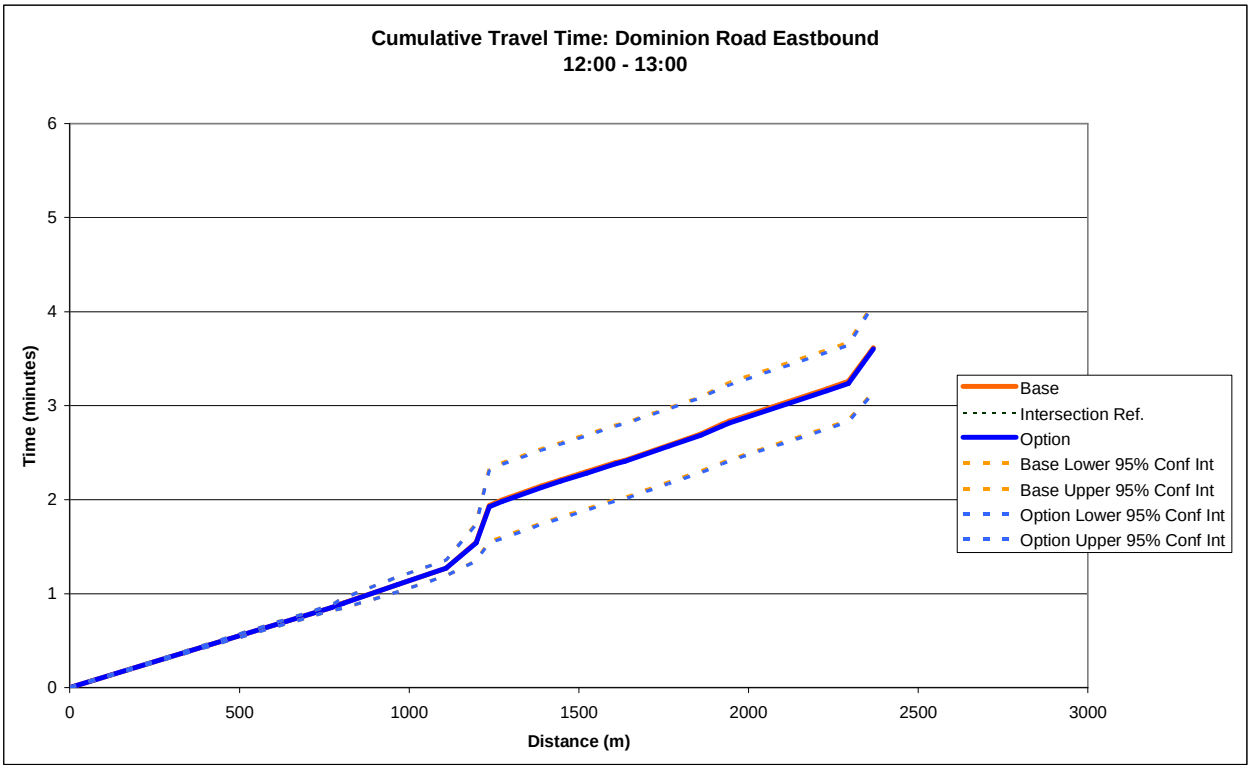

Figure 24 – Journey time graph of Balmoral Road Eastbound in the Saturday peak hour of Option 2

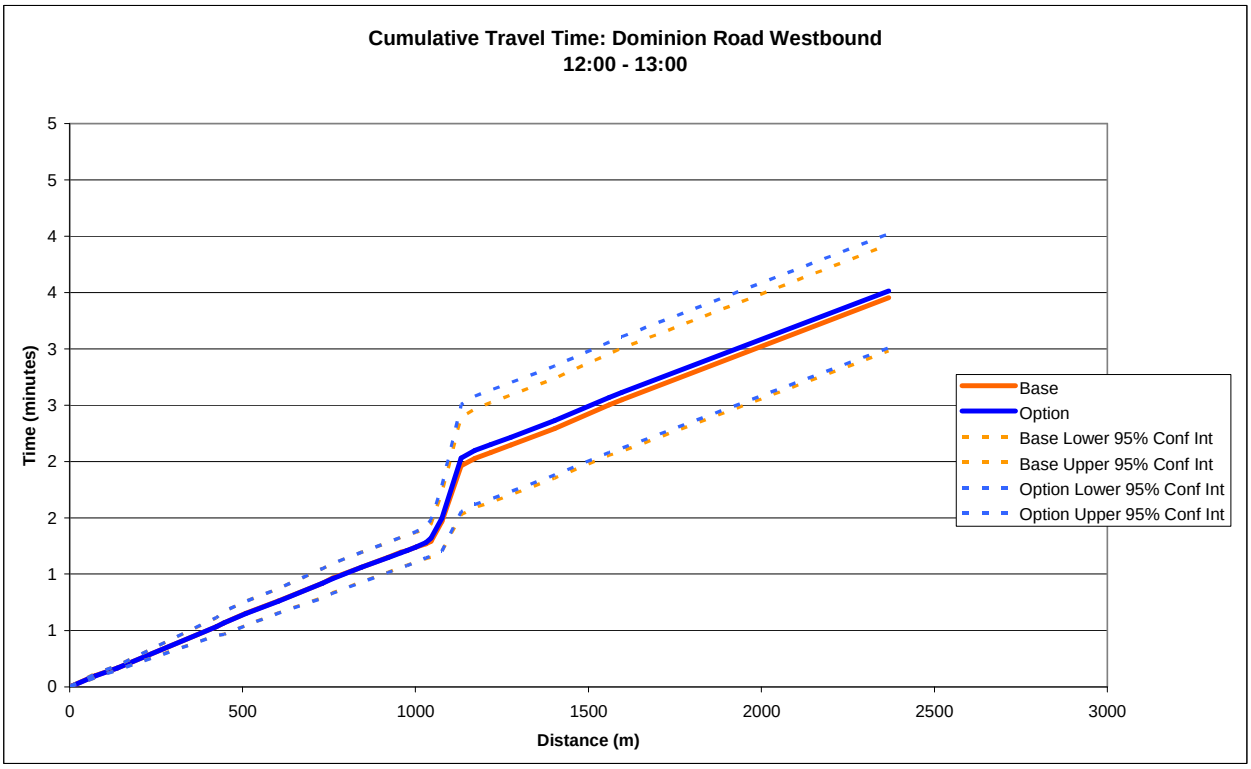

Figure 25 – Journey time graph of Balmoral Road Westbound in the Saturday peak hour of Option 2

Appendix E
Option 1 Evening Queue Graphs

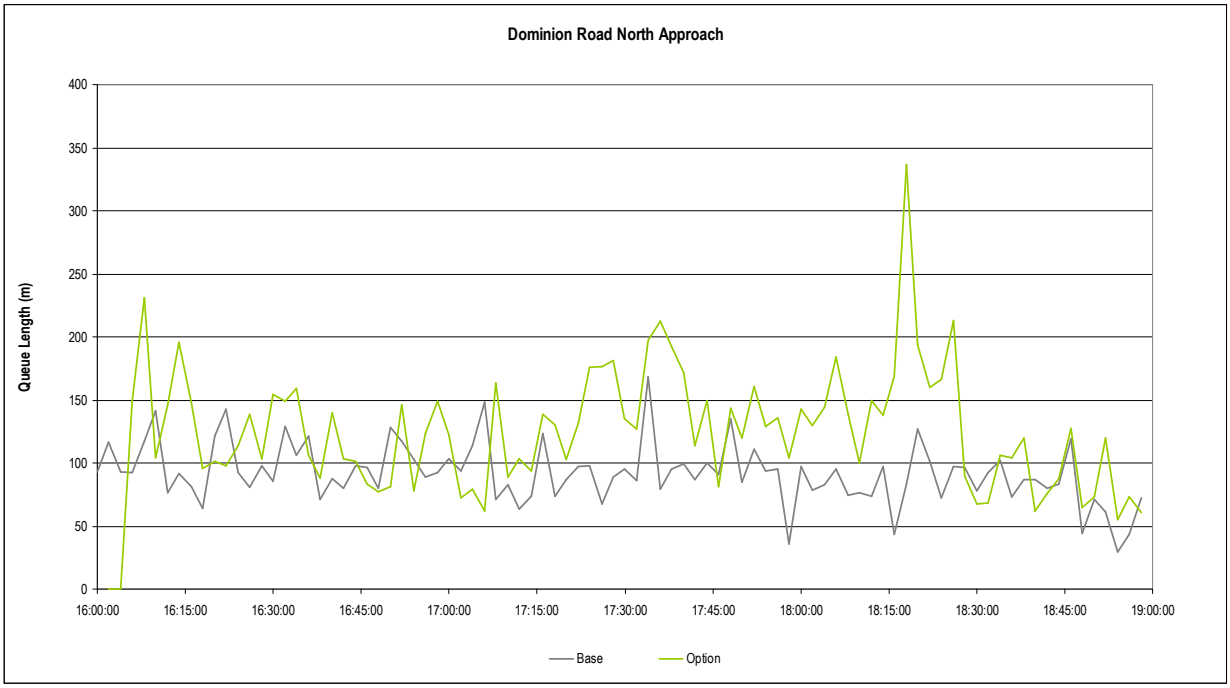

Figure 26 – Queue graph of Dominion Road North approach to Dominion Road/ Balmoral Road in the Evening period of Option 1

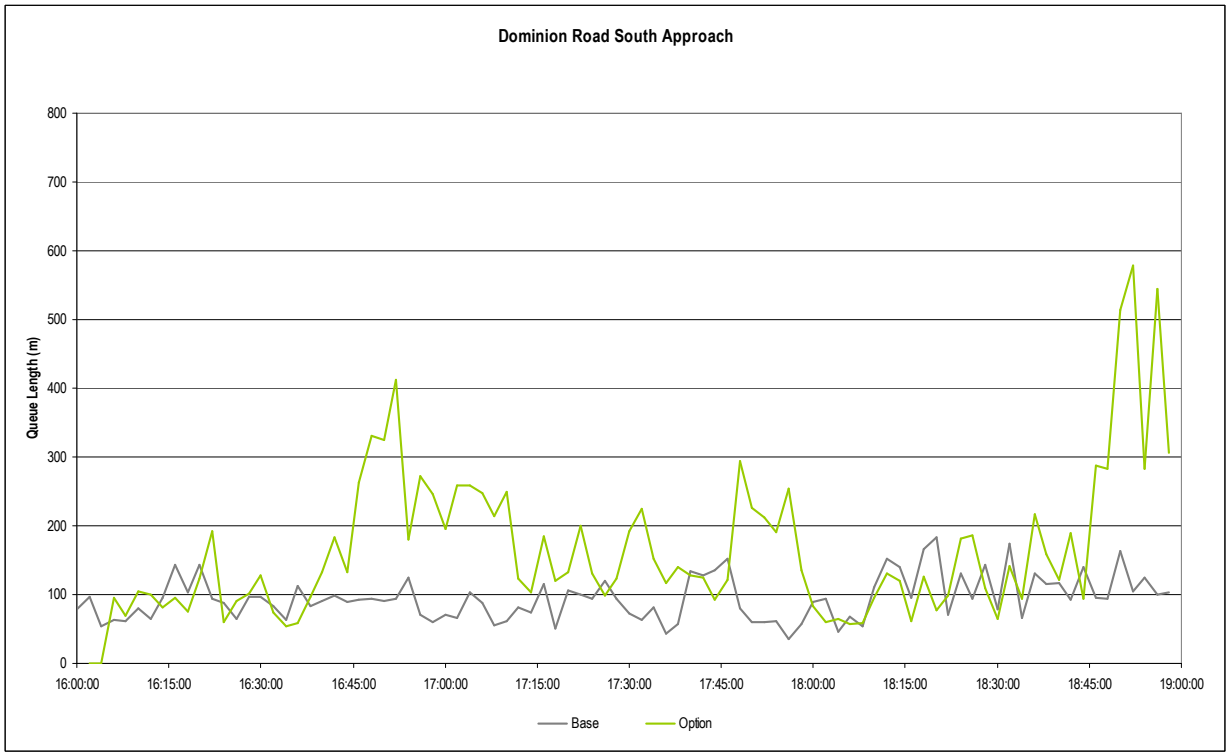

Figure 27 – Queue graph of Dominion Road South approach to Dominion Road/ Balmoral Road in the Evening period of Option 1

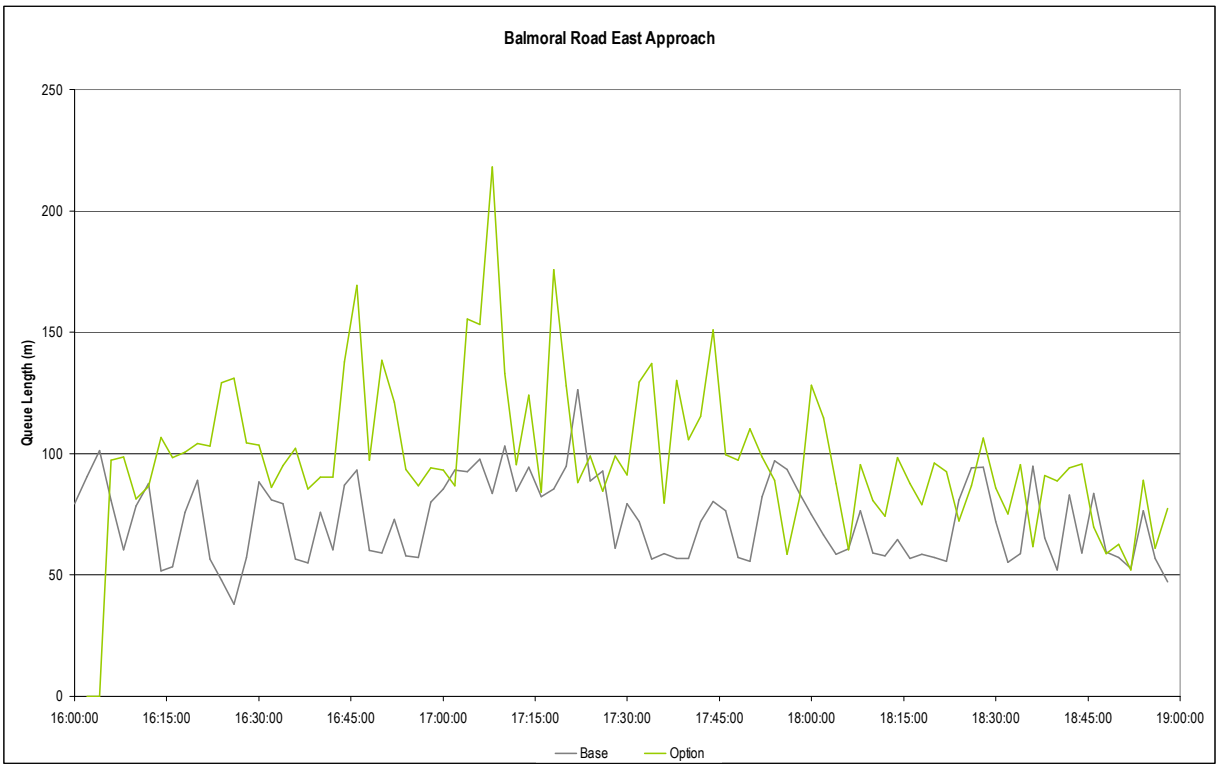

Figure 28 – Queue graph of Dominion Road East approach to Dominion Road/ Balmoral Road in the Evening period of Option 1

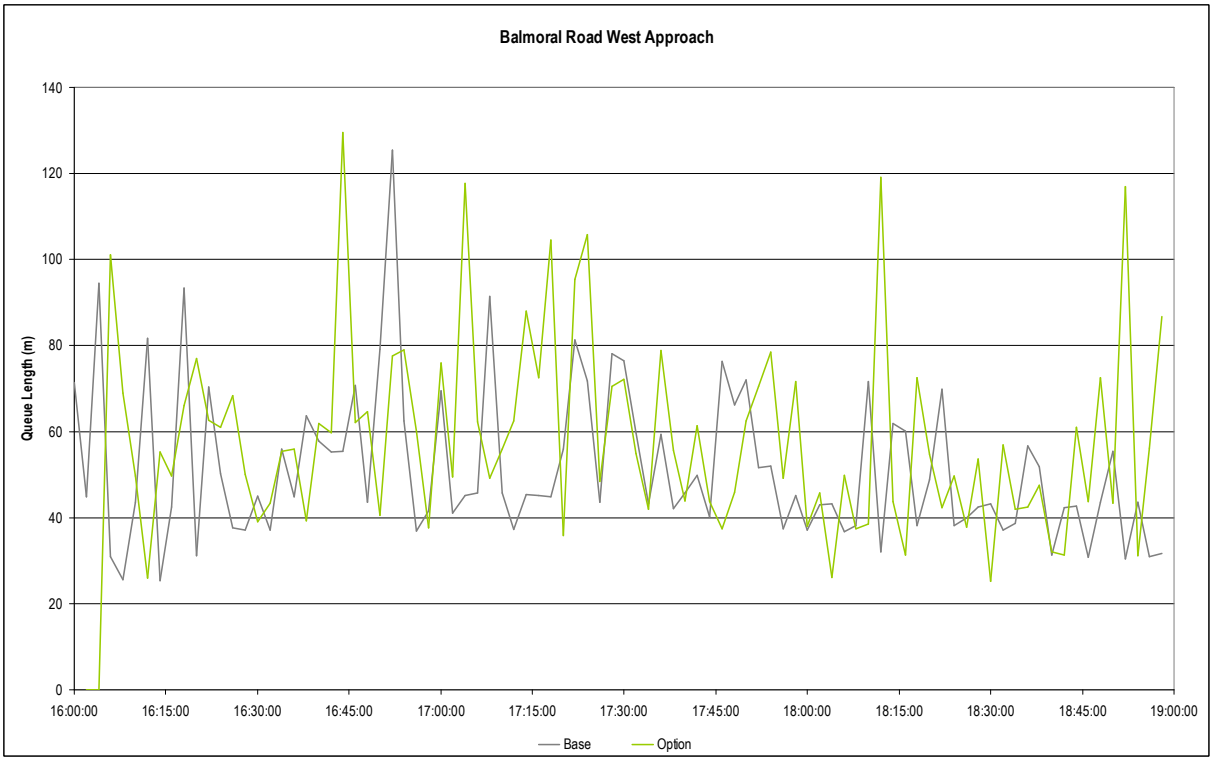

Figure 29 – Queue graph of Dominion Road West approach to Dominion Road/ Balmoral Road in the Evening period of Option 1

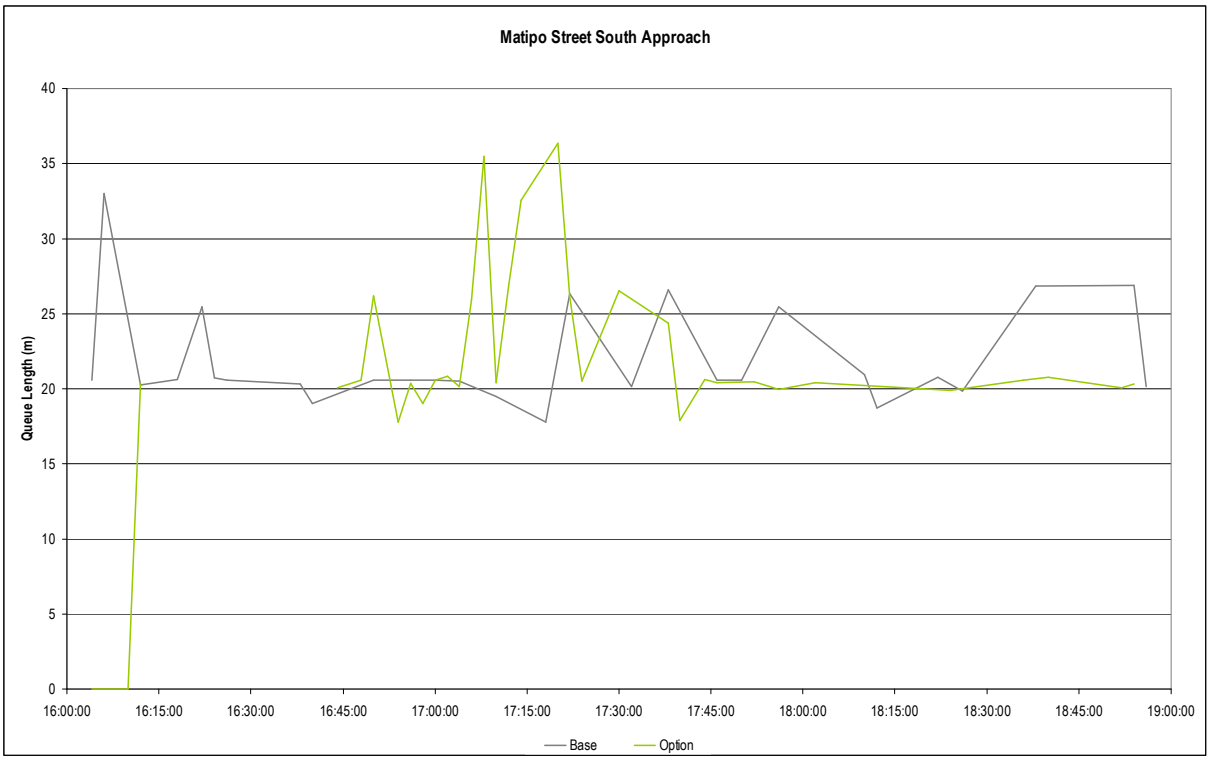

Figure 30 – Queue graph of Matipo Street approach to Balmoral Road/ Matipo Street in the Evening period of Option 1

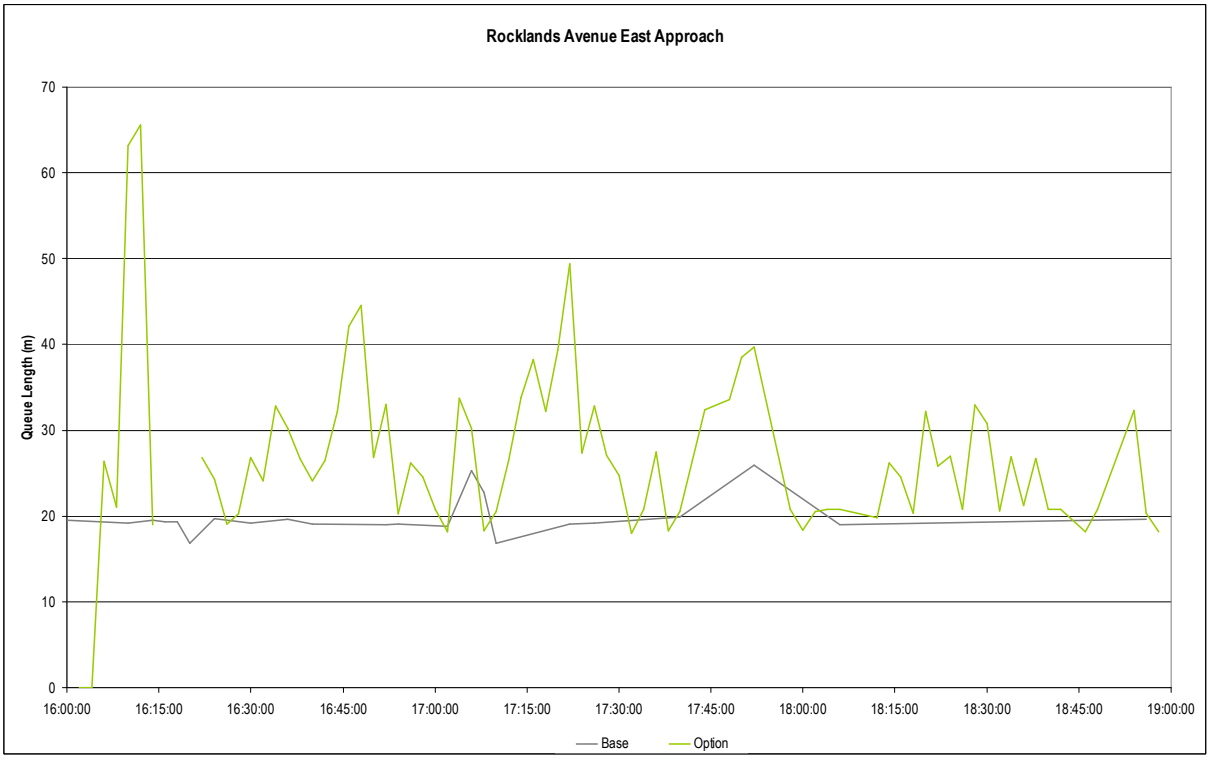

Figure 31 – Queue graph of Rocklands Avenue approach to Dominion Road/ Rocklands Avenue in the Evening period of Option 1

Appendix F
Option 1 Saturday Queue Graphs

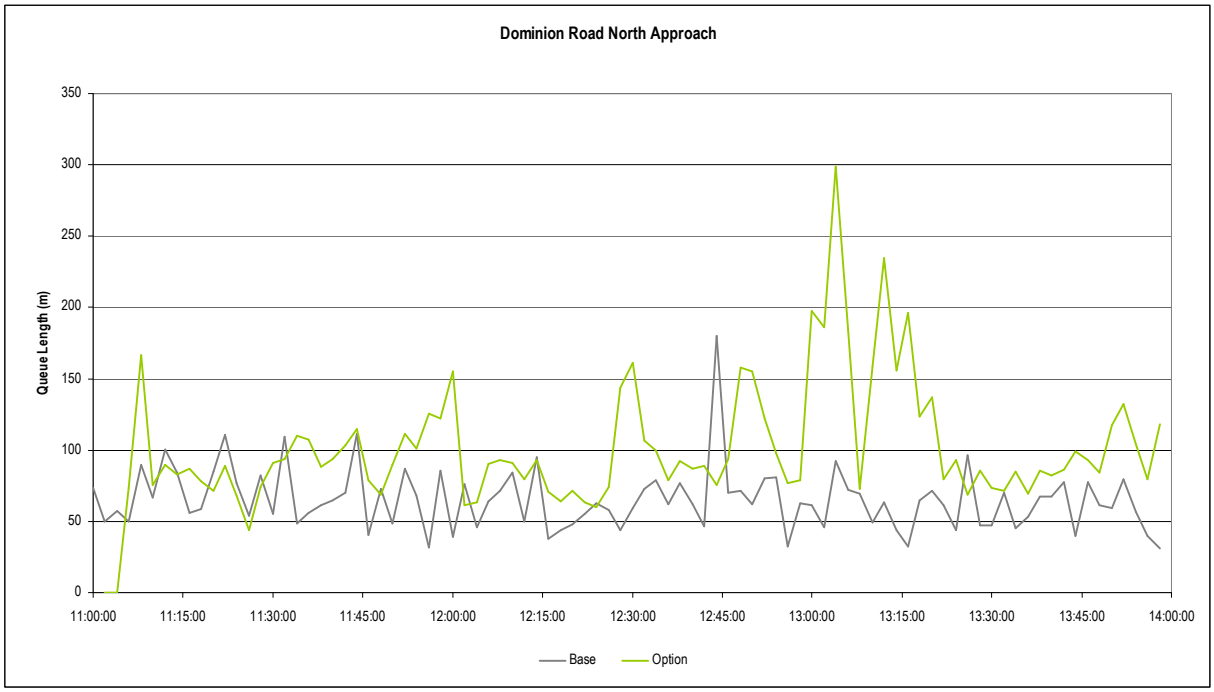

Figure 32 – Queue graph of Dominion Road North approach to Dominion Road/ Balmoral Road in the Saturday period of Option 1

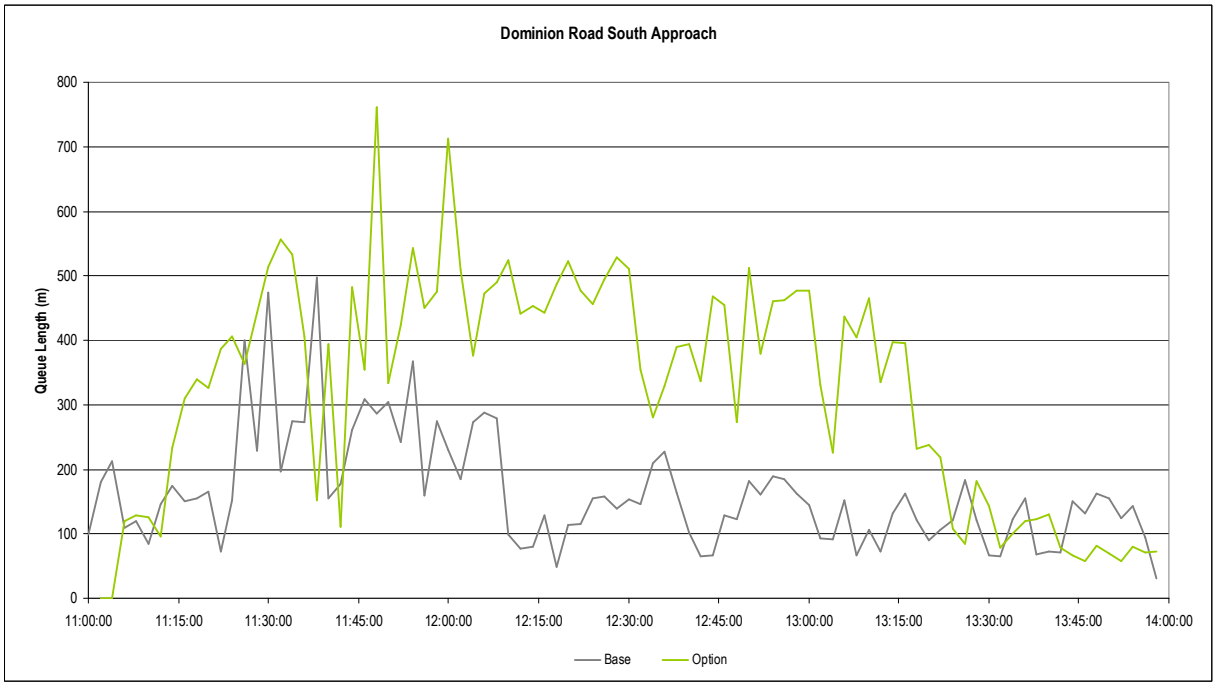

Figure 33 – Queue graph of Dominion Road South approach to Dominion Road/ Balmoral Road in the Saturday period of Option 1

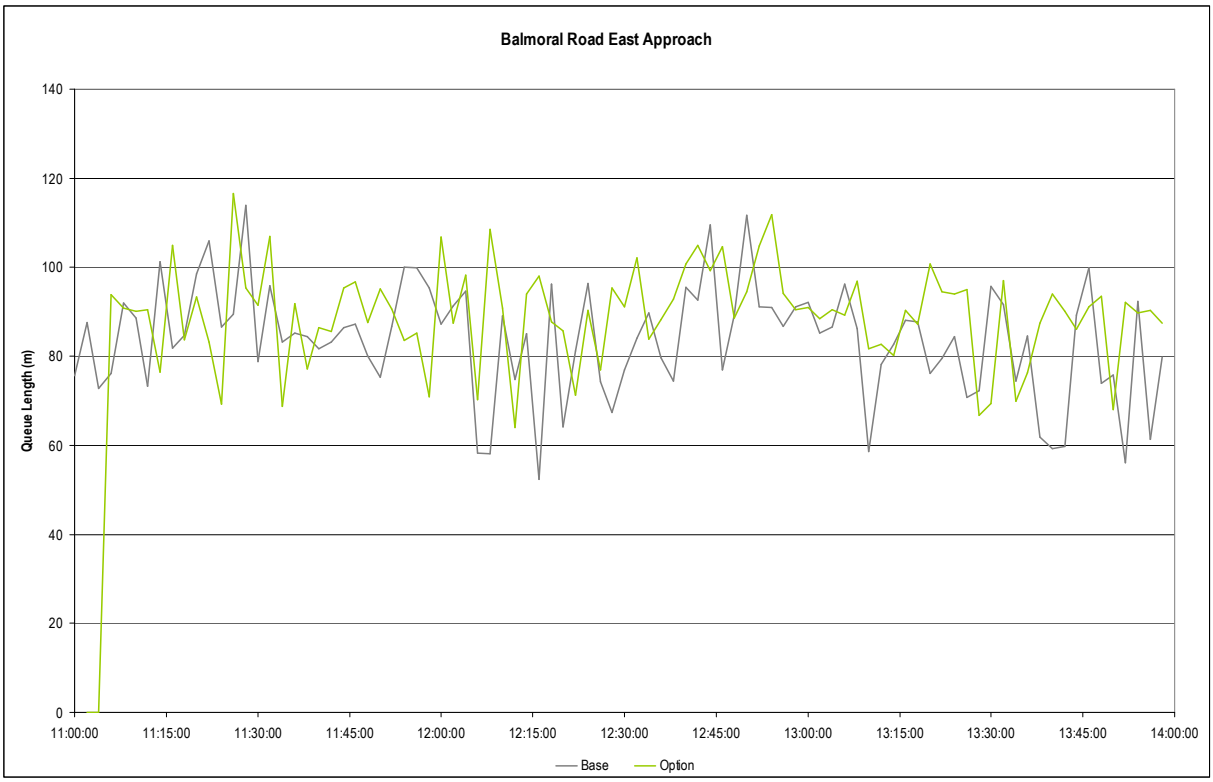

Figure 34 – Queue graph of Dominion Road East approach to Dominion Road/ Balmoral Road in the Saturday period of Option 1

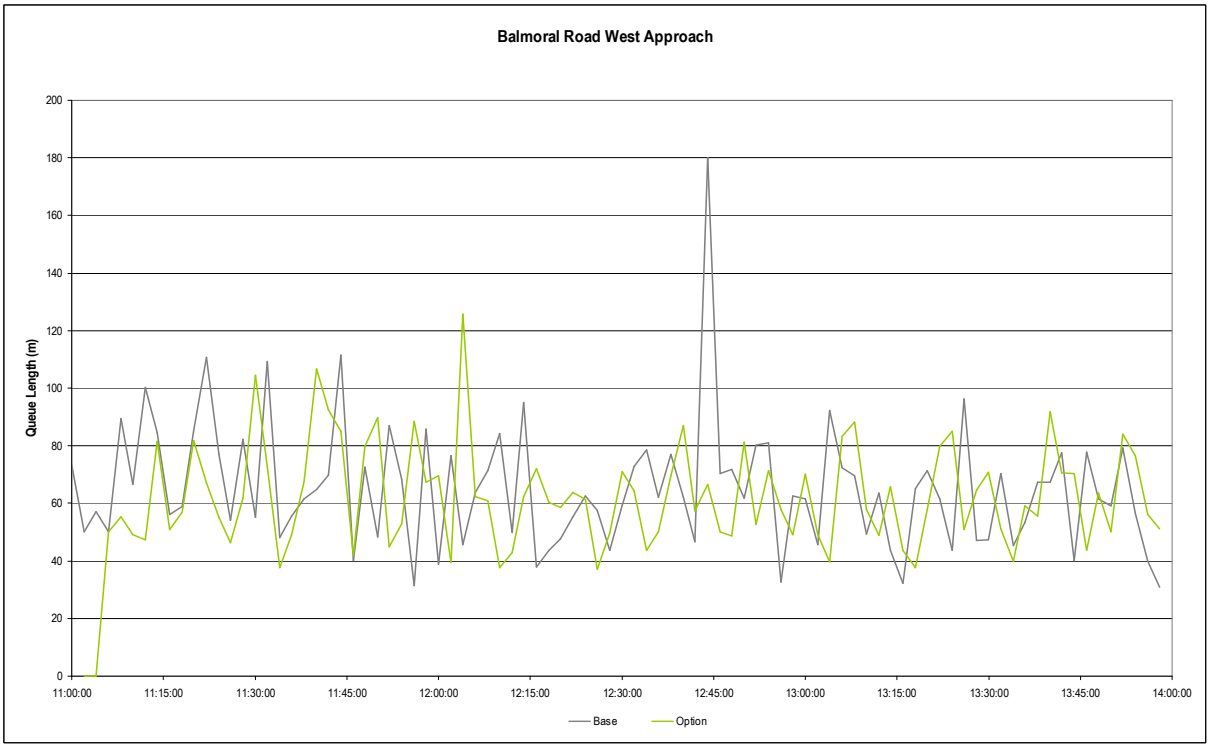

Figure 35 – Queue graph of Dominion Road West approach to Dominion Road/ Balmoral Road in the Evening period of Option 1

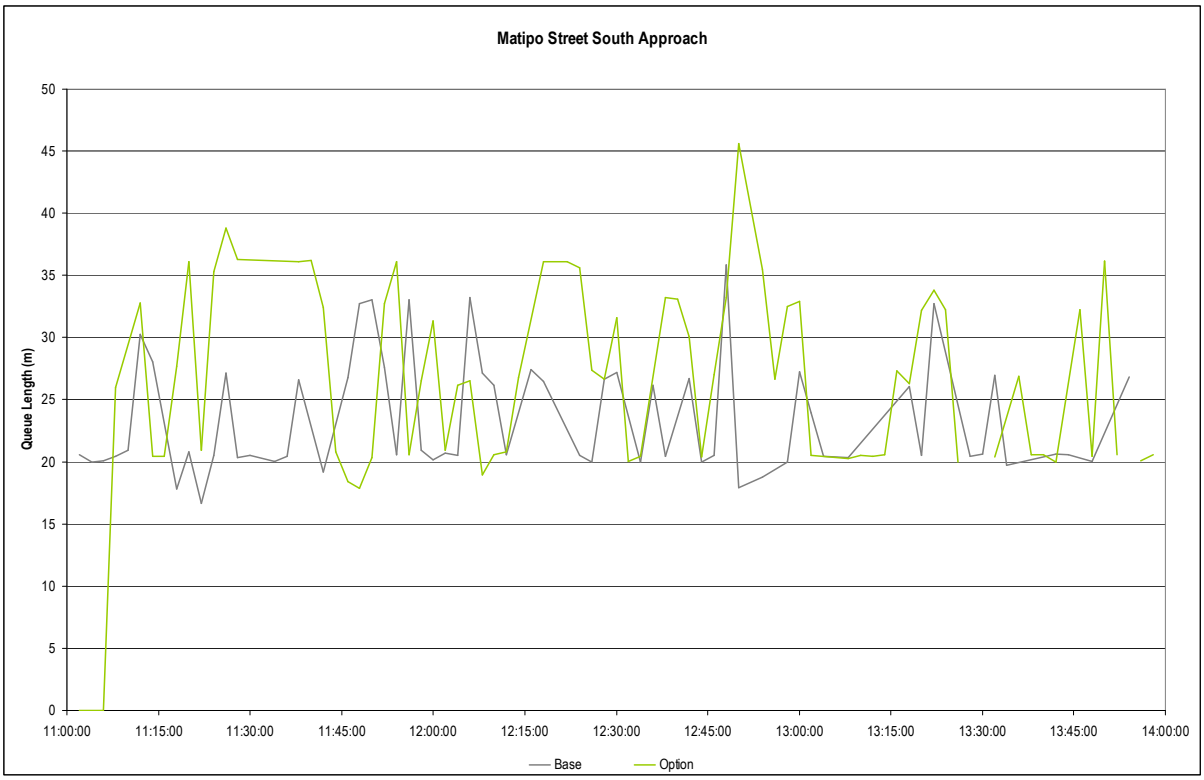

Figure 36 – Queue graph of Matipo Street approach to Balmoral Road/ Matipo Street in the Evening period of Option 1

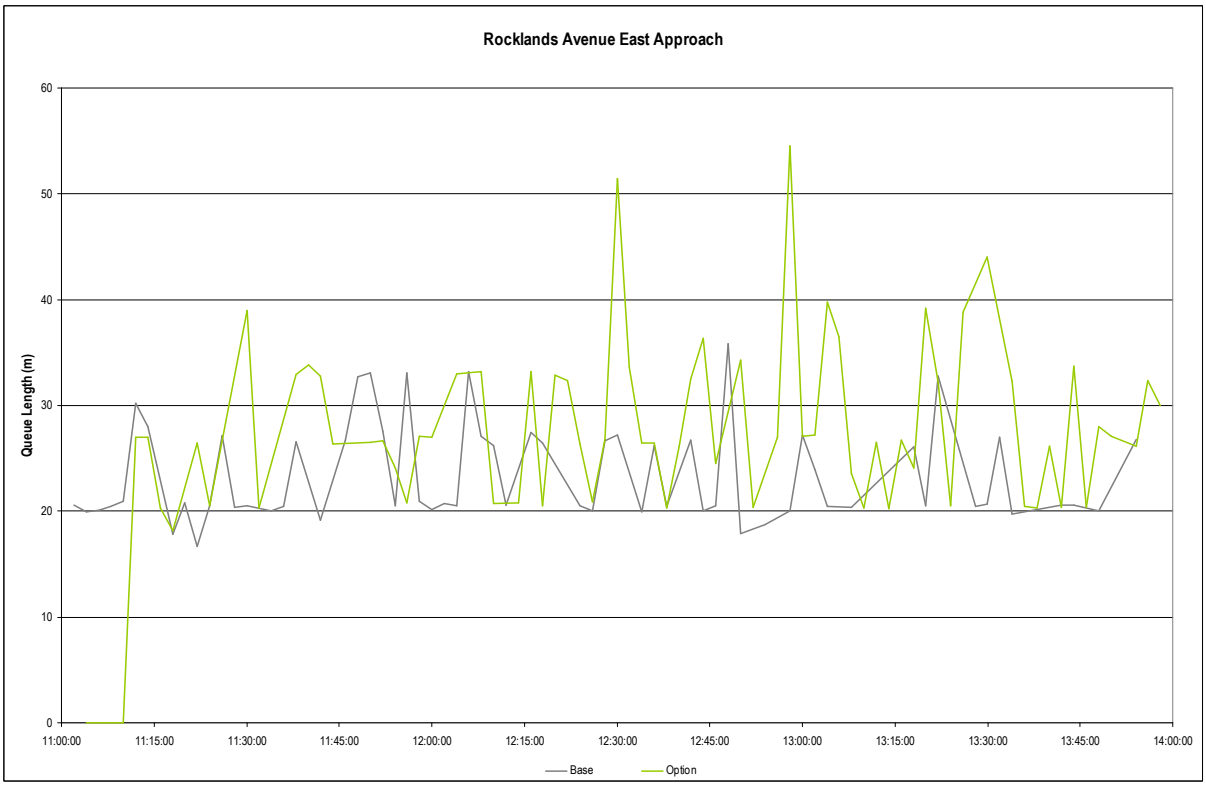

Figure 37 – Queue graph of Rocklands Avenue approach to Dominion Road/ Rocklands Avenue in the Evening period of Option 1

Appendix G
Option 2 Evening Queue Graphs

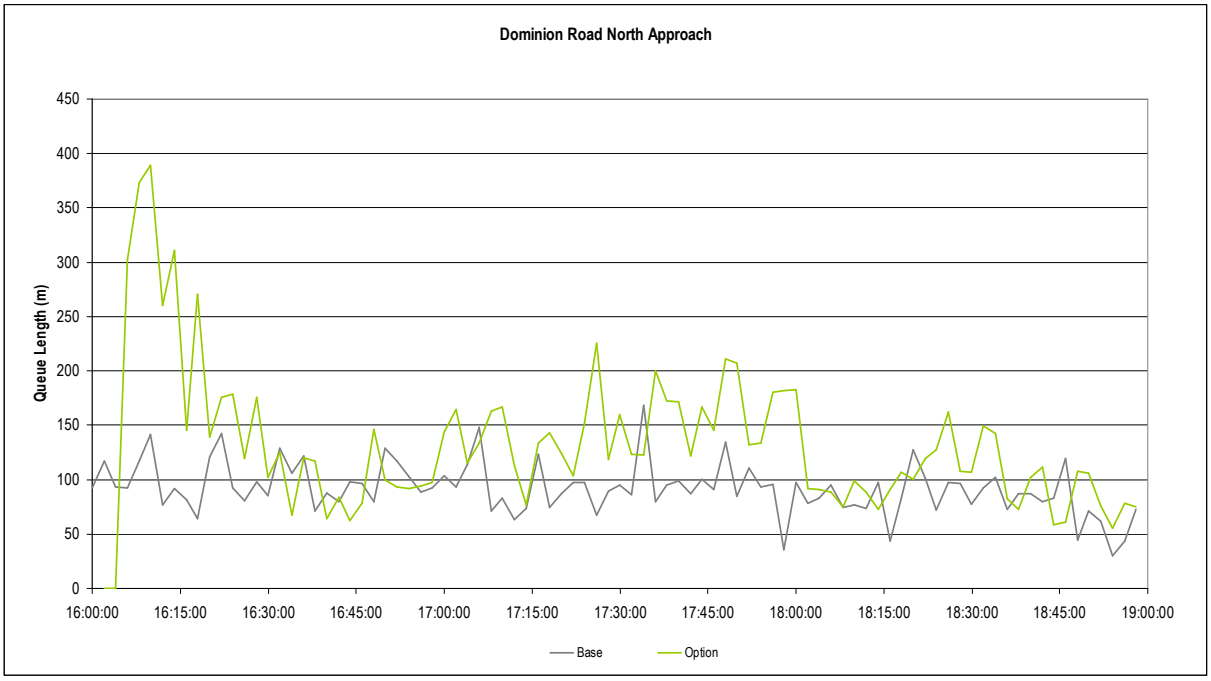

Figure 38 – Queue graph of Dominion Road North approach to Dominion Road/ Balmoral Road in the Evening period of Option 2

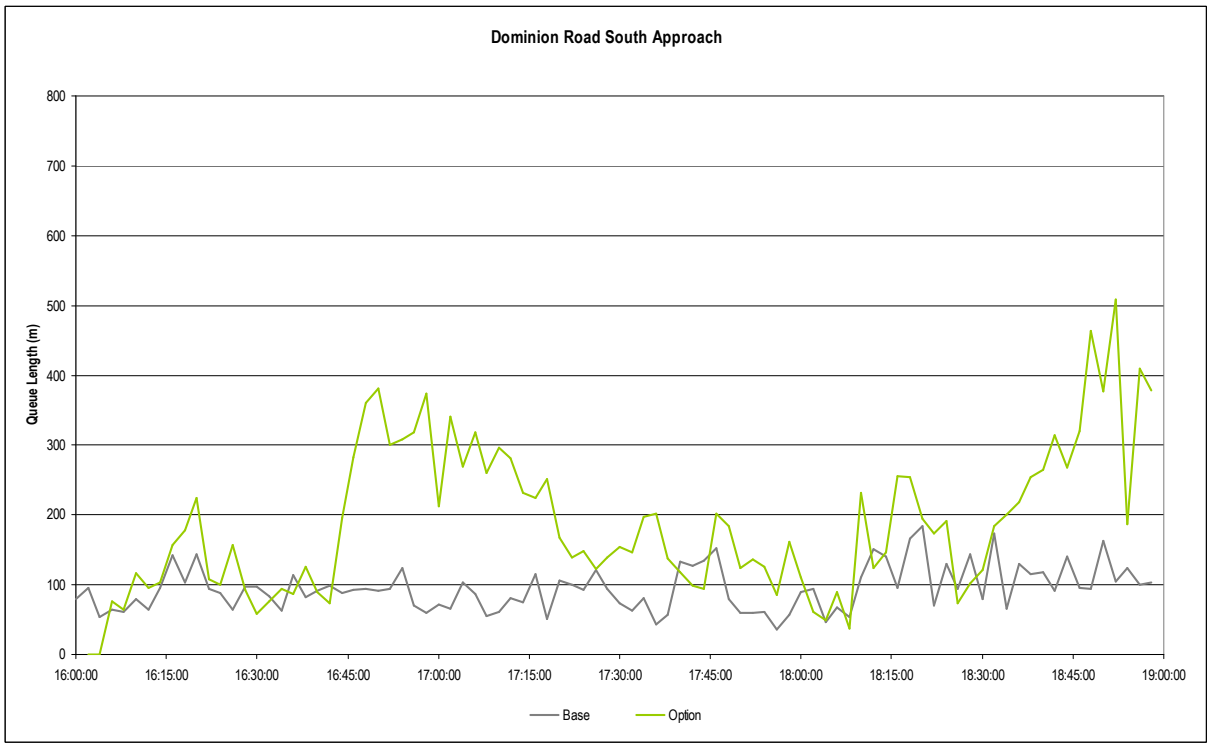

Figure 39 – Queue graph of Dominion Road South approach to Dominion Road/ Balmoral Road in the Evening period of Option 2

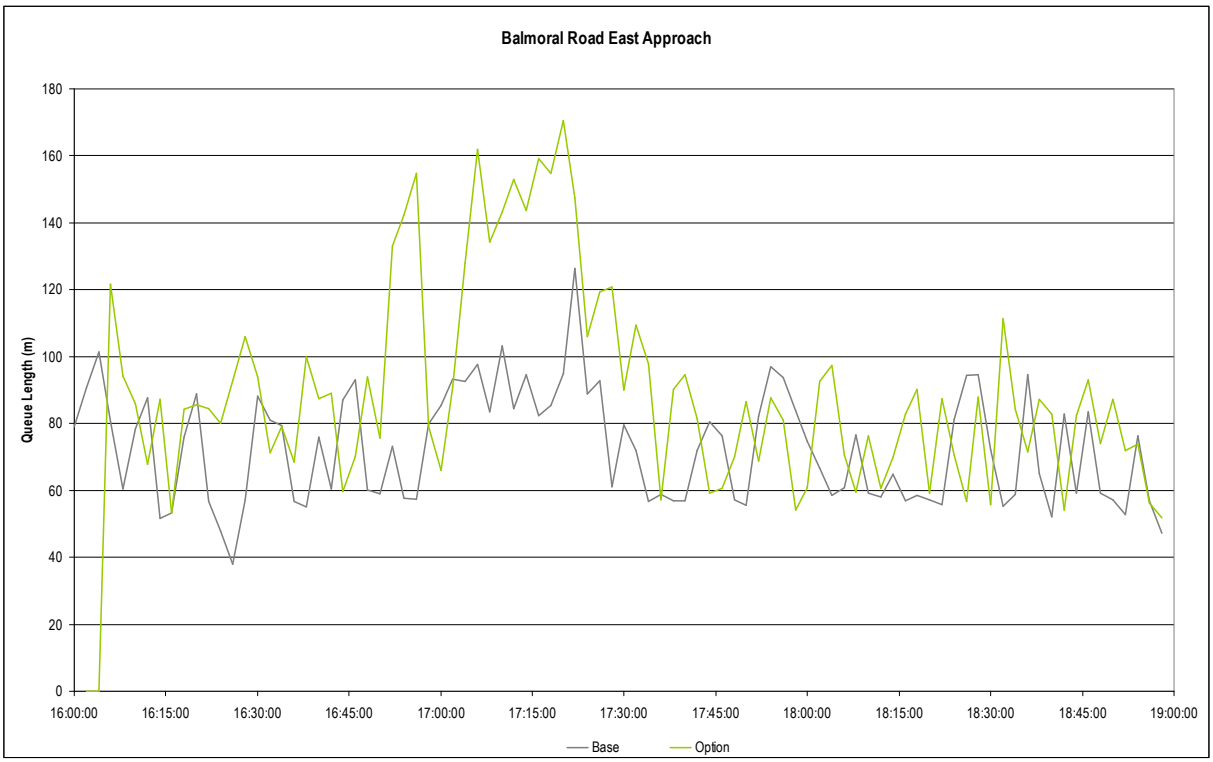

Figure 40 – Queue graph of Dominion Road East approach to Dominion Road/ Balmoral Road in the Evening period of Option 2

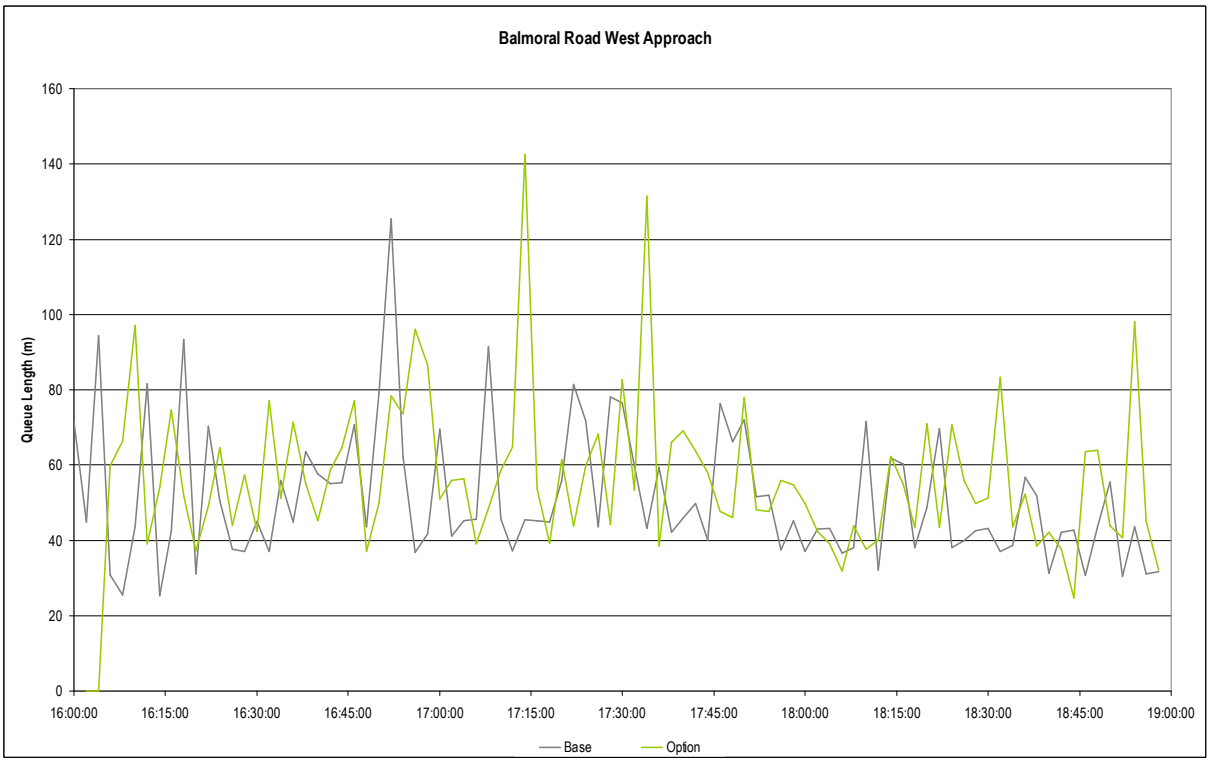

Figure 41 – Queue graph of Dominion Road West approach to Dominion Road/ Balmoral Road in the Evening period of Option 2

Figure 42 – Queue graph of Matipo Street approach to Balmoral Road/ Matipo Street in the Evening period of Option 2

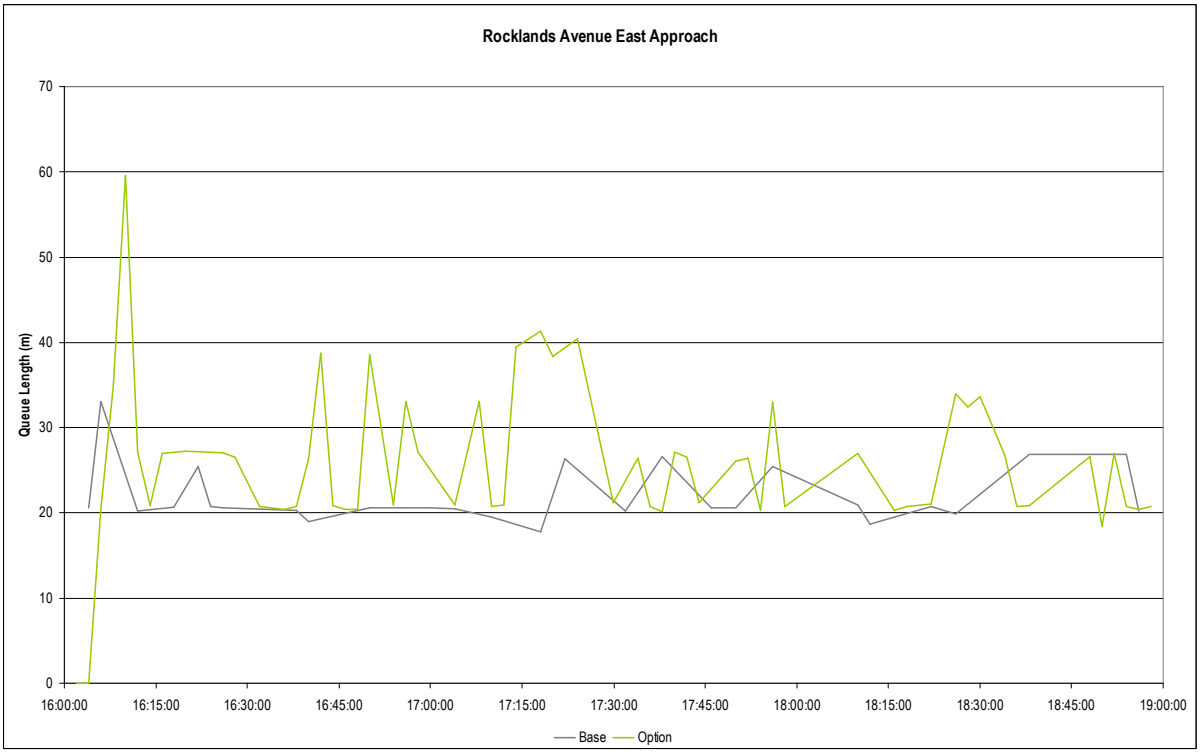

Figure 43 – Queue graph of Rocklands Avenue approach to Dominion Road/ Rocklands Avenue in the Evening period of Option 2

Appendix H
Option 2 Saturday Queue Graphs

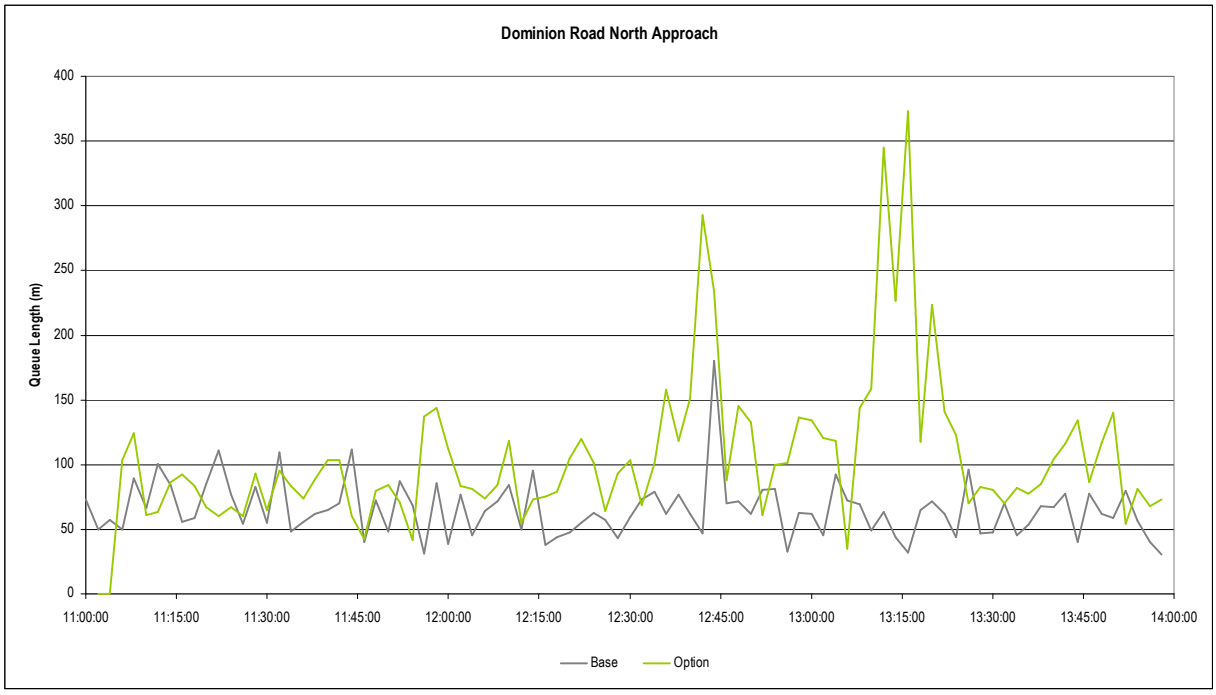

Figure 44 – Queue graph of Dominion Road North approach to Dominion Road/ Balmoral Road in the Saturday period of Option 2

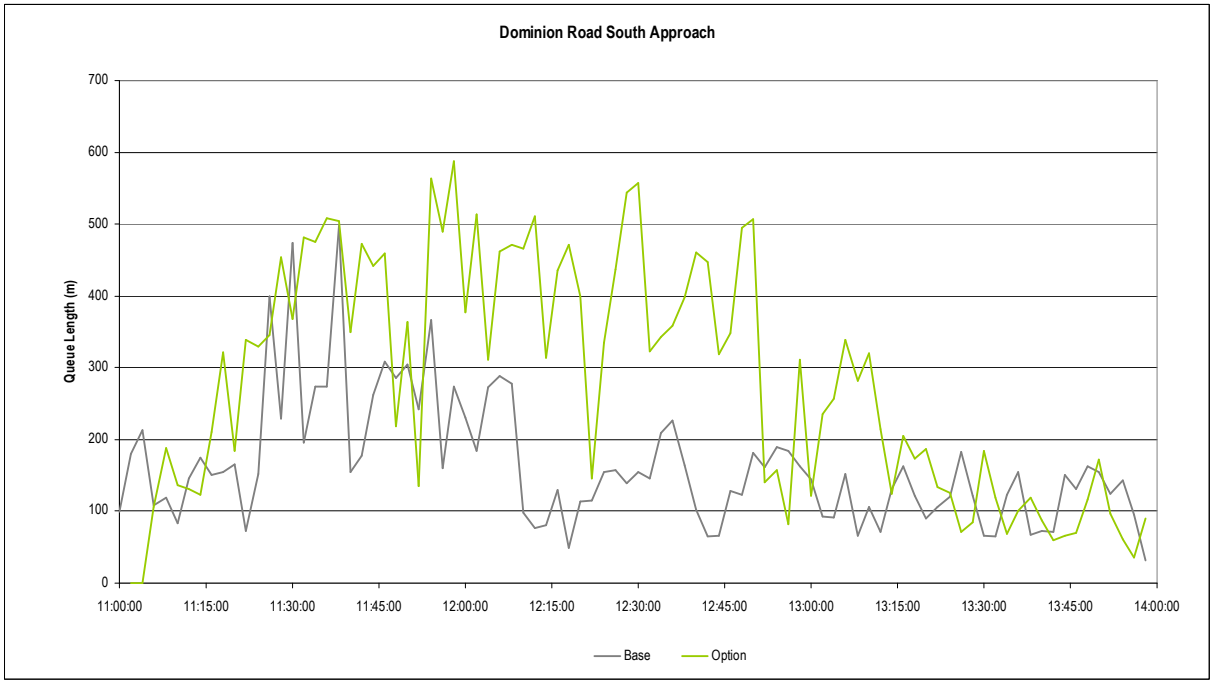

Figure 45 – Queue graph of Dominion Road South approach to Dominion Road/ Balmoral Road in the Saturday period of Option 2

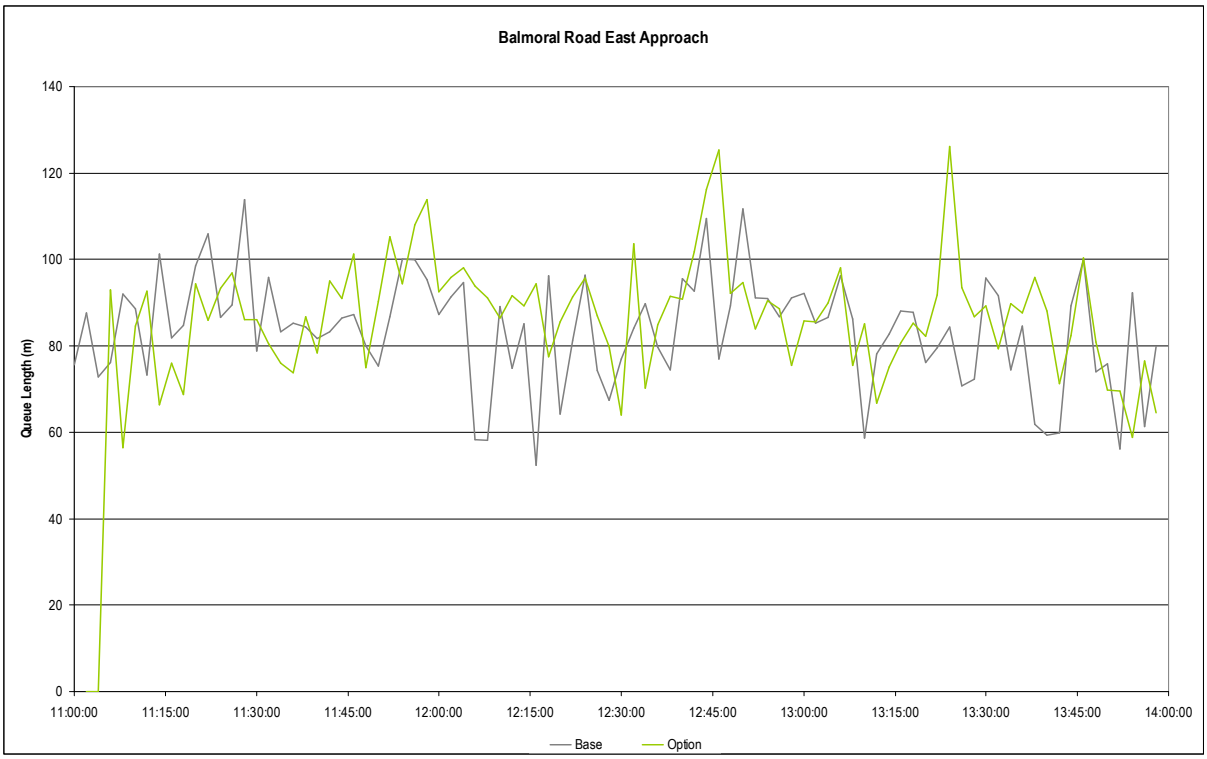

Figure 46 – Queue graph of Dominion Road East approach to Dominion Road/ Balmoral Road in the Saturday period of Option 2

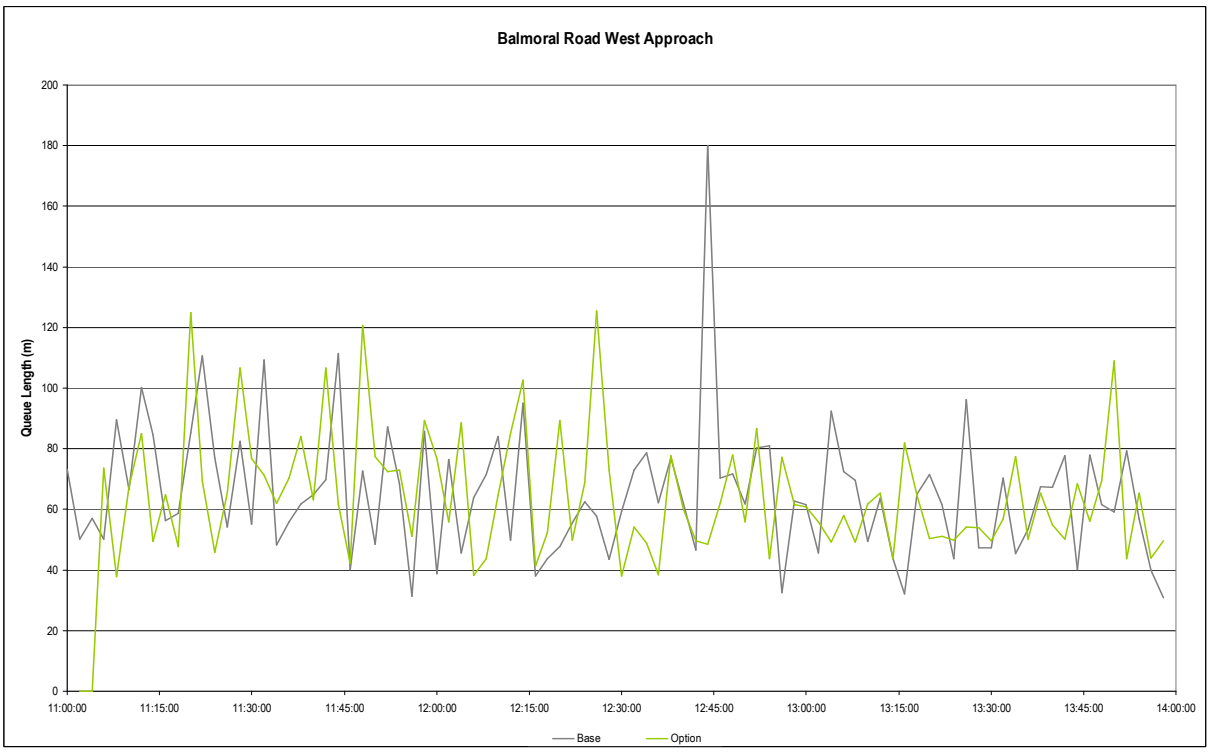

Figure 47 – Queue graph of Dominion Road West approach to Dominion Road/ Balmoral Road in the Evening period of Option 2

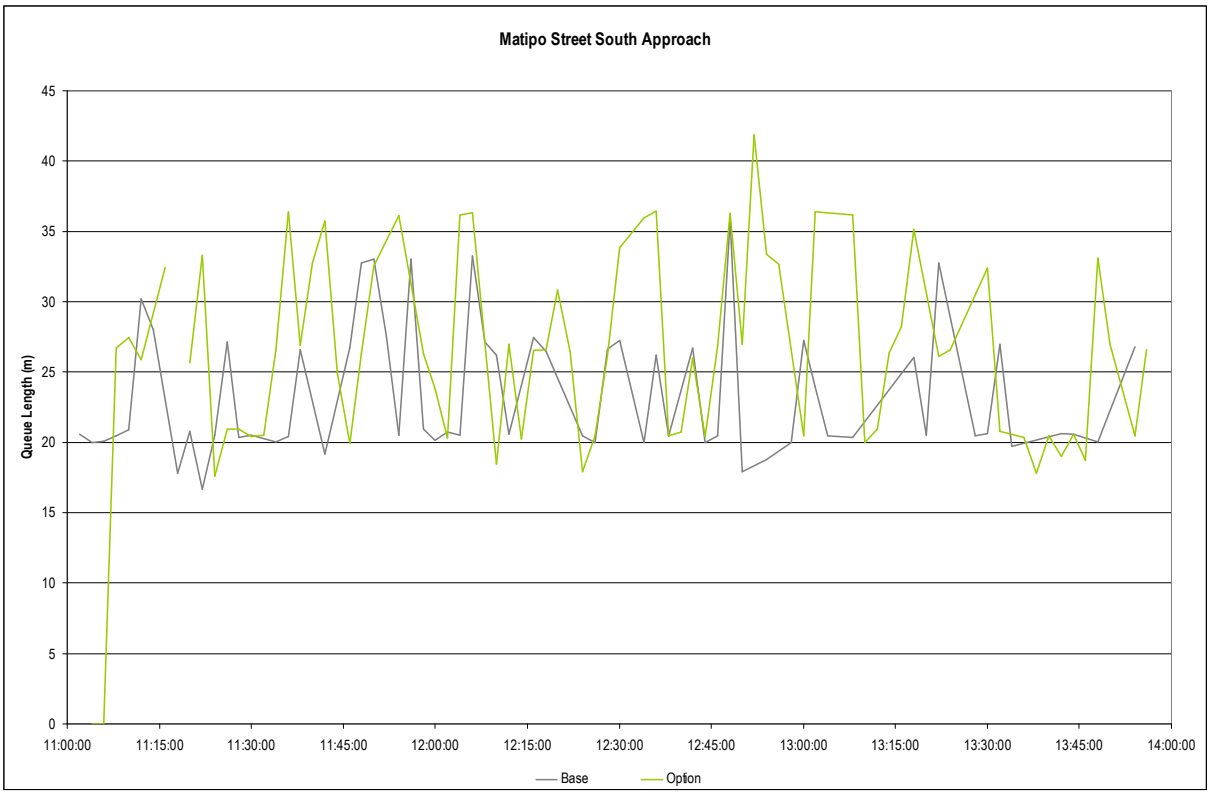

Figure 48 – Queue graph of Matipo Street approach to Balmoral Road/ Matipo Street in the Evening period of Option 2

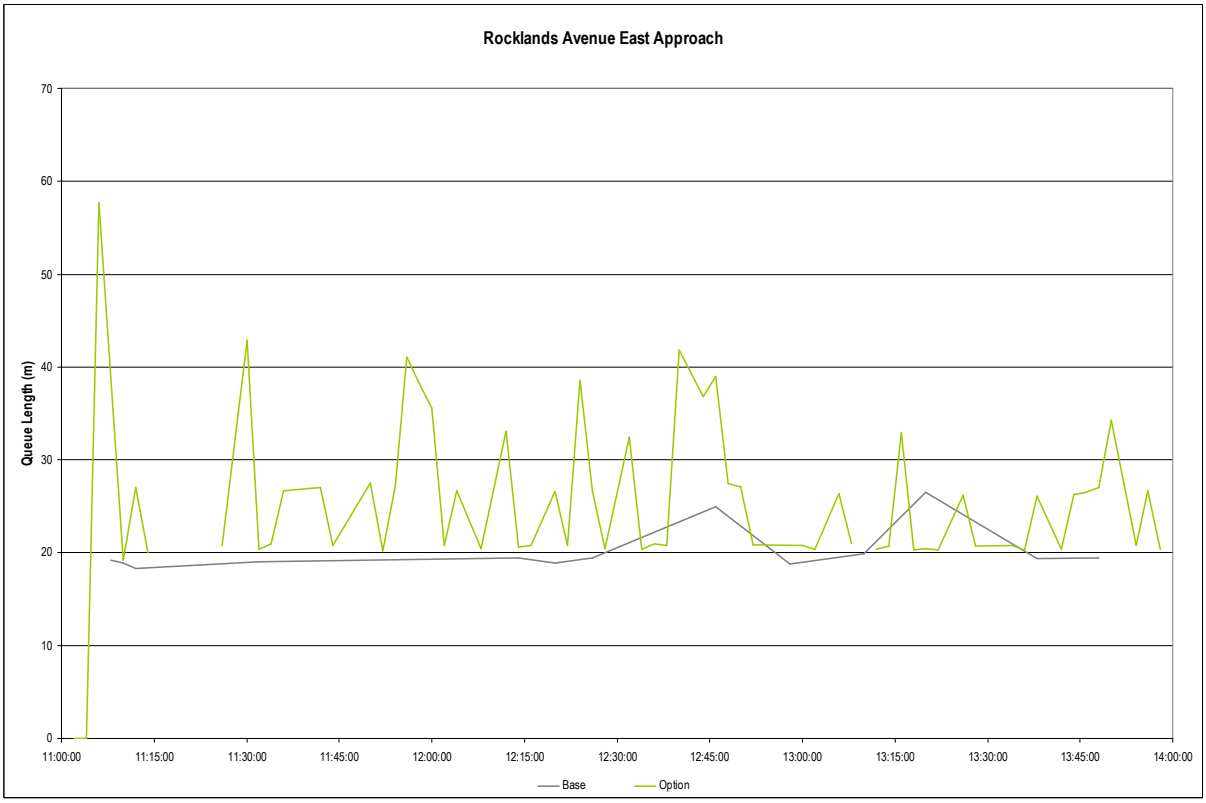

Figure 49 – Queue graph of Rocklands Avenue approach to Dominion Road/ Rocklands Avenue in the Evening period of Option 2

Appendix I
Base Model Evening LOS diagrams

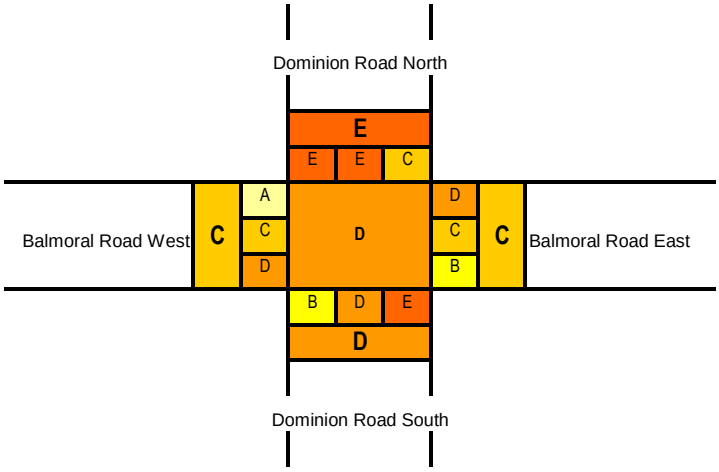

Figure 50 – LOS diagram of Dominion Road/ Balmoral Road in the Evening peak hour of the base model

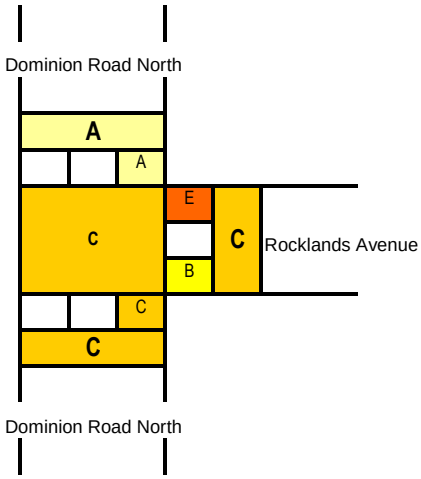

Figure 51 – LOS diagram of Dominion Road/ Rocklands Avenue in the Evening peak hour of the base model

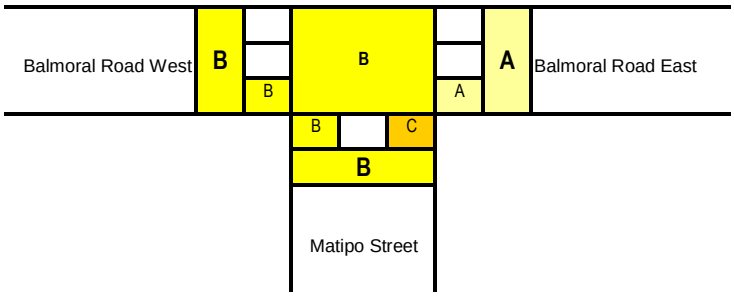

Figure 52 – LOS diagram of Balmoral Road/ Matipo Street in the Evening peak hour of the base model

Appendix J
Base Model Saturday LOS diagrams

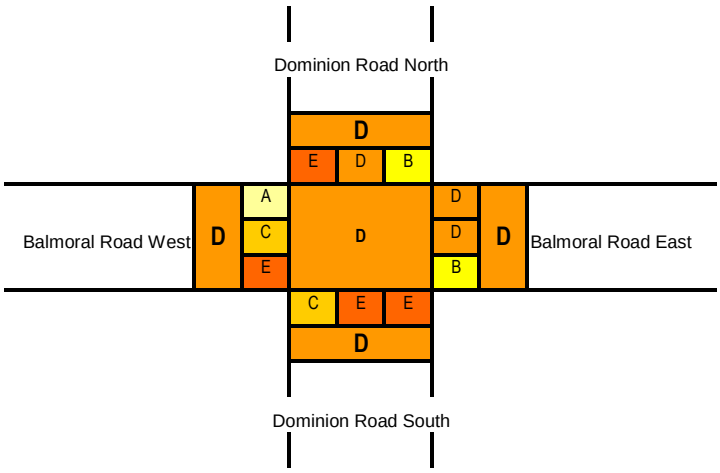

Figure 53 – LOS diagram of Dominion Road/ Balmoral Road in the Saturday peak hour of the base model

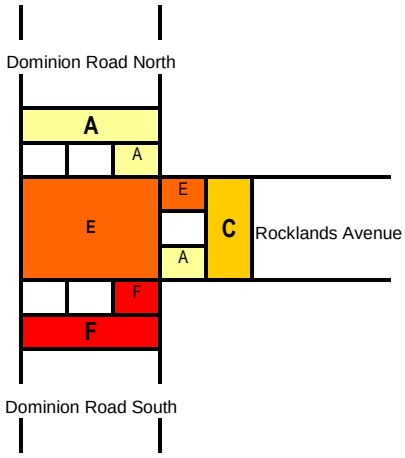

Figure 54 – LOS diagram of Dominion Road/ Balmoral Road in the Saturday peak hour of the base model

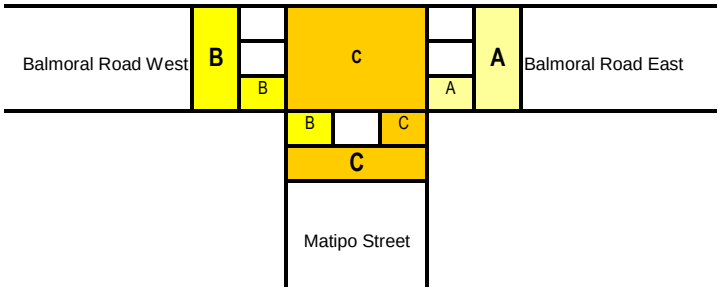

Figure 55 – LOS diagram of Balmoral Road/ Matipo Street in the Saturday peak hour of the base model

Appendix K
Option 1 Evening LOS diagrams

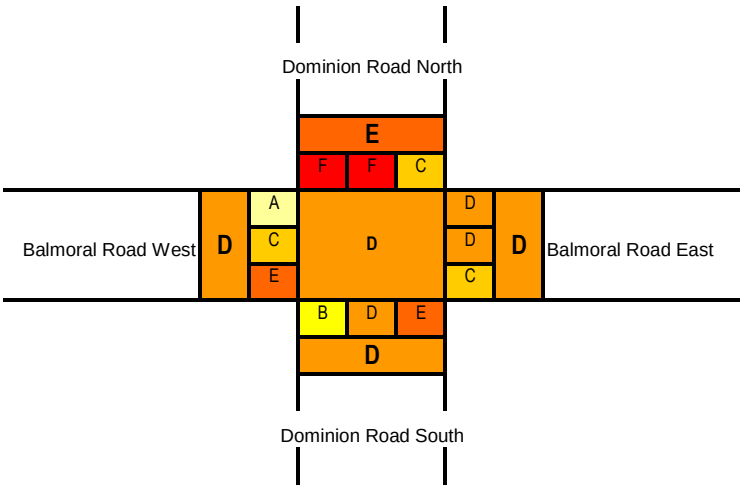

Figure 56 – LOS diagram of Dominion Road/ Balmoral Road in the Evening peak hour of Option 1

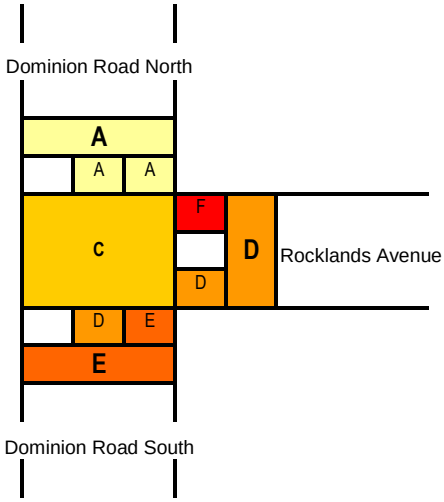

Figure 57 – LOS diagram of Dominion Road/ Rocklands Avenue in the Evening peak hour of Option 1

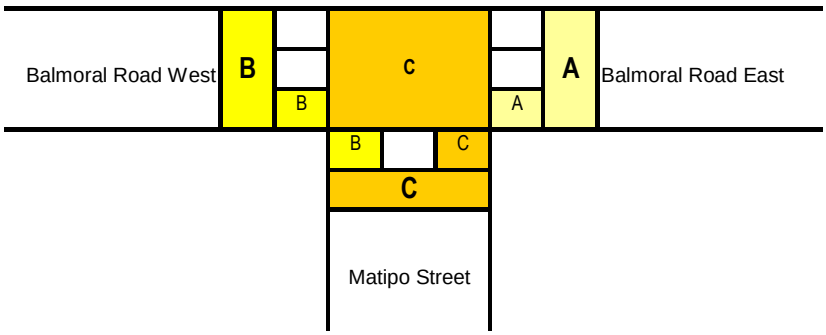

Figure 58 – LOS diagram of Balmoral Road/ Matipo Street in the Evening peak hour of Option 1

Appendix L
Option 1 Saturday LOS diagrams

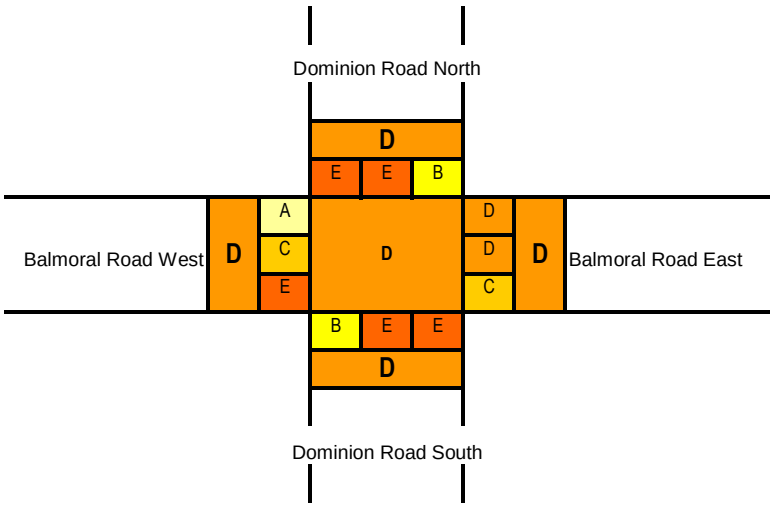

Figure 59 – LOS diagram of Dominion Road/ Balmoral Road in the Saturday peak hour of Option 1

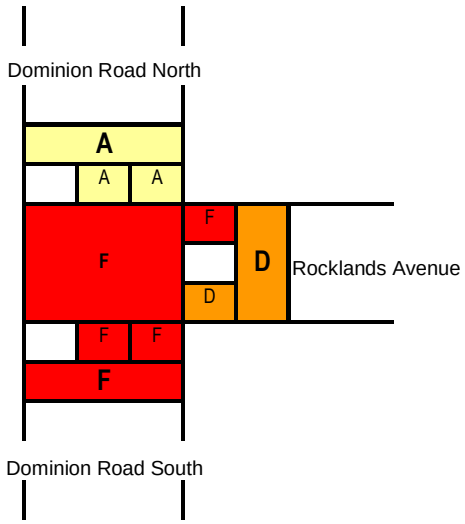

Figure 60 – LOS diagram of Dominion Road/ Rocklands Avenue in the Saturday peak hour of Option 1

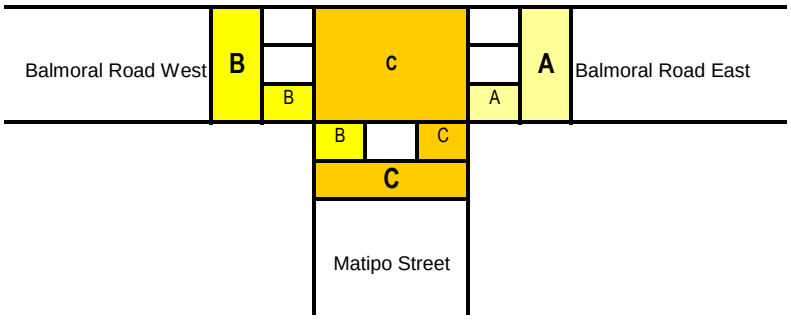

Figure 61 – LOS diagram of Balmoral Road/ Matipo Street in the Saturday peak hour of Option 1

Appendix M
Option 2 Evening LOS diagrams

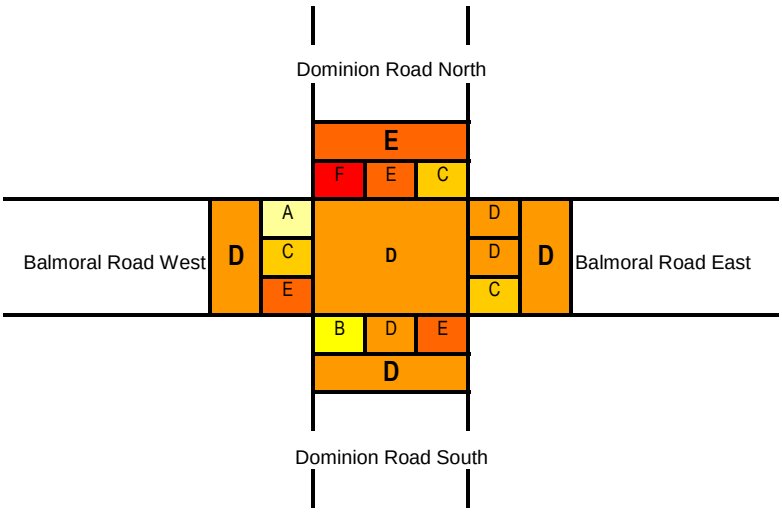

Figure 62 – LOS diagram of Dominion Road/ Balmoral Road in the Evening peak hour of Option 2

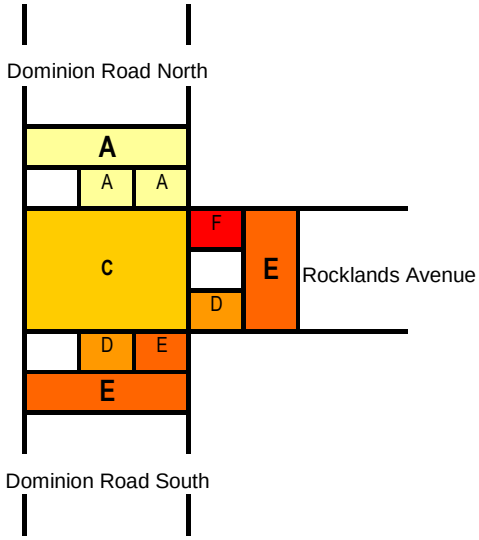

Figure 63 – LOS diagram of Dominion Road/ Rocklands Avenue in the Evening peak hour of Option 2

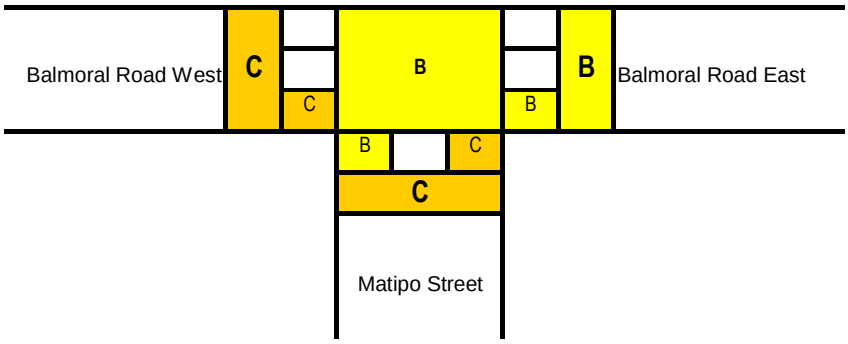

Figure 64 – LOS diagram of Balmoral Road/ Matipo Street in the Evening peak hour of Option 2

Appendix N
Option 2 Evening LOS diagrams

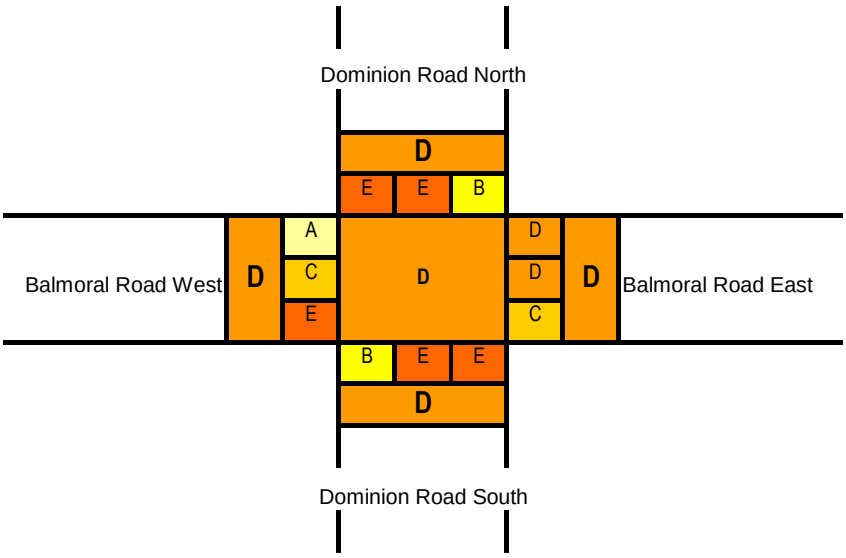

Figure 65 – LOS diagram of Dominion Road/ Balmoral Road in the Saturday peak hour of Option 2

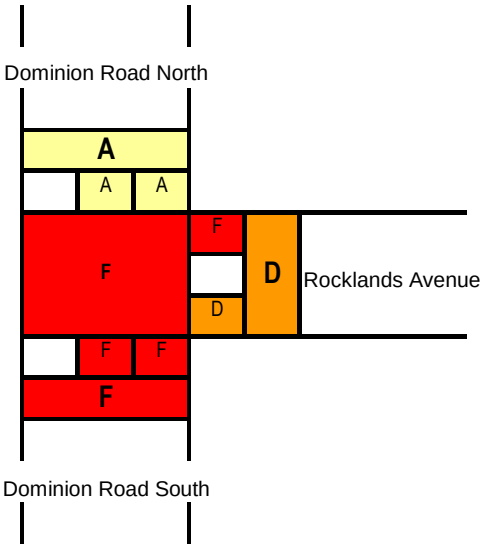

Figure 66 – LOS diagram of Dominion Road/ Rocklands Avenue in the Saturday peak hour of Option 2

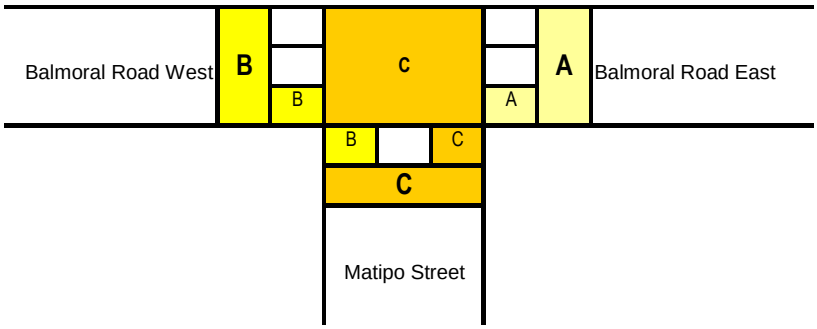

Figure 67 – LOS diagram of Balmoral Road/ Matipo Street in the Saturday peak hour of Option 2