ABERDEEN
CITY COUNCIL

LEZ OPTION TESTING REPORT

SYSTRA

ABERDEEN LEZ MODEL TESTING

LEZ OPTION TESTING REPORT

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1. INTRODUCTION

1.1 Study Brief

1.1.1 SYSTRA Ltd (SYSTRA) was commissioned by Aberdeen City Council in August 2019 for professional services to develop a microsimulation model of Aberdeen City Centre to assess road network options associated with the development of a Low Emission Zone (LEZ) in Aberdeen.

1.1.2 This technical note outlines the development and model testing of LEZ model scenarios, as defined by ACC and in conjunction with the Aberdeen *National Low Emission Framework – Interim Stage 2 Assessment Report* (SYSTRA, Ref: GB01T19I15/281119, 01/06/20).

1.2 Background

1.2.1 The initial Base Model development is detailed in the report '*Aberdeen City Centre Paramics Model Upgrade 2019*' (SYSTRA Ref: GB01T19F42/2, 13/10/2020) and the development of the 2024 Reference Case Model, from which the LEZ scenarios have been assessed, is detailed in the report '*Aberdeen City Centre: Future Year (2024) Model Development Report* (SYSTRA, Ref: GB01T20D62/1, 18/12/20).

1.2.2 For the purposes of this report, the 2024 future year Aberdeen City Centre traffic model, which all testing will be undertaken, will be deemed the '*ACCPM24'*.

1.3 Purpose of Report

1.3.1 This report provides the traffic model testing of LEZ options for Aberdeen and considers these scenarios in combination with other committed proposals for Aberdeen to provide a package of measures which will meet the objectives of the LEZ and wider Council objectives for Aberdeen City Centre.

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2. MODEL DEVELOPMENT OF LEZ SCENARIOS

2.1 2024 Reference Case Model (ACCPM24)

2.1.1 The development and operational assessment of the LEZ options was to be undertaken using the ACCPM24. This future reference case model scenario includes all committed infrastructure and development content due to be completed by 2024.

2.1.2 ASAM14 was utilised to provide the strategic impact of the future committed developments and infrastructure proposals on the ACCPM24 network. This includes planning data from the TELMoS14 model and City and Shire Councils (reflecting the 2018 Strategic Development Plan).

2.1.3 A resultant uplift of **6 to 8%** over the 2019 traffic levels is included within the ACCPM24. This results in an approximate 20% increase in the number of queuing vehicles on average.

2.1.4 The prediction of a 6-8% traffic growth over 5 years is considered a 'high growth' in the context of Aberdeen City Centre. Historical future year growth predictions for Aberdeen included a 9% growth between 2012 and 2017, then reducing by 4% by 2023 due to the opening of the AWPR. In reality, the impact of the opening of the AWPR and the downturn in the oil industry between 2014-2018 resulted in an overall traffic network shrinkage compared to 2012.

2.1.5 High traffic growth predictions are developed from the aspirational development growth detailed in the local and regional development plans. They are effectively a worst case scenario in terms of the volume of traffic in the network.

2.1.6 The ACCPM24 therefore includes high traffic growth and fleet compliance improvements that were derived before the COVID-19 Pandemic. This is still a plausible future, but not the only one. Further consideration of plausible futures and uncertainty, in light of the COVID-19 pandemic is detailed in Chapter 9 of this report.

> The ACCPM24 model includes between 6 and 8% traffic growth from the 2019 Base Model traffic levels.

2.2 Initial LEZ Options from NLEF Appraisal

2.2.1 The Interim NLEF Stage 2 Appraisal recommended that four LEZ boundary options be assessed through the traffic modelling. Within each of these options, a variant was also to be considered relating to Denburn Road and whether this corridor is included within the LEZ boundary or essentially runs outside the LEZ area.

2.2.2 The LEZ options are detailed as follows:

- Option 1A – Union St Area, including Denburn Rd
- Option 1B – Union St Area, excluding Denburn Rd
- Option 2A – Union St & George St Area, including Denburn Rd
- Option 2B – Union St & George St Area, excluding Denburn Rd
- Option 3A – CCMP East, including Denburn Rd

- Option 3B – CCMP East, excluding Denburn Rd
- Option 4A – CCMP, including Denburn Rd
- Option 4B – CCMP, excluding Denburn Rd.

2.2.3 **Appendix A** shows the boundary associated with each of these eight LEZ options.

2.3 Strategic Assessment of LEZ Impact on City Centre

2.3.1 Prior to the detailed assessment of the eight LEZ boundary options in the ACCPM24, additional input was required from the higher tier strategic Aberdeen Sub Area Model (ASAM). The current ASAM14 (2014 Base) 2024 Reference Case Models have been used to identify any strategic impact of the LEZ proposals. This impact is then fed into the ACCPM24, to allow an operational assessment of the scheme options.

2.3.2 Whist there are differences in the LEZ boundaries of the eight options, it is noted that the key strategic differences between the options is the inclusion of Denburn Rd within 4 options, and the inclusion of the West North St corridor within 4 options. From this, 3 scenarios were considered for assessment within ASAM as follows:

- Boundary A - Neither Denburn Rd or West North St with LEZ restriction (As per LEZ area 1B)
- Boundary B – West North St within LEZ restriction (As per LEZ area 3A)
- Boundary C – Denburn Rd & West North St within LEZ restriction (As per LEZ area 3B).

2.3.3 Within the three ASAM scenarios, it was assumed that all traffic originating or destinating within the LEZ would be compliant. The key output requirement from the ASAM scenario testing was to assess whether traffic would re-route away from the LEZ at a more strategic level, i.e. at route choice locations out-with the extents of the ACCPM24.

2.3.4 **Appendix B** provides a visual representation of the traffic flow differences between the ASAM LEZ Test Boundary A, B and C compared against the 2024 Reference Case.

2.3.5 The figures in **Appendix B** show that:

- for Boundary A there is little difference in strategic routing to the Reference Case
- For Boundary B there is an increase in traffic routing through Denburn Road and through Skene Square. There is also some rerouting out to Anderson Drive
- For Boundary C there is an increase in traffic routing along Anderson Drive but also through the area around the west end of Union Street and Ferryhill.

2.3.6 The trip matrices for the three ASAM LEZ scenarios were cordoned to the ACCPM24 model extent. The cordoned trip matrix totals for the three scenarios were almost identical to the 2024 Reference Case, suggesting that all the traffic diversion from the LEZ scheme was captured within the ACCPM24 cordon area.

2.3.7 The demand difference between each of the LEZ test scenarios and the Reference Case were applied to each of the ACCMP24 as follows:

Table 1. Correlation between ASAM LEZ scenarios and ACCPM24 LEZ scenarios

LEZ Test	Denburn Rd Restriction	West North St Restriction	ASAM Scenario
1A	Yes	No	Boundary A
1B	No	No	Boundary A
2A	Yes	No	Boundary A
2B	No	No	Boundary A
3A	Yes	Yes	Boundary C
3B	No	Yes	Boundary B
4A	Yes	Yes	Boundary C
4B	No	Yes	Boundary B

2.4 LEZ Assumptions For Microsimulation Modelling

2.4.1 Following discussions with ACC, Transport Scotland, and modelling teams from the other Scottish LEZ cities, a series of assumptions were made to allow modelling of the impact of an LEZ on the traffic network. Table 2 and Table 3 summarise the key considerations and the assumptions applied to each of the four cities, with a rationale provided for the Aberdeen LEZ modelling.

Table 2. LEZ Modelling Assumptions (Part 1)

Element	Detail		City				Comments relating to Aberdeen
			Edinburgh	Dundee	Glasgow	(Proposed)	
Fleet Composition - Observed	(Compliant / non compliant)		Derived by SEPA / ANPR Data	Derived by SEPA / ANPR Data	Derived by SEPA / ANPR Data	Derived by SEPA / ANPR Data	Detailed in Section 2.5
Fleet Composition - Opening Year	Consideration of fleet composition change by opening year		Yes	No	Yes	Yes	Detailed in Section 2.5
Mode Shift Assumption	Consideration of mode shift from vehicles to bus or cycle or taxi as a direct result of the LEZ implementation		None	None	None	None	Mode shift as a direct result of the implementation of a LEZ is difficult to quantify. The three other cities have assumed that no mode shift occurs so that a worst case scenario can be modelled, in terms of impact of traffic re-routing away from the LEZ and if there is potential for a new AQ exceedance to occur elsewhere.
LEZ adherence level	Percentage of non-compliant vehicles that adhere to the LEZ restriction		100%	100%	100%	100%	Assume that all non-compliant vehicles do not cross LEZ boundary. Again, this allows the modelling of a worst case scenario
Traffic Routing Through LEZ	Consideration of what vehicle types will require to divert away fropm the LEZ area	Buses	All compliant	All compliant	All compliant	All compliant	All buses to be compliant by full LEZ opening date (whether through TRC or not)
		HGVs	All non- compliant vehicles re-route	no through traffic	All non- compliant vehicles re-route	All non- compliant vehicles re-route	All non-compliant HGV's will re-route away from LEZ. Dundee LEZ has no through routing so this doesn't apply
		LGVs	All non- compliant vehicles re-route	no through traffic	All non- compliant vehicles re-route	All non- compliant vehicles re-route	All non-compliant LGV's will re-route away from LEZ. Dundee LEZ has no through routing so this doesn't apply
		Taxis	All non- compliant vehicles re-route	no through traffic	All non- compliant vehicles re-route	All non- compliant vehicles re-route	All non-compliant Taxi's will re-route away from LEZ. Dundee LEZ has no through routing so this doesn't apply. In Aberdeen Model, taxi's are modelled as a vehicle proportion of all cars, so not possible to separate them out anyway

Table 3. LEZ Modelling Assumptions (Part 2)

Element	Detail		Edinburgh	Dundee	Glasgow	Aberdeen (Proposed)	Comments relating to Aberdeen
Traffic Originating / Destinating within LEZ	Consideration that vehicles currently originating / destinating within the LEZ will divert to out with the LEZ	Cars	None	Yes - Car Park revised destination	None	Yes - Car Park revised destination	Glasgow & Edinburgh has taken the simplest approach for modelling. Dundee LEZ has no through routing traffic to consider, therefore gave more consideration to internal parking. Some non compliant traffic was assumed to move from CP within the LEZ to those just outside the LEZ. For the Aberdeen modelling, car park re-allocation was undertaken -Detailed in Section 2.6
		Buses	All compliant	All compliant	All compliant	All compliant	All buses to be compliant by full LEZ opening date (whether through TRC or not)
		HGV's	All compliant	All compliant	All compliant	All compliant	The assumption across all cities is that all HGV's destinating or originating within the LEZ area will have prior knowledge of the LEZ and either update the fleet accordingly or only utilise fleet vehicles that are compliant for this trip
		LGV's	All compliant	All compliant	All compliant	All compliant	The assumption across all cities is that all LGV's destinating or originating within the LEZ area will have prior knowledge of the LEZ and either update the fleet accordingly or only utilise fleet vehicles that are compliant for this trip. This is potentially an overestimation of fleet change for small business vans etc. However, if a business cannot access the LEZ due to their vehicle not being compliant, the likelihood is that another business would undertake this trip with a compliant vehicle.
		Taxi's	All compliant	All compliant	All compliant	All compliant	The assumption across all cities is that all taxis destinating or originating within the LEZ area will have prior knowledge of the LEZ and either update their vehicle accordingly or will be replaced by a taxi driver whose vehicle is compliant. Funding is available for taxi drivers to upgrade their vehicle
LEZ Model Options	No. of LEZ options brought forward for model testing		1	3	2	8	From NLEF process, there are 4 LEZ boundary options with a variation to Denburn Road in each option
Total Model Test Options			3 (2 variations in infrastructure)	3 - No infrastructure variation measures proposed	4 (includes 2 fleet projections: 2020 and 2023)	Multiple, including various CCMP measures considered	The inclusion of assessing the CCMP infrastructure phases together with the LEZ options creates a matrix of model test scenarios to consider. This is detailed in Chapter 4

2.5 Fleet Compliance

2.5.1 The future forecast of fleet composition was derived by SEPA using the 'Emission Factor Toolkit, Version 8' (EFT) for national fleet. This methodology for deriving the proportion of compliant and non-compliant vehicles (to a LEZ) was utilised by all four city studies. However, there is general consensus that this methodology may result an overestimation of the potential fleet compliance level by 2024.

2.5.2 To address this, for the Aberdeen LEZ modelling, the change in vehicle compliance predicted from the EFT was applied to actual local fleet compliance levels observed in 2019 through ANPR traffic surveys.

2.5.3 Table 4 shows the EFT fleet compliance changes between 2019 and 2024 and the application of this to the Aberdeen observed fleet.

Table 4. Aberdeen Fleet Compliance Prediction to 2024

Source	Emissions	Year	Car (%)	LGV (%)	HGV (%)
EFT National Data	Non Compliant	2019	24.6	43.68	24.6
EFT National Data	Compliant	2019	75.41	56.32	75.4
EFT National Data	Non Compliant	2024	8.14	14.09	4.9
EFT National Data	Compliant	2024	91.86	85.91	95.1
EFT National Data	Non Compliant % Change 2019-2024	-	-16.45	-29.59	-19.70
EFT National Data	Compliant Change % 2019-2024	-	16.45	29.59	19.70
ANPR 2019	Non Compliant	2019	30.3	59.8	27
	Compliant	2019	69.7	40.2	73
Projected 2024	**Non Compliant**	**2024**	**13.85**	**30.21**	**7.30**
	Compliant	**2024**	**86.15**	**69.79**	**92.70**

2.5.4 Table 4 shows that the EFT predicts a 16% increase in car compliance (to the LEZ adherence levels) by 2024. For Aberdeen, this equates to a compliance level of 86% from a 2019 level of 70%.

> Vehicle compliance levels applied in the ACCPM24 include a 16% increase in Car compliance, 30% increase in LGV compliance, and 20% increase in HGV compliance between 2019 and 2024.

2.5.5 It should be noted that the above fleet prediction changes to 2024 is only one plausible outcome following the COVID-19 pandemic. Further consideration of plausible futures and uncertainty, in light of the COVID-19 pandemic is detailed in Chapter 9 of this report.

2.6 City Centre Car Parking within LEZ

2.6.1 The traffic modelling has also considered the impact to car parking for non-compliant vehicles under each LEZ boundary option.

2.6.2 Some city centre car parks will be within the proposed LEZ area. This will result in a likely relocation of non-compliant cars to car parks out-with the LEZ area. The scale of traffic relocation will be different for each LEZ boundary.

2.6.3 For example, LEZ Option 1B will include 3 City Centre Car Parks, namely Chapel Street, IQ (Hardgate), and Ship Row, as per Figure 1 (Note: Trinity Centre CP is still accessible for non-compliant vehicles when Denburn Rd in not in the LEZ).

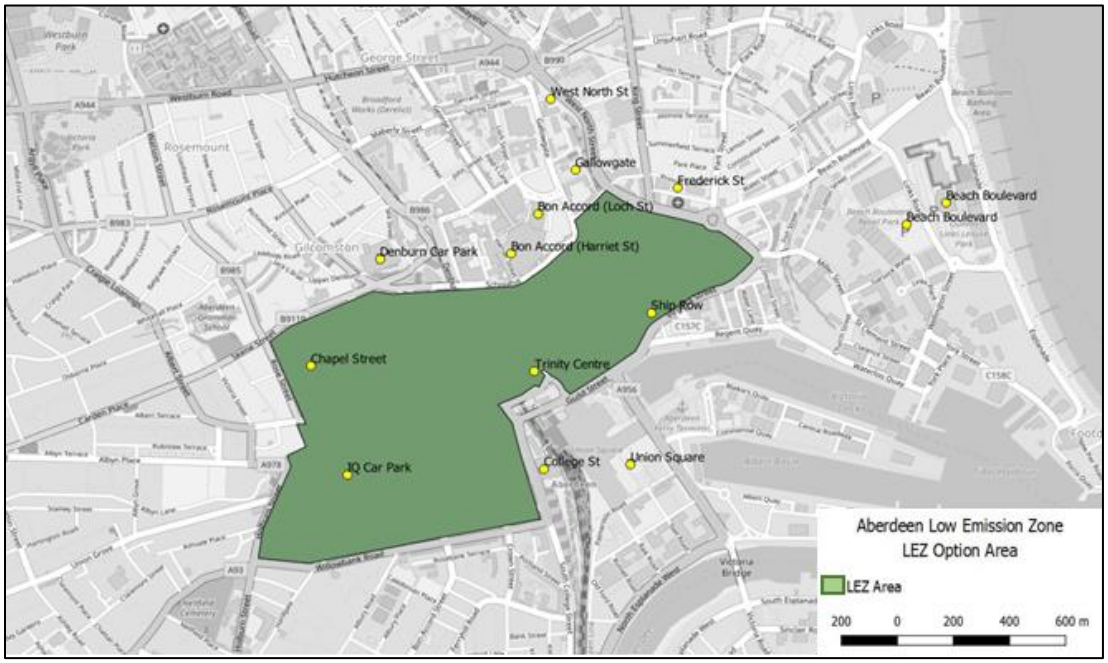

Figure 1. LEZ Option 1B / City Centre Car Parks

2.6.4 As the scale of the LEZ boundary increases, the number of city centre car parks available for non-compliant vehicles reduces. Figure 2 shows the network coverage of LEZ Option 4A. In this case, only the Denburn Car Park is available for non-compliant vehicles.

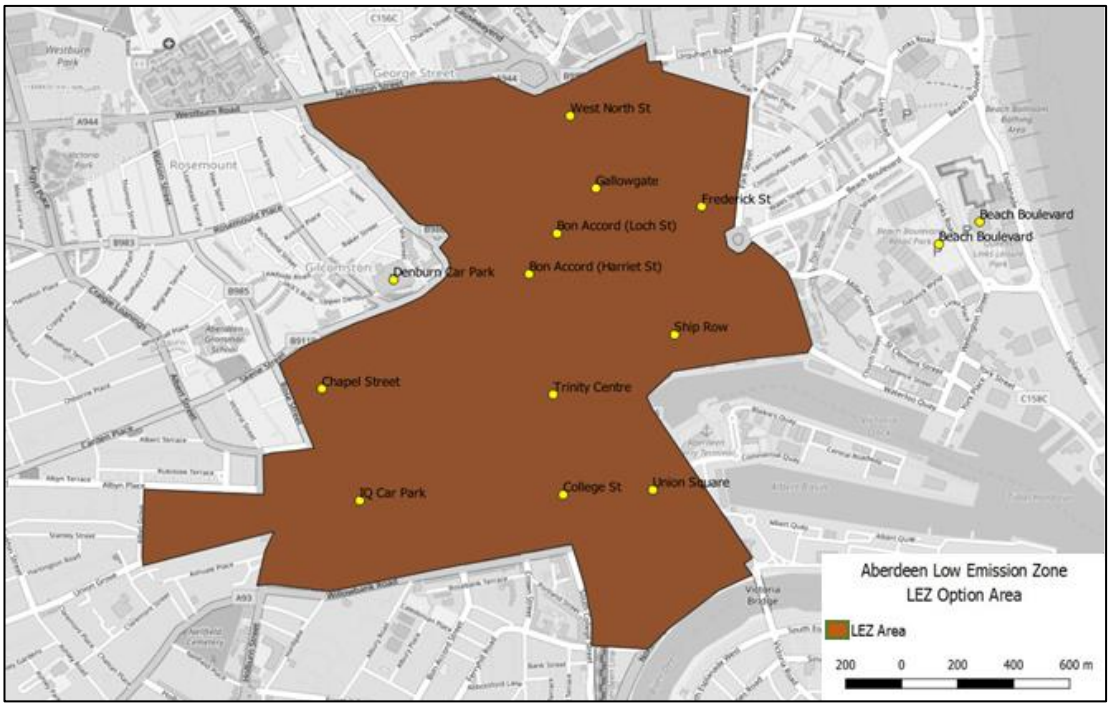

Figure 2. LEZ Option 4A / City Centre Car Parks

2.6.5 As observed in Figure 1 and Figure 2, the Beach Boulevard Retail Car Parks are highlighted. On advice from ACC, these private car parks were to be included within the relocation of non-compliant traffic, as a likely outcome of parking restrictions within the city centre may be that non-compliant vehicles park in these available free parking areas on the outskirts of the city centre.

2.6.6 Table 5 details the Car Park implications for non-compliant vehicles in each of the eight LEZ scenarios.

Table 5. Car Park Availability for Non- Compliant Vehicles

Reference	Name	Capacity	Max % full	1A	1B	2A	2B	3A	3B	4A	4B
1	Chapel Street	500	55%	x	x	x	x	x	x	x	x
2	Denburn	325	53%	✓	✓	✓	✓	✓	✓	✓	✓
3	Bon Accord (Loch St)	990	61%	✓	✓	x	x	x	x	x	x
4	Bon Accord (Harriet St)	400	66%	✓	✓	x	x	x	x	x	x
5	College Street	456	68%	✓	✓	✓	✓	✓	✓	x	x
6	Ship Row	365	30%	x	x	x	x	x	x	x	x
7	Gallowgate	138	88%	✓	✓	x	x	x	x	x	x
8	West North Street	160	69%	✓	✓	✓	✓	x	x	x	x
9	Trinity Centre	397	63%	x	✓	x	✓	x	✓	x	✓
10	Union Square	1200	61%	✓	✓	✓	✓	✓	✓	x	x
11	IQ Car Park	260	64%	x	x	x	x	x	x	x	x
12	Frederick Street	150	55%	✓	✓	✓	✓	✓	✓	x	x
13	Beach Boulevard Retail Park / Esplanade	1900	49%	✓	✓	✓	✓	✓	✓	✓	✓
No. of City Centre Car Parks available for Non Compliant Vehicles (Excl. Beach Boulevard)		12		8	9	5	6	4	5	1	2
Total spaces (Excl. Beach Boulevard)		5341		3819	4216	2291	2688	2131	2528	325	722
% of Total Spaces Available				72%	79%	43%	50%	40%	47%	6%	14%

x Car Park Available for Compliant Vehicles Only
✓ Car Park Available for all Traffic

2.6.7 As the number of car parks available to non-compliant vehicles decreases, then the volume of traffic re-allocated to car parks on the outskirts of the city centre increases.

2.6.8 For Option 4A and 4B, the volume of traffic that would need to reallocate from the city centre area to the limited available off street car parks was deemed unreasonable and unworkable (by ACC). In this case, a proportion of the non-compliant car parking vehicles were re-assigned as compliant vehicles.

2.6.9 In Option 4a and 4B therefore, the percentage of non-compliant car park vehicles was re-adjusted until the total number of re-distributed non-compliant vehicles was similar to the other scenarios. Instead of an 86% car compliance level, this was increased to a 95% car compliance level for car parking traffic.

2.6.10 Table 6 summarises the volume of non-compliant traffic re-assigned from with the LEZ area in each scenario.

Table 6. Volume of Non-Compliant Car Park Traffic Re-assigned from within LEZ

Option	AM Period			IP Period			PM Period		
	To	From	Total	To	From	Total	To	From	Total
1A	99	9	108	108	106	214	76	198	274
1B	78	8	86	39	48	88	40	134	174
2A	185	25	211	276	285	561	165	421	587
2B	164	24	188	207	227	435	129	358	487
3A	198	30	228	290	304	594	184	457	641
3B	176	29	205	222	246	469	148	393	541
4A*	99	15	114	171	160	331	137	242	379
4B*	91	14	105	147	140	287	125	219	344

* Cars assumed to be 95% compliant instead of 86% compliant

The Option 4 LEZ scenarios includes a higher proportion of compliant vehicles than the other options, to limit the volume of non-compliant vehicles seeking to park around the LEZ area. This is based upon the broad assumption that the very limited car parking options for non-compliant vehicles in this Option would encourage a higher uptake of vehicle compliance. [or "would result in less reallocation of parking trips with some replacement of non-compliant vehicles with compliant vehicles parking inside the proposed LEZ area assumed".]

2.7 Traffic Signal Optimisation

2.7.1 Within each of the LEZ test models, it was necessary to review the timings of the signalised junctions to try to replicate the optimisation of signal phasing and timings that would occur within the real-time SCOOT system (Split Cycle Offset Optimisation Technique). This was a necessary modelling consideration to try to accommodate the changes in traffic demand and flow patterns around the city centre area arising from the application of each LEZ to the model network.

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3. LEZ OPTION ASSESSMENT

3.1 Introduction

3.1.1 The primary criteria for the assessment of each LEZ test scenario was to identify the level of traffic demand that the model could run in each peak period. For example, if a model ran at 80% demand, then this suggests that there would need to be a 20% reduction in the 2024 traffic levels (or 13% reduction on 2019 levels) within the city centre to enable the network to operate without significant congestion and network instability.

3.1.2 In parallel with the demand level assessment, model flow plots have been collated which show geographically where traffic is displaced within each of the LEZ scenarios.

3.1.3 Locations where network congestion and capacity issues have been noted are also detailed in the following sections

3.2 Model Network Demand

3.2.1 Table 7 shows the demand level that each LEZ test scenario was able to run at in each peak.

Table 7. LEZ Options - Network Demand Level

	LEZ Boundary Options							
Peak Period	1A	1B	2A	2B	3A	3B	4A	4B
AM	100%	100%	100%	100%	100%	100%	95%	95%
IP	100%	100%	100%	100%	100%	100%	100%	100%
PM	95%	100%	95%	80%	90%	95%	95%	95%

3.2.2 These high level test results suggest that the smaller cordon of LEZ Option 1B is the only scenario that can cater for the full forecast traffic demand levels in the ACCPM24. The results also suggest that the PM Peak is the critical peak period.

3.2.3 Further analysis of the PM Peak runs shows the number of model runs that gridlock in each scenario, (out of a total of 5 model runs).

3.2.4 Note: If the number of successful runs were at least 4 out of 5, this was deemed a successful run at that demand level.

Table 8. LEZ Options – PM Peak Model Run Success Rate

	LEZ Boundary Options							
Network Demand Level	1A	1B	2A	2B	3A	3B	4A	4B
100% Demand	3 of 5	4 of 5	1 of 5	0 of 5	0 of 5	0 of 5	1 of 5	3 of 5
95% Demand	5 of 5	5 of 5	4 of 5	0 of 5	2 of 5	5 of 5	5 of 5	4 of 5
90% Demand	-	-	-	1 of 5	5 of 5	-	-	-
85% Demand	-	-	-	0 of 5	-	-	-	-
80% Demand	-	-	-	5 of 5	-	-	-	-

3.2.5 Table 7 and Table 8 show that the LEZ boundary Option1B is the only clear option which could run at the full predicted 2024 traffic demand levels. Option 4B shows similar results, but this

option also has AM peak issues, and critically, includes different assumptions on the level of compliant vehicles in the network.

3.3 Model Flow Plots

- The model flow difference plots provided in **Appendix C** show the traffic flow differences between the ACCPM24 and the LEZ Test Scenario.
- Blue bars represent a decrease in traffic flows, Red bars represent an increase in traffic flows
- The results are presented for the PM Peak Period 16:00-19:00 as this is the critical operational period, as demonstrated above
- In addition, the black circles represent junctions or corridors in the model that display high levels of congestion and result in the model network failure at higher demand levels
- It is important to note that the model flow difference plots have been generated from model runs at the same demand level. For example, if the LEZ option runs at 95% demand, the flow plots have been compared against the ACCPM24 at 95% demand. This approach provides more clarity in the image to clearly show the locations where traffic has increased / decreased as a result of the LEZ. A reduced percentage demand level achieved by the LEZ scenario is still a primary consideration when reviewing these flow plots.

3.4 LEZ Options 1A to 4B – Results Summary

Option 1A (link to Figure 1A)

- Model runs at 95% of predicted 2024 demand in the PM peak , but shows potential to be able to run at full demand
- Small LEZ area allows 8 of 12 City Centre Car Parks to still be available for non-compliant vehicles
- Small LEZ area has the least impact on residential properties within the LEZ boundary
- Congestion issues occur:
  - Harbour Route (West North Street) as non-compliant vehicles divert around the periphery of the LEZ area
  - West end of Union Street (LEZ periphery)
  - Argyll Place / Craigie Loanings corridor
- Some traffic increases conflict with network hierarchy proposals i.e. Willowbank Rd and Ferryhill area
- With the Denburn Link within the LEZ, this reduces the pressure on the Berryden Rd / Hutcheon St junction, compared with 1B
- Some re-routing shown around north and south routes along River Dee.

Option 1B (link to Figure 1B)

- Model runs at 100% of predicted 2024 demand in all peaks
- Residential area coverage as per Option 1A
- Small LEZ area allows 9 of 12 City Centre Car Parks to still be available for non-compliant vehicles

- Congestion issues occur:
  - Harbour Route (West North Street) as non-compliant vehicle divert around the periphery of the LEZ area. This includes the junction of Guild Street / Market Street
  - Additional congestion around Mounthooly Roundabout and King St / Mounthooly Way, compared to Option1A
  - Some congestion around the north end of Berryden Rd (Powis Terrace junction) and at the 6 roads roundabout
  - Note: Denburn Road open to all traffic does not appear to help the network operation.

Option 2A (link to Figure 2A)

- Model runs at 95% of predicted 2024 demand in the PM peak
- LEZ area extended through George Street area to Hutcheon Street, resulting in fewer Car Parks available for non-compliant traffic (5 of 12)
- LEZ area extension will impact on residential properties around the George Street Area
- Congestion issues occur:
  - Harbour Route (West North Street through Virginia St and Market Street) as non-compliant vehicles divert around the periphery of the LEZ area. This is more pronounced compared to Option 1A, potentially due to the additional volume of non-compliant vehicles routing to alternative car parks as well as the additional displacement from the George Street area
  - Powis Terrace and 6 Roads Roundabout as per Option 1A
  - Argyle Place / Craigie Loanings corridor
- Some traffic increases conflict with network hierarchy proposals i.e. Willowbank Rd and Ferryhill area
- With the Denburn Link within the LEZ, this reduces the pressure on the Berryden Rd / Hutcheon St junction, compared with 2B
- Overall, there are more congestion locations and a higher scale of congestion compared to Option 1, this is due to the larger LEZ area combined with more non-compliant traffic re-routing from Car Parks that are now within the LEZ.

Option 2B (link to Figure 2B)

- Model runs at 80% of predicted 2024 demand in all peaks
- Residential area coverage as per Option 2A
- Mid-sized LEZ area allows 6 of 12 City Centre Car Parks to still be available for non-compliant vehicles
- Congestion issues occur:
  - Harbour Route (West North Street through Virginia St and Market Street) as non-compliant vehicles divert around the periphery of the LEZ area. This is more pronounced compared to Option 1B, potentially due to the additional volume of non-compliant vehicles routing to alternative car parks as well as the additional displacement from the George Street area
  - As Denburn Road is open to all traffic, this creates congestion issues further north at the Berryden Road / Hutcheon Street junction and Woolmanhill Roundabout

- Some traffic increases conflict with network hierarchy proposals i.e. Willowbank Rd, Ferryhill area, and Rosemount Place
- Overall, there are more congestion locations and a higher scale of congestion compared to Option 1, this is due to the larger LEZ area combined with more non-compliant traffic re-routing from Car Parks that are now within the LEZ.

Option 3A (link to Figure 3A)

- Model runs at 90% of predicted 2024 demand in the PM peak
- LEZ area extended through West North Street and the South end of King Street resulting in fewer Car Parks available for non-compliant traffic (4 of 12)
- LEZ area extension will impact on residential properties between West North Street and King Street
- Congestion issues occur:
  - Harbour Route (West North Street through Virginia St and Market Street). Even with the removal of non-compliant vehicles from this corridor, congestion issues remain in the network. It may be that mitigation to control the flow of traffic through this corridor is required in any LEZ option (e.g. the CCMP proposed mitigation for this location)
  - West end of Union Street (and wider to Skene St, St Swithen St etc) – this area becomes congested due to non-compliant traffic seeking a route north-south through the city centre as the harbour route and Denburn route is not available in this scenario
- Option 3 starting to show an increase in traffic routing away from the city centre completely (via Anderson Drive) as routing options become more limited
- The lack of car parking options within the city centre area for non-compliant vehicles results in more traffic routing around the city centre area.

Option 3B (link to Figure 3B)

- Model runs at 95% of predicted 2024 demand in the PM peak
- LEZ area extension will impact on residential properties around the George Street Area as per Option 3A
- Mid-sized LEZ area allows 5 of 12 City Centre Car Parks to still be available for non-compliant vehicles
- Congestion issues occur:
  - Harbour Route (West North Street through Virginia St and Market Street). Even with the removal of non-compliant vehicles from this corridor, congestion issues remain in the network. It may be that mitigation to control the flow of traffic through this corridor is required in any LEZ option (e.g. the CCMP proposed mitigation for this location)
  - As Denburn Road is open to all traffic, this creates congestion issues further north at the Berryden Road / Hutcheon Street junction and also Mounthooly Roundabout
- Some traffic increases conflict with network hierarchy proposals i.e. Willowbank Rd, Ferryhill area, Skene St, Cairncry Rd/ Back Hilton Rd etc.
- Overall, there are more congestion locations and a higher scale of congestion compared to Option 1, this is due to the larger LEZ area combined with more non-compliant traffic re-routing from Car Parks that are now within the LEZ.

Option 4A (Link to Figure 4A)

- Model runs at 95% of predicted 2024 demand in the AM and PM peak
- LEZ area extended through Rail Station, Union Square, and the North Dee Quarter resulting very few car parks available for non-compliant traffic (1 of 12)
- LEZ area extension will impact on properties between Guild Street and North Esplanade West
- This scenario requires an assumption of a higher car compliance level compared to the other scenarios, due to the very limited parking available for non-compliant cars originating/destination in the city centre
- Congestion issues occur:
  - Some issues through the Harbour Route (Guild St / Market St and Mounthooly Rdbt)
  - Significant re-routing occurs through residential areas to the west of the city centre as non-compliant traffic routes around available corridors
- Option 4 also starting to show an increase in traffic routing away from the city centre completely (via Anderson Drive) as routing options become more limited
- The lack of car parking options within the city centre area for non-compliant vehicles results in more traffic routing around the city centre area
- A clear advantage of Option 4 over smaller LEZ options is the lesser impact on key junctions around the harbour route (West North St / Beach Boulevard).

Option 4B (Link to Figure 4B)

- Model runs at 95% of predicted 2024 demand in the AM and PM peak
- LEZ area extension as per Option 4A
- Large LEZ area allows only 2 of 12 City Centre Car Parks to still be available for non-compliant vehicles
- This scenario requires an assumption of a higher car compliance level compared to the other scenarios, due to the very limited parking available for non-compliant cars originating/destination in the city centre
- Congestion issues occur:
  - Some issues through the Harbour Route (Guild St / Market St, West North St / Beach Boulevard Rdbt)
  - As Denburn Road is open to all traffic, this creates congestion issues further north at the Berryden Road / Hutcheon Street junction and Woolmanhill Rdbt
- Some traffic increases conflict with network hierarchy proposals i.e. Willowbank Rd, Ferryhill area, Skene St, Westburn Drive etc.
- Overall, the large LEZ area does not improve the congestion issues within the network. There are still some routing options through the city centre which carry all the non-compliant traffic, resulting in junction capacity issues through these corridors.

3.5 Conclusions to Initial LEZ Option Assessment

3.5.1 From the traffic model testing, the model outputs show that increased traffic flows around the LEZ boundary contribute to the various congestion issues and network failure of the model.

3.5.2 Comparing the LEZ options, the results suggest that where the LEZ boundary encompasses sections of key routes through the city centre area, this has a positive impact on the levels of traffic and congestion in that specific area or further out along that arterial route. Examples of this include:

- Denburn Road (for Berryden/ Hutcheon St junction)
- Harbour Corridor (East North St/Commerce St/Virginia St/Trinity Quay).

3.5.3 This initially suggests that larger LEZ boundaries, which intersect more of these routes, will allow the network to operate. However, the larger proposed LEZ boundaries create additional issues for car parking availability as well as a higher impact on residents living within the LEZ area. In addition, the larger LEZ areas have so far not shown any network wide operational benefits over the smallest LEZ area*.

*Note: None of the tested LEZ scenarios restrict all arterials into/from the City Centre.

4. OPTION SIFTING

4.1 Introduction

4.1.1 From the initial four LEZ options (plus the Denburn Rd variant) derived through the NLEF appraisal process, model testing has shown congestion issues may occur to different degrees in the network, depending upon the scale and coverage of the LEZ boundary.

4.1.2 Consideration of the ability for the network to be able to operate is one of the key factors in filtering the LEZ options down to a preferred scenario. The key factors which have been considered as part of the option sifting process include:

- Network Demand Level & Congestion Areas
- Impact through Exceedance Locations
- Alignment with revised North East Scotland Roads Hierarchy
- Car Park Accessibility Impact
- Impact to residential properties within LEZ area.

4.1.3 This chapter details the rationale behind the option sifting process.

4.2 NO_2 Exceedance Locations

4.2.1 Nitrogen Dioxide ($N0_2$) is released into the atmosphere when fuels are burned, for example petrol or diesel in car engines.

4.2.2 There is evidence that high levels of NO_2 can inflame the airways in our lungs and, over a long period of time, affect how our lungs work. The concentration of NO_2 is measured in micrograms in each cubic metre of air ($\mu g/m^3$).

4.2.3 The UK Government has set air quality objectives for NO_2 in their Air Quality Strategy that adopts legislation set out by the European Union (EU). The UK Air Quality Objective (AQO) sets an annual limit value of $40\mu g/m^3$ for concentration of NO_2 in the air.

4.2.4 As detailed in the Interim NLEF Stage 2 Report, ACC undertook non-automatic (passive diffusion tube) monitoring of $N0_2$ at 70 sites during 2019 as part of the air quality monitoring Annual Progress Reporting (APR).

4.2.5 In total, there are 8 locations where annual mean concentrations of NO_2 exceed the AQO of $40\mu g/m^3$ and a further 6 sites where the annual mean concentrations of $N0_2$ exceed 36 $\mu g/m^3$.

4.2.6 Figure 3 shows the locations where annual concentrations of $N0_2$ were recorded as greater than 36 $\mu g/m^3$ in 2019.

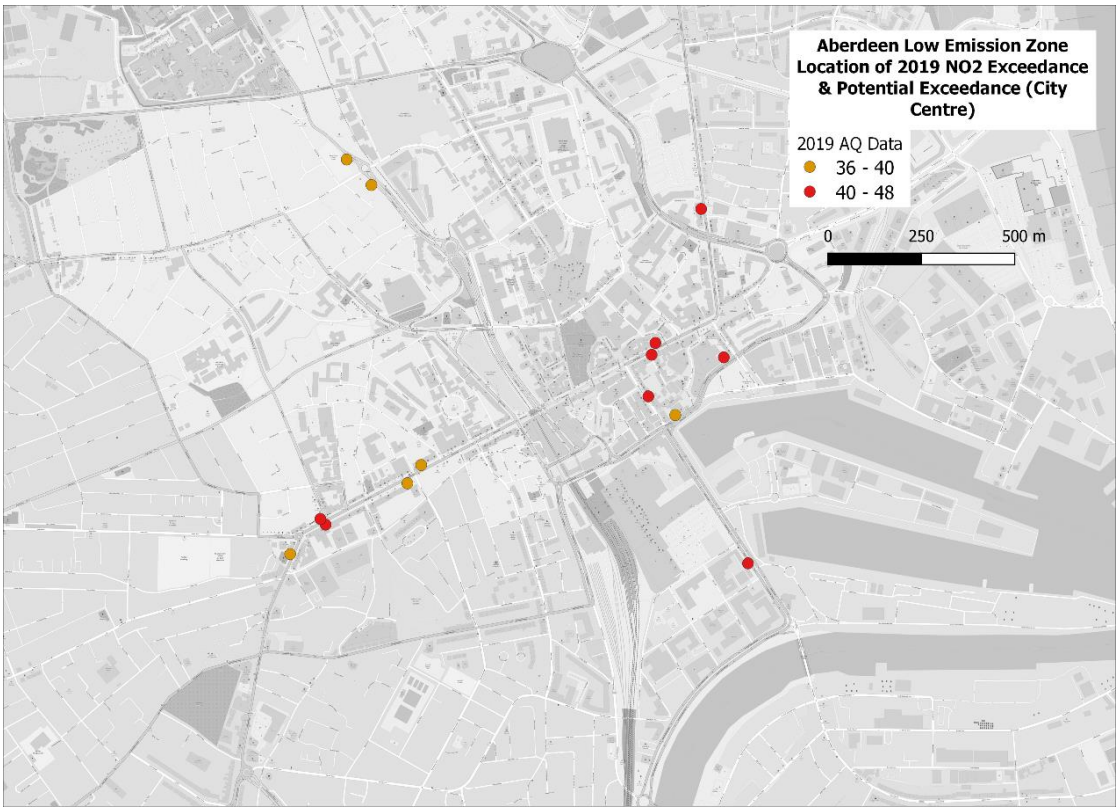

Figure 3. Locations of 2019 Annual Mean Concentrations of NO_2 greater than 36 µg/m³ (City Centre AQMA)

4.2.7 Each of the LEZ boundary options encompassed the majority of the locations detailed in Figure 3. Table 9 details the exceedance / potential exceedance locations that are directly within each of the LEZ boundary options.

Table 9. LEZ Coverage of Air Quality Interest Locations

		Exceedance Location Within LEZ ?					
Site	**Exceedance Location**	1A	1B	2A	3B	4A	4B
DT30	335 Union St	✓	✓	✓	✓	✓	✓
DT73	61 Skene Square	×	×	×	×	×	×
DT18	14 Holburn St	×	×	×	×	✓	✓
CM2	Union Street	✓	✓	✓	✓	✓	✓
DT16	1 Trinity Quay	×	×	×	✓	✓	✓
DT77	27 Skene Square	×	×	×	×	×	×
DT11	105 King St	×	×	×	×	✓	✓
DT10	184/192 Market St	×	×	×	×	✓	✓
DT9	39 Market St	✓	✓	✓	✓	✓	✓
DT29	469 Union St	✓	✓	✓	✓	✓	✓
DT12	40 Union St	✓	✓	✓	✓	✓	✓
DT17	43/45 Union St	✓	✓	✓	✓	✓	✓
DT82	7 Virgina Street	×	×	×	✓	✓	✓
DT19	468 Union St	✓	✓	✓	✓	✓	✓

4.2.8 The locations detailed above that are out-with the LEZ boundary can still be influenced by the impact of the LEZ scheme. The impact of each boundary option on each of the exceedance / potential exceedance locations will form part of the option sifting process. This is detailed further in the following sections.

4.3 Network Demand Level

4.3.1 The 2024 future year traffic models include approximately 7% predicted growth over the 2019 Baseline traffic levels in the PM Peak. It could therefore be considered that models running at 95% demand is equivalent to a small level of traffic growth on the 2019 baseline traffic demand (i.e. 2% traffic growth from 2019). In addition, due to the potential impact of the COVID-19 pandemic, a zero growth future is also a plausible future.

4.3.2 In the LEZ option testing, there are two network scenarios that do not meet either the 95% or 100% demand levels.

4.3.3 As detailed in Tables 7 and 8, each of the model scenarios were able to run at 95% demand, with the exception of boundary Option 2B and 3A, which could only run at 80% and 90% demand respectively, representing a reduction in traffic demand from the 2019 baseline traffic.

4.3.4 Option 2B also allows non-compliant traffic to route through Denburn Road. There are other implications to the Denburn Road exclusion from the LEZ that are detailed in the following sections.

4.3.5 Option 3A is similar in scale to Option 4 but critically does not include coverage of the west end of Union Street within the LEZ area. As noted in Chapter 3, this creates congestion due to non-compliant traffic seeking a route north-south through the city centre as the harbour route and Denburn route is not available in this scenario.

Due to the required demand level being lower than 2019 baseline in order for the networks to operate, LEZ Boundary **Options 2B and 3A** are omitted from consideration at this stage.

4.4 Denburn Road Variation

4.4.1 The remaining LEZ boundary options 1B, 3B and 4B exclude Denburn Road from the LEZ area. The traffic model testing has shown that this has the effect of increasing (non-compliant) traffic through the Denburn corridor and through Skene Square to the Hutcheon Street junction. There are two key issues with this occurrence:

- Skene Square includes 2 locations where there are potential NO^2 exceedances
- Additional traffic demand through Skene Square adds pressure to a critical pinch point on the network – Berryden Road/ Hutcheon Street junction. This junction, even with capacity improvements from the Berryden Corridor Improvement proposals, shows junction capacity issues through the model testing. It is known from parallel testing that further traffic restrictions within the city centre area (from CCMP) will put even more pressure on this junction.

4.4.2 A review of the model traffic flows through Skene Square corridor was undertaken for each of the remaining LEZ boundary options. Table 10 provides a summary of the 12 hour flow comparisons between the LEZ scenario options and the 2019 Base model. Note the 2019 Base model is used for all flow comparisons for consistency with the 2019 observed air quality dataset.

Table 10. Skene Square Flow Change (12 Hr flows)

Site	Exceedance Location	Op 1A		Op 1B		Op 2A		Op 3B		Op 4A		Op 4B	
		Flow Diff	%	Flow Diff	%	Flow Diff	%	Flow Diff	%	Flow Diff	%	Flow Diff	%
DT73	61 SkeneSquare	-1297	-8%	-375	-2%	-1254	-8%	1892	12%	-596	-4%	1208	8%
DT77	27 SkeneSquare	-1299	-8%	-371	-2%	-1260	-8%	1884	12%	-597	-4%	1214	8%

4.4.3 Table 10 shows that for Option 3B, there is predicted to be an increase in traffic flow in the region of 12% over the 2019 baseline. For Option 4B, this increase is observed to be in the region of 8%. These traffic increases will likely include a more concentrated proportion of non-compliant traffic.

4.4.4 As the Berryden Rd/Skene Square/Woolmanhill corridor is a priority route into the city centre, there are no other network proposals, as part of the CCMP or other, that would likely result in a decrease in traffic flow though this corridor of a scale greater than these increases.

4.4.5 The option to allow non-compliant traffic to route through Denburn Road does therefore not comply with other city centre strategies and is highly likely to worsen the NO_2 emission levels at Skene Square.

4.4.6 Option 1B does not show the same increases in traffic flows through Skene Square as 3B and 4B. This is likely to be due to the smaller LEZ area impacting fewer vehicles. Even with a 2% decrease in traffic volume, this option may still not result in a reduction in NO_2 emissions through Skene Square. Further analysis of this option is detailed in the following sections..

Due to the predicted increases in traffic flow (of non-compliant vehicles) and resultant congestion through the Skene Square corridor as well as the potential impact on NO_2 emissions along this corridor, LEZ Boundary **Options 3B and 4B** are omitted from consideration at this stage.

4.5 Exceedance Location Review

4.5.1 The locations where 2019 annual mean concentrations of NO_2 are recorded as greater than 36µg/m^3 is detailed in Table 11. Concentrations greater than 36µg/m^3 are presented (in orange) as locations that may be at risk of future exceedance. The cells highlighted in red are the locations where the AQO of 40µg/m^3 was exceeded (current exceedance level).

4.5.2 As detailed in Chapter 4 of the Aberdeen NLEF Report (SYSTRA, Ref: GB01T19I15/281119, 01/06/20), high level scenario testing using the baseline Aberdeen National Modelling Framework (NMF) Air Quality Model concluded that improving the city bus fleet to LEZ compliant standard (Euro VI) will bring the single biggest reduction in NO_2 levels and that buses therefore must be included in an Aberdeen LEZ. The NMF quantified the impact that an all compliant bus scenario would have on the NO_2 emission levels city wide and at the 2019 exceedance/potential exceedance locations. Table 11 therefore also shows the predicted NO_2

levels for each location, under the assumption that all buses have been upgraded to a compliant emission level.

4.5.3 The NMF scenario test results show that if all buses are compliant with LEZ vehicle emission standards, there would still likely be four 2019 exceedance locations where NO_2 levels would be greater than 40µg/m^3 and a further 9 locations where the NO_2 is near to this maximum allowable level.

Table 11. Annual Mean Concentrations of NO2 greater than 36µg/m³

Site	Exceedance Location	Mean NO2 2019 (µg / m^3)	Impact of Bus Compliant	Bus Compliant Mean NO2 (µg / m^3)
DT30	335 Union St	39.0	-2.4%	38.0
DT73	61 Skene Square	38.0	-4.8%	36.2
DT18	14 Holburn St	39.0	-2.1%	38.2
CM2	Union Street	36.0	-10.5%	32.2
DT16	1 Trinity Quay	39.0	-2.7%	37.9
DT77	27 Skene Square	38.0	-2.2%	37.2
DT11	105 King St	45.0	-2.5%	43.9
DT10	184/192 Market St	47.0	-4.9%	44.7
DT9	39 Market St	44.0	-12.8%	38.4
DT29	469 Union St	42.0	-12.7%	36.7
DT12	40 Union St	43.0	-14.8%	36.6
DT17	43/45 Union St	43.0	-2.5%	41.9
DT82	7 Virgina Street	43.0	-1.6%	42.3
DT19	468 Union St	42.0	-11.0%	37.4

4.5.4 The figures presented in Table 11 are critical when considering the traffic model flow changes in the LEZ option test scenarios.

4.5.5 Table 12 provides a traffic flow percentage difference comparison between the remaining LEZ scenarios and the 2019 Base Model at each of the exceedance locations in the network. The data is based upon the 12 Hr model flows*.

4.5.6 For absolute clarity, this comparison is between a 2024 future year scenario with a LEZ and a 2019 Base scenario. The traffic flow differences therefore include the influence of background traffic growth as well as the impact of the LEZ.

*Where the model only runs at 95% demand, the traffic flows have been factored to 100% to enable a like for like comparison with the Base Model.

Table 12. Traffic Flow Analysis at Air Quality Exceedance Locations

Site	Exceedance Location	Flow Change from 2019 Baseline 1A	1B	2A	4A
DT30	335 Union St	-1%	0%	0%	-2%
DT73	61 Skene Square	-8%	-2%	-8%	-4%
DT18	14 Holburn St	9%	5%	7%	-6%
CM2	Union Street	1%	0%	1%	-3%
DT16	1 Trinity Quay	11%	10%	16%	-9%
DT77	27 Skene Square	-8%	-2%	-8%	-4%
DT11	105 King St	16%	13%	11%	-3%
DT10	184/192 Market St	11%	7%	14%	-8%
DT9	39 Market St	-4%	-5%	-3%	-3%
DT29	469 Union St	0%	-1%	-1%	-3%
DT12	40 Union St	10%	10%	7%	1%
DT17	43/45 Union St	10%	10%	7%	1%
DT82	7 Virgina Street	13%	10%	16%	-4%
DT19	468 Union St	0%	-1%	-1%	-3%

4.5.7 Table 12 shows that there are traffic flow increases observed at seven of the exceedance locations in Options 1A, 1B and 2A. It is also evident that there isn't a significant difference between each of these three scenarios.

4.5.8 It should also be noted that four of the seven locations where traffic flows have increased in options 1A, 1B and 2A are locations that are out-with the LEZ area (See Table 9).

4.5.9 For Option 4A, the LEZ area covers all of the exceedance locations and therefore the traffic flows have reduced as a result of non-compliant vehicles being excluded from these locations. The comparisons show that Option 4A results in traffic flows reducing to a level below the 2019 Baseline.

4.5.10 In lieu of Air Quality modelling available at this point in the assessment, in order to predict the emission level changes for each scenario, a methodology was adopted using the traffic model outputs and the NMF NO_2 outputs detailed in Table 11.

4.5.11 The methodology applied considered the following information:

- Model Traffic flow changes between 2024+LEZ model and the 2019 Base model
- Impact to NO_2 levels when all buses are compliant
- Consideration whether exceedance locations were inside or outside the LEZ area.

4.5.12 Table 13 details the predicted impact of the LEZ options on the air quality exceedance locations. These results are presented as coloured banding, representing the predicted impact to the NO_2 levels.

Table 13. Predicted Impact of LEZ on Air Quality Exceedance Locations

Site	Exceedance Location	Predicted Air Quality Impact 1A	1B	2A	4A
DT30	335 Union St				
DT73	61 Skene Square				
DT18	14 Holburn St				
CM2	Union Street				
DT16	1 Trinity Quay				
DT77	27 Skene Square				
DT11	105 King St				
DT10	184/192 Market St				
DT9	39 Market St				
DT29	469 Union St				
DT12	40 Union St				
DT17	43/45 Union St				
DT82	7 Virgina Street				
DT19	468 Union St				

NO_2 Levels predicted to be Under Threshhold
NO_2 Levels predicted to be Near Threshhold
NO_2 Levels predicted to be Over Threshhold
NO_2 Levels predicted to be Significantly Over Threshhold

4.5.13 Table 13 shows a very similar pattern to the traffic flow changes detailed in Table 12. Where traffic flows are predicted to increase significantly, and particularly at locations out-with the LEZ boundary, then there is a high degree of certainty that the NO_2 levels will not improve.

4.5.14 For options 1A,1B, and 2A, due to the scale of the LEZ, many of the exceedance areas are not positively influenced by the LEZ, in terms of traffic flow levels or improvements in the fleet (due to removal of non-compliant vehicles).

4.5.15 Only Option 4A, which boundary covers all the exceedance areas, is anticipated to positively impact on the emission level at each of the exceedance locations. Even so, it can be seen from Table 13 that at four locations, the exceedance levels are likely to be still near the AQO of 40µg/m^3.

4.5.16 The exceedance location assessment strongly indicates that the smaller LEZ areas assessed do not address many of the exceedance issues identified in the local network.

4.5.17 A parallel study on the City Centre Masterplan indicates that the proposed traffic interventions within the core area of the city centre will significantly reduce traffic levels through key routes of Union St and Market St (among others), but will not provide significant reduction to traffic demand levels along King Street or the harbour route of Virginia St and Trinity Quay.

4.5.18 Therefore, without significant additional interventions not historically considered, the LEZ Options 1A, 1B and 2A are not anticipated to meet the objectives of the scheme.

> Due to the limited impact of **Option 1A, 1B and 2A** on the observed NO_2 emission locations, these options were no longer considered.

4.5.19 Additional implications of the LEZ boundary options were reviewed and are detailed in the following sections:

4.6 Alignment with Network Hierarchy

4.6.1 ACC and regional partners Nestrans and Aberdeenshire Council commissioned the North East Scotland Roads Hierarchy Study, which aims to update the cities roads hierarchy to provide a system that reflects the new role of the city centre (as a destination). The revised network hierarchy around the city centre area is shown in Figure 4.

4.6.2 It is considered important, in the context of Aberdeen's changes to the roads hierarchy, that the LEZ area aligns with the new hierarchy. This is also detailed in Section 8.9 of the NLEF Report *(National Low Emission Framework – Interim Stage 2 Assessment Report* -SYSTRA, Ref: GB01T19I15/281119, 01/06/20).

Figure 4. City Centre Network Hierarchy Package

4.6.3 The NLEF Report also highlights the potential issues of including two secondary routes within the LEZ area (Denburn Road and Harbour Route) . The report noted that non-compliant

vehicles re-routing away from these corridors would likely shift to western secondary and minor routes. The model flow difference plots (Appendix C), show a migration of traffic to the west end on Union Street and into the local routes between Union Street and Anderson Drive.

4.6.4 In Option 4, where the explicit West end of Union Street and Alford Place / Holburn Street are included within the LEZ, this has the effect of displacing traffic further out to the Ashley Rd and Forrest Avenue corridors.

4.6.5 In each of the LEZ options, traffic flow increases are observed along the southern boundary of the Willowbank Road corridor and/or the parallel east-west corridor of Ferryhill Road, Neither of these routes are likely to be deemed acceptable to carry additional non-compliant vehicles under the revised network hierarchy (the former A93 Willowbank Road has been downgraded to a tertiary route).

4.6.6 The traffic model outputs therefore suggest that none of the remaining LEZ options directly align with the proposed network hierarchy. The conflicts could be mitigated by either traffic management measures or revisions to the LEZ boundary. This is considered further in Section 4.10.

4.7 Car Park Accessibility

4.7.1 As detailed in Table 5 (Section 2.6), some city centre car parks will be within the proposed LEZ area. This will result in a likely relocation of non-compliant cars to car parks outside the LEZ area. The scale of traffic relocation is different for each LEZ boundary.

4.7.2 For the LEZ options, the proportion of City Centre Off-street car parks accessible for all vehicles is:

- Option 1A – 8 of 12 Car Parks available (72% of total spaces)
- Option 1B – 9 of 12 Car Parks available (79% of total spaces)
- Option 2A – 5 of 12 Car Parks available (43% of total spaces)
- Option 2B –6 of 12 Car Parks available (50% of total spaces)
- Option 3A – 4 of 12 Car Parks available (40% of total spaces)
- Option 3B – 5 of 12 Car Parks available (47% of total spaces)
- Option 4A – 1 of 12 Car Parks available (6% of total spaces)
- Option 4B – 2 of 12 Car Parks available (14% of total spaces).

4.7.3 The smallest LEZ area (Option 1A/1B) will retain the most accessibility to the city centre for all traffic fleet, whilst Option 4 would effectively force non-compliant vehicle drivers to either upgrade their vehicle, travel into the city centre by a different mode or not travel to the city at all. These differences between the LEZ boundary options raise several key implications to consider, including:

- equal opportunity implications
- City Centre economy and resilience implications
- Wider air quality implications.

4.8 LEZ Boundary – Residential Consideration

4.8.1 For residents within the LEZ boundaries, there would be a requirement for their vehicles to be fully compliant to the emission restrictions after the defined grace period for enforcement. It is recognised that the larger the LEZ area, the greater or wider impact there will likely be for air quality improvements. However, where a LEZ covers residential areas, this also raises implications to equal opportunities where residents are forced to comply with the LEZ measures. It should be noted that the Scottish Government, through its 2018 Programme for Government, committed to help those who will have most difficulty preparing for the introduction of LEZs through various support funds and the Transport (Scotland) Act 2019 legislation allows for additional 2-year grace period to be applied for residents of a LEZ.

4.8.2 The LEZ options identified in the Interim NLEF Stage 2 Report included residential areas that do not contain air quality exceedance locations. These options were developed to capture key trip generators, such as car parks. For example, Option 2 extended the Option 1 (Union Street) area to include Gallowgate and Bon Accord car parks but to do so, Option 2 also had to include all residential properties in the Gallowgate/George Street area. The Interim NLEF Stage 2 Report concluded that these options should be tested in the traffic model to assess their wider impacts on air quality and provide evidence for the inclusion or exclusion of residential areas with no current air quality issues.

4.9 Decision on Remaining Option

4.9.1 Whilst the option sifting process results in only Option 4A remaining, there remain key issues and implications for this large area LEZ scenario as identified above and in the NLEF Interim Stage 2 Report, namely:

- Alignment with revised NE Scotland Roads Hierarchy
- Implications to accessibility to city centre car parks
- Implications to the large number of residential properties within the LEZ area
- Ability for the network to operate at full 2024 network demand
- Assumptions that Option 4 would incentivise more people to convert their non-compliant vehicle compared to the alternative LEZ options.

4.9.2 From the option sifting process, there was clear evidence that further consideration of potential boundary options could be undertaken which would combine the benefits of both the smaller scale LEZ options (i.e. Option 1A) and the large scale LEZ options (i.e. Option 4A) and also reduce their disbenefits.

4.10 Revised LEZ Boundary Considerations – Option 5

4.10.1 The process of developing a further boundary scenario, included the following considerations:

- Ability for the transport network to cater for traffic displacement
- Requirement to displace non-compliant traffic away from the city centre area and onto pertinent routes of a suitable standard and with no existing air quality issues
- Maximise the influence on non-compliant vehicles within the city centre to improve air quality
- Retain a reasonable degree of accessibility for all vehicle fleet (both compliant and non-compliant)

- Limit the number of residential properties within the LEZ area.

4.10.2 As noted in Section 3.4, and although it has been discounted for its limited impact on NO_2 emission, Options 1A/1B were shown to be the most likely scenario to be able to cater for the displacement of non-compliant traffic from the LEZ. From the initial model testing, congestion issues were identified at locations in all LEZ boundary options as concentrations of non-compliant traffic routed around the LEZ area.

4.10.3 To address this issue, several variations to the LEZ Option 1A boundary were considered, with a view to enabling a better management of traffic around the LEZ boundary. These variations should also assist in reducing congestion areas around the city centre.

4.10.4 In addition, changes to the extent of the boundary were also considered based upon the conflict between the modelled traffic flow increases recorded and the network hierarchy.

4.10.5 Table 14 details the boundary variations to the LEZ Option 1A and the rationale behind each.

Table 14. LEZ Area Revisions

Detail	Rationale
LEZ covers Union Street Area, including Denburn Road	Area derived from NLEF Process
Extension of 1A to Holburn St	All LEZ scenarios show traffic increase through the west end of Union Street and particularly the north-south route of Holburn St up through Albert St and Argyll Place. Extending the LEZ through the west end of Union Street will cut this cross city routing option for non-compliant traffic. Note: May need to consider subsequent impact through St. Swithin St / Fountainhill Rd corridor
Extension of 1A to A93 Willowbank Road	Traffic flow increases through this route in all LEZ options as a result of diversion of non-compliant traffic. Corridor de-classified as part of Network Hierarchy review so not appropriate route for this traffic. Will need to consider the impact through Ferryhill Rd area, but may need weight up benefits of a LEZ extension or other traffic management measures through this corridor.
Extension of 1A to Littlejohn St	Where Littlejohn St is on the periphery of the LEZ, some traffic congestion occurs through the junction onto West North Street
Extension of 1A to Upperkirkgate	In Options 1A/1B, Schoolhill is on the periphery of the LEZ, resulting in slight increases in traffic flow through this corridor. This is not an appropriate route to carry additional traffic (and higher emission traffic).
Extension of 1A to Harbour Corridor (East North St /Commerce St / Virginia St / Trinity Quay / Market St	Congestion issues occur through this corridor when it is open to all traffic. The CCCMP measures may be able to partially or fully address this issue. However, it would be prudent, in the first instance, to assess the impact of restricting access through this corridor for non-compliant vehicles with a small scale LEZ boundary.
Combination of Above	Full restriction of city centre through traffic to non-compliant vehicles

4.10.6 When the above boundary variations to Option 1A are considered together (deemed Option 5 – see Figure 5 below), this LEZ area has the effect of restricting all non-compliant vehicles from routing through the city centre area, but critically, it does not restrict access to the city centre (Car Park options still available). This is consistent with other policies and aspirations for Aberdeen City Centre.

4.10.7 The proposed boundary for Option 5 also intersects all key approach routes into the city centre, therefore it has an impact on the volume of non-compliant traffic in the city centre on a much wider scale than the boundary itself.

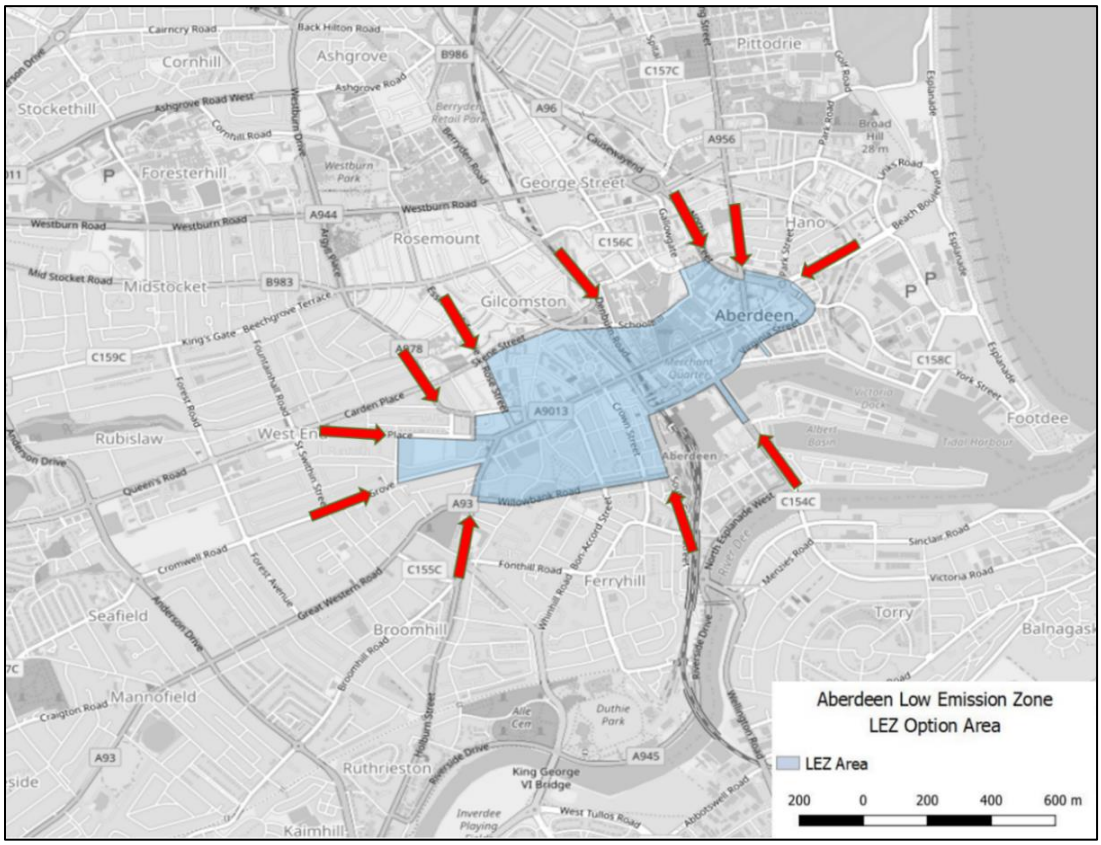

Figure 5. LEZ Option 5

4.10.8 The rationale for the proposed LEZ Option 5 was presented to ACC on Monday 22nd February 2021. ACC subsequently agreed to consider this option for further assessment alongside Option 4A, the final remaining option from the initial 8 LEZ options identified in the Interim NLEF Stage 2 Report.

4.11 LEZ Option 5 – Initial Model Findings

4.11.1 The model testing assessment carried out for the initial 8 LEZ boundary options was also undertaken for Option 5 and is detailed in the following sections.

Option 5 - Model Network Demand

4.11.2 Table 15 shows the updated network demand level that each scenario was able to run at. Table 16 presents the number of PM Peak model runs that ran through successfully.

Table 15. Network Demand Level (Updated)

Peak Period	LEZ Boundary Options							
	1A	1B	2A	2B	3A	3B	4A	5
AM	100%	100%	100%	100%	100%	100%	95%	100%
IP	100%	100%	100%	100%	100%	100%	100%	100%
PM	95%	100%	95%	80%	90%	95%	95%	95%

Table 16. PM Peak Model Run Success Rate (Updated)

Network Demand Level	LEZ Boundary Options							
	1A	1B	2A	2B	3A	3B	4A	5
100% Demand	3 of 5	4 of 5	1 of 5	0 of 5	0 of 5	0 of 5	1 of 5	0 of 5
95% Demand	5 of 5	5 of 5	4 of 5	0 of 5	2 of 5	5 of 5	5 of 5	5 of 5
90% Demand	-	-	-	1 of 5	5 of 5	-	-	-
85% Demand	-	-	-	0 of 5	-	-	-	-
80% Demand	-	-	-	5 of 5	-	-	-	-

4.11.3 Table 15 shows that Option 5 was able to run at the full future year traffic demand level in the AM and Interpeak, but, similar to Option 4A, was able to run at 95% of the future year traffic demand level. Note that 95% demand is equivalent to approximately 2% growth on 2019 levels.

4.11.4 Table 16 also shows that the number of successful model runs in the PM Peak at 95% was 5 out of 5 for both Option 4A and Option 5.

Option 5 - Model Flow Plots (Link To Option 5)

4.11.5 The model flow difference plot between the (PM Peak) ACCPM24 and the Option 5 LEZ Test scenario is shown in **Appendix C.**

- Option 5 shows a much lower level of congestion through the core area of the city centre and also through the Harbour route compared to many of the other LEZ options
- Congestion issues are observed to occur through junctions along the Argyll Place corridor and along Hutcheon St at Mounthooly Roundabout
- Some rat running is observed through the Ferryhill area and around the area west of Union Street (Ashley Road, Albyn Grove, St. Swithen St).

Option 5 - NO_2 Exceedance Locations

4.11.6 Table 17 provides an updated traffic flow percentage difference comparison between the LEZ scenarios and the 2019 Base Model at each of the exceedance locations in the network. The data is based upon the 12 Hr model flows.

Table 17. Traffic Flow Analysis at Air Quality Exceedance Locations (Updated)

Site	Exceedance Location	% Flow Change from 2019 Baseline				
		1A	1B	2A	4A	5
DT30	335 Union St	-1%	0%	0%	-2%	5%
DT73	61 Skene Square	-8%	-2%	-8%	-4%	-8%
DT18	14 Holburn St	9%	5%	7%	-6%	1%
CM2	Union Street	1%	0%	1%	-3%	3%
DT16	1 Trinity Quay	11%	10%	16%	-9%	-7%
DT77	27 Skene Square	-8%	-2%	-8%	-4%	-8%
DT11	105 King St	16%	13%	11%	-3%	3%
DT10	184/192 Market St	11%	7%	14%	-8%	-4%
DT9	39 Market St	-4%	-5%	-3%	-3%	1%
DT29	469 Union St	0%	-1%	-1%	-3%	3%
DT12	40 Union St	10%	10%	7%	1%	9%
DT17	43/45 Union St	10%	10%	7%	1%	9%
DT82	7 Virgina Street	13%	10%	16%	-4%	-8%
DT19	468 Union St	0%	-1%	-1%	-3%	3%

4.11.7 It can be seen from Table 17 that the traffic flow changes around the exceedance areas in Option 5 are much better than Option 1A,1B and 2A, due to the extension of the LEZ area to include the key radial routes in Option 5.

4.11.8 Whilst there is an increase in traffic observed on Union Street (East), this is within the boundary of the LEZ, therefore this traffic increase will be compliant vehicles.

4.11.9 The resultant predicted impact on the NO_2 exceedance areas is provided in Table 18.

Table 18. Predicted Impact of LEZ on Air Quality Exceedance Locations (Updated)

Site	Exceedance Location	Predicted Air Quality Impact 1A	1B	2A	4A	5
DT30	335 Union St					
DT73	61 Skene Square					
DT18	14 Holburn St					
CM2	Union Street					
DT16	1 Trinity Quay					
DT77	27 Skene Square					
DT11	105 King St					
DT10	184/192 Market St					
DT9	39 Market St					
DT29	469 Union St					
DT12	40 Union St					
DT17	43/45 Union St					
DT82	7 Virgina Street					
DT19	468 Union St					

NO_2 Levels predicted to be Under Threshhold

NO_2 Levels predicted to be Near Threshhold

NO_2 Levels predicted to be Over Threshhold

NO_2 Levels predicted to be Significantly Over Threshhold

4.11.10 Table 18 shows that the majority of the exceedance locations for LEZ Option 5 are predicted to be under the exceedance threshold.

4.11.11 The Union Street (Site DT17) location is anticipated to be near or over the AQO of 40µg/m^3, even though it is within the LEZ area. This suggests that further mitigation may be required to reduce traffic levels within the LEZ area.

4.11.12 In addition, the NO_2 levels on King St are predicted to be above the threshold. This could be an issue as there are no clear measures within the CCMP which would obviously impact on traffic flows at this location.

4.11.13 Further analysis of the traffic flows on King Street in Option 5 showed that almost zero percent of traffic on this route southbound was non-compliant confirming that even though the Option 5 LEZ boundary does not include the King Street exceedance locations, non-compliant traffic and therefore NO_2 levels at this location are influenced by the LEZ.

4.11.14 Holburn St and Virginia St are predicted to be near the exceedance threshold however, these locations are also within the LEZ boundary, therefore NO_2 levels are not expected to reach the threshold.

4.11.15 Finally, Market St (Site DT10 – South end of Market St) is out-with the LEZ, but like King St, is heavily influenced by the LEZ boundary further north on Market Street. Only non-compliant

vehicles routing to the Harbour area or Union Square would potentially route along this section of Union Street, therefore the proportion of compliant vehicles would be very high.

Option 5 -Alignment with Network Hierarchy

4.11.16 The boundary of LEZ Option 5 includes the Willowbank Road corridor. This inclusion has the effect of slightly reducing the total volume of traffic using this route. This is in contrast to the traffic increases (of non-compliant vehicles) noted in other LEZ options.

4.11.17 However, non-compliant traffic has migrated to the alternative east-west route of Fonthill Rd / Ferryhill Road. Traffic increases are also noted around the West end of Union Street through routes including Ashley Road and Albyn Grove to by-pass the city centre.

4.11.18 If this LEZ option, and option 4A, are to be considered further, then these rat-run issues would need to be addressed.

4.11.19 Aside from the above, the Option 5 LEZ generally fits well with the Network Hierarchy.

Option 5- Car Park Accessibility

4.11.20 The Option 5 boundary is concise around the city centre area (as per Option 1). The small LEZ area allows 8 of 12 City Centre Car Parks to be available for non-compliant vehicles.

Option 5 - Residential Consideration

4.11.21 The smaller LEZ area associated with Option 5 has very limited impact on residential properties within the LEZ boundary and is primarily limited to the core city centre area.

4.12 Network Summary Statistics For Option 4A and Option 5

4.12.1 Network summary statistics report on the overall network performance of a model. Four key global network statistics that can be extracted from the models are:

- Total Distance Travelled
- Average Time Taken
- Mean Speed
- Average Number of Vehicles in a Queue.

4.12.2 The total distance travelled statistic is based upon the cumulative travelled distance for all vehicles in the model. An increase in the total distance travelled is usually representative of an increase in travel demand.

4.12.3 The average time taken statistic is based upon the average time for all trips in the network to make their journey. An increase in this statistic represents a deterioration in the operation of the network.

4.12.4 The mean speed statistic represents the average speed for all vehicles in the model network. A decrease in average speed represents a deterioration in the operation of the model network.

4.12.5 The average number of vehicles in a queue is an hourly statistic that collates the total number of queueing vehicles across the network. An increase in the number of vehicles queueing is a good indicator of an increase in congestion within the model network.

4.12.6 Table 19 provides a summary of the first three global statistics for LEZ Options 4A and 5 against ACCPM24. Table 20 provides the results for Average Vehicles in a Queue.

Table 19. Network Summary Statistics

Percentage Difference to the Ref Case						
Peak	Percentage demand level	Scenario	Number of Vehicles	Total Distance Travelled (km)	Average Time Taken (hh:mm:ss)	Mean Speed (mph)
AM	95%	2024 Ref Case	78779	259881	00:07:15	16.96
	95%	Option 4A	-0.3%	1.0%	5.5%	-4.0%
	95%	Option 5	-0.4%	1.2%	13.2%	-10.2%
IP	95%	2024 Ref Case	164848	474968	00:05:48	18.53
	95%	Option 4A	-0.9%	0.3%	10.0%	-8.0%
	95%	Option 5	-0.2%	1.4%	5.1%	-3.3%
PM	95%	2024 Ref Case	93788	300136	00:08:05	14.77
	95%	Option 4A	-1.2%	0.4%	13.9%	-10.8%
	95%	Option 5	-0.8%	1.2%	15.9%	-12.0%
12 Hr	**95%**	**2024 Ref Case**	**337415**	**1034985**	**00:07:02**	**16.75**
	95%	**Option 4A**	**-0.9%**	**0.5%**	**10.0%**	**-7.5%**
	95%	**Option 5**	**-0.4%**	**1.3%**	**12.0%**	**-8.2%**

Table 20. Average No. Vehicles in a Queue

	Average Number of Vehicles in a Queue (Veh)		
Time	Ref Case 2024	Op 4A	Op 5
07:00:00	11045	8813	9507
08:00:00	12230	10331	10677
09:00:00	10083	8872	9566
10:00:00	9055	7791	7751
11:00:00	9257	8096	8156
12:00:00	9920	8729	8857
13:00:00	10054	9061	9063
14:00:00	9582	8664	8708
15:00:00	10436	9443	9580
16:00:00	12573	11662	12631
17:00:00	14359	13602	15070
18:00:00	11808	11178	12821
Total	**130400**	**116244**	**122387**
% Diff.	-	**-11%**	**-6%**

4.12.7 The following comments can be drawn from the global network statistics:

- The increase in global distance travelled in the LEZ scenarios relates to the additional distance that non-compliant traffic requires to route. This is 0.5% for Option 4 and 1.3% for Option 5. Note that there is an assumption of more compliant vehicles in Option 4A than Option 5
- The results for the Average time taken and mean speed suggest that there is a deterioration on the network operation when the LEZ is in place. This is anticipated as the LEZ requires traffic to route further. Option 4A operates slightly better than Option 5
- However the results of the average vehicles in a queue statistic suggest that the LEZ reduces the overall queueing in the network. It is assumed that this is due to the removal of traffic from some of the high queue areas within the LEZ area. Essentially the LEZ dissipates traffic out wider thus reducing overall queueing. Option 4A operates better than Option 5 but both are lower than the ACCPM24.

4.13 Outcome From LEZ Sifting Process

From the additional assessment of Option 5, ACC agreed to take LEZ boundary Options 4A and 5 forward for further consideration and assessment.

These two LEZ boundary options were fed back to the NLEF process for further appraisal of their suitability.

The NLEF appraisal concluded that Option 4A did not meet all the criteria for accessibility and inclusion. In addition, in light of the impact of COVID -19 to the city centre economy, it was considered that in LEZ Option 4A, due to the accessibility limitations within this option there would be a higher risk to the economic recovery and resilience of the city centre.

For these reasons, only the LEZ boundary **Option 5** was taken forward for further consideration.

5. LEZ SUPPORTING MEASURES – CITY CENTRE MASTERPLAN

5.1 Introduction

5.1.1 The Aberdeen LEZ is required to complement other committed network proposals for Aberdeen City Centre to provide a package of measures which will meet the objectives of the LEZ and wider Council objectives for Aberdeen City Centre. These committed proposals include the City Centre Masterplan (CCMP).

5.1.2 The model testing of the LEZ has identified a preferred boundary option. However, the modelling suggests that the LEZ alone is not enough to reduce all NO_2 levels below the AQO of 40µg/m^3 across the city centre area.

5.1.3 To enable the development of a package of measures to meet the objectives of the LEZ study, traffic modelling was utilised to identify if any elements of the City Centre Masterplan not yet implemented would enhance and support the LEZ in meeting the objectives.

5.1.4 The approach taken to the traffic modelling was to identify the impact of LEZ and CCMP measures separately, before utilising the model outputs of each study to develop a combined scenario package which is most likely to meet the overall objectives of the LEZ study.

5.1.5 A separate modelling exercise was therefore undertaken on various elements and projects within the CCMP. This is detailed in the Report: *City Centre Masterplan Model Testing Report* (Ref: GB01T20D62/3, March 2021).

5.1.6 This Chapter details the development of a proposed package of measures combining the proposed LEZ with CCMP infrastructure to best meet the objectives of the LEZ study.

5.2 City Centre Masterplan – Project Detail

5.2.1 The Aberdeen City Centre Masterplan (CCMP) road infrastructure proposals were initially assessed in the previous Aberdeen City Centre Model (ACCPM12) in 2016 to derive an initial implementation strategy for the full scheme proposals over a 25 year programme. The outcome of this assessment is detailed in Figure 6.

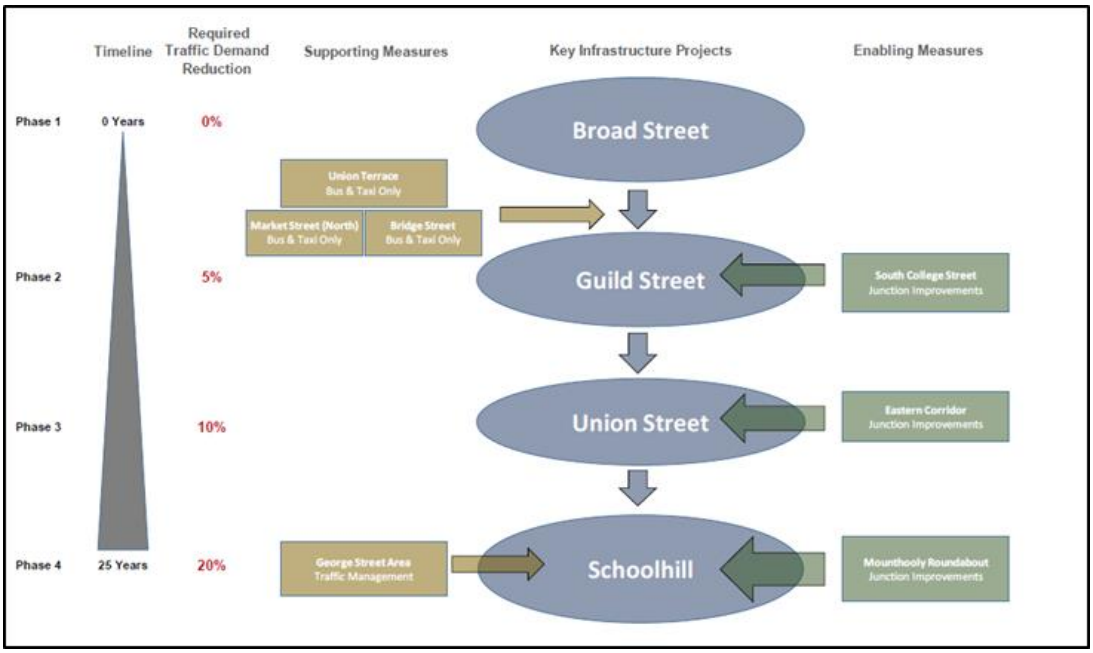

Figure 6. CCMP Proposed Implementation Programme

5.2.2 As detailed in Figure 6, there were four key infrastructure projects proposed over a 25 year programme, numbered as Phase 1 to Phase 4. Phase 1 has already been completed (Broad Street Project).

5.2.3 Within each Phase of the Masterplan, there are supporting measures and enabling measures proposed. These have been identified through the extensive model testing exercise undertaken in 2016. It was not proposed to reconsider the individual measures making up each of the identified implementation phases, unless they contradict other more recent project proposals (i.e. Road Network Hierarchy Reclassification).

5.2.4 The above phasing of the proposed CCMP implementation includes the requirement to gradually reduce traffic demand across the city centre area down by a total of 20% to facilitate the measures proposed.

5.2.5 Given that traffic demand and patterns are constantly changing, continual monitoring of the proposed implementation programme is essential. Therefore, under the remit of the current LEZ study, it was important to consider different combinations of 'projects' within the overarching CCMP proposals to assess whether the order of the implementation programme could be re-considered. This also highlights if the global traffic demand requirements have deviated from the initial analysis.

5.2.6 The 2019 model test programme considered the impact of each of the key City Centre Masterplan (CCMP) projects separately, then in combination with each other. The network mitigation, which was previously identified in the original CCMP project (2016), was assessed separately to gauge the updated impact of the additional measures.

5.2.7 The model demand level that each test scenario was able to run at is detailed in Table 21.

Table 21. CCMP Model Scenarios – Traffic Demand Level Achieved

Scenario	Detail	Peak Period		
		AM Peak	IP Peak	PM Peak
CCMP1	Full Scheme	90%	90%	85%
CCMP2a	Guild St Scheme	95%	100%	95%
CCMP2b	Guild St Scheme + Mitigation	100%	100%	95%
CCMP3a	Union St Scheme	100%	100%	90%
CCMP3b	Unioin St Scheme + Mitigation	100%	95%	95%
CCMP4a	Schoolhill Scheme	100%	100%	95%
CCMP4b	Schoolhill Scheme + Mitigation	100%	100%	95%
CCMP5a	Guild St & Union St Scheme	95%	100%	85%
CCMP5b	Guild St & Union St Scheme + Mitigation	95%	100%	85%
CCMP6a	Guild St & Schoolhill Scheme	100%	100%	90%
CCMP6b	Guild St & Schoolhill Scheme + Mitigation	100%	100%	90%
CCMP7a	Union St & Schoolhill Scheme	95%	95%	90%
CCMP7b	Union St & Schoolhill Scheme + Mitigation	95%	95%	90%

5.2.8 The results suggest that none of the scenarios would be able to cater for the full 2024 network demand. However, a 95% demand level was achieved in the PM peak for several scenarios. This is essentially equivalent to a 2% background growth on the 2019 observed traffic levels.

5.2.9 It should also be noted that the LEZ is only able to run in ACCPM24 at 95% demand. Both the results of the LEZ and the CCMP testing suggest that allowing the traffic volume within the city centre to continue to grow exponentially would make it very difficult to introduce traffic restriction measures in the city centre in the longer term.

5.2.10 Assessing network restrictions at 95% of the predicted future demand level still allows the network to operate, but highlights the need for these proposed traffic restrictive measures to be implemented before the traffic demand level gets too high. In essence, the LEZ and the CCMP assist with traffic demand management in the city centre.

5.2.11 Whilst some of the above CCMP scenarios did not run at even 95% demand, it is important to note that the LEZ effectively reduces traffic within the city centre area by the re-distribution of non-compliant vehicles.

5.2.12 Therefore, the CCMP measure and the LEZ measures do complement each other well, as the LEZ reduces traffic demand around the city centre to enable the CCMP measures to operate, whilst at the same time the CCMP measures further reduce traffic volumes through the areas of air quality concern.

5.3 Identification of Required Measures

5.3.1 As detailed in Section 4.11, the Option 5 LEZ boundary is anticipated to positively impact on the vast majority of air quality exceedance areas within the city centre. Table 18 showed that 13 of the 18 NO_2 exceedance locations were predicted to be well within the 40µg/m^3 exceedance threshold. Three of the five remaining locations were predicted to be just under the threshold, and two: Site DT11-King St and Site DT17-Union St were predicted to still be over the threshold.

5.3.2 In order to identify which CCMP scheme, or combination of schemes, would best address the remaining predicted exceedance locations, traffic flow changes between the 2019 base model and each of the CCMP test scenarios were compared at each of the exceedance locations.

5.3.3 It is a logical assumption that where the CCMP is anticipated to result in an increase in traffic flows, then this would subsequently result in an increase in vehicle emissions.

5.3.4 Table 22 shows a summary of the traffic flow changes at the 14 NO2 exceedance locations compared to the 2019 base. The figures provided are the 12 hr percentage flow change from the 2019 baseline in two-way traffic flow.

5.3.5 From analysis of the results, it was identified that CCMP test CCMP3a: 'Union St Scheme' was the best scenario to potentially address the remaining exceedances.

5.3.6 Traffic modelling of the Union Street Scheme showed a reduction in traffic flows through the NO_2 exceedance locations of King St and Union Street whilst also potentially providing some traffic reductions through Holburn Street.

5.3.7 As a result of the Union Street Scheme, the traffic flows through the harbour route of Trinity Quay and Virginia St showed a very marginal increase. However this was significantly lower than many of the alternative CCMP scenarios.

Table 22. CCMP Scenarios – Exceedance Location Flow Analysis (% change from 2019 Base)

Site	Exceedance Location	LEZ Option 5 AQ Impact	CCMP 1 Full Scheme	CCMP 2a Guild St Scheme	CCMP 2b Guild St Scheme + Mitigation	CCMP 3a Union St Scheme	CCMP 3b Unioin St Scheme + Mitigation	CCMP 4a Schoolhill Scheme	CCMP 4b Schoolhill Scheme + Mitigation	CCMP 5a Guild St & Union St Scheme	CCMP 5b Guild St & Union St Scheme + Mitigation	CCMP 6a Guild St & Schoolhill Scheme	CCMP 6b Guild St & Schoolhill Scheme + Mitigation	CCMP 7a Union St & Schoolhill Scheme	CCMP 7b Union St & Schoolhill Scheme + Mitigation
DT30	335 Union St		-36%	0%	1%	-36%	-22%	7%	11%	-22%	-28%	1%	6%	-20%	-19%
DT73	61 Skene Square		25%	-3%	-4%	-12%	8%	0%	18%	27%	14%	2%	16%	1%	19%
DT18	14 Holburn St		-14%	13%	14%	-25%	-7%	10%	11%	8%	0%	14%	11%	-5%	-5%
CM2	Union Street		-47%	-7%	-6%	-45%	-35%	9%	9%	-33%	-38%	-5%	1%	-33%	-32%
DT16	1 Trinity Quay		31%	17%	17%	2%	19%	11%	15%	40%	17%	20%	19%	27%	33%
DT77	27 Skene Square		25%	-3%	-4%	-12%	8%	0%	18%	28%	14%	2%	16%	1%	19%
DT11	105 King St		32%	4%	36%	-15%	35%	8%	14%	26%	43%	13%	42%	4%	45%
DT10	184/192 Market St		28%	14%	14%	4%	12%	7%	7%	37%	15%	17%	17%	13%	18%
DT9	39 Market St		-64%	-70%	-70%	-30%	-22%	0%	7%	-63%	-66%	-70%	-70%	-22%	-15%
DT29	469 Union St		-43%	6%	7%	-43%	-29%	9%	9%	-27%	-33%	7%	5%	-29%	-29%
DT12	40 Union St		-85%	-6%	-5%	-57%	-56%	19%	33%	-81%	-83%	-1%	18%	-54%	-51%
DT17	43/45 Union St		-85%	-6%	-5%	-57%	-56%	19%	33%	-81%	-83%	-1%	18%	-54%	-51%
DT82	7 Virgina Street		18%	16%	17%	6%	15%	10%	16%	43%	17%	20%	21%	25%	30%
DT19	468 Union St		-43%	6%	7%	-43%	-29%	9%	9%	-27%	-33%	7%	5%	-29%	-29%

5.4 CCMP – Union Street Scheme

5.4.1 The Union Street Scheme is a package of measures within the CCMP, based around proposed restrictions to general traffic through Union Street, between Bridge Street and Market Street

5.4.2 The key elements of the Union Street Scheme are:

- Union St - Bus and Taxi only between Bridge Street and Market Street
- Union Terrace - Bus and Taxi only (potentially south end only)
- Rose St - Pedestrianised between Union St and Thistle St.

5.4.3 Figure 7 schematically shows the key elements of Union Street CCMP Scheme.

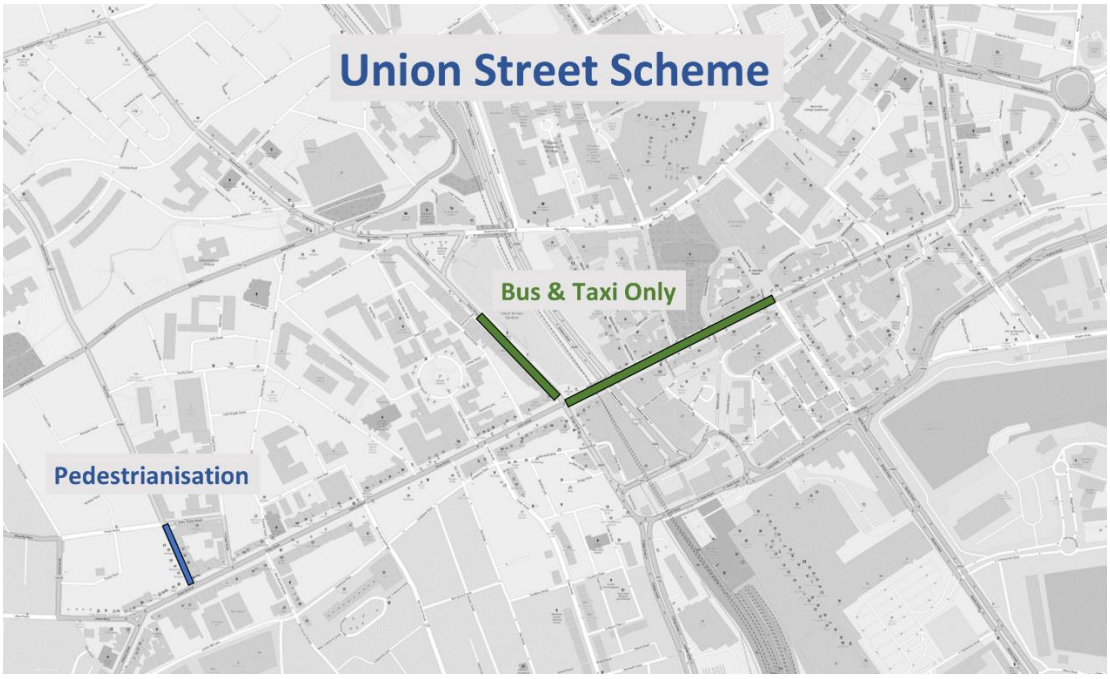

Figure 7. CCMP – 'Union St Scheme'

5.4.4 The rationale for the package of measures associated with the Union Street Scheme are as follows:

- Extensive testing of individual elements of the CCMP in 2016 identified that Union Terrace restrictions were required in combination with the Union St restrictions to prevent local traffic diversions through Schoollhill / Upperkirkgate
- With the Union Terrace restriction in place, traffic seeking to route between Union St and Skene Street utilise Rose Street as a rat run, hence the requirement to restrict this movement to push through routing traffic out-with the city centre area
- Rose St pedestrianisation is identified within the CCMP Master documents. This proposals also has placemaking advantages.

5.5 Model Testing of LEZ with CCMP: Union St Scheme

5.5.1 LEZ Option 5 was utilised to develop the wider package of measures including the CCMP: Union St Scheme. This model scenario including both the Union St Scheme and the LEZ is named Test Option 6 (for the purposes of this report).

Option 6 - Model Demand Level

5.5.2 Table 23 shows the demand level that the test scenarios were able to run at in each peak.

Table 23. LEZ & CCMP – Network Demand Level

Peak Period	Scenario: CCMP - Union St Scheme	LEZ - Option 5	LEZ+CCMP - Option 6
AM	100%	100%	100%
IP	100%	100%	100%
PM	90%	95%	95%

5.5.3 This high level model test result shows that whilst the Union St Scheme could only be run at 90% of the future year traffic demand, when it was tested in combination with the LEZ, a 95% demand level was attained. This is consistent with the demand level attained for LEZ Option 5.

5.5.4 ***Option 6 - NO_2 Exceedance Locations***

5.5.5 Table 24 provides both the traffic flow difference to the 2019 baseline and the resultant predicted air quality impact at the NO2 exceedance locations.

5.5.6 The traffic flow differences are provided as a percentage difference of 12 hour traffic flow compared to the 2019 Base model.

Table 24. LEZ & CCMP Impact at Air Quality Exceedance Locations

Site	Exceedance Location	Flow Difference to Base Option 5	Flow Difference to Base Option 6	Air Quality Impact Option 5	Air Quality Impact Option 6
DT30	335 Union St	5%	-25%		
DT73	61 Skene Square	-8%	-10%		
DT18	14 Holburn St	1%	-14%		
CM2	Union Street	3%	-41%		
DT16	1 Trinity Quay	-7%	8%		
DT77	27 Skene Square	-8%	-10%		
DT11	105 King St	3%	-2%		
DT10	184/192 Market St	-4%	-2%		
DT9	39 Market St	1%	-36%		
DT29	469 Union St	3%	-32%		
DT12	40 Union St	9%	-61%		
DT17	43/45 Union St	9%	-61%		
DT82	7 Virgina Street	-8%	5%		
DT19	468 Union St	3%	-32%		

NO_2 Levels predicted to be Under Threshhold

NO_2 Levels predicted to be Near Threshhold

NO_2 Levels predicted to be Over Threshhold

5.5.7 Table 24 shows that the Union St Scheme has a significant impact on the volume of traffic routing through Union Street, with a 60% reduction in traffic at two of the NO_2 exceedance sites. This also has an additional impact to the volume of traffic approaching Union St from both Holburn St and King St. These traffic reductions will therefore have a direct impact on the air quality figures at these locations.

5.5.8 The Union St restrictions also result in traffic diversions to other local routes. The harbour routes of Trinity Quay and Virginia Street therefore show a slight increase in traffic volumes due to the restrictions on Union St. It should, however, be noted that these locations are still within the LEZ boundary and therefore any slight increase in traffic flow will have a limited detrimental impact on the NO_2 levels.

5.5.9 In summary, the CCMP -Union St Scheme results in traffic reductions through key areas of the city centre network where measures are required in addition to the LEZ.

The City Centre Masterplan – 'Union St Scheme' has shown to complement the proposed LEZ to positively impact on the NO2 exceedance locations. This combination of the LEZ plus the Union Street Scheme is predicted to significantly reduce the emission levels at all the 2019 observed NO_2 exceedance locations.

SYSTRA therefore recommends that the LEZ and the CCMP- Union St Project is viewed as a combined package of measures to meet the objectives of the LEZ scheme.

5.6 Union Street Scheme: Alternative Traffic Intervention Detail

5.6.1 The Aberdeen City Centre Masterplan is a 20 year development strategy which includes significant changes to the operation of the traffic network around the city centre area. Whilst the Masterplan Report (BDP, June 2015) outlines the proposed traffic interventions within the city centre area, ACC view these as outline proposals and are flexible to the changing road space demands and overarching vision for the city centre as the project moves forward over time.

5.6.2 As part of the development of a package of measures associated with the LEZ, alternative traffic intervention detail within the Union St scheme was considered. This was primarily split into two elements:

- Extent of the Union Street interventions
- Classification of Vehicle Restrictions on Union Street.

Extent of Union Street Restrictions

5.6.3 The proposed Union St restrictions result in traffic diversions to other local routes including the harbour routes of Trinity Quay and Virginia Street. In order to help alleviate the additional traffic volume on the harbour route, consideration was given to extending the restrictions on Union Street from Market Street through to Broad Street (See Figure 8).

5.6.4 This extension would effectively result in Market Street (North of Guild Street) operate as a bus and taxi only corridor, which in turn, would allow improved priority for the Harbour route traffic movement at the Guild St / Market St signalised junction.

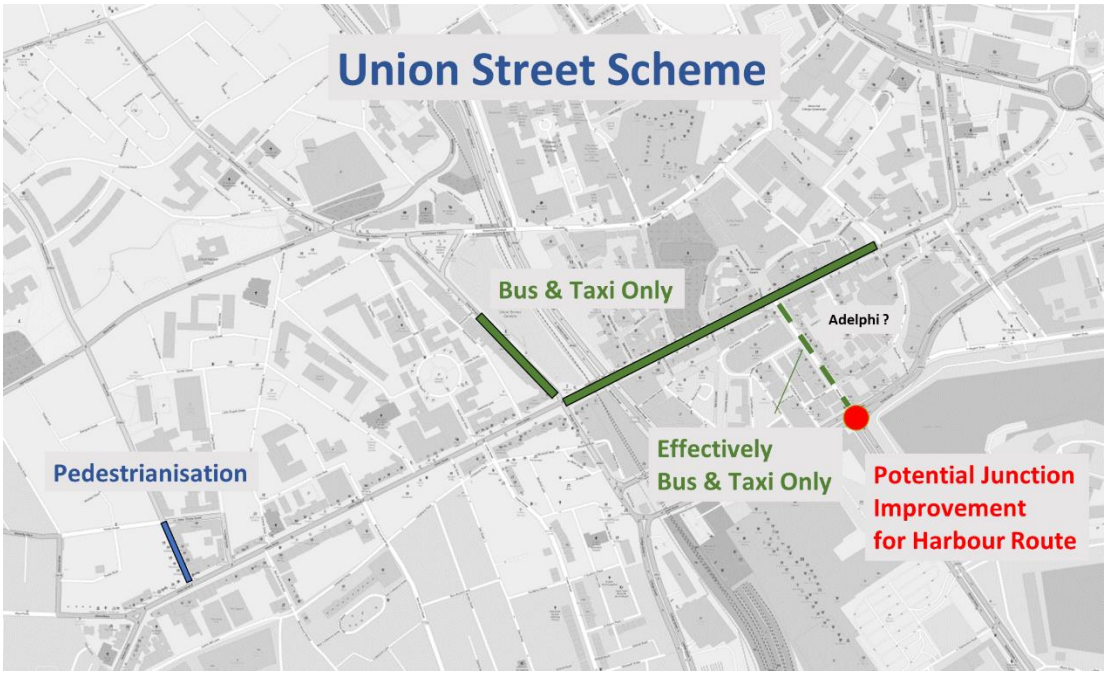

Figure 8. Alternative Union Street Restrictions

5.6.5 Model testing of the revised restrictions were undertaken. The modelling showed that the effective closure of Market St (north) and Union St (east of Market St) resulted in a further

increase in traffic on Trinity Quay and Virginia Street. Any signal timing benefit accrued at the Guild St / Market St junction was offset by the increase in traffic displaced to the harbour corridor.

> SYSTRA would recommend that, for the LEZ package of measures, the proposed Union Street interventions remain between Bridge Street and Market Street.

Classification of Vehicle Restrictions on Union Street

5.6.6 ACC requested that SYSTRA undertake a high level assessment of various traffic restriction scenarios on Union Street and Union Terrace.

5.6.7 Whilst these considerations are not within the remit of the LEZ study, any deviation to the proposed restrictions through the city centre would require to be assessed as part of a final LEZ scheme.

5.6.8 The alternative options for the Union Street Scheme restrictions include:

- Bus only on Union Street and Union Terrace (no Taxis)
- Full pedestrianisation of Union Street.

5.6.9 High level model testing has shown that the alternative restrictions through the city centre do not impact on the demand level that the model is able to run at nor do they impact greatly on the traffic flows around the NO_2 exceedance areas. There are additional considerations within these proposals, especially for the full pedestrianisation option, which would potentially impact the public transport network.

5.6.10 SYSTRA have recommended that further work is required to fully assess the implications of the various traffic restriction options through the city centre.

5.6.11 Whilst the detail of the restrictions are therefore not fully defined at this point in the study, traffic modelling has shown that restrictions to through-routing general traffic on Union St and Union Terrace would enhance the air quality levels within the city centre when considered in combination with the LEZ.

5.6.12 Similarly, the detail of the restrictions proposed for traffic on Rose Street may require further consideration by ACC.

> Given the requirement to investigate the level and detail of traffic restrictions in the city centre, and the requirement to gauge wider opinion on the level of restrictions proposed, the restrictions identified through Union Street, Union Terrace, and Rose Street will currently be classified as ‘General Traffic Restrictions’ within the proposed LEZ package of measures.

6. LEZ SUPPORTING MEASURES – MANAGEMENT OF DISPLACED TRAFFIC

6.1 Introduction

6.1.1 The Aberdeen LEZ is required to complement other network proposals for Aberdeen City Centre to provide a package of measures which will meet the objectives of the LEZ and wider Council objectives for Aberdeen City Centre.

6.1.2 As detailed in Section 4.11, the proposed LEZ boundary generally fits well with the revised hierarchy proposals, with the exception of a noticeable increase in traffic through the east-west route of Fonthill Road / Ferryhill Road. (Non-compliant) traffic increases were also noted around the west end of Union Street through routes including Ashley Road and Albyn Grove to by-pass the city centre LEZ boundary.

6.1.3 This chapter details the model sensitivity testing undertaken to better manage non-compliant traffic displacement from the LEZ.

6.2 Management of Non-Compliant Traffic

6.2.1 LEZ Boundary Option 5 (&6) has the effect of restricting all non-compliant vehicles from routing through the city centre area, but critically, it does not restrict access to the city centre (car park options still available for all traffic). This is consistent with other policies and aspirations for Aberdeen City Centre.

6.2.2 Figure 9 shows the ideal routing strategy for non-compliant vehicles around the city centre. These trips fall into three general categories:

- Local & strategic non-compliant vehicles routing to/from the city centre – multiple access routes to car parks and roads around the periphery of the LEZ
- Local non-compliant vehicles routing around the LEZ – local distributor routes (including Anderson Drive) to cater for trips originating and destinating within Aberdeen
- Strategic non-compliant vehicles routing around the LEZ via the Aberdeen Western Periphery Route (AWPR).

6.2.3 The model testing of LEZ Option 5 (&6) has shown that non-compliant traffic (due to the LEZ) and compliant traffic (due to the Union St restrictions) are finding local routes around the periphery of the LEZ but within the boundary of Anderson Drive (See schematic in Figure 10 and model flow plot in Appendix C. ***Link To Option 5*)**.

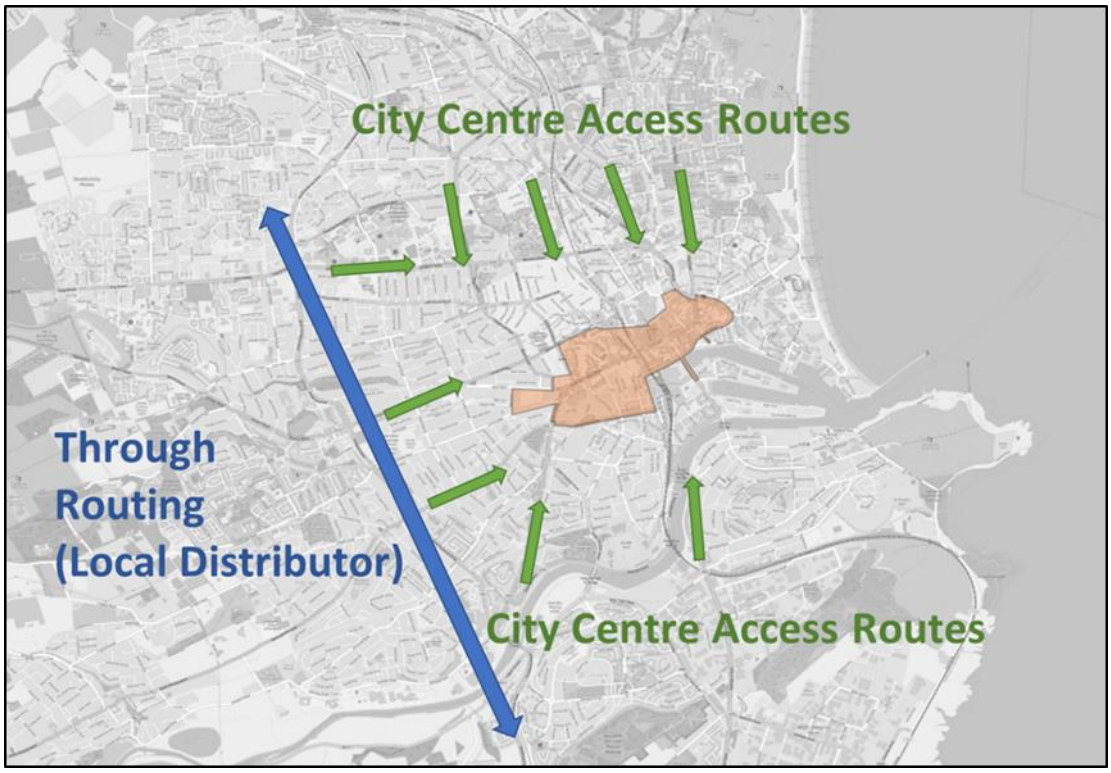

Figure 9. Ideal Routing Strategy for Displaced Traffic

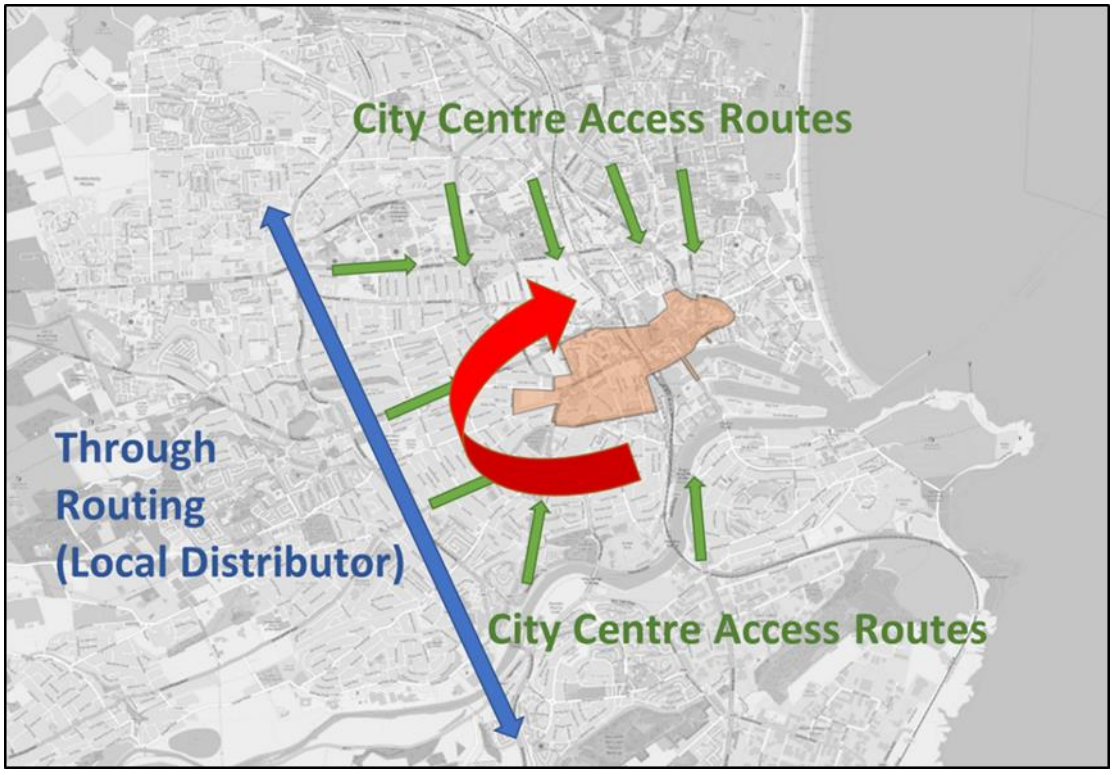

Figure 10. Actual Model Routing of Displaced Traffic

6.2.4 Some of the key routes affected by the diversion of traffic around the west end of the LEZ boundary are given in the summary table below. This table shows the traffic flow changes between the ACCPM24 and LEZ Option 6 in the PM Peak Period.

Table 25. Key Rat Run Areas for LEZ Option 6

Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Ashley Rd	SB	544	868	324	59%
Ashley Rd	NB	567	863	297	52%
Albyn Grove	NB	718	1062	345	48%
St Swithin St	SB	773	1124	351	45%
Fonthill Rd	WB	1048	1415	368	35%
Fonthill Rd	EB	746	978	232	31%

6.3 Traffic Management Options

6.3.1 Through discussions with ACC, several options were developed to better manage the displacement of traffic around the south and west border of the proposed LEZ. These included:

1. Extension of LEZ boundary to include full South College Street corridor
2. Bus Gate on Ferryhill Road
3. Traffic Management Measures to restrict routing on Ashley Road and Forrest Avenue
4. Revised Milburn St / South College Street Junction as part of South College Street Improvements – Phase 2.

6.3.2 Figure 11 shows the location of these proposals together with the LEZ boundary.

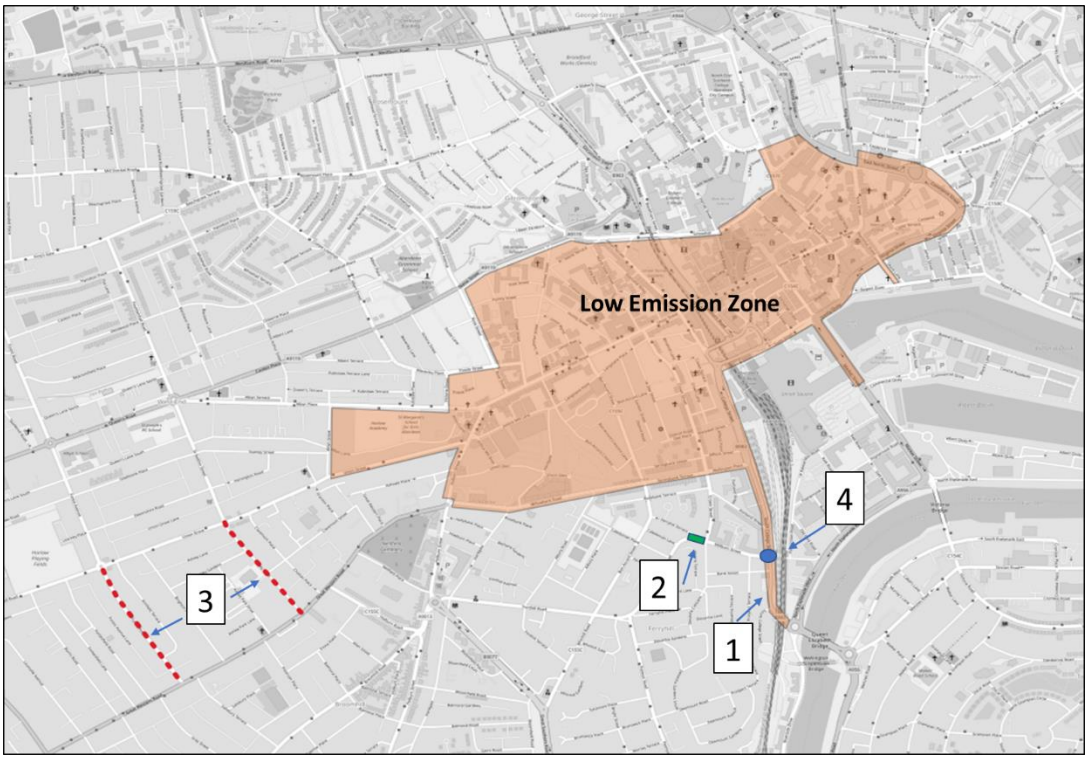

Figure 11. Traffic Management Options

6.3.3 Through model testing of the various options, and in consultation with ACC, the following conclusions were drawn from each option:

1. Extension of LEZ Boundary

   - ACC raised an issue with extending the LEZ for a traffic management reason and not for an air quality reason
   - Model testing showed only a slight improvement to traffic volume through Ferryhill Road corridor. A high proportion of the traffic on this corridor was actually compliant vehicles. This suggests that the Union St measures were also a key factor in the traffic increases through this corridor
   - The LEZ extension option would therefore not fully manage traffic displaced from the city centre area and was excluded from further consideration.

2. Bus Gate on Ferryhill Road

   - ACC advised that this was an acceptable consideration but not preferable over alternative proposed measures at Milburn Street / South College Street junction as it is more intrusive than other measures, and includes maintenance costs and may not be popular with the general public
   - Model testing showed a significant reduction in traffic through the Ferryhill corridor by as much as 95%. However a significant proportion of this traffic was observed to divert through Albury Road to Springbank Terrace, thus retaining traffic routes through the area.

3. Traffic Management Measures through Ashley Road and Forrest Avenue

   - Model testing had shown a high volume of traffic routing around the western edge of the LEZ / City Centre area. SYSTRA identified that Ashley Road carried a high proportion of this traffic. Whilst Forrest Avenue was not included within the model, ACC advised that rat-running traffic is also known to use this route in parallel with Ashely Road
   - Model Testing showed a significant reduction on traffic on Ashley Road when routing costs were increased (actual traffic management measures not defined at this point)
   - Model testing also showed little improvement on traffic routing through the Ferryhill corridor as the restrictions pushed traffic out to Anderson Drive but still left routing between Holburn St and South College Street through the Ferryhill corridor.

4. Revised Milburn St / South College Street Junction

   - The South College Street Scheme is to be implemented in 2022 and is considered as Phase 1 of a two phase programme of works. The first phase involves the creation of a link road between South College Street and North Esplanade West to alleviate traffic congestion at the QEII Bridge roundabout
   - As advised by ACC, a second phase will consider changes to the junctions at either end of QEII Bridge. As part of Phase 2, ACC were also considering restricting access to Milburn St from South College St, pending a review of the operation of the junction (post-implementation of Phase 1)
   - Following advisement of the traffic modelling impact of the LEZ, ACC advised SYSTRA to consider restricting access to/ from Milburn St to restrict strategic movement through this corridor
   - Model testing was undertaken on a design option (specific design detail will be developed in due course)
   - The traffic modelling showed that there was only a small (approx. 10% on average) increase in the two way traffic flow on the Milburn Street corridor in the LEZ scenario compared to ACCPM24
   - This proposal effectively cuts off the Ferryhill corridor as a rat-run and pushes traffic back out to Anderson Drive. It was found to be, on balance, the best solution of the options considered.

The model testing of various proposals to manage traffic displaced from the city centre has identified that a revision to the operation of the Milburn St / South College Street junction is best placed to address potential rat runs through the south and west border of the LEZ.

Junction changes are required to restrict or prevent strategic traffic easily routing through Milburn St and through the Ferryhill corridor. Further assessment of the specifics of these measures will be considered by ACC in due course.

6.4 Further consideration of Rose Street Pedestrianisation Proposal

6.4.1 As detailed in Section 5.4.4, the pedestrianisation of the south end of Rose Street has been identified within the CCMP core proposals. Previous traffic modelling has shown that, when Union Terrace and Broad Street are closed to routing traffic, alternative routes connecting Union St to Skene Street become more attractive alternative routes. This is the primary reason for including Rose St pedestrianisation as part of the Union Street Scheme package of measures.

6.4.2 As a sensitivity test, Rose St was re-opened to general traffic to assess the impact of this proposed measure.

6.4.3 Figure 12 shows the PM Peak flow difference plots between the two Rose St scenarios and the ACCPM24. Red banding represents traffic flow increases, Blue banding flow reductions.

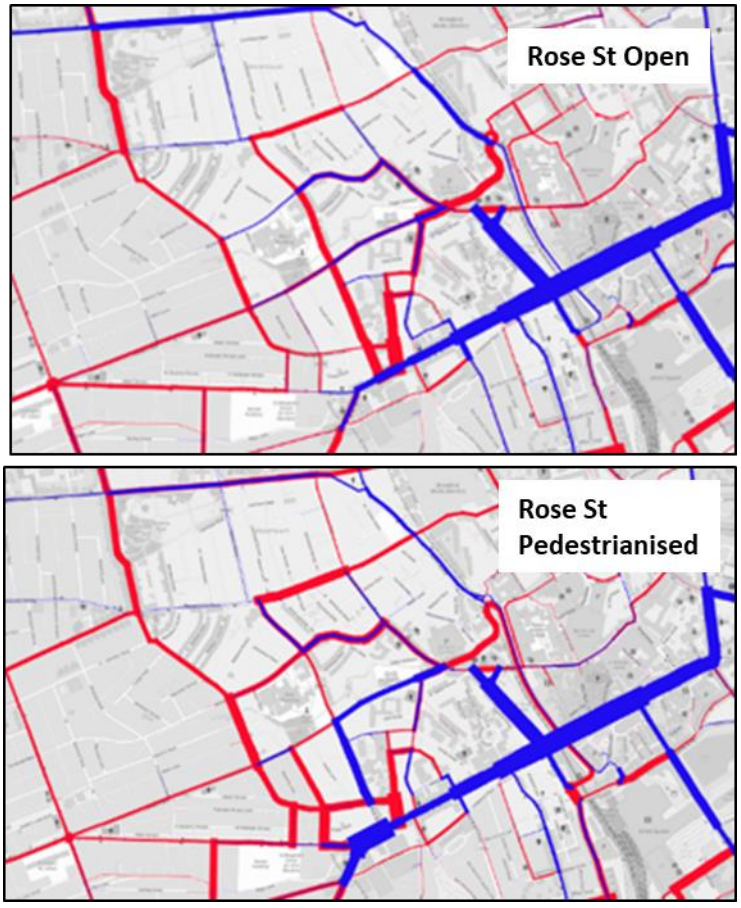

Figure 12. PM Peak Flow Difference Plot for Rose St Variation

6.4.4 Table 26 Provides 12 hour traffic flow differences between the two Rose St scenarios and ACCPM24.

Table 26. Key Traffic Flow Differences for Rose St Restrictions (12 Hr Veh)

Location	Ref Case (Veh)	Percentage Change from Ref Case	
		Rose St Open	Rose St Pedestrianised
Albyn Place EB	4694	-9%	-27%
Rose St NB	4292	40%	-100%
Albyn Place WB	2962	-11%	89%
Chapel St SB	2843	54%	67%
Albert Street NB	1957	13%	44%
Holburn St NB	6912	-1%	-7%
Holburn St SB	7715	8%	12%
Woolmanhill NB	3415	42%	29%

6.4.5 The model testing suggests that by not including the restrictions on Rose St, this allows increased traffic flow through the Rose St corridor and Esslemont Avenue to Skene Street. However, the modelling also suggests that restricting traffic through Rose St diverts some of this traffic though Albyn Place and Albert St.

6.4.6 The scale of the traffic rat running may not be as high as the modelling suggests due to the fixed trip nature of the traffic modelling – see comments on this in Section 6.7.

6.4.7 What is clear is that the modelling suggests the Rose St restrictions do prevent an increase in rat-running through this corridor as well as placemaking benefits through the retail section of this corridor.

6.4.8 SYSTRA would recommend that the volume of traffic on Holburn St through Albyn Place is monitored post-LEZ implementation. If a north-south corridor through this route is established, then further traffic restrictions could be considered. Some of which are detailed in the CCMP and Network Hierarchy reports.

6.5 Traffic Management through Springbank Terrace Corridor

6.5.1 As noted in Section 6.2, the traffic modelling of LEZ Option 6 (Including Union Street CCMP scheme) has shown that non-compliant traffic (due to the LEZ) and compliant traffic (due to the Union St restrictions) are finding local routes around the periphery of the LEZ but within the boundary of Anderson Drive.

6.5.2 The closure of Union Street to general traffic was observed to put additional pressure on the Wellington Place/Springbank Terrace/Willowbank Road corridor. Model observations showed traffic queuing at the junctions of Springbank Terrace / Crown St and Springbank Terrace / Bon Accord St (Figure 13).

Figure 13. Location of Potential Future Traffic Management Requirements

6.5.3 The cause of the congestion in the model was found to be an increase in right turning traffic at these junctions. As they are both narrow single lane approach junctions, waiting right turning traffic can block other traffic behind it. Model testing has found that by banning all the right turning movements at these junctions, the congestion levels are significantly reduced.

6.5.4 Given that this is a relatively minor change in the future year traffic modelling, and the mitigation identified may not necessarily be required under a different future network, ACC are planning to monitor this area of the network once the LEZ is in operation to understand how traffic is using this area and whether these additional restrictions are required.

6.5.5 Further comment on future year modelling is provided in Section 6.7.

6.6 Traffic Diversion Options around Union Street

6.6.1 As part of the current spaces for people measures that have been in place in Aberdeen city centre during the COVID pandemic, the right turn from Union Street to Bridge Street was re-opened to all traffic (See Figure 14). This is normally a banned movement but was opened to allow general traffic a route around the temporary pedestrianised section of Union Street.

6.6.2 The allowance of a right turn from Union Street to Bridge Street was not included within the core testing of the LEZ & CCMP measures as it was not explicitly identified as part of the CCMP scheme.

6.6.3 ACC have highlighted that allowing this right turn for general traffic provides an exit strategy for vehicles routing along Union Street eastbound on approach to the proposed restrictions between Bridge St and Market Street.

6.6.4 From the perspective of the LEZ, the key concern with allowing this movement would be that it potentially allows an alternative east-west route through Union Street to Market Street via Bridge Street and Guild Street. This may not only have a detrimental impact at some of the NO_2 exceedance locations, but also potentially goes against one of the councils key city centre objectives to restrict traffic movement through the city centre. A sensitivity test was therefore undertaken to ascertain the impact of allowing the right turn movement from Union Street to Bridge Street under the LEZ & Union St Scheme (CCMP) scenario.

Figure 14. Temporary Changes to Traffic Movements on Union St between 2019 and 2020

6.6.5 Figure 15 shows a PM peak traffic flow difference plot between the LEZ Option 6 and LEZ Option 6 with the right turn from Union St to Bridge St allowed for all vehicles.

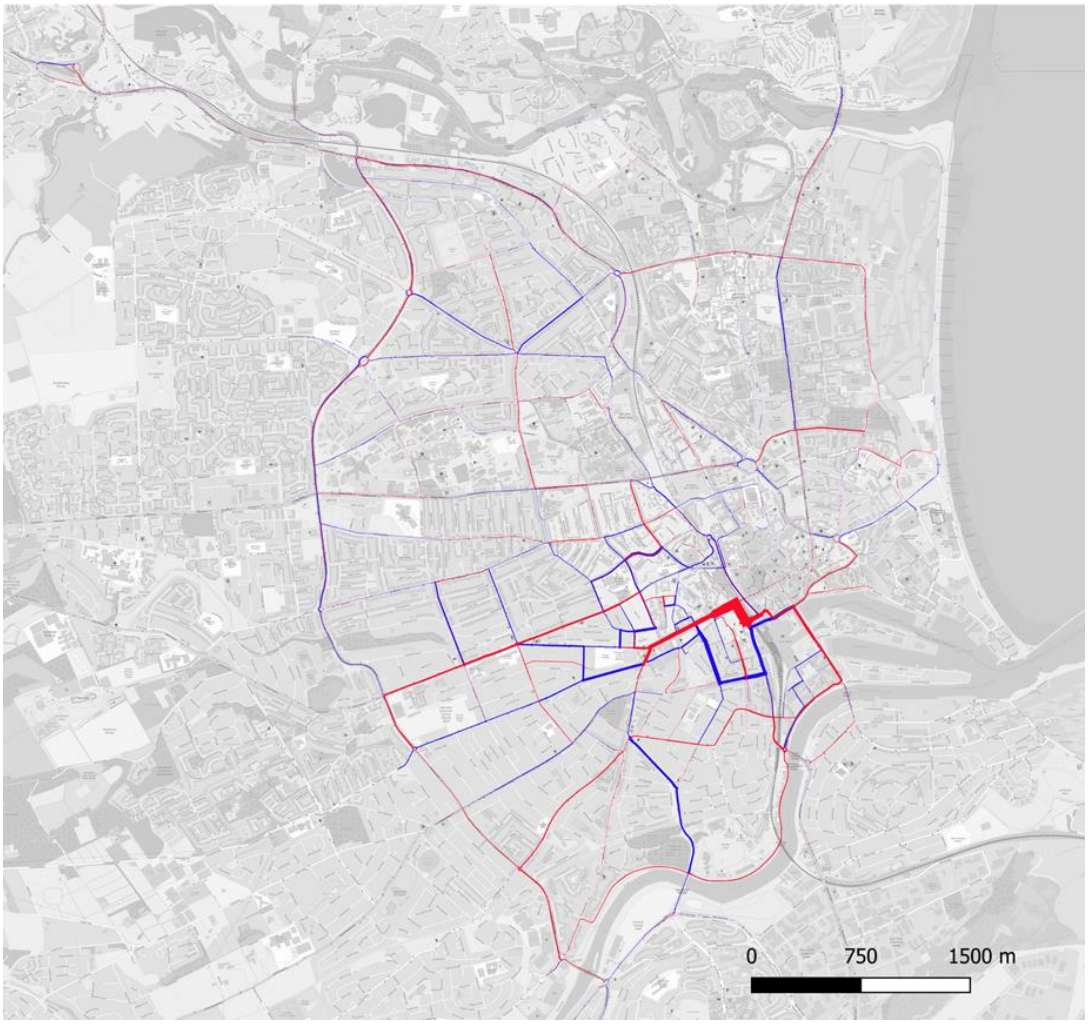

Figure 15. PM Peak Flow Difference Plot (Impact of R/T open on Union St to Bridge St)

6.6.6 It can be seen from Figure 15 that the opening of the right turn from Union Street to Bridge Street does allow for the creation of an alternative route through the city centre area utilising Bridget Street and Guild Street. Traffic flow increases are also observed through Union Street on the eastbound approach to the Union Street restrictions.

6.6.7 When the right turn movement is banned from Union St to Bridge Street in LEZ Option 6, there is some rat running within the model through Bon Accord St and Springbank Terrace. It can be seen in the above figure that this rat run is lessened when the right turn is allowed.

6.6.8 Table 27 provides the key 12 hour traffic flow comparisons between LEZ Option 6 with and without the right turn allowed from Union St to Bridge Street. The ACCPM24 flows are also provides for reference.

Table 27. 12 Hr Traffic Flow Comparison to ACCMP24

Location	Ref Case (at 95% demand) (Veh)	LEZ Option 6F R/T banned (Veh)	LEZ Option 6F R/T allowed (Veh)	LEZ Option 6F R/T allowed (% Diff to 6F)
Bridge St SB	1845	250	4496	1702%
Union St EB (West of restriction)	4301	2765	4780	73%
Albyn Place EB	4694	3408	4302	26%
Guild St EB	4009	5057	5858	16%
Holburn St NB	6912	6437	7076	10%
Denburn Rd NB	6958	8211	8966	9%
Union St WB (East of restriction)	5128	599	634	6%
Chapel St SB	2843	4740	4994	5%
Springbank Terrace WB	2049	2700	2812	4%
Market St SB	13205	11518	11836	3%
S College St NB (S of Palmerston Pl)	5201	7356	7545	3%
S College St SB (S of Palmerston Pl)	4772	5108	5181	1%
S College St SB (N of Palmerston Pl)	4639	4475	4475	0%
Holburn St SB	7715	8634	8407	-3%
Market St NB	11968	10996	10413	-5%
Bon-Accord St SB	2107	940	872	-7%
Bridge St NB	2317	2630	2436	-7%
Guild St WB	3210	5066	4521	-11%
Bon-Accord St NB	1291	774	689	-11%
Denburn Rd SB	6034	6502	5771	-11%
Union St EB (East of restriction)	5303	702	605	-14%
Albyn Place WB	2962	5596	4736	-15%
S College St NB (N of Palmerston Pl)	7417	9233	7669	-17%
Springbank Terrace EB	3012	6287	4594	-27%
Union St WB (West of restriction)	5171	4331	3144	-27%

6.6.9 The 12 hour traffic flow table shows a significant increase in traffic through Bridge Street southbound when the right turn from Union St is allowed. Not only is this a considerable increase compared to the alternative scenario, but is also significantly higher than the ACCPM24 Reference Case.

6.6.10 The allowance of the right turn from Union St to Bridge St also has an impact on the volume of traffic routing eastbound on Union St towards Bridge Street with almost double the traffic. This increase can also be traced back through Holburn Street and Albyn Place, and also forwards through Guild Street.

6.6.11 There are beneficial impacts of allowing the right turn manoeuvre, traffic flows on some of the potential rat run areas including Springbank Terrace and Albyn Place westbound are reduced.

6.6.12 The impact that the allowance of the right turn into Bridge Street has on the NO_2 exceedance locations can be seen in Table 28 below.

Table 28. Impact of R/T into Bridget St on Air Quality Exceedance Locations

		Flow Change from 2019 Base (Veh) LEZ Option 6F		Predicted Air Quality Impact LEZ Option 6F	
Site	Exceedance Location	R/T banned	R/T allowed	R/T banned	R/T allowed
DT30	335 Union St	-24%	-15%		
DT73	61 Skene Square	-10%	-8%		
DT18	14 Holburn St	-14%	-4%		
CM2	Union Street	-40%	-30%		
DT16	1 Trinity Quay	6%	6%		
DT77	27 Skene Square	-10%	-8%		
DT11	105 King St	2%	3%		
DT10	184/192 Market St	-5%	-7%		
DT9	39 Market St	-37%	-38%		
DT29	469 Union St	-32%	-23%		
DT12	40 Union St	-62%	-61%		
DT17	43/45 Union St	-62%	-61%		
DT82	7 Virgina Street	5%	5%		
DT19	468 Union St	-32%	-23%		

NO_2 Levels predicted to be Under Threshhold
NO_2 Levels predicted to be Near Threshhold
NO_2 Levels predicted to be Over Threshhold

6.6.13 It can be seen in Table 28 that when the right turn into Bridget Street is allowed, the higher traffic flows on Union Street (at DT29 and DT30) are not anticipated to be sufficient enough to bring the exceedance levels back up near the NO_2 compliance limit. The increase in traffic flows on Holburn Street in the model is anticipated to have a slight impact on the NO_2 levels at this location but again, are not anticipated to create NO_2 exceedance levels.

6.6.14 To summarise, allowing the right turn from Union St to Bridge Street for all traffic in the model does create an alternative east-west route through the city centre. The LEZ and CCMP restrictions are predicted to still keep the NO_2 levels below the exceedance threshold even if this manoeuvre is allowed for all traffic

6.6.15 What is not clear from the traffic model testing is the potential negative impact to air quality on Bridge Street itself and also to public transport which routes through Bridget Street and Guild Street. It is possible that the traffic flows in the model using this right turn manoeuvre are an overestimation of what would occur in reality. This is because the traffic model is a fixed trip matrix and all traffic that originally routed along Union Street must be diverted elsewhere in the network. In reality, some of these trips would not occur through this route

due to the diversions required and also if advanced signing was utilised to advise of city centre restrictions. Also note the comments on modelling in Section 6.7.

6.6.16 However, given the wider ACC objective to gradually reduce the volume of traffic routing through the city centre, SYSTRA would recommend that this right turn manoeuvre is not permitted for general traffic (but could be for buses).

6.6.17 Careful consideration of advisory signing would therefore be required in advance of Union Street to notify drivers that there was no through route available on Union St. As a final exit option, traffic could divert through Crown Street but it would be anticipated that, due to the advanced signing, the traffic volume would be low at this point.

6.6.18 ACC may wish to still consider allowing this manoeuvre for all traffic but it has not been included in subsequent model testing or outputs.

6.7 Comment on Future Year Modelling

6.7.1 Given the impact Covid-19 is having on trip making, future travel patterns are still uncertain. There is therefore a high degree of variability in the various plausible futures of the city centre traffic network. The plausible futures work undertaken as part of this study assesses the wider, key elements of the LEZ under different travel demand scenarios (See Chapter 8), so it is important to note that minor mitigation measures identified to support the wider LEZ scheme may be required in one plausible future scenario may not necessarily the another.

6.7.2 The traffic modelling undertaken to date is based upon pre-COVID network and the 'spaces for people' measures currently in place include some of the traffic restrictions proposed as part of the permanent LEZ package of measures (e.g. restrictions on Union St) . If ACC considers that these temporary measures should remain in place until the LEZ is operational, then the city centre travel patterns, post-Covid, will build back up around the current restrictions. This is therefore subtly different to how the modelled traffic patterns are currently constructed and adds a degree of uncertainty to the actual future traffic volumes that the scheme can be assessed against.

6.7.3 It is therefore important to utilise the traffic modelling appropriately, and extract the key findings to aid the decision making process, whilst acknowledging that the need for additional mitigation measures can be monitored and reviewed after the wider LEZ scheme is implemented, post-Covid.

SYSTRA recognises the current uncertainty in predicting the future city centre travel patterns post-COVID. Because of this, SYSTRA recommends that the consideration of additional mitigation measures as part of the wider LEZ package should be reviewed after the key LEZ elements are implemented to determine if these, or other measures are still required.

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7. FINALISATION OF LEZ BOUNDARY

7.1 Introduction

7.1.1 As part of the development of the final package of measures proposed for the LEZ scheme, the boundary of the LEZ itself was reviewed by both SYSTRA and ACC and some minor amendments considered as detailed in the following section:

7.2 LEZ Boundary Detail

1. Ashvale Place / Holburn St

7.2.1 The LEZ boundary on Holburn Street required to be moved from, just north of the junction with Willowbank Road to just north of the junction with Ashvale Place. This is to allow non-compliant traffic an exit on Ashvale Place, as it is a one-way eastbound route onto Holburn St. – See Figure 16.

Figure 16. Revised LEZ Boundary on Holburn Street

7.2.2 The revised location of the LEZ on Holburn St does not affect the impact of the LEZ through this corridor.

2. Regent Quay Area

7.2.3 ACC identified the need to rationalise the LEZ boundary around the Regent Quay area of the network, noting the following:

- A requirement to retain access to the Virginia St Car Park on Mearns Street for all vehicles

- A requirement for the LEZ to include roads connecting Virginia St to Regent Quay, for operational purposes
- A requirement to limit the number of residential properties affected to a minimum
- Noting the requirement to exclude Regent Quay from the LEZ as this road is under the jurisdiction of the Harbour Board and not ACC, therefore cannot be included within the LEZ.

7.2.4 The LEZ boundary was subsequently revised to take accordance of the above requirements – See Figure 17. This boundary revision was agreed with ACC.

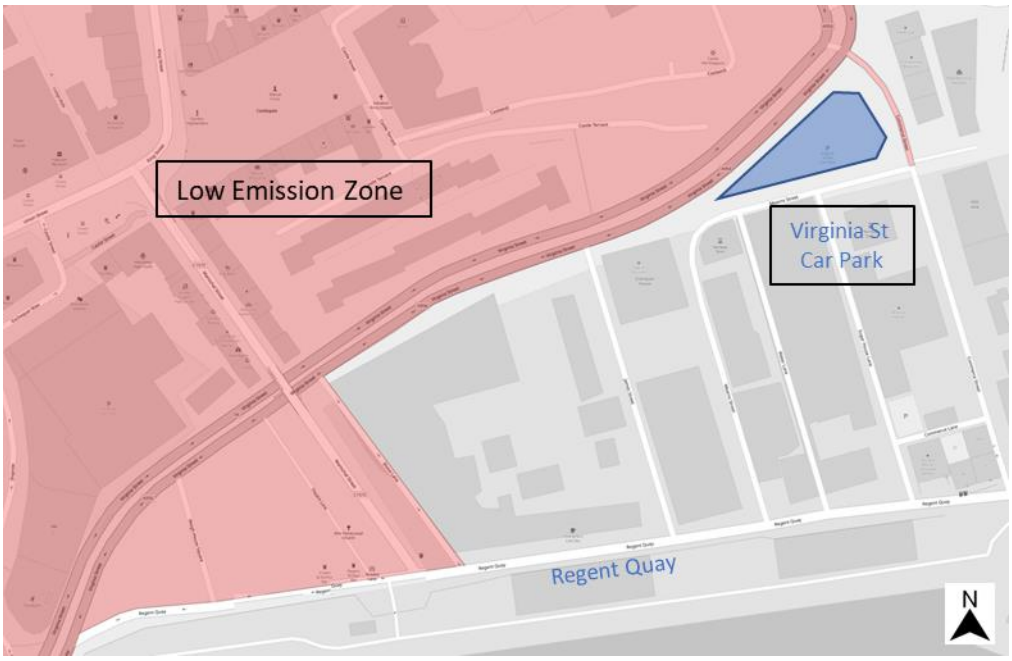

Figure 17. Revised LEZ Boundary around Regent Quay

3. East North Street / King Street

7.2.5 The LEZ boundary is proposed to include the Harbour route of Virginia St and Commerce St. This will restrict non-compliant vehicles from routing through this corridor and reduce the emissions through the exceedance locations of Trinity Quay, Virginia St and also the South end of Market Street.

7.2.6 The LEZ boundary is proposed to exclude the roundabout of Beach Boulevard / West North Street. This is to allow an exit route for non-compliant vehicles on Beach Boulevard and Park Street (i.e. to undertake a U-turn) – See Figure 18.

7.2.7 The inclusion of East North Street within the LEZ was queried by ACC. The rationale for including East North Street in the LEZ was to further limit the volume of non- compliant vehicles on King Street. If East North Street remains outwith the LEZ, then non-compliant traffic can route between King Street and Park St & Beach Boulevard.

7.2.8 There is a NO_2 exceedance location on King Street which is out-with the LEZ boundary. There is a need to maximise the influence of the LEZ at this location to reduce the emission levels.

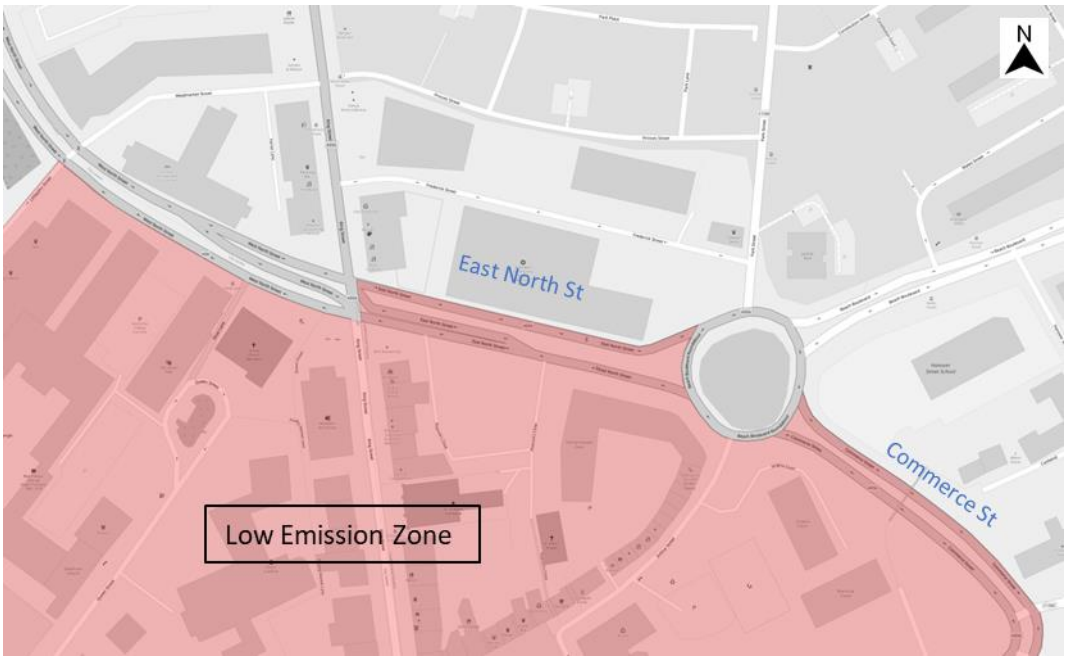

Figure 18. LEZ Boundary On East North Street

7.2.9 A sensitivity test was undertaken whereby East North Street was removed from the LEZ.

7.2.10 The test scenarios were deemed:

- Option F1 – Final Proposed LEZ package of measures
- Option F2 – Final Proposed LEZ package of measures – excluding East North St from LEZ.

7.2.11 Table 29 provides a summary of the two-way traffic flows on King Street for each scenario. The table also identifies the volume of compliant and non-compliant traffic separately.

Table 29. Impact on King St of Alternative LEZ Boundary

	Option F1			Option F2		
PEAK	Compliant	Non-Compiant	Total	Compliant	Non-Compliant	Total
AM	1929	1	1929	2001	141	2141
IP	3375	3	3378	3464	271	3734
PM	1915	0	1915	1716	84	1800
12 Hr	7218	4	7221	7180	495	7675

7.2.12 The results suggest that there are almost 500 trips (6%) more on King St in a 12 hr period when East North Street is outwith the LEZ. Critically, these trips are essentially all non-compliant vehicles.

7.2.13 Given the NO_2 exceedance levels on King St, it is therefore recommended that East North Street is retained within the LEZ boundary.

7.2.14 This option would require careful signing for non-compliant vehicles on King St as there is no right turn allowed for vehicles on King St to West North Street. Alternative routing would be required for non-compliant vehicles much further north on King St – See Section 7.3.

7.3 Exit Strategy for Non-Compliant Vehicles

7.3.1 The full LEZ signing strategy is not complete at present. However, the immediate signage around the periphery of the LEZ is required to be considered in line with the finalisation of the LEZ boundary.

7.3.2 Transport Scotland are developing guidance and regulations for road signing associated with a LEZ. The advisory signing will include:

- Warning sign to advise that you are entering a LEZ Zone
- Warning sign to advise that a LEZ is on an approaching route
- Diversion sign – to avoid LEZ.

7.3.3 Table 30 provides an initial consideration of locations where advisory signs will be required to provide an exit for non-compliant vehicles. Note that this list does not include repeat or initial signage that will be required further out from the city centre area.

7.3.4 Figure 19 provides a map detailing the location of the initial consideration of LEZ signage for non-compliant vehicles.

Table 30. Initial Consideration of LEZ Signage for Non-Compliant Vehicles

Location	Approach	Diversion Route	Comment / Sign Type
1	King St	Mounthooly Way	Diversion Sign
2	West North St	King St	Diversion Sign
3	Park St	Beach Boulevard	Diversion Sign
4	Beach Boulevard	Park St	Diversion Sign
5	Castle Terrace	Cotton St	Diversion Sign
6	Regent Quay / Waterloo Quay	Church St	Diversion Sign
7	Mearns St	Commerce St (South)	Diversion Sign
8	Regent Quay (West)	Regent Quay (East)	Diversion Sign
9	James St	Regent Quay (East)	Diversion Sign
10	Market St	7A:Commercial Quay (for HGV)	Warning & Diversion Sign
		7B: Victoria Bridge/North Esplande West (for Traffic from Torry)	Diversion Sign
		7C: North Esplanade West / Palmerston Link Road (for Traffic from North Esplanade)	Diversion Sign
11	South College St	Milburn St	Diversion Sign
12	Ferryhill Road into Crown St	-	Warning Sign
13	Fonthill Road into Bon Accord St	-	Warning Sign
14	Fonthill Road into Albury Road	-	Warning Sign
15	Fonthill Road into Hardgate	-	Warning Sign
16	Holburn St	Great Southern Road	Diversion Sign
17	Great Southern Road	Nellfield Place	Diversion Sign
18	Union Grove	Albyn Grove	Diversion Sign
19	Albyn Place	Victoria St	Diversion Sign
20	Thistle St	Rose St	Diversion Sign
21	Rose St into Huntly St	-	Warning Sign
22	Skene St into Rose St	-	Warning Sign
23	Skene St into Summer St	-	Warning Sign
24	Rosemount Viaduct into Skene Terrace	-	Warning Sign
25	Rousemount Viaduct into Union Terrace (both east & west approach)	-	Warning Sign
26	Schoolhill	Harriet St	Diversion Sign
27	Gallowgate	Berry St	Diversion Sign
28	Berry St	Gallowgate	Diversion Sign
29	Woolmanhill (North)	John St or Woolmanhill (East)	Diversion Sign
30	John St	Woolmanhill (North) or Woolmanhill (East)	Diversion Sign
31	Woolmanhill (East)	John St or Woolmanhill (North)	Diversion Sign

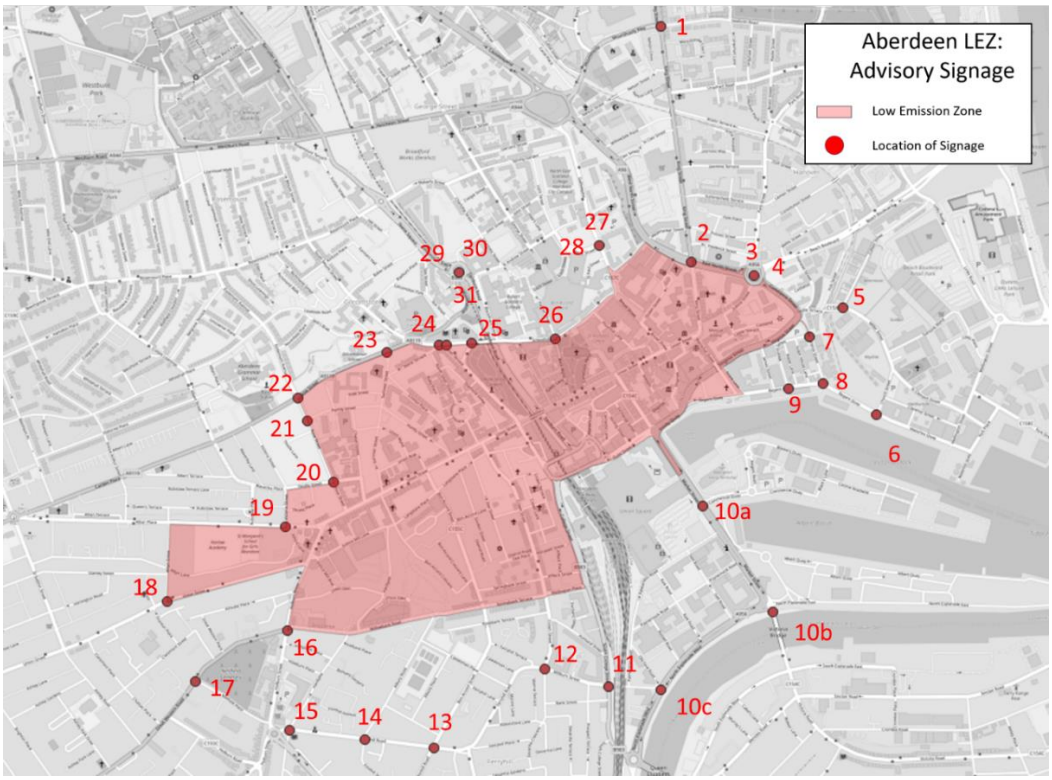

Figure 19. Location of Advisory LEZ Signage (Initial Consideration)

8. FINAL PROPOSED LEZ PACKAGE – MODEL RESULTS

8.1 Introduction

8.1.1 The following section provides a summary of the model outputs for the proposed LEZ Boundary and associated package of measures. The statistics presented include:

- Predicted Impact of LEZ Scheme on Air Quality Exceedance Locations
- Predicted Impact of LEZ Scheme on Traffic Flows through Network
- Predicted Impact of LEZ Scheme on Global Network.

8.1.2 As a reminder, and for the purposes of this report, the following Model Scenario naming has been used:

- **Option 5**: Preferred LEZ Boundary Option
- **Option 6**: LEZ Option 5 & Union Street CCMP Scheme
- **Option F**: Final proposed scheme (Option 6 & revised boundary, & management of non-compliant vehicles as detailed in previous chapters).

8.1.3 The Option F – 'Final Proposed Scheme' includes the package of measures shown in Figure 20.

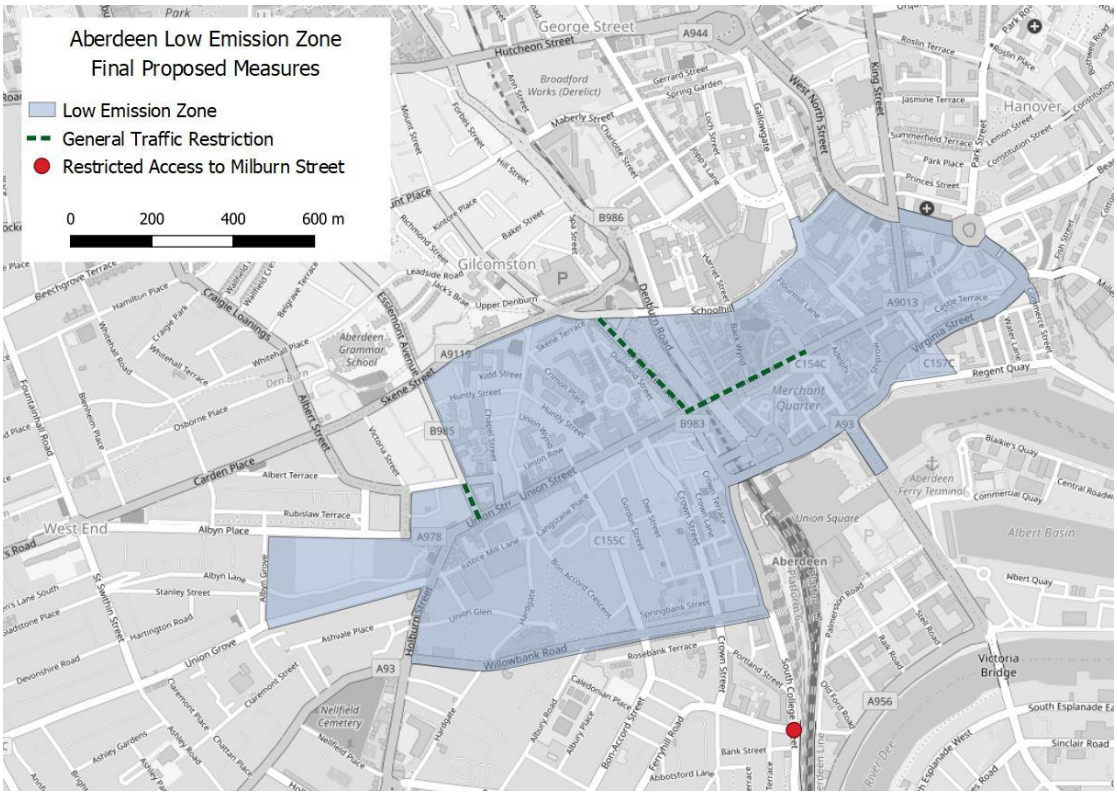

Figure 20. Final Proposed LEZ Scheme Detail

8.2 Model Demand Level

8.2.1 Through all model testing of the various LEZ options, the maximum percentage demand that the models were able to run at was 95% of the ACCPM24 Reference Case Demand.

8.2.2 The 2024 future year traffic models are based upon a high traffic growth scenario and include approximately 7% predicted growth over the 2019 Baseline traffic levels in the PM Peak. It could therefore be considered that models running at 95% demand is equivalent to a small level of traffic growth on the 2019 baseline traffic demand (i.e. 2% traffic growth from 2019).

8.3 Predicted Impact of LEZ on Air Quality Exceedance Locations

8.3.1 Table 31 provides a traffic flow percentage difference comparison between the remaining LEZ scenarios and the 2019 Base Model at each of the exceedance locations in the network. The data is based upon the 12 Hr model flows. The resultant predicted impact on the NO_2 exceedance levels is also provided.

8.3.2 For absolute clarity, this comparison is between a 2024 future year scenario (at 95% demand) with the final LEZ scenario and the 2019 Base scenario. The traffic flow differences therefore include the influence of background traffic growth as well as the impact of the LEZ.

Table 31. Predicted Impact of Final LEZ Scheme on Air Quality Exceedance Locations

Site	Exceedance Location	Air Quality Impact 2019	Flow Change from 2019 Baseline LEZ Option F	Predicted Air Quality Impact LEZ Option F
DT30	335 Union St		-24%	
DT73	61 Skene Square		-10%	
DT18	14 Holburn St		-14%	
CM2	Union Street		-40%	
DT16	1 Trinity Quay		6%	
DT77	27 Skene Square		-10%	
DT11	105 King St		2%	
DT10	184/192 Market St		-5%	
DT9	39 Market St		-37%	
DT29	469 Union St		-32%	
DT12	40 Union St		-62%	
DT17	43/45 Union St		-62%	
DT82	7 Virgina Street		5%	
DT19	468 Union St		-32%	

NO_2 Levels predicted to be Under Threshhold
NO_2 Levels predicted to be Near Threshhold
NO_2 Levels predicted to be Over Threshhold

8.3.3 The above figure shows that the predicted traffic flow changes associated with the final proposed LEZ scheme are predicted to significantly reduce emissions through each of the NO_2 exceedance locations. This is the principal objective of the study.

8.3.4 A separate air quality exercise will provide more definitive detail on the emission improvements predicted through the modelling.

8.4 Predicted Impact of LEZ Scheme on Network Traffic Flow

8.4.1 The AM Peak, Interpeak and PM Peak flow difference plots provided in Appendix D show the traffic flow differences between the ACCPM24 and the final LEZ Scenario

8.4.2 Blue bars represent a decrease in traffic flows, Red bars represent an increase in traffic flows.

8.4.3 The model flow plots show a general trend of traffic reduction through the core area of the city centre with displaced traffic pushed out to Anderson Drive.

8.4.4 Some local routing increases are observed within the model but it is important to highlight the comments raised in Section 6.4.4 relating to the difference between the fixed trip nature of the models compared to the potential actuality of traffic levels building back up around the LEZ.

8.4.5 The proposed restrictions on Union St, for example, require the modelled displacement of approximately 1500 trips in each direction within the 3 hr PM peak period. This traffic has to be diverted somewhere else in the model network. In reality, traffic erosion is likely to occur if the Union St restrictions (that are currently in place as part of spaces for people) are retained as the network recovers post-COVID.

> SYSTRA recognises the current uncertainty in predicting the future city centre travel patterns post-COVID. Because of this, SYSTRA recommends that the consideration of additional mitigation measures as part of the wider LEZ package should be reviewed after the key LEZ elements are implemented to determine if these, or other measures are still required.

8.4.6 From the model testing, SYSTRA would highlight the following corridors as areas where traffic monitoring is suggested as the network recovers and also after the key elements of the LEZ are implemented:

- Springbank Terrace / Willowbank Road – and approach roads on Bon Accord St and Crown St
- Huntly Street (Note: already restricted in the model coding)
- Chapel Street
- Albyn Place
- Ferryhill Road / Fonthill Road
- Albert Street

- Ashley Road
- Seaforth Road.

8.5 Predicted Impact of LEZ Scheme on Global Network

8.5.1 As detailed in Section 4.12, model network summary statistics report on the overall network performance of a model. Four key global network statistics that can be extracted from the models are:

- Total Distance Travelled
- Average Time Taken
- Mean Speed
- Average Number of Vehicles in a Queue.

8.5.2 The total distance travelled statistic is based upon the cumulative travelled distance for all vehicles in the model. An increase in the total distance travelled is usually representative of an increase in travel demand.

8.5.3 The average time taken statistic is based upon the average time for all trips in the network to make their journey. An increase in this statistic represents a deterioration in the operation of the network.

8.5.4 The mean speed statistic represents the average speed for all vehicles in the model network. A decrease in average speed represents a deterioration in the operation of the model network.

8.5.5 The average number of vehicles in a queue is an hourly statistic that collates the total number of queueing vehicles across the network. An increase in the number of vehicles queueing is a good indicator of an increase in congestion within the model network.

8.5.6 Table 32 provides a summary of the first three global statistics for LEZ Option 6 and the final scheme Option F, against the ACCPM24 Reference Case. Table 33 provides the results for Average Vehicles in a Queue.

Table 32. Network Summary Statistics

Percentage Difference to the Ref Case						
Peak	Percentage demand level	Scenario	Number of Vehicles	Total Distance Travelled (km)	Average Time Taken (hh:mm:ss)	Mean Speed (mph)
AM	95%	2024 Ref Case	78779	259881	00:07:15	16.96
	95%	Option 6	-0.6%	1.5%	25.1%	-18.3%
	95%	Option F	-0.2%	2.3%	17.6%	-12.8%
IP	95%	2024 Ref Case	164848	474968	00:05:48	18.53
	95%	Option 6	-0.6%	1.8%	10.3%	-7.2%
	95%	Option F	-0.5%	1.8%	9.5%	-6.5%
PM	95%	2024 Ref Case	93788	300136	00:08:05	14.77
	95%	Option 6	-1.4%	1.2%	24.0%	-17.2%
	95%	Option F	-1.1%	1.2%	16.5%	-12.1%
12 Hr	**95%**	**2024 Ref Case**	**337415**	**1034985**	**00:07:02**	**16.75**
	95%	**Option 6**	**-0.8%**	**1.5%**	**20.6%**	**-13.9%**
	95%	**Option F**	**-0.6%**	**1.8%**	**15.0%**	**-10.3%**

Table 33. Average No. Vehicles in a Queue

Time	Average Number of Vehicles in a Queue (Veh)		
	Ref Case 2024	Op 6	Op F
07:00:00	11045	9015	8881
08:00:00	12230	10855	10775
09:00:00	10083	9643	9640
10:00:00	9055	7873	7233
11:00:00	9257	8089	7601
12:00:00	9920	8907	8324
13:00:00	10054	9235	8735
14:00:00	9582	9096	8463
15:00:00	10436	10354	9625
16:00:00	12573	12067	11878
17:00:00	14359	14564	13565
18:00:00	11808	12707	11479
Total	**130400**	**122405**	**116199**
% Diff.	-	**-6%**	**-11%**

8.5.7 The following comments can be drawn from the global network statistics:

- The increase in global distance travelled in the LEZ scenarios relates to the additional distance than non-compliant traffic requires to route. This is less than 2% on average in the final LEZ model scenario
- The results for the average time taken and mean speed suggest that there is a deterioration on the network operation when the LEZ is in place. This is anticipated

as the LEZ requires traffic to route further. The final Option F operates better than Option 6, due to the improved management of non-compliant vehicles

- However the results of the average vehicles in a queue statistic suggest that the LEZ reduces the overall queueing in the network. It is assumed that this is due to the removal of traffic from some of the high queue areas within the LEZ area. Essentially the LEZ dissipates traffic out wider thus reducing overall queueing. The final Option F operates better than Option 6 and shows over 10% less queueing than the ACCPM24 Reference Case Scenario.

9. ALTERNATIVE FUTURES TESTING

9.1 Introduction

9.1.1 The Covid-19 pandemic has had a dramatic impact on travel across all modes and specifically travel in Scotland's city centres. For the consideration of an LEZ in the future Aberdeen network, further evidence is required by applying the principals of modelling to consider the uncertainty over what travel will look like after the pandemic has ended. This evidence will help inform decision makers for the LEZ schemes.

9.1.2 On Behalf of Transport Scotland, SYSTRA set out a framework for embracing uncertainty by consulting with Aberdeen City Stakeholders on what will travel look like post COVID-19'. This exercise was undertaken for each of the four proposed LEZ cities (Edinburgh, Glasgow, Aberdeen, and Dundee).

9.1.3 This framework set out the rationale for any additional modelling required to provide supporting evidence relating to uncertainty which would enhance the acceptability of the modelling work undertaken to date.

9.1.4 Detail of the study undertaken and the development of common plausible futures is provided in the SYSTRA briefing Note*: LEZ Post-Covid Uncertainty*, Ref: GB01T20E86/11024112/005, 208/01/21)

9.1.5 For each of the four LEZ cities, the four identified plausible futures were considered against the model assessments undertaken to date. From this, to address uncertainty, further sensitivity testing of the LEZ schemes was proposed.

9.1.6 Three of the four plausible futures were identified for Aberdeen, these were:

- **Future Scenario SP1:** ' *LDP Growth'* The fleet projections follow pre-Covid trends provided by SEPA and the traffic growth is in line with current Local Development Plan Allocations/uptake. This scenario is the future year growth scenario developed as the 2024 Reference Case Model (ACCPM24)
- **Future Scenario SP2:** '*Economic Downturn'*: Following an economic downturn, the fleet projections are lower than pre-Covid trends provided by SEPA and traffic shrinkage is experienced, similar to the 2010 downturn
- **Future Scenario SP3:** '*Brave New World'*: The fleet projections follow pre-Covid trends provided by SEPA however behavioural change results in traffic levels remaining consistent with pre-Covid levels.

9.1.7 Table 34 details a simplified version of the above plausible future scenarios considered for model testing of the Aberdeen LEZ. The growth and fleet compliance level changes are referred against the 2019 baseline. For example, 'high growth' is the 7% traffic growth applied in the 2024 Reference Case Model (ACCPM24), and the 'increased trajectory' of the fleet is the increase in compliance levels between 2019 and 2024 (cars increased from 70% compliant to 86% compliant- See Table 4).

9.1.8 Within each future scenario, the LEZ will be assessed with and without the proposed CCMP mitigation to understand the extent that this will provide benefit to the air quality levels in the city centre under the alternative future scenarios.

9.1.9 The high growth future scenario SP1 has already been assessed, as detailed in previous chapters, and was shown to require the CCMP mitigation to bring the air quality levels down below the exceedance levels.

Table 34. Alternative Future Scenarios

Future Scenario		Growth	Fleet Compliance	Infrastructure Scenario LEZ	Infrastructure Scenario LEZ + CCMP Mitigation
1	LDP Growth	High	Increasing trajectory	Traffic Assessment	Traffic Assessment & Air Quality Assessment
2	Economic Downturn	Shrinkage	No Change	Traffic Assessment	Traffic Assessment
3	Brave New World	Low or none	Increasing trajectory	Traffic Assessment	Traffic Assessment

9.1.10 The above table shows that the full air quality assessment will be undertaken by SEPA on the high growth future scenario SP1 (run at 95% demand) only.

9.1.11 A traffic modelling assessment on the traffic flow changes at the exceedance locations was undertaken on the other future scenarios.

9.1.12 The following sections outline the development of the alternative future traffic models and the subsequent test results.

9.2 Development of Alternative Future Model Scenarios

9.2.1 As detailed above, the high growth future scenario SP1 is the 2024 Reference Case (ACCPM24) scenario against which all model testing has been undertaken to date. Although a resultant 7% traffic growth over the 2019 baseline was assigned within the future year model (via background LDP growth from ASAM), the LEZ model scenarios only ran at 95% of the future year demand. This is essentially the equivalent of a 2% increase in traffic demand over the 2019 baseline.

9.2.2 The proportion of demand constraint assigned to the second future scenario 'SP2' was derived through an assessment of traffic data during the downturn in the oil industry between 2014 and 2016. This analysis suggested that there was an approx. 7% drop in traffic demand around Aberdeen during this period. It was agreed with ACC a similar drop in traffic demand could be used to represent a plausible economic downturn scenario resulting from the COVID-19 Pandemic.

9.2.3 Therefore, for SP2, the traffic demand assigned in this scenario was 93% of the 2019 baseline traffic demand level (individual peak ranges slightly due to rounding in the trip matrix development).

9.2.4 Associated with an economic downturn, it was considered unlikely the traffic fleet compliant / non-compliant projections would occur to the same level as SP1, therefore the 2019 baseline observed traffic fleet compliant / non-compliant proportions were assigned to this scenario.

9.2.5 For SP3, to consider a network where the travel demand remains consistent with pre-COVID levels, the 2019 Base model traffic demand levels were applied. The difference between this scenario and the 2019 Base model is that the proportions of compliant traffic continues to increase on the existing projections applied in SP1.

9.2.6 For the model assessment of the proposed LEZ under alternative futures, the actual extent of traffic growth or shrinkage was considered less critical than capturing the direction of travel. Ultimately, the scale of change is not known, but the model testing of various future scenarios allows consideration for the potential impact on a LEZ under different futures.

9.2.7 From the above, Table 35 details the trip matrix totals developed for each model scenario.

Table 35. Traffic Model Matrix Totals for Alternative Future Scenarios

Scenario	Peak			
	AM (Veh)	IP (Veh)	PM (Veh)	12 Hr (Veh)
2019 Base	79494	165061	95331	339886
2024 Ref Case	85227	177409	101654	364290
% Change	**7%**	**7%**	**7%**	**7%**
SP1 ' Limited Growth'	80926	168497	96544	345967
% Change	**2%**	**2%**	**1%**	**2%**
SP2 'Economic Downturn'	75558	150598	90602	316758
% Change	**-5%**	**-9%**	**-5%**	**-7%**
SP3 ' Brave New World'	79497	165107	95338	339942
% Change	**0%**	**0%**	**0%**	**0%**

9.2.8 The above table shows the trip matrix total differences correlate with the demand level assumptions derived for each scenario: SP1 Includes high 7% growth , but can only run at 95% of this growth, hence a 2% growth. SP2 includes a 5-7% demand constraint associated with an economic downturn, and SP3 is effectively the same traffic demand level as the 2019 Base.

9.2.9 Table 4 detailed the traffic fleet compliance levels included in the ACCPM24 Scenario and subsequent LEZ testing. The projected future fleet compliance levels were applied to scenarios SP1 and SP3 and the 2019 observed compliance level was applied to scenario SP2. This is summarise in Table 36 below.

Table 36. Fleet Compliance Levels for Alternative Future Scenarios

Scenario	Emissions	Car (%)	LGV (%)	HGV (%)
SP1	Non Compliant	14	30	7
Improved Fleet	Compliant	86	70	93
SP2	Non Compliant	30	60	27
2019 Fleet	Compliant	70	40	73
SP3	Non Compliant	14	30	7
Improved Fleet	Compliant	86	70	93

9.2.10 The resultant number of compliant and non-compliant vehicles for each future scenario is provided in Table 37. The figures shown are the total number of vehicles in the model 12 Hr period (07:00-19:00).

Table 37. Total Compliant Vehicles for Alternative Future Scenarios

Scenario	Total Compliant (12 Hr Veh)	Total Non- Compliant (12 Hr Veh)	Total (12 Hr Veh)
SP1 ' Limited Growth'	301617	44350	345967
SP2 'Economic Downturn'	252963	63795	316758
SP3 ' Brave New World'	296492	43450	339942

9.2.11 Table 37 shows that whilst there is fewer vehicles in the network under SP2, the volume of non-compliant vehicles that will be diverted from the LEZ will be higher than SP1, due to the lower traffic compliance level.

9.2.12 As SP1 was only able to run at 95% of the high growth level, SP3 at 100% demand has only marginally less traffic than SP1 at 95% demand, and with similar compliant proportions.

9.3 Model Testing of Alternative Future Scenarios

9.3.1 The following section provides a summary of the model outputs for the alternative future scenarios. For consistency with previously detailed model analysis, the statistics presented include:

- Predicted Impact of LEZ Scheme on Air Quality Exceedance Locations
- Predicted Impact of LEZ Scheme on Traffic Flows

Model Network Demand

- As noted above, SP1 was only able to run at 95% of the high growth level in the PM peak
- SP2 included approximately 5% less traffic than the 2019 baseline and was able to run at 100% of this demand level in all peaks
- SP3 had the equivalent traffic demand of the 2019 Base Model and was able to run at 100% of this demand level in all peaks

Predicted Impact of LEZ on Air Quality Exceedance Locations

9.3.2 Table 38 provides a 12 Hr traffic flow percentage difference comparison between the alternative future LEZ scenarios and the 2019 Base Model at each of the exceedance locations in the network. The data is based upon the 12 Hr model flows.

Table 38. Alternative Futures: Traffic Flow Impact at Air Quality Exceedance Locations (12 Hr)

Site	Exceedance Location	% Flow Change from 2019 Baseline SP1 LEZ+CCMP	SP2 LEZ	SP2 LEZ+CCMP	SP3 LEZ	SP3 LEZ+CCMP
DT30	335 Union St	-24%	-12%	-31%	-2%	-26%
DT73	61 Skene Square	-10%	-24%	-23%	-15%	-14%
DT18	14 Holburn St	-14%	-19%	-27%	-9%	-17%
CM2	Union Street	-40%	-18%	-46%	-8%	-42%
DT16	1 Trinity Quay	6%	-21%	-6%	-10%	3%
DT77	27 Skene Square	-10%	-24%	-23%	-15%	-14%
DT11	105 King St	2%	-11%	-18%	-2%	-3%
DT10	184/192 Market St	-5%	-17%	-15%	-12%	-7%
DT9	39 Market St	-37%	-15%	-43%	-13%	-37%
DT29	469 Union St	-32%	-29%	-40%	-19%	-34%
DT12	40 Union St	-62%	-11%	-64%	-3%	-61%
DT17	43/45 Union St	-62%	-11%	-64%	-3%	-61%
DT82	7 Virgina Street	5%	-22%	-7%	-10%	2%
DT19	468 Union St	-32%	-29%	-40%	-19%	-34%

9.3.3 The resultant predicted impact on the NO_2 exceedance levels is also provided in Table 39

Table 39. Alternative Futures: Predicted Air Quality Impact

Site	Exceedance Location	Predicted Air Quality Impact SP1 LEZ+CCMP	SP2 LEZ	SP2 LEZ+CCMP	SP3 LEZ	SP3 LEZ+CCMP
DT30	335 Union St					
DT73	61 Skene Square					
DT18	14 Holburn St					
CM2	Union Street					
DT16	1 Trinity Quay					
DT77	27 Skene Square					
DT11	105 King St					
DT10	184/192 Market St					
DT9	39 Market St					
DT29	469 Union St					
DT12	40 Union St					
DT17	43/45 Union St					
DT82	7 Virgina Street					
DT19	468 Union St					

NO_2 Levels predicted to be Under Threshhold

NO_2 Levels predicted to be Near Threshhold

NO_2 Levels predicted to be Over Threshhold

9.3.4 Table 38 shows that, for SP2 -'Economic Downturn' with the LEZ , there are traffic reductions across each of the NO_2 exceedance locations compared to the 2019 baseline. This is due to a combination of the traffic network shrinkage applied and the LEZ itself. When these changes are considered as a predicted impact to the NO_2 exceedances, the results in Table 39 suggest that the CCMP measures are not necessarily required to further reduce NO_2 levels below the exceedance threshold at this point in time.

9.3.5 However, under this economic downturn scenario, the traffic fleet will certainly improve over time whilst there is no guarantee that the traffic levels will rise to a point beyond 2019 levels. As the fleet compliance levels increase, the volume of traffic within the LEZ area will increase thus impacting on the NO_2 emission levels (even although these are complaint vehicles).

9.3.6 Under the SP2 'Economic Downturn' scenario, the LEZ plus the CCMP would therefore protect the city centre from the almost certain changes to the fleet compliance levels over time.

9.3.7 For SP3- 'Brave New World' , Table 38 shows that there are traffic reductions across each of the exceedance locations compared to the baseline (but not to the extent of the reductions observed in SP2). This result is expected as the traffic demand levels in SP3 are the same as the 2019 baseline so the flow changes are a direct result of the LEZ alone. At each of the exceedance areas, there are fewer vehicles due to removal or diversion of non-compliant vehicles.

9.3.8 When these changes are considered as a predicted impact to the NO_2 exceedances, the results in Table 39 suggest that there are still locations where NO_2 levels are predicted to be near the exceedance threshold. These locations are consistent with the high growth scenario SP1 which suggested there would be NO_2 exceedances at King St and Union Street (Table 18, Page 41).

9.3.9 Whilst the results of SP3-without the CCMP suggest that their would be some locations where the NO_2 levels would be near the threshold, if traffic growth occurs beyond the opening date of the LEZ, then there is a strong possibility that these and other NO_2 levels would increase to a point beyond the exceedance threshold

9.3.10 In both alterative futures: SP2 and SP3, the combination of the LEZ and the CCMP measures are predicted to positively impact the NO_2 emission levels at each of the 14 locations of concern.

9.3.11 From these results, the proposed LEZ package of measures are predicted to meet the objectives of the study under different future scenarios. Whilst there is the possibility that the CCMP measures may not initially be required to provide additional air quality benefits under certain futures, the CCMP proposals will protect the city centre area from potential future changes to traffic growth and fleet compliance levels.

9.3.12 An alternative view on these results is to consider the committed objective to implement the CCMP over the next 15 years. The CCMP carries its own benefits relating to placemaking, sustainable transport and the attraction of the city centre to boost the local economy. The various future scenario tests all suggest that the LEZ reduces traffic levels within the city centre area to facilitate the implementation of key aspects of the CCMP. Therefore, the LEZ and CCMP core measures complement each other to provide the benefits to air quality AND placemaking.

Predicted Impact on Network Traffic Flow

9.3.13 The PM Peak flow difference plots and tables provided in Appendix E show the traffic flow differences between the ACCPM19 Base Model and the following model scenarios:

- SP1 with LEZ & CCMP
- SP2 with LEZ & CCMP
- SP3 with LEZ & CCMP

9.3.14 Blue bars represent a decrease in traffic flows, Red bars represent an increase in traffic flows.

9.3.15 It can be seen from the flow difference plots and the flow difference table that the general trend of traffic displacement is very similar under each future scenario. In all future scenarios the model flow plots show a general trend of traffic reduction through the core area of the city centre with displaced traffic pushed out to Anderson Drive.

9.3.16 The key differences between the alternative future scenarios primarily lies in the extent of change in traffic flow.

9.3.17 In general, there is little difference in the traffic flow between SP1 and SP3, due to SP1 only being able to run at 95% of the high future growth scenario and both scenarios having an improved fleet compliance level.

9.3.18 For SP2, there are two conflicting factors affecting the traffic flows; the overall traffic demand is lower than the other future scenarios due to the economic downturn, however, the volume of non-compliant traffic displaced from the LEZ area is highest in this scenario (due to the lower fleet compliance level).

9.3.19 From this, under SP2, the volume of traffic within the LEZ is lower than other future scenarios, but the volume of traffic outside the LEZ area will therefore vary by location in comparison to the other future scenarios. In general, there are not large differences in key traffic flows between the three future scenario considered.

9.3.20 It should be noted however, that the low fleet compliance level will only ever increase over time, so the volume of traffic displaced from the city centre area will reduce over time (assuming background growth does not occur to a similar rate).

9.3.21 As noted in the main option testing chapters, some local routing increases are observed within the LEZ model scenario. This occurs to different extents under the various plausible futures assessed.

9.4 Summary of Alternative Future Testing of the Proposed LEZ Scheme

9.4.1 From the model testing of alternative future scenarios, the proposed LEZ package of measures are predicted to meet the objectives of the study under the different future scenarios considered. Whilst there is the possibility that the CCMP measures may not initially be required to meet the emission targets under certain futures, the CCMP proposals will protect the city centre area from potential changes to traffic growth or slow improvements to fleet compliance proportions.

9.4.2 Until there is more understanding and evidence of the scale and direction of travel of the post-COVID traffic network, there remains uncertainty over the finer details of the impact of the LEZ scheme and therefore the level of requirement of additional mitigating measures as part of the wider LEZ package.

9.4.3 SYSTRA would recommend continued monitoring of the traffic network post-COVID to understand the projection of network recovery and fleet change over time. In addition, it is recommended that the network behaviour is also monitored after the key LEZ elements are implemented to determine if the areas identified through modelling , or other locations require additional mitigating measures.

9.4.4 An alternative viewpoint on the outcome of the alternative futures model testing is to consider the committed objective to implement the CCMP over the next 15 years. The CCMP carries its own benefits relating to placemaking, sustainable transport and the attraction of the city centre to boost the local economy. The various future scenario model tests all suggest that the LEZ reduces traffic levels within the city centre area to facilitate the implementation of key aspects of the CCMP.

> The LEZ and CCMP measures are therefore predicted to work well together to deliver the objectives of the LEZ and wider council objectives for the city centre under varying future traffic outcomes.

10. SUMMARY & CONCLUSIONS

10.1 Summary

10.1.1 SYSTRA Ltd (SYSTRA) was commissioned by Aberdeen City Council in August 2019 for professional services to develop a microsimulation model of Aberdeen City Centre to assess road network options associated with the development of a Low Emission Zone (LEZ) in Aberdeen.

10.1.2 This technical note outlines the development and model testing of LEZ model scenarios, as defined by ACC and in conjunction with the Aberdeen *National Low Emission Framework – Interim Stage 2 Assessment Report* (SYSTRA, Ref: GB01T19I15/281119, 01/06/20).

10.1.3 The Interim NLEF Stage 2 Appraisal recommended that four LEZ boundary options be assessed through the traffic modelling. As part of the model testing process, a fifth boundary option was developed, based upon the initial assessment of the initial four options.

10.1.4 An option appraisal and sifting process was undertaken to filter the LEZ scenarios down to a preferred option. This process included consideration of:

- Network demand level & congestion areas
- Impact through exceedance locations
- Alignment with revised network hierarchy
- Car park accessibility impact
- Impact to residential properties within LEZ area.

10.1.5 A preferred LEZ boundary option was derived from the sifting process. However, modelling suggested that the LEZ on its own was not enough to reduce the NO_2 air quality levels below the AQO of 40µg/m^3 across the city centre area.

10.1.6 The Aberdeen LEZ is required to complement other committed network proposals for Aberdeen City Centre to provide a package of measures which will meet the objectives of the LEZ and wider Council objectives for Aberdeen City Centre. These committed proposals include the City Centre Masterplan (CCMP).

10.1.7 To enable the development of a package of measures to meet the objectives of the LEZ study, traffic modelling was utilised to identify if any elements of the City Centre Masterplan not yet implemented would enhance and support the LEZ in meeting the objectives.

10.1.8 The 'Union Street Scheme' within the CCMP was identified as the best combination of CCMP measures to potentially address the remaining air quality exceedances. The Union Street scheme includes general traffic restrictions on Union Street (between Bridge St and Market St) and through Union Terrace.

10.1.9 Further network mitigation measures were derived to help manage the non-compliant traffic and general traffic displaced from the city centre area as a result of the LEZ and the Union St / Union Terrace restrictions. Changes to the junction design of the South College Street / Milburn St junction were recommended to restrict access for strategic routing traffic through the Milburn St / Ferryhill corridor.

10.1.10 These changes will form part of the South College Street junction improvements: Phase 2. The specifics of the proposed restrictions will be developed following the implementation of Phase 1 in 2022.

10.1.11 The proposed boundary of the LEZ was reviewed and revised to take account of operational and advisory signage considerations.

10.1.12 The final proposed LEZ scheme includes the package of measures shown in 10.1.12.

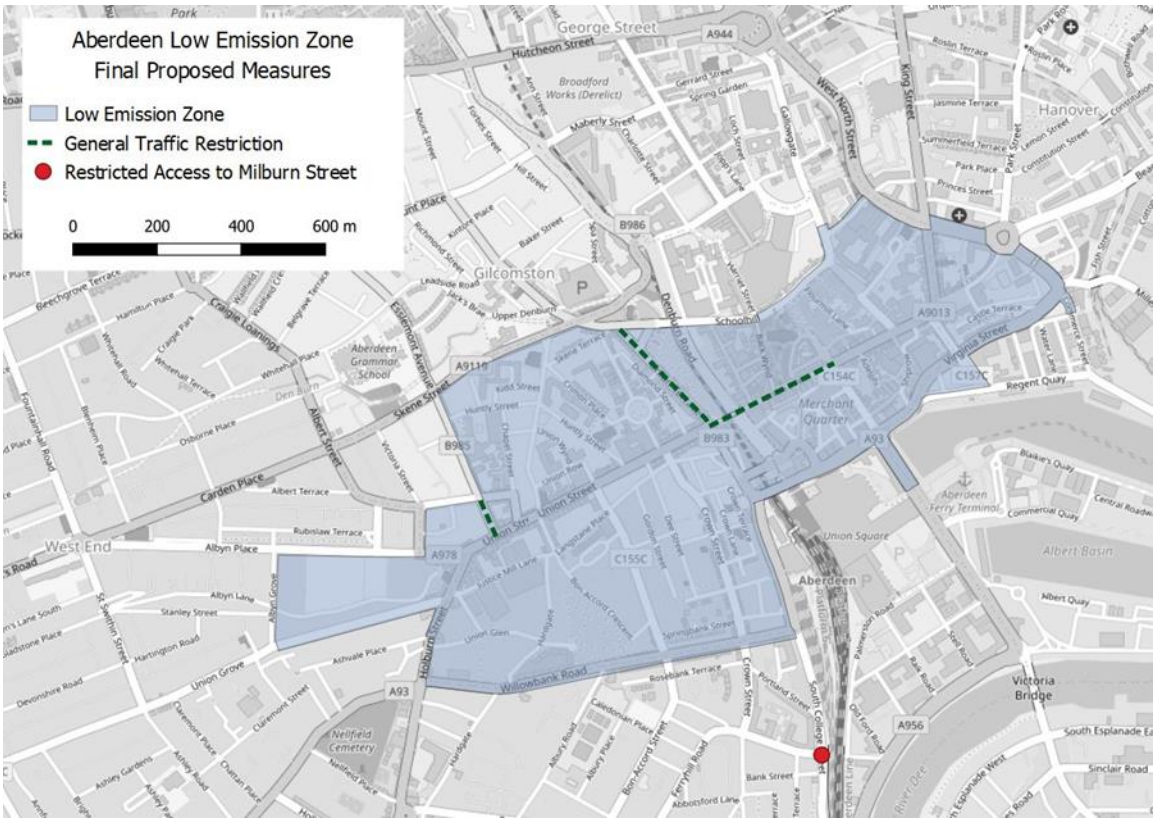

Figure 21. Final Proposed LEZ Scheme

10.1.13 Due to the uncertainty over what the future traffic network will be, post-COVID, the proposed LEZ Scheme has been tested under alternative future demand scenarios. From the model testing, the proposed LEZ package of measures are predicted to meet the objectives of the study under different future scenarios. Whilst there is the possibility that the CCMP measures may not initially be required to provide additional air quality benefits under certain futures, the CCMP proposals will protect the city centre area from potential future changes to traffic growth and fleet compliance levels.

10.2 Conclusions

10.2.1 Through the NLEF and model testing process, a LEZ scheme has been developed which is anticipated to significantly improve the air quality levels through Aberdeen City Centre.

10.2.2 The measures proposed includes other committed proposals for Aberdeen to provide a package of measures which should meet the objectives of the LEZ and wider Council objectives for Aberdeen City Centre.

10.2.3 SYSTRA recognises the current uncertainty in predicting the future city centre travel patterns post-COVID. Because of this, SYSTRA recommends that the consideration of additional mitigation measures as part of the wider LEZ package should be reviewed after the key LEZ elements are implemented to determine if these, or other measures are still required.

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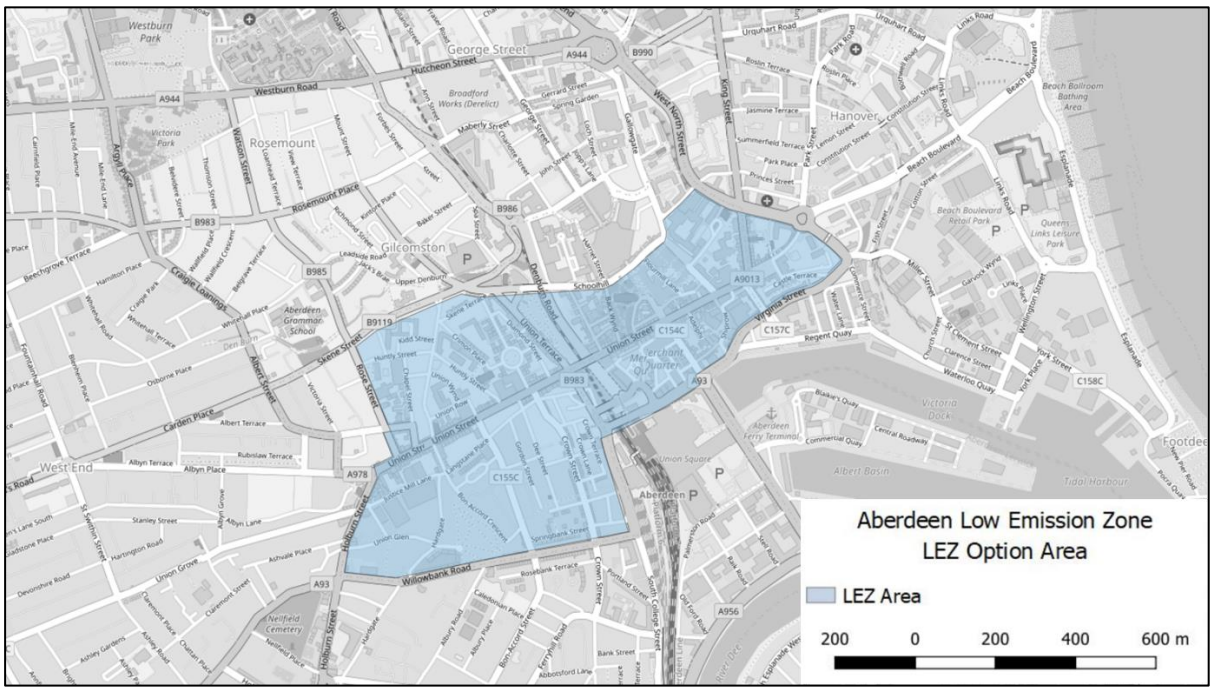
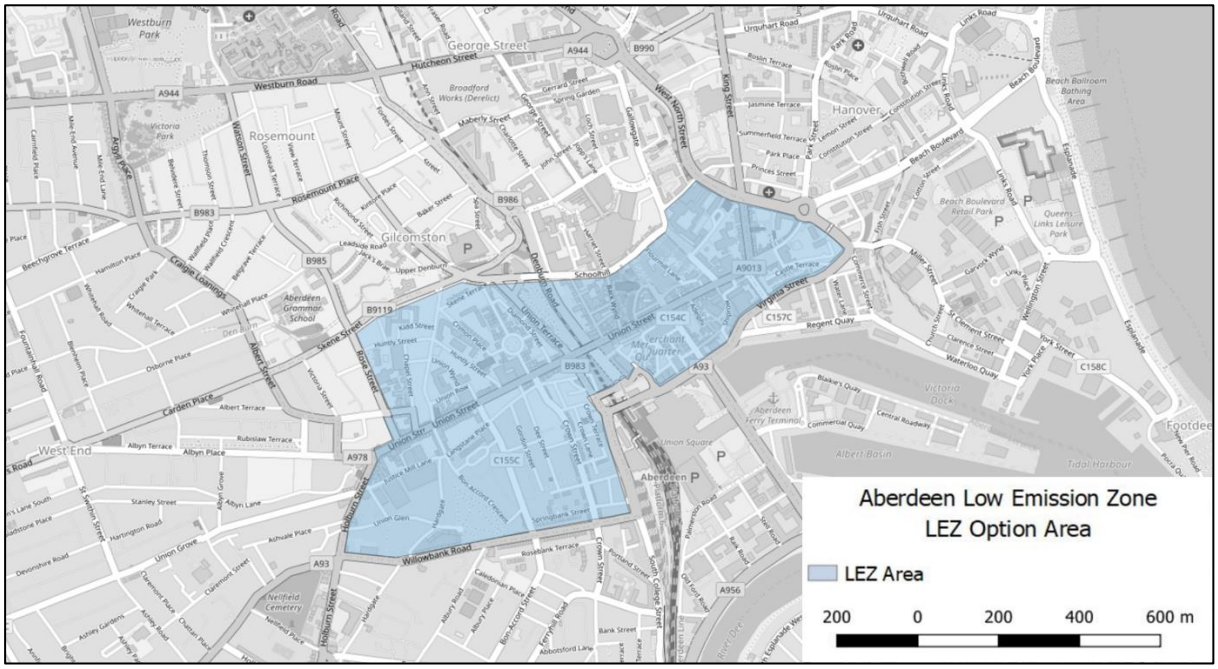
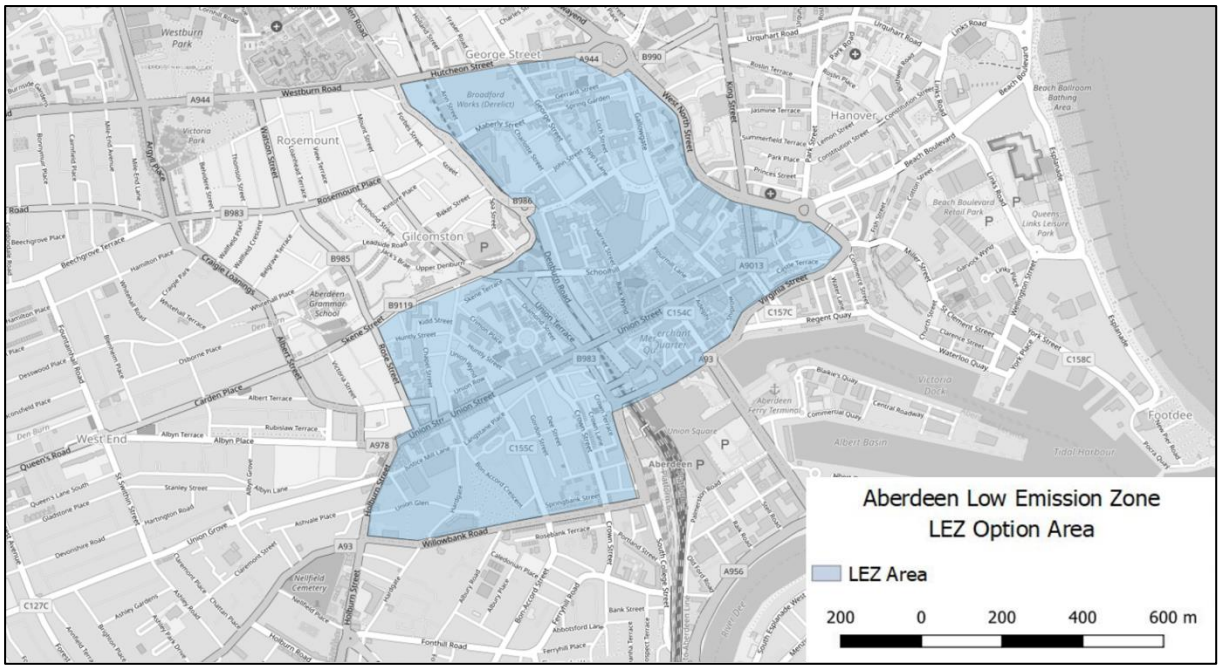
APPENDIX A: INITIAL LEZ BOUNDARY OPTIONS (FROM NLEF)



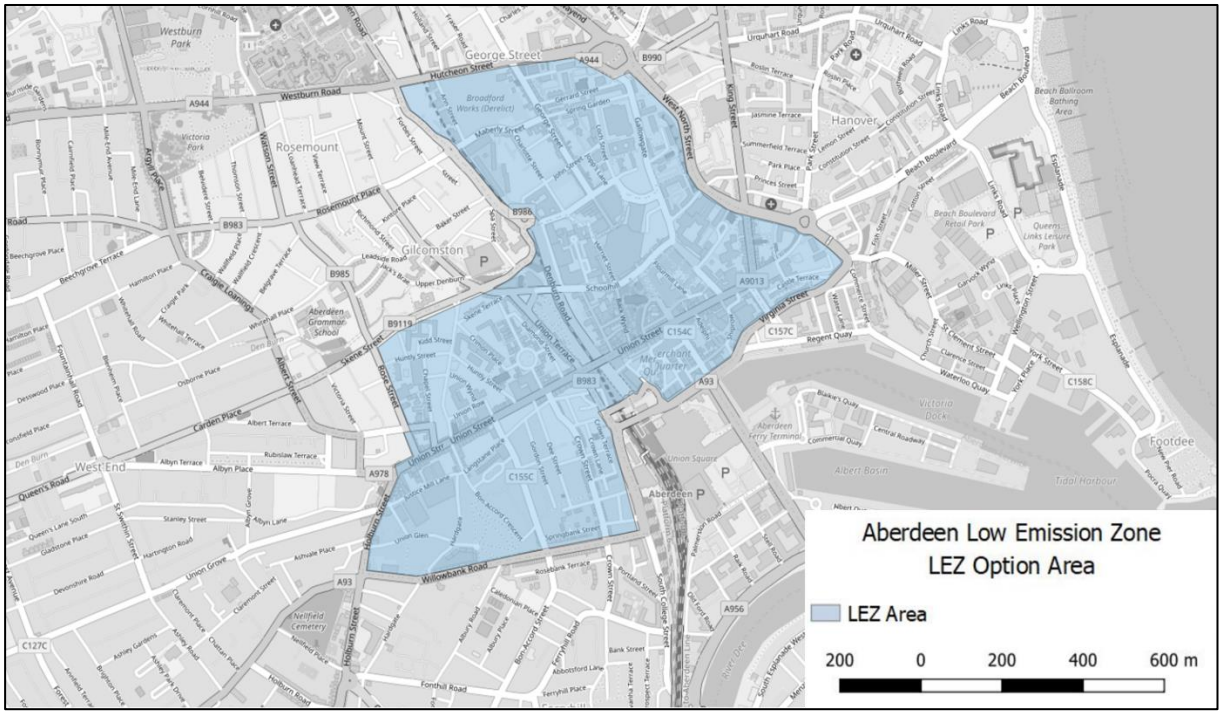
LEZ Boundary Option 1A



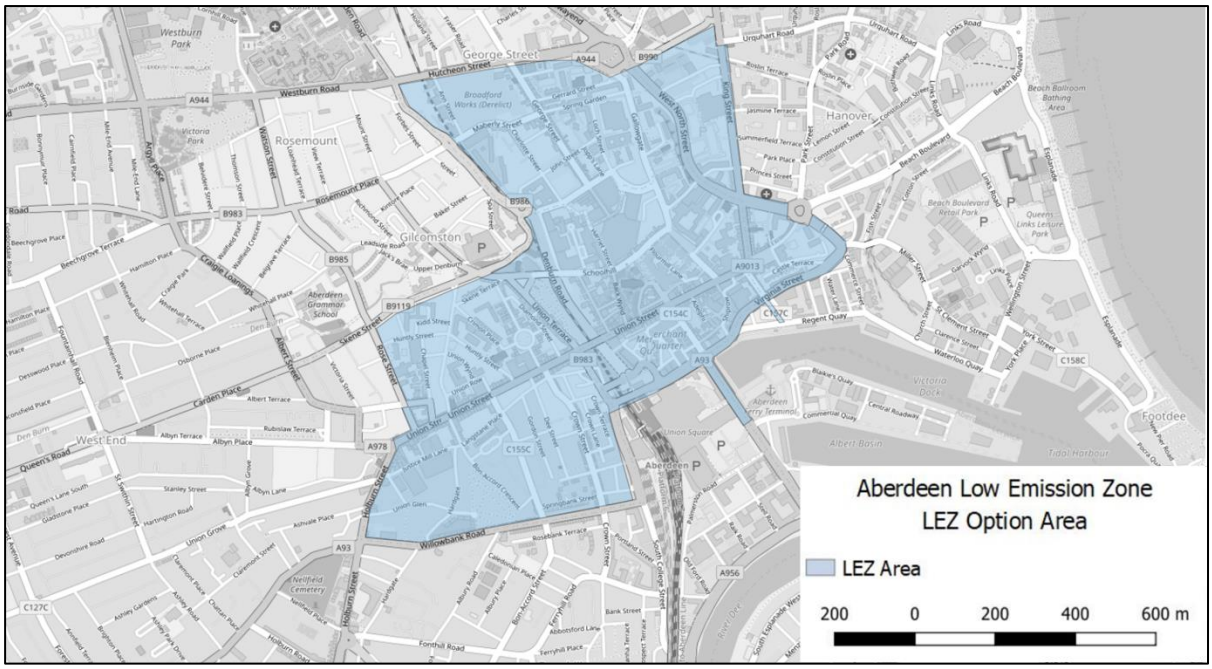
LEZ Boundary Option 1B



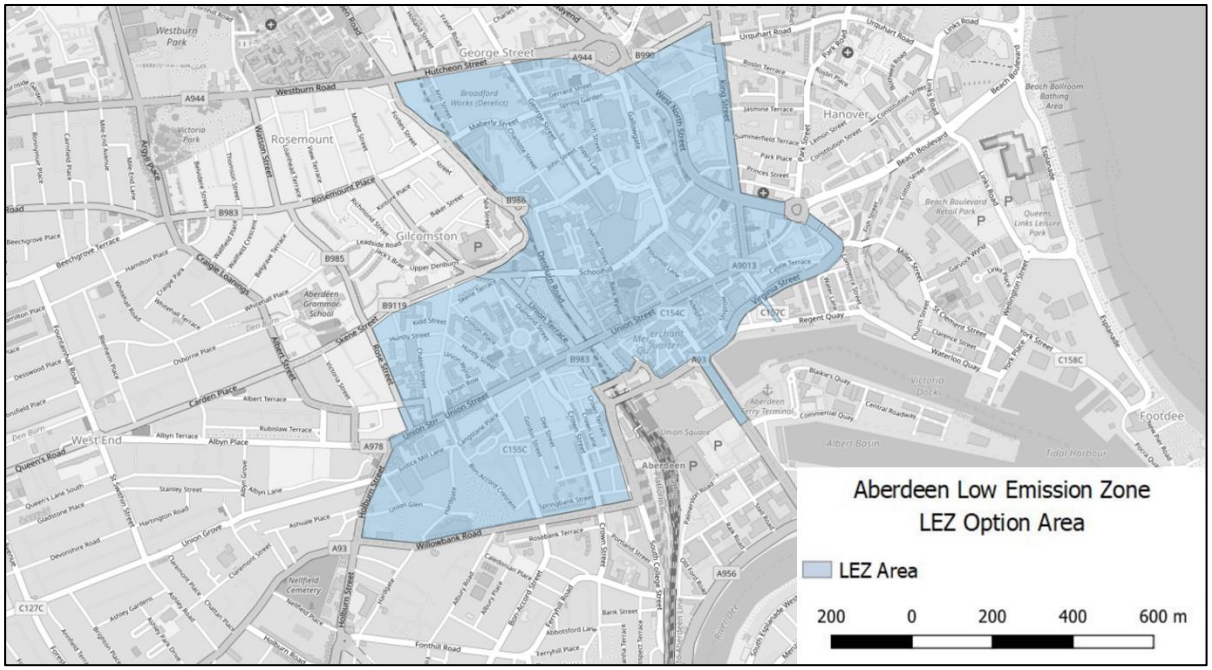
LEZ Boundary Option 2A



LEZ Boundary Option 2B

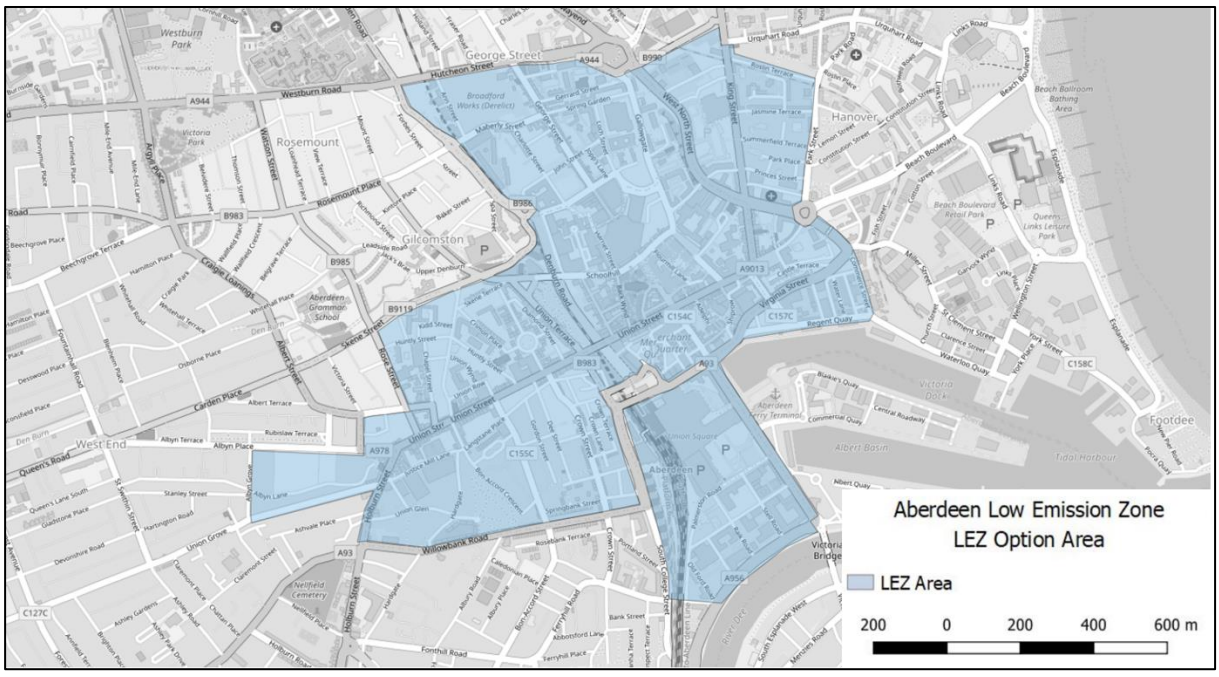


LEZ Boundary Option 3A



LEZ Boundary Option 3B

LEZ Boundary Option 4A



LEZ Boundary Option 4B

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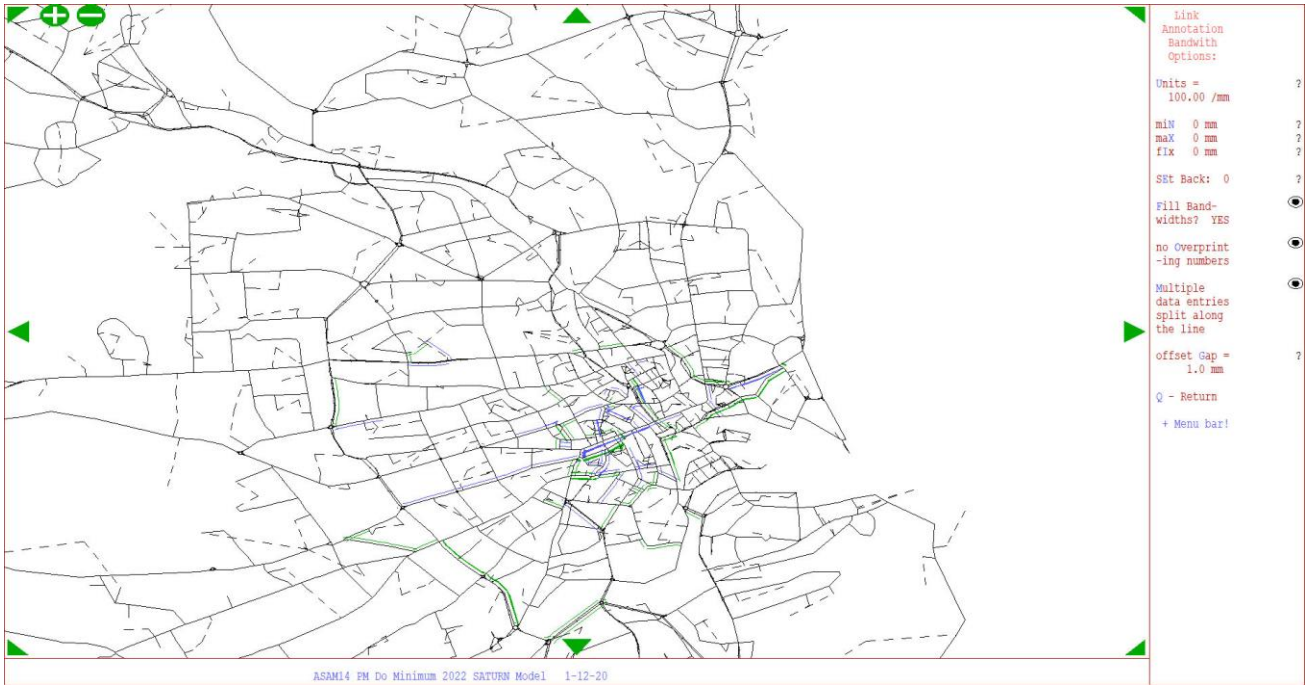
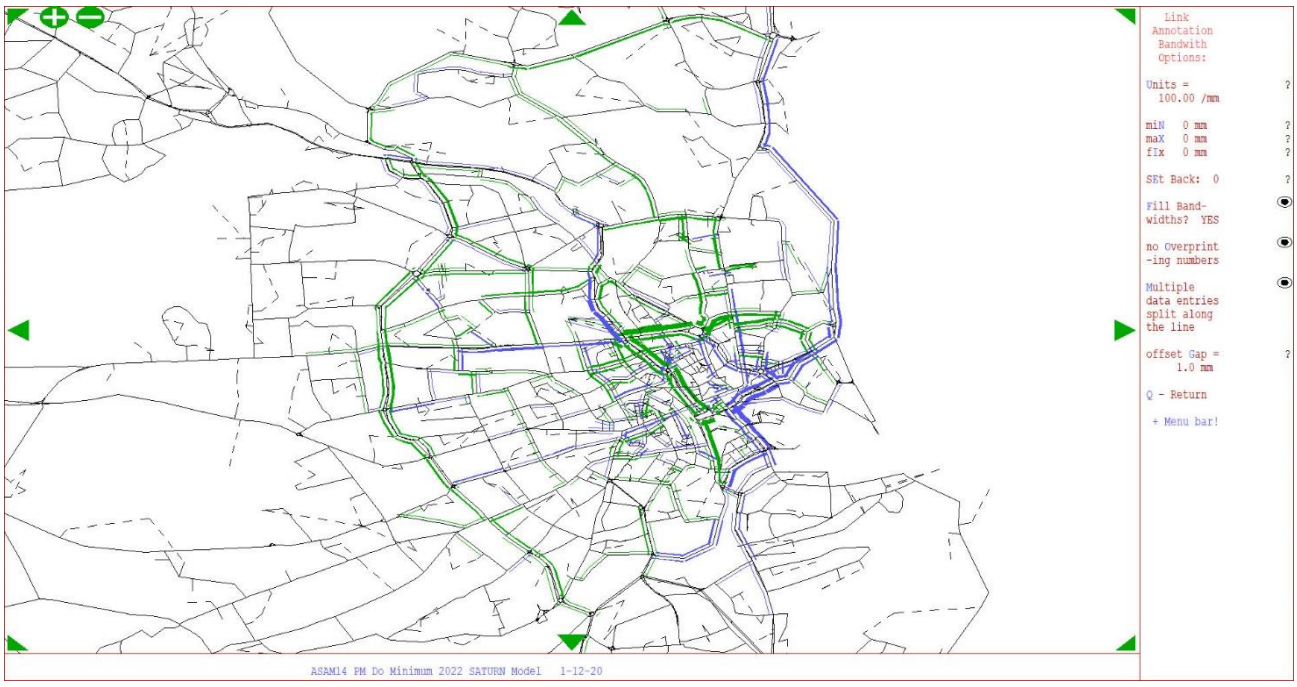
APPENDIX B – ASAM14 – LEZ FLOW DIFFERENCE PLOTS

Boundary A: LEZ Test 1B (Denburn & Harbour Route open to all)



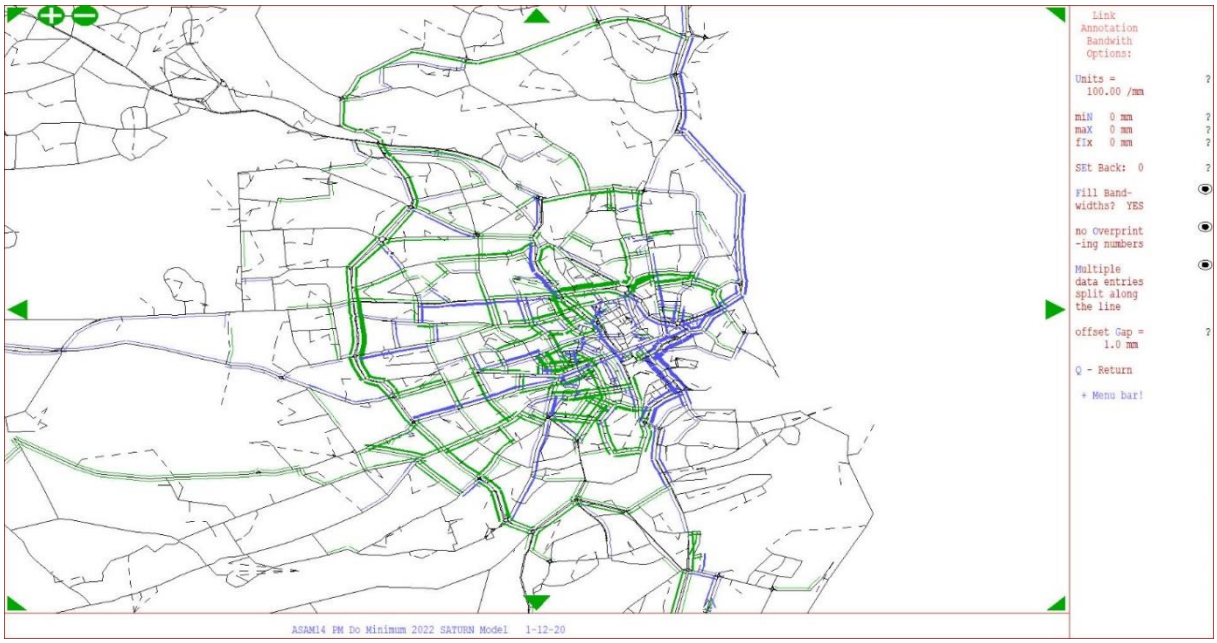
Blue = Traffic Flow Reduction, Green = Traffic Flow Increase

Boundary B: LEZ Test 3B (Harbour Route Restricted)



Blue = Traffic Flow Reduction, Green = Traffic Flow Increase

Boundary C: LEZ Test 3A (Denburn & Harbour Route Restricted)



Blue = Traffic Flow Reduction, Green = Traffic Flow Increase

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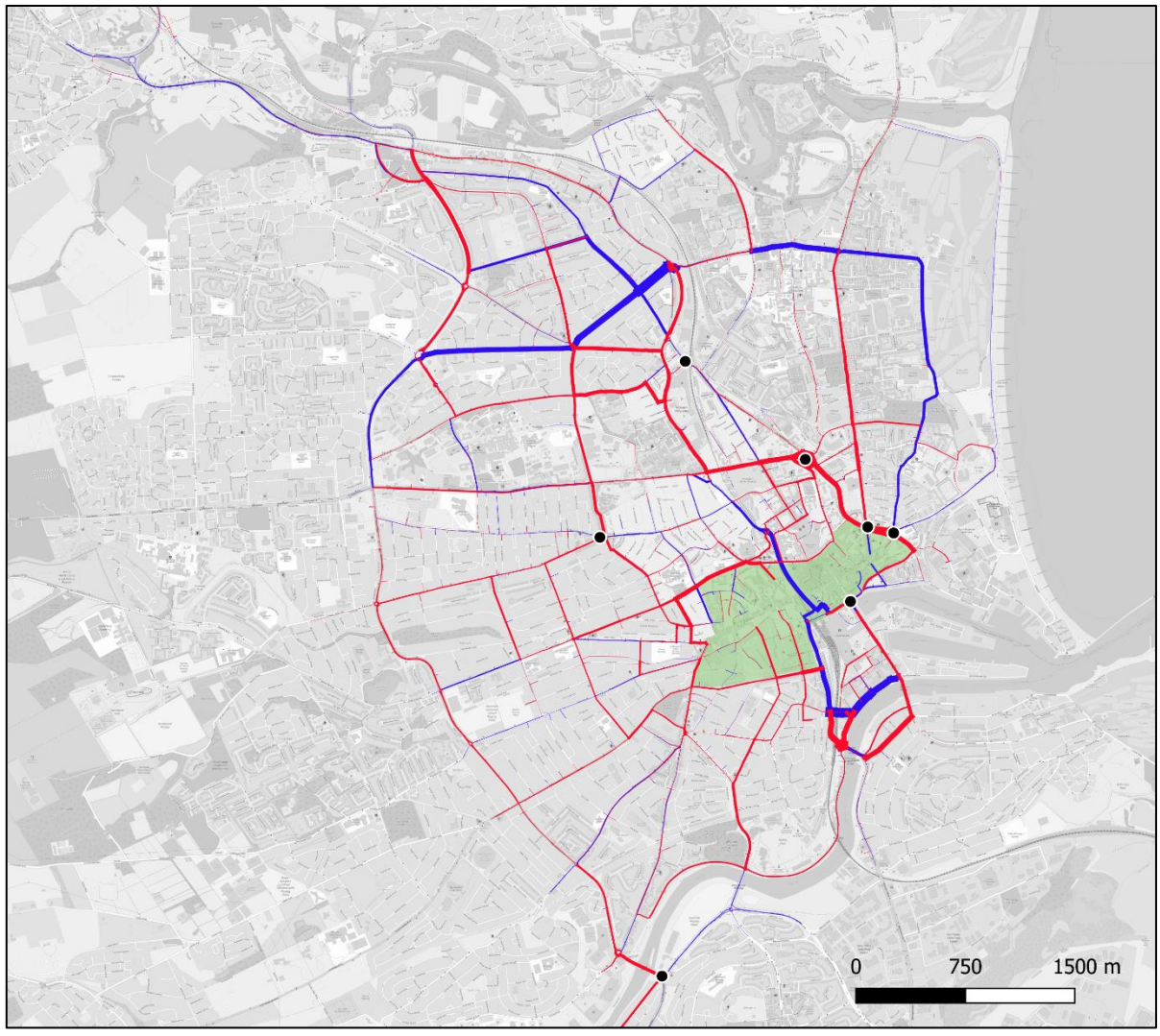
APPENDIX C: MODEL TRAFFIC FLOW COMPARISONS

Option 1A



Option 1A – PM Peak Period (16:00-19:00)

Option 1A – PM Peak Period (16:00-19:00)

Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Springbank Terrace	EB	801	1022	221	28%
Skene St	WB	1127	1343	216	19%
S College St NB (S of Palmerston Pl)	NB	1607	1891	284	18%
East North St	SB	2290	2681	392	17%
East North St	NB	2142	2484	342	16%
Hutcheon St	EB	1461	1668	207	14%
Commerce St	SB	1938	2171	234	12%
N Esplanade W (S of Palmerston Pl)	SB	2732	3000	268	10%
Hutcheon St	WB	1612	1757	145	9%
Holburn St	NB	1942	2062	120	6%
Virginia St	WB	2027	2133	106	5%
Skene St	EB	1578	1639	61	4%
N Esplanade W (S of Palmerston Pl)	NB	2078	2153	75	4%
Holburn St	SB	2363	2432	69	3%
Commerce St	NB	2627	2677	50	2%
Springbank Terrace	WB	724	738	14	2%
Park Rd	SB	1214	1217	3	0%
Virginia St	EB	3271	3235	-36	-1%
N Esplanade W (N of Palmerston Pl)	NB	2122	2089	-33	-2%
S College St (S of Palmerston Pl)	SB	1638	1611	-28	-2%
S College St (N of Palmerston Pl)	SB	1707	1594	-113	-7%
Denburn Rd	NB	2429	2266	-163	-7%
Park Rd	NB	1642	1491	-152	-9%
S College St (N of Palmerston Pl)	NB	2184	1966	-219	-10%
N Esplanade W SB (N of Palmerston Pl)	SB	3522	3010	-513	-15%
Denburn Rd	SB	1681	1408	-273	-16%

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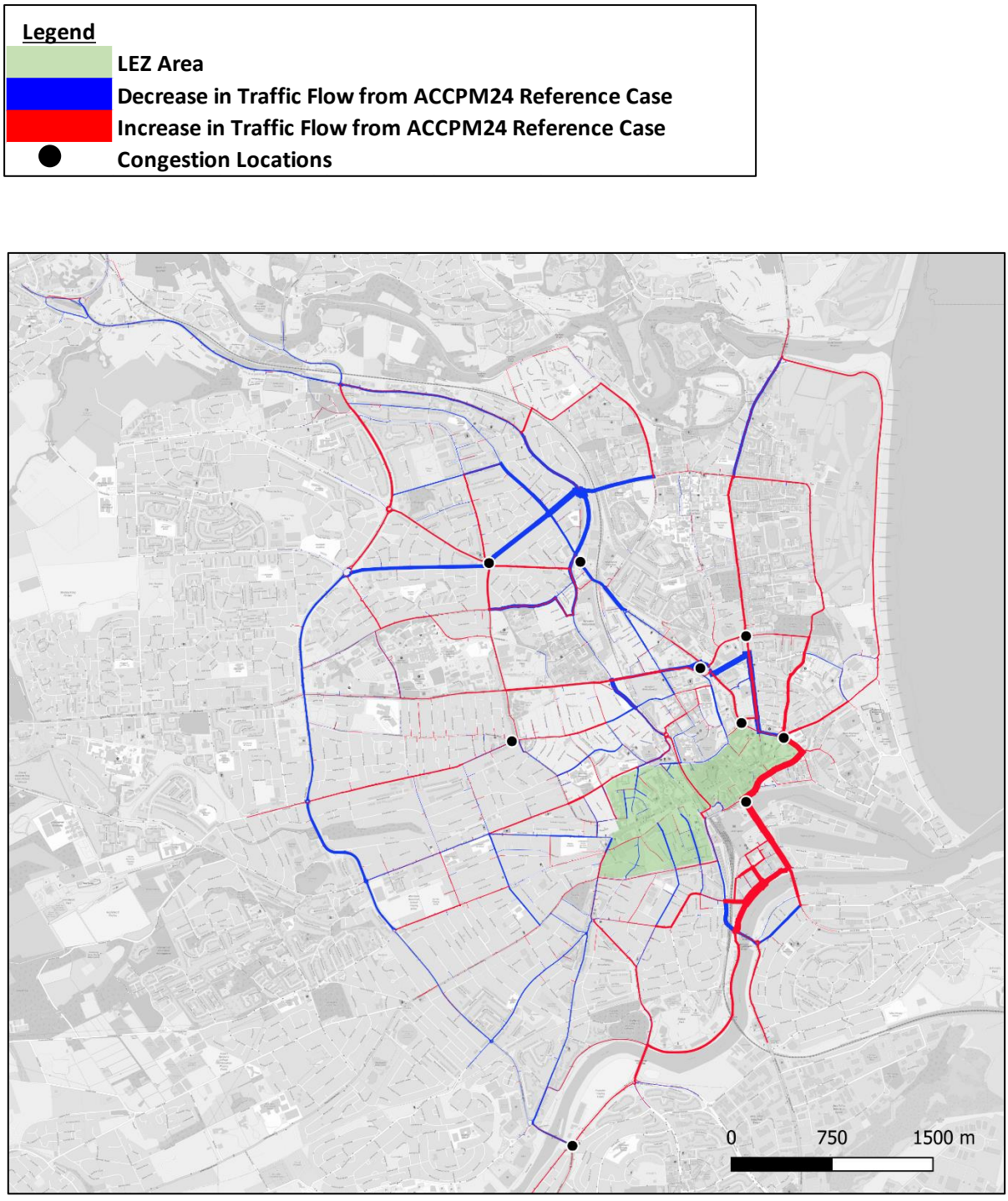
Option 1B



Option 1B – PM Peak (16:00-19:00)

Option 1B – PM Peak (16:00-19:00)

Location	Dir.	Ref Case Flow at 100% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Commerce St	NB	2141	2760	619	29%
Virginia St	EB	2716	3433	717	26%
Virginia St	WB	1850	2322	473	26%
N Esplanade W (N of Palmerston Pl)	SB	3101	3792	691	22%
N Esplanade W (S of Palmerston Pl)	SB	2289	2756	467	20%
Commerce St	SB	1945	2223	278	14%
Park Rd	NB	1497	1709	212	14%
N Esplanade W (S of Palmerston Pl)	NB	1998	2263	265	13%
Market St	NB	3454	3889	436	13%
Springbank Terrace	WB	803	900	97	12%
Market St	SB	3075	3431	356	12%
Park Rd	SB	1247	1375	128	10%
N Esplanade W (N of Palmerston Pl)	NB	2155	2297	142	7%
Berryden Rd (Powis Rd Jct)	SB	1704	1811	107	6%
Denburn Rd	SB	1769	1843	74	4%
Springbank Terrace	EB	959	992	33	3%
S College St (N of Palmerston Pl)	NB	2361	2406	45	2%
Hutcheon St	WB	1680	1711	32	2%
Denburn Rd	NB	2561	2595	34	1%
East North St	NB	2281	2311	30	1%
S College St (N of Palmerston Pl)	SB	1879	1859	-20	-1%
S College St (S of Palmerston Pl)	SB	1929	1751	-178	-9%
Berryden Rd (Powis Rd Jct)	NB	1901	1720	-181	-10%
S College St (S of Palmerston Pl)	NB	1897	1712	-186	-10%
Hutcheon St	EB	1660	1496	-164	-10%
East North St	SB	2851	2451	-400	-14%

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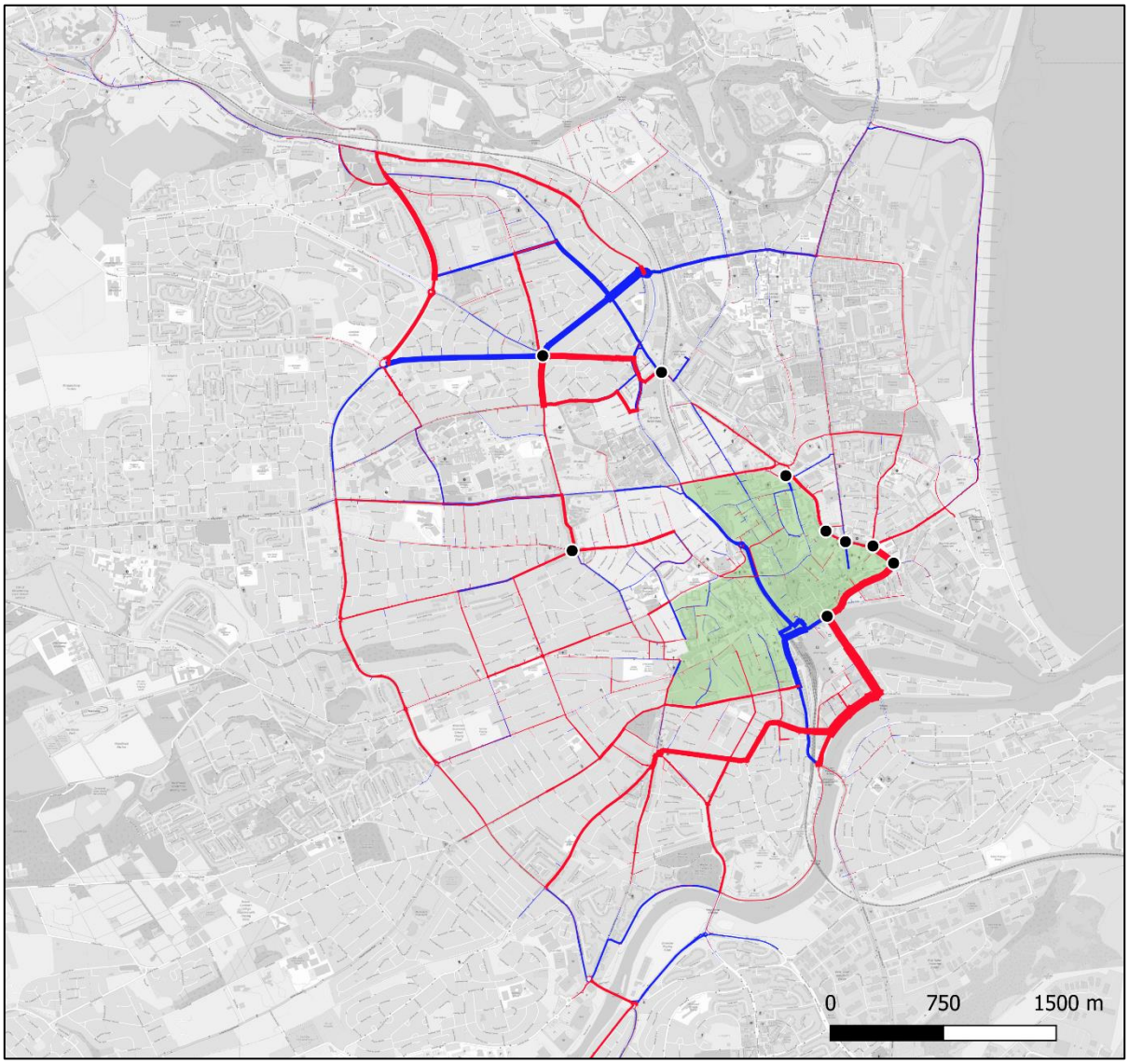
Option 2A

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



Option 2A – PM Peak (16:00-19:00)

Option 2A – PM Peak (16:00-19:00)

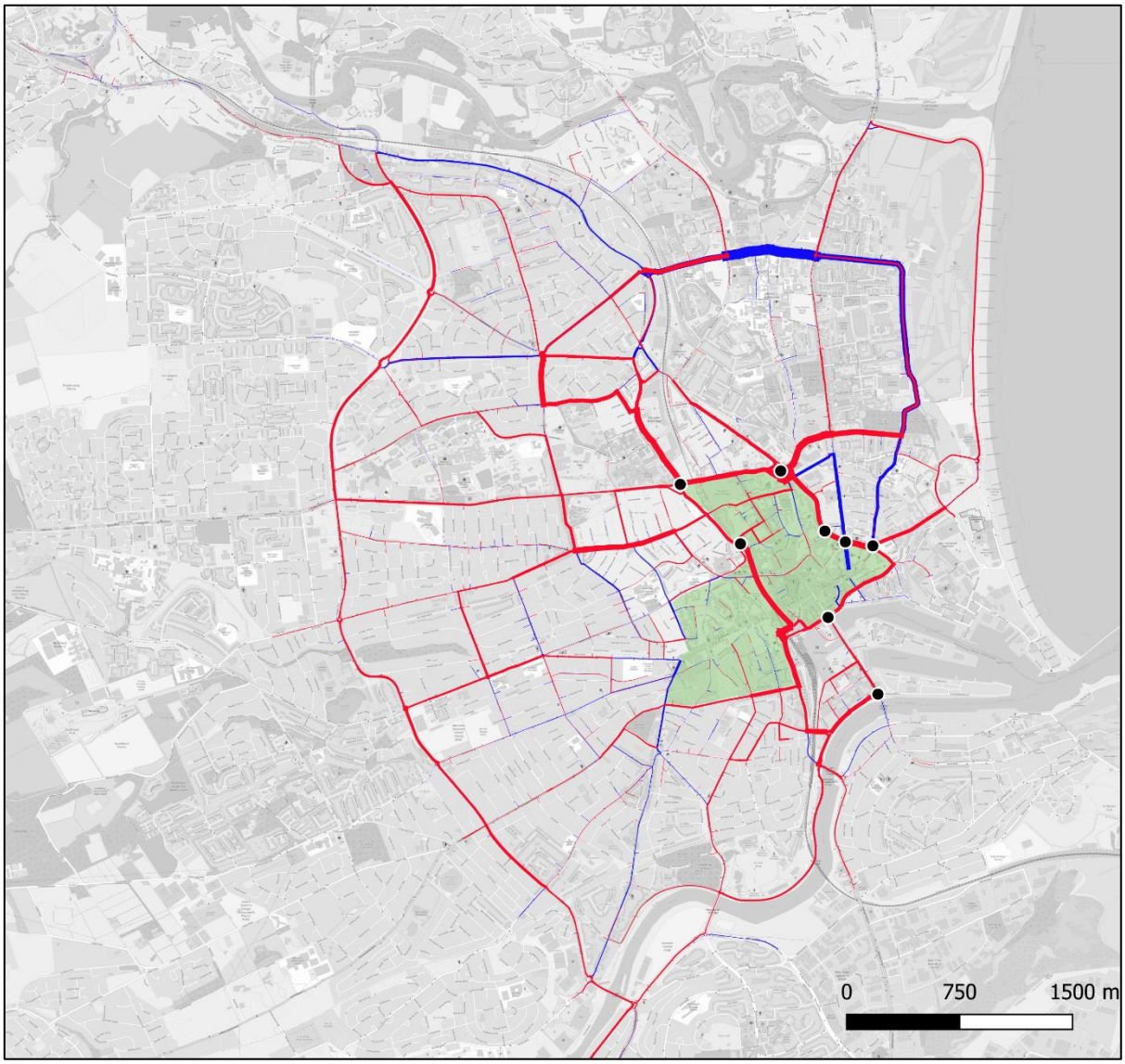
Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Back Hilton Rd	EB	957	1248	291	30%
Fonthill Rd	WB	1048	1302	254	24%
Virginia St	WB	2027	2385	358	18%
Springbank Terrace	EB	801	938	137	17%
Commerce St	SB	1938	2268	331	17%
Market St	SB	3426	3818	393	11%
Beechgrove Ter	EB	1305	1452	147	11%
North Anderson Dr (Haudagain)	SB	3529	3807	278	8%
Hutcheon St	EB	1461	1550	89	6%
Commerce St	NB	2627	2762	135	5%
Virginia St	EB	3271	3436	166	5%
Market St	NB	3735	3868	133	4%
Hutcheon St	WB	1612	1669	57	4%
Fonthill Rd	EB	746	755	9	1%
North Anderson Dr (Haudagain)	NB	5281	5337	57	1%
Springbank Terrace	WB	724	708	-17	-2%
Skene Sq	NB	2989	2917	-73	-2%
Beechgrove Ter	WB	1846	1779	-67	-4%
Berryden Rd (Powis Rd J)	SB	1489	1418	-71	-5%
S College St (N of Palmerston Pl)	NB	2184	2032	-152	-7%
Skene Sq	SB	1797	1663	-134	-7%
Denburn Rd	NB	2429	2222	-207	-9%
Back Hilton Rd	WB	1586	1439	-147	-9%
Berryden Rd (Powis Rd J)	NB	1652	1489	-163	-10%
Denburn Rd	SB	1681	1434	-247	-15%
S College St (N of Palmerston Pl)	SB	1707	1348	-360	-21%

Return to Report

Option 2B

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



Option 2B – PM Peak (16:00-19:00)

Option 2B – PM Peak (16:00-19:00)

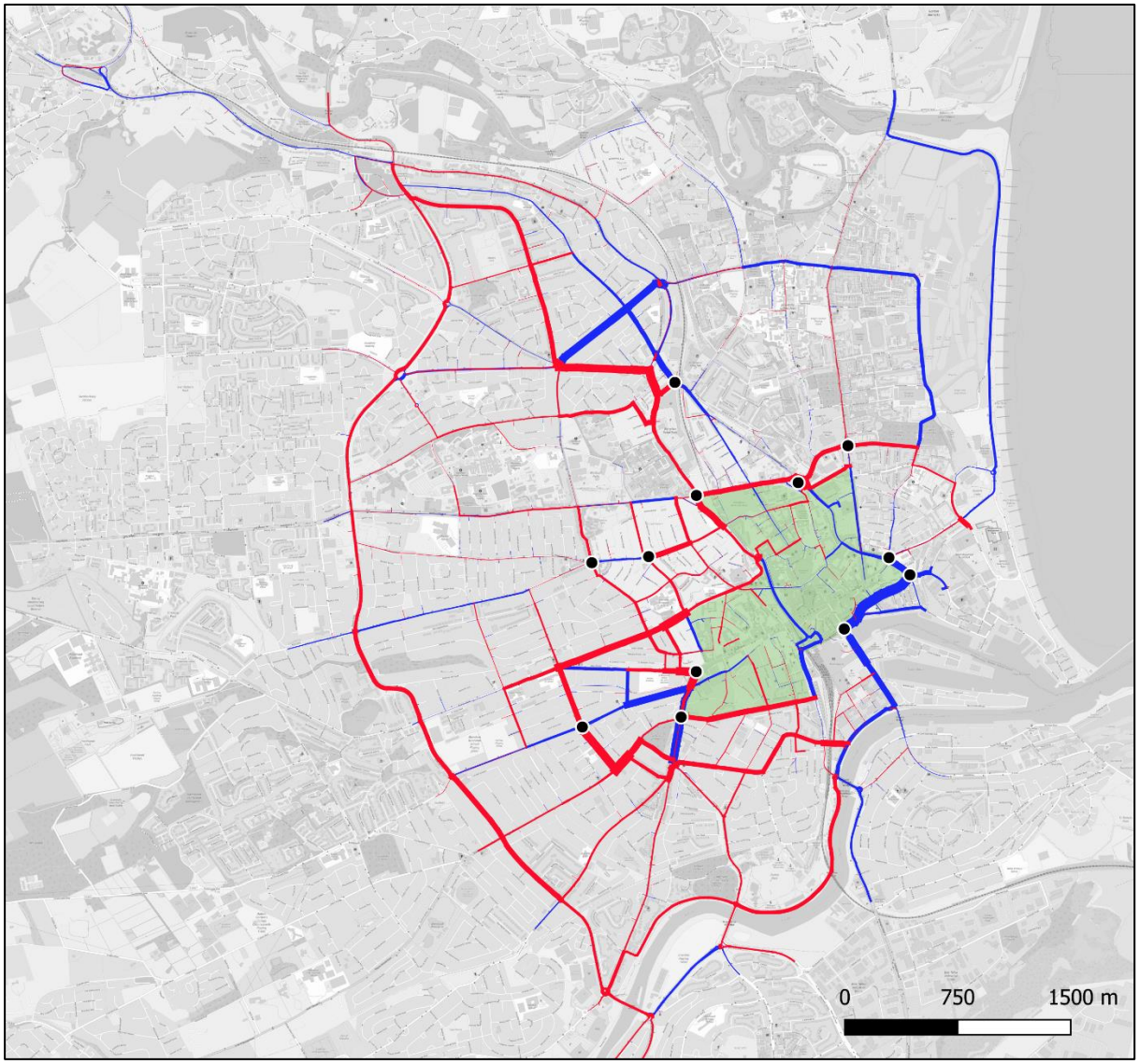
Location	Dir.	Ref Case Flow at 80% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Mounthooly Way	WB	1119	1399	280	25%
Palmerston Pl	WB	937	1144	207	22%
Rosemount Pl	WB	1185	1413	228	19%
Springbank Terrace	EB	676	788	113	17%
Hutcheon St	WB	1454	1657	203	14%
East North Street	NB	1770	2010	240	14%
Denburn Rd	NB	2030	2236	207	10%
Springbank Terrace	WB	576	633	57	10%
Virginia St	WB	1911	2061	150	8%
Commerce St	SB	1798	1920	122	7%
N Esplanade W (S of Palmerston Pl)	NB	1885	1992	108	6%
N Esplanade W (N of Palmerston Pl)	SB	3356	3525	169	5%
Park Rd	SB	992	1024	32	3%
Virginia St	EB	2911	2989	78	3%
Denburn Rd	SB	1383	1419	36	3%
N Esplanade W (S of Palmerston Pl)	SB	2632	2693	62	2%
Mounthooly Way	EB	1156	1182	26	2%
Hutcheon St	EB	1295	1324	29	2%
Commerce St	NB	2298	2316	18	1%
Palmerston Pl	EB	222	223	1	0%
Rosemount Pl	EB	1051	1051	0	0%
N Esplanade W (N of Palmerston Pl)	NB	1864	1842	-22	-1%
East North Street	SB	1951	1885	-66	-3%
Kings St	SB	1145	1105	-40	-3%
Park Rd	NB	1446	1245	-201	-14%
Kings St	NB	1136	859	-277	-24%

Return to Report

Option 3A

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



Option 3A – PM Peak (16:00-19:00)

Option 3A – PM Peak (16:00-19:00)

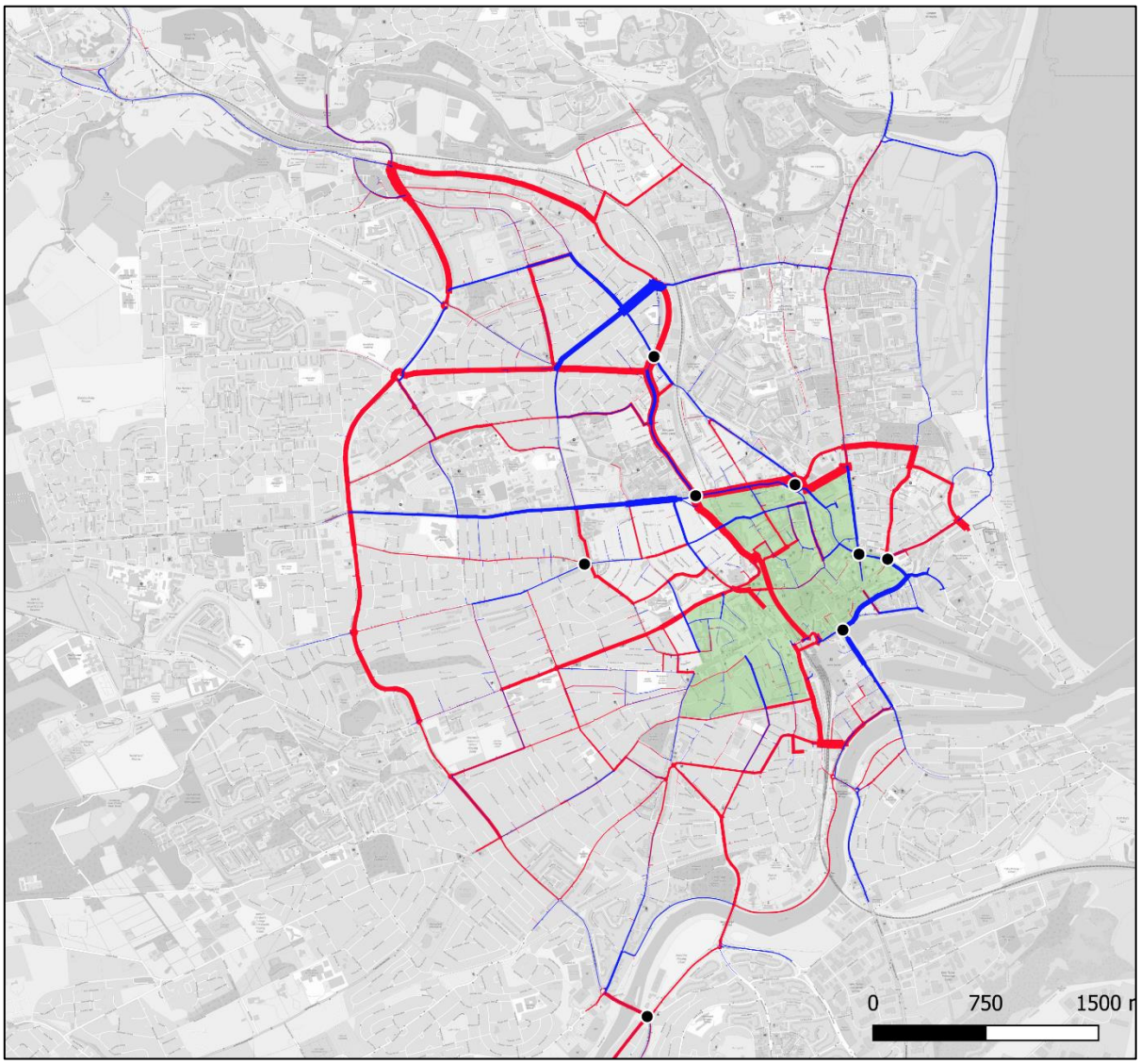
Location	Dir.	Ref Case Flow at 90% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Ashley Rd	NB	526	905	379	72%
Back Hilton Rd	EB	873	1232	359	41%
Carden Pl	EB	1030	1338	308	30%
Springbank Terrace	EB	798	1012	214	27%
Fonthill Rd	WB	899	1126	227	25%
Springbank Terrace	WB	655	784	130	20%
Holburn Street (Union St J)	SB	2141	2512	371	17%
Hutcheon St	EB	1400	1635	235	17%
Mounthooly Way	WB	1302	1513	211	16%
Carden Pl	WB	837	954	117	14%
Ashley Rd	SB	494	560	66	13%
Skene Sq	NB	2671	2977	306	11%
South Anderson Dr (Great Western Rd)	NB	2784	3032	249	9%
Fonthill Rd	EB	698	758	60	9%
Back Hilton Rd	WB	1258	1363	105	8%
Mounthooly Way	EB	1305	1411	106	8%
Hutcheon St	WB	1553	1646	93	6%
South Anderson Dr (Great Western Rd)	SB	2879	2986	107	4%
Skene Sq	SB	1687	1724	37	2%
Denburn Rd	NB	2223	2109	-114	-5%
Holburn Street (Union St J)	NB	1649	1541	-108	-7%
S College St (N of Palmerston Pl)	NB	2065	1924	-141	-7%
Denburn Rd	SB	1556	1438	-118	-8%
Commerce St	SB	1930	1783	-147	-8%
Market St	SB	3512	3211	-302	-9%
Market St	NB	3600	3189	-411	-11%
Commerce St	NB	2571	2223	-348	-14%
S College St (N of Palmerston Pl)	SB	1451	1237	-214	-15%

Return to Report

Option 3B

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



Option 3B – PM Peak (16:00-19:00)

Option 3B – PM Peak (16:00-19:00)

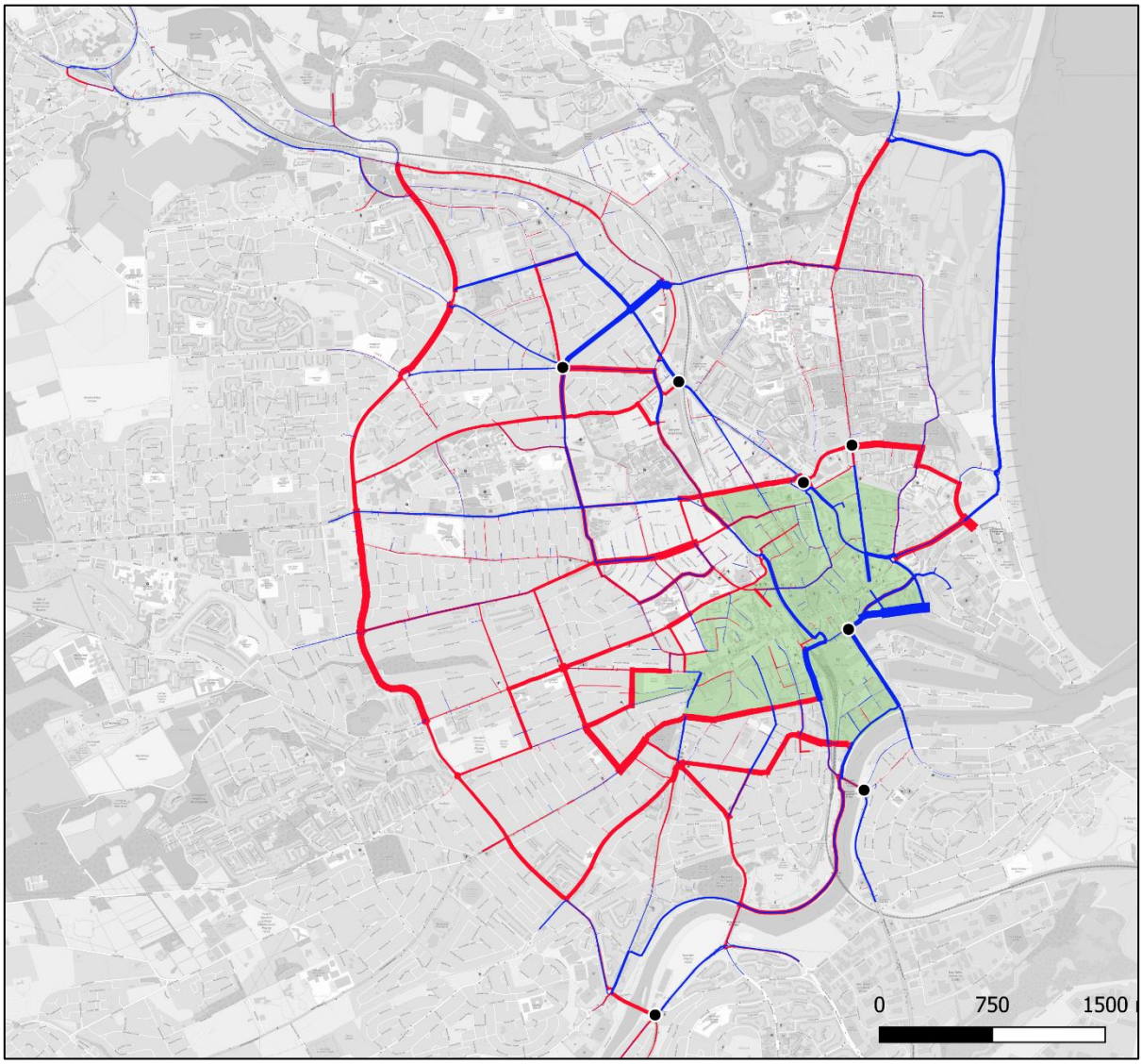
Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Seaforth Rd	EB	737	974	237	32%
Back Hilton Rd	EB	957	1205	248	26%
Berryden Rd (Powis Rd J)	SB	1489	1831	342	23%
Hutcheon St	EB	1461	1747	286	20%
Skene St	WB	1127	1281	154	14%
Carden Pl	EB	1175	1325	150	13%
Springbank Terrace	WB	724	815	91	13%
Ashley Rd	SB	544	607	63	12%
Denburn Rd	SB	1681	1870	189	11%
Skene Sq	NB	2989	3280	291	10%
Seaforth Rd	WB	800	871	71	9%
S College St (N of Palmerston Pl)	NB	2184	2376	192	9%
Fonthill Rd	WB	1048	1136	89	8%
Carden Pl	WB	953	1033	80	8%
Skene Sq	SB	1797	1946	149	8%
Skene St	EB	1578	1693	115	7%
North Anderson Dr (Haudagain)	SB	3529	3760	231	7%
Fonthill Rd	EB	746	791	45	6%
Denburn Rd	NB	2429	2560	132	5%
N Anderson Dr	SB	3609	3804	195	5%
Springbank Terrace	EB	801	843	42	5%
Ashley Rd	NB	567	593	27	5%
S College St (N of Palmerston Pl)	SB	1707	1779	72	4%
N Anderson Dr	NB	3825	3943	119	3%
Back Hilton Rd	WB	1586	1616	31	2%
North Anderson Dr (Haudagain)	NB	5281	5376	96	2%
Berryden Rd (Powis Rd J)	NB	1652	1616	-36	-2%
Virginia St	WB	2027	1927	-101	-5%
Market St	SB	3426	3210	-216	-6%
Hutcheon St	WB	1612	1509	-104	-6%
Westburn Rd	WB	2321	2113	-208	-9%
Market St	NB	3735	3400	-335	-9%
Virginia St	EB	3271	2947	-324	-10%
Westburn Rd	EB	1542	1107	-435	-28%

Return to Report

Option 4A

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



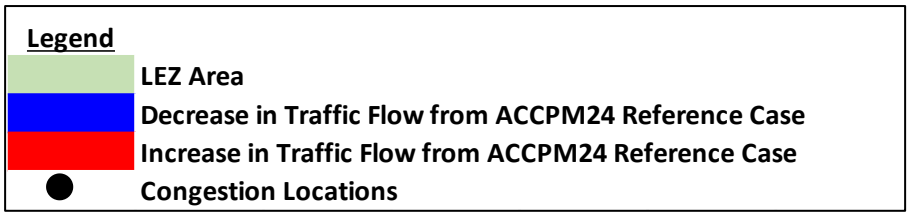
Option 4A – PM Peak (16:00-19:00)

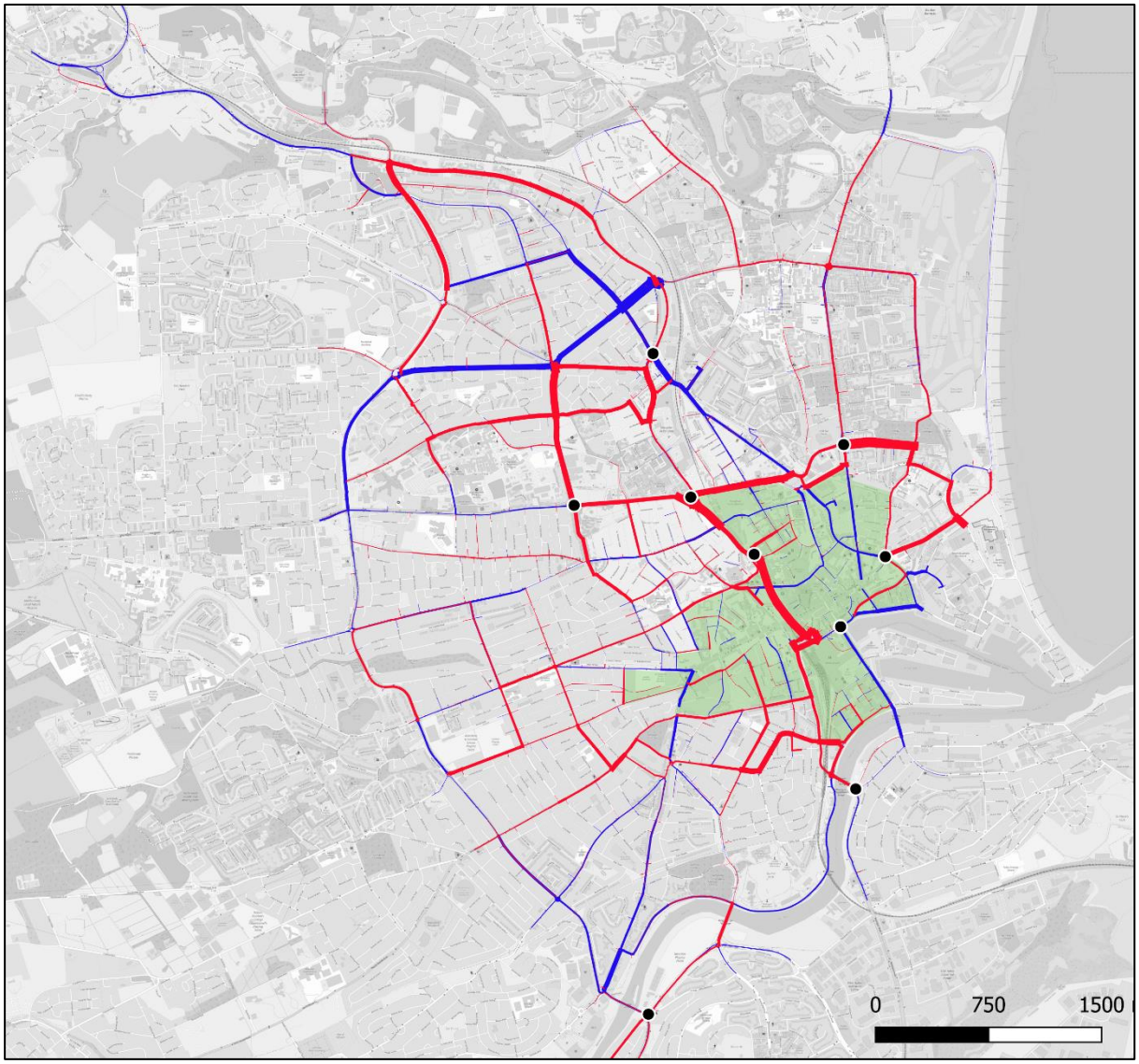
Option 4A – PM Peak (16:00-19:00)

Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Ashley Rd	NB	567	829	262	46%
Albyn Grove	NB	718	1015	298	41%
Seaforth Rd	EB	737	1017	280	38%
Ashley Rd	SB	544	743	199	37%
Springbank Terrace	EB	801	1026	225	28%
Back Hilton Rd	EB	957	1222	265	28%
Palmerston Pl	WB	991	1216	225	23%
Seaforth Rd	WB	800	960	160	20%
Rosemount Pl	WB	1319	1569	250	19%
Fonthill Rd	WB	1048	1214	166	16%
Hutcheon St	EB	1461	1686	225	15%
N Anderson Dr	SB	3609	3952	343	10%
N Anderson Dr	NB	3825	4055	231	6%
Springbank Terrace	WB	724	766	42	6%
Skene Sq	NB	2989	3143	154	5%
Albyn Grove	SB	905	946	42	5%
Hutcheon St	WB	1612	1683	71	4%
Kings St	SB	1403	1456	53	4%
Commerce St	SB	1938	2000	62	3%
Back Hilton Rd	WB	1586	1605	19	1%
Fonthill Rd	EB	746	750	4	1%
Denburn Rd	NB	2429	2394	-35	-1%
Palmerston Pl	EB	283	278	-5	-2%
Skene Sq	SB	1797	1704	-93	-5%
S College St (N of Palmerston Pl)	NB	2184	2064	-121	-6%
Rosemount Pl	EB	1099	1026	-74	-7%
Market St	NB	3735	3417	-319	-9%
Commerce St	NB	2627	2375	-253	-10%
Market St	SB	3426	3017	-409	-12%
Denburn Rd	SB	1681	1446	-235	-14%
Kings St	NB	1390	1113	-277	-20%
S College St (N of Palmerston Pl)	SB	1707	1238	-469	-27%
Regent Quay	EB	127	89	-38	-30%
Regent Quay	WB	916	116	-801	-87%

Return to Report

Option 4B





Option 4B – PM Peak (16:00-19:00)

Option 4B – PM Peak (16:00-19:00)

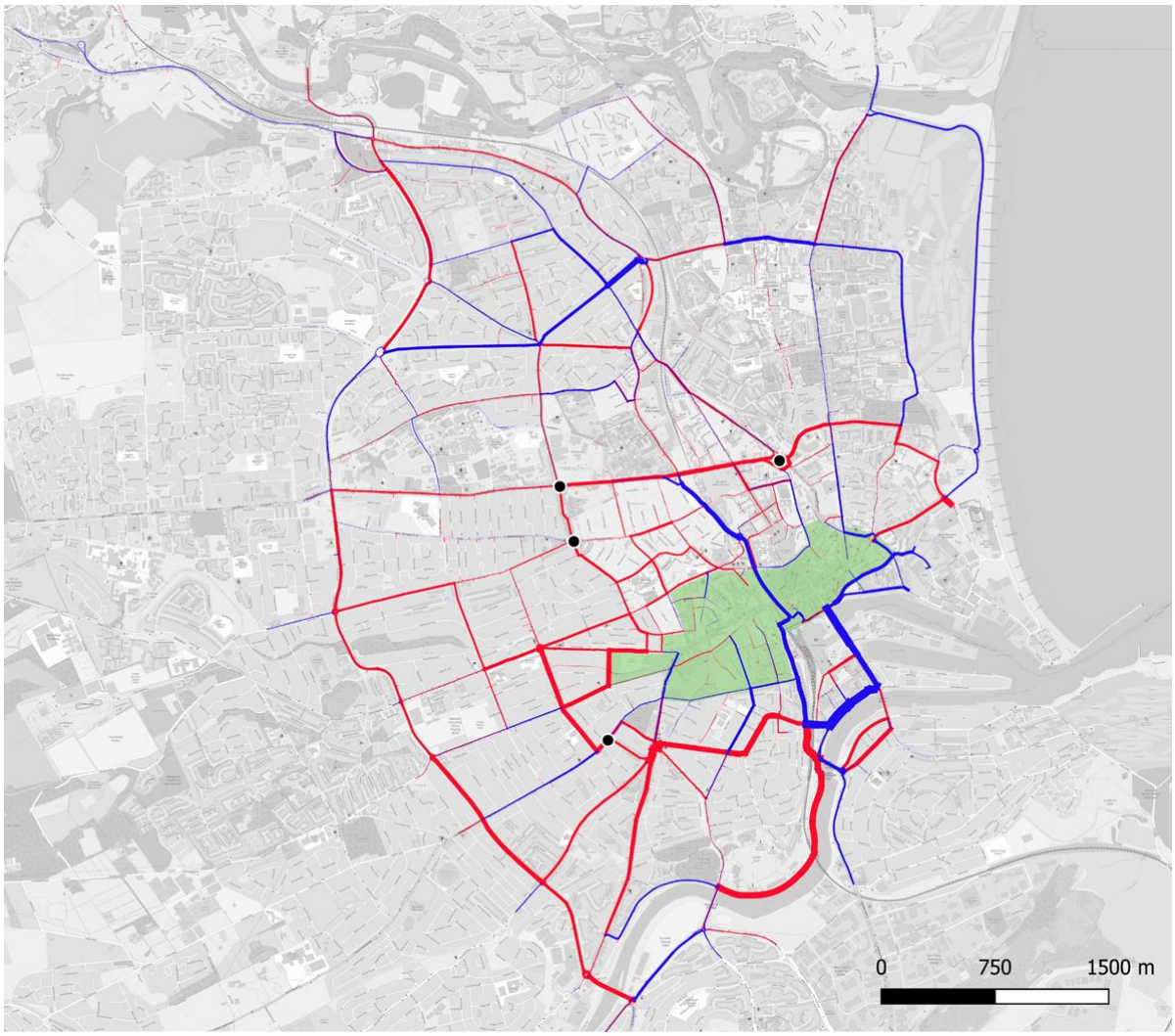
Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Seaforth Rd	EB	737	1063	326	44%
Palmerston Pl	WB	991	1241	250	25%
Denburn Rd	SB	1681	2059	379	23%
Skene Sq	SB	1797	2189	392	22%
Ashley Rd	NB	567	673	106	19%
Hutcheon St	EB	1461	1728	267	18%
Back Hilton Rd	EB	957	1118	161	17%
Springbank Terrace	WB	724	842	118	16%
Seaforth Rd	WB	800	928	128	16%
Westburn Dr	SB	1402	1579	177	13%
Springbank Terrace	EB	801	883	82	10%
S College St (N of Palmerston Pl)	SB	1707	1880	173	10%
Regent Quay	EB	127	138	11	9%
Denburn Rd	NB	2429	2637	209	9%
S College St (N of Palmerston Pl)	NB	2184	2366	182	8%
Ashley Rd	SB	544	581	37	7%
Berryden Rd (Powis Rd J)	SB	1489	1582	94	6%
North Anderson Dr (Haudagain)	SB	3529	3750	222	6%
Hutcheon St	WB	1612	1689	77	5%
Westburn Dr	NB	2158	2256	98	5%
Kings St	SB	1403	1406	4	0%
North Anderson Dr (Haudagain)	NB	5281	5244	-37	-1%
Skene Sq	NB	2989	2966	-24	-1%
Palmerston Pl	EB	283	274	-9	-3%
Market St	SB	3426	3291	-135	-4%
Kings St	NB	1390	1318	-72	-5%
Back Hilton Rd	WB	1586	1491	-95	-6%
Market St	NB	3735	3506	-230	-6%
Berryden Rd (Powis Rd J)	NB	1652	1505	-147	-9%
Regent Quay	WB	916	711	-205	-22%

Return to Report

Option 5

Legend

- LEZ Area
- Decrease in Traffic Flow from ACCPM24 Reference Case
- Increase in Traffic Flow from ACCPM24 Reference Case
- Congestion Locations



Option 5 – PM Peak (16:00-19:00)

Option 5 – PM Peak (16:00-19:00)

Location	Dir.	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Ashley Rd	SB	544	868	324	59%
Ashley Rd	NB	567	863	297	52%
Albyn Grove	NB	718	1062	345	48%
St Swithin St	SB	773	1124	351	45%
Fonthill Rd	WB	1048	1415	368	35%
S College St (S of Palmerston Pl)	NB	1607	2113	507	32%
Fonthill Rd	EB	746	978	232	31%
Seaforth Rd	EB	737	942	205	28%
Riverside Dr	NB	1726	2164	439	25%
Holburn St	SB	2525	3079	554	22%
Holburn St	NB	1894	2307	413	22%
Seaforth Rd	WB	800	974	174	22%
Hutcheon St	WB	1612	1933	321	20%
Back Hilton Rd	EB	957	1135	178	19%
Hutcheon St	EB	1461	1723	262	18%
Albyn Grove	SB	905	1026	122	13%
St Swithin St	NB	626	691	65	10%
Riverside Dr	SB	2310	2486	176	8%
Back Hilton Rd	WB	1586	1701	115	7%
Springbank Terrace	EB	801	845	44	5%
S College St (S of Palmerston Pl)	SB	1638	1714	76	5%
Skene Sq	SB	1797	1765	-32	-2%
Palmerston Pl	EB	283	277	-6	-2%
Market St	NB	3735	3652	-83	-2%
S College St (N of Palmerston Pl)	SB	1707	1614	-93	-5%
Denburn Rd	SB	1681	1508	-173	-10%
Skene Sq	NB	2989	2616	-373	-12%
Denburn Rd	NB	2429	2097	-331	-14%
N Esplanade W (N of Palmerston Pl)	NB	2122	1830	-291	-14%
Springbank Terrace	WB	724	606	-118	-16%
S College St (N of Palmerston Pl)	NB	2184	1816	-368	-17%
Market St	SB	3426	2734	-691	-20%
N Esplanade W (N of Palmerston Pl)	SB	3522	2654	-868	-25%
Regent Quay	WB	916	662	-254	-28%
Regent Quay	EB	127	85	-41	-33%
Palmerston Pl	WB	991	342	-649	-66%

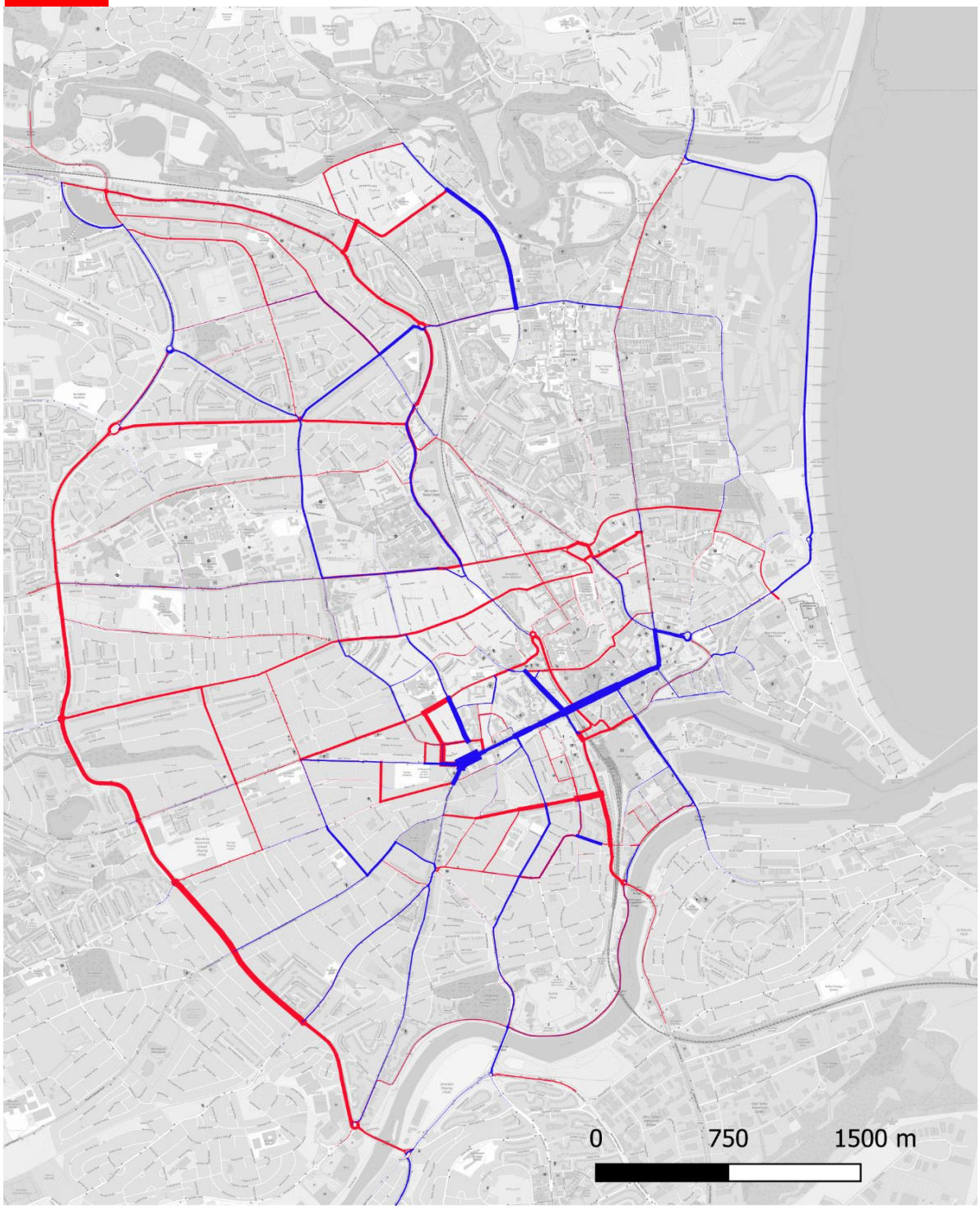
Return To Report

APPENDIX D: FINAL SCHEME - MODEL TRAFFIC FLOWS

Legend

Decrease in Model Traffic Flow from ACCPM24 Reference Case

Increase in Model Traffic Flow from ACCPM24 Reference Case



Final LEZ Scheme – AM Peak (07:00-09:00)

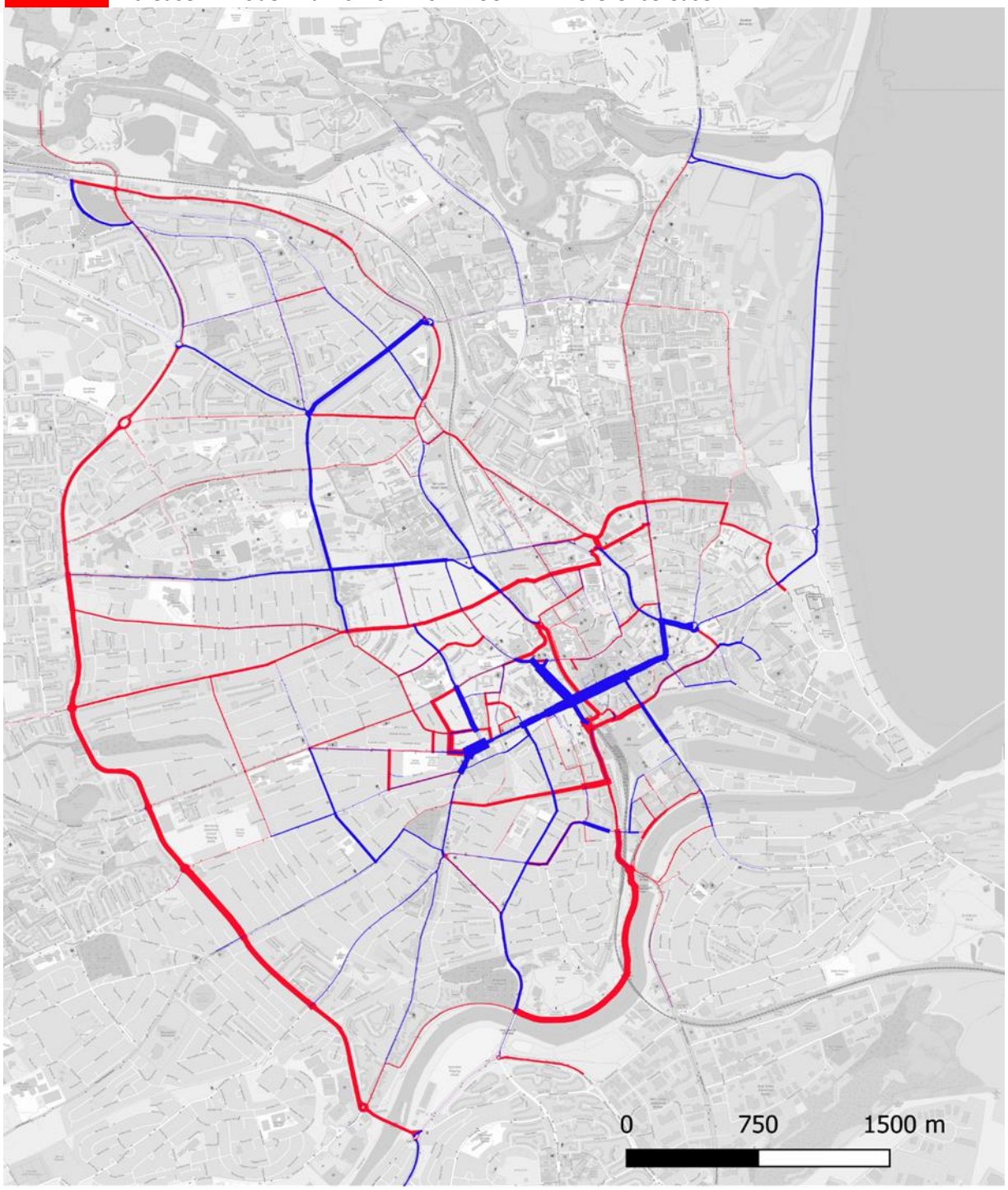
Final LEZ Scheme – AM Peak (07:00-09:00)

Location	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Albyn Place WB	650	1407	757	116%
Ferryhill Road SB	253	514	260	103%
Willowbank Road EB	540	1025	485	90%
Seaforth Rd EB	331	585	254	77%
Springbank Terrace EB	1036	1517	481	46%
Chapel St SB	733	1057	324	44%
Willowbank Road WB	384	506	121	32%
Albert Street NB	316	412	96	30%
Anderson Dr NB	3058	3956	897	29%
Hutcheon St EB	1027	1275	247	24%
Fonthill Rd WB	538	661	123	23%
Back Hilton Rd EB	1366	1658	292	21%
Springbank Terrace WB	354	425	71	20%
Hutcheon St WB	1117	1304	187	17%
Anderson Dr SB	2691	3077	386	14%
Back Hilton Rd WB	727	807	80	11%
Fonthill Rd EB	465	501	36	8%
Seaforth Rd WB	723	772	49	7%
Ashley Rd SB	294	310	16	5%
Holburn St SB (S of Fonthill Road)	712	747	35	5%
Great Southern Rd NB	1638	1690	52	3%
Great Southern Rd SB	1307	1306	-2	0%
Palmerston Pl WB	551	541	-11	-2%
Westburn Dr NB	1441	1409	-32	-2%
Albert Street SB	461	438	-23	-5%
Palmerston Pl EB	303	268	-36	-12%
Westburn Dr SB	1655	1449	-206	-12%
Holburn St NB (S of Fonthill Road)	685	539	-146	-21%
Regent Quay WB	403	302	-101	-25%
Ferryhill Road NB	581	430	-151	-26%
Kings St SB	1660	992	-668	-40%
Albyn Place EB	1258	722	-536	-43%
Bon-Accord St SB	388	221	-168	-43%
Ashley Rd NB	660	339	-322	-49%
Kings St NB	980	480	-500	-51%
Bon-Accord St NB	533	230	-303	-57%
Regent Quay EB	131	47	-84	-64%
Union St EB	1314	173	-1141	-87%
Union St WB	1300	143	-1158	-89%

Legend

Decrease in Model Traffic Flow from ACCPM24 Reference Case

Increase in Model Traffic Flow from ACCPM24 Reference Case



Final LEZ Scheme – Inter Peak (10:00-16:00)

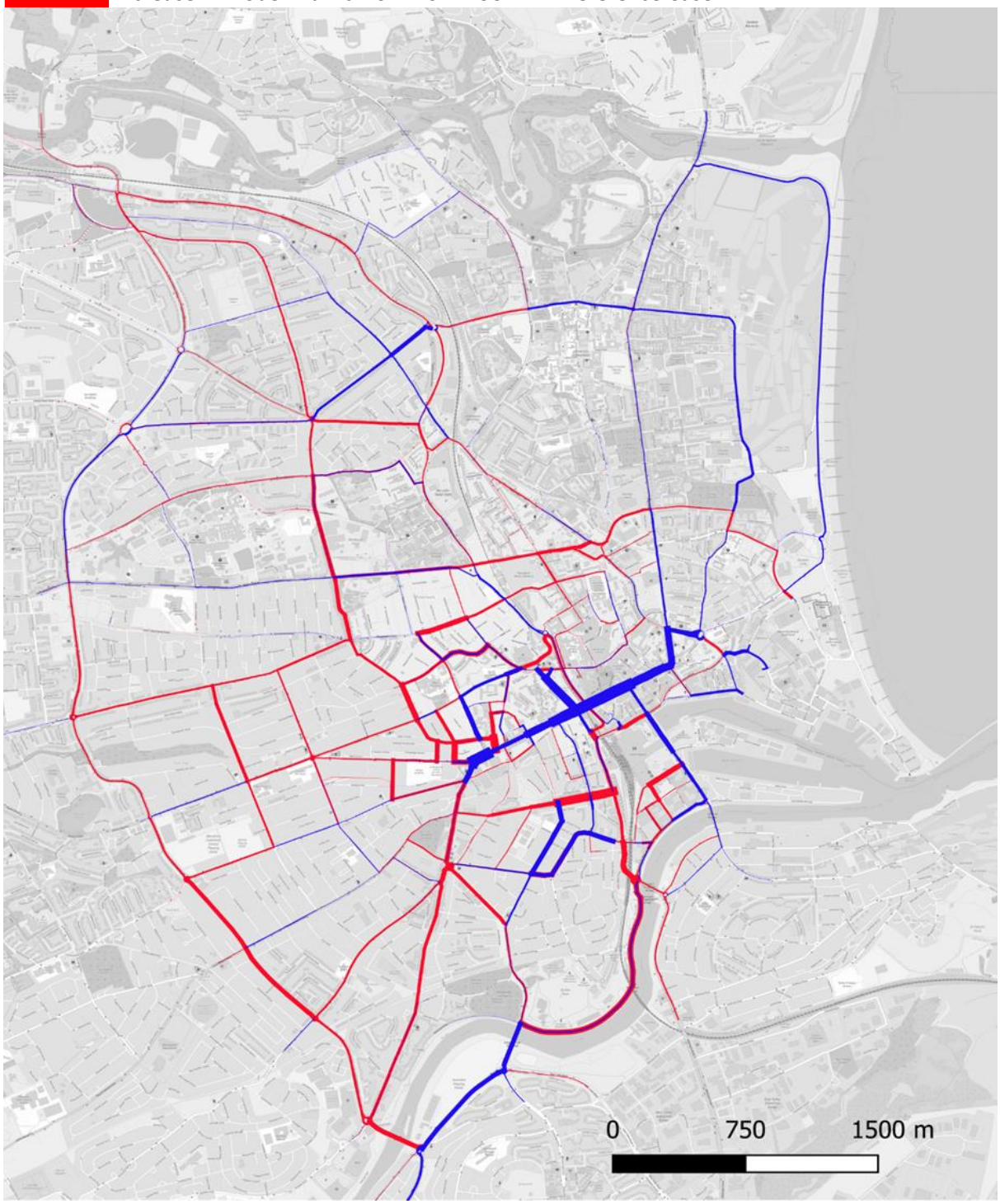
Final LEZ Scheme – Inter Peak (10:00-16:00)

Location	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Albyn Place WB	1474	2712	1238	84%
Springbank Terrace EB	1229	2065	836	68%
Willowbank Road EB	921	1534	613	67%
Seaforth Rd EB	750	1232	482	64%
Ferryhill Road SB	836	1363	527	63%
Chapel St SB	1198	1817	619	52%
Seaforth Rd WB	1004	1516	512	51%
Willowbank Road WB	750	1059	309	41%
Albert Street NB	1023	1383	359	35%
Back Hilton Rd EB	1354	1746	392	29%
Anderson Dr NB	4997	6349	1352	27%
Back Hilton Rd WB	1986	2426	440	22%
Anderson Dr SB	4835	5818	982	20%
Great Southern Rd SB	2353	2643	290	12%
Fonthill Rd WB	1204	1297	93	8%
Springbank Terrace WB	993	1065	72	7%
Albert Street SB	1176	1255	78	7%
Hutcheon St EB	2663	2734	71	3%
Palmerston Pl EB	221	222	1	1%
Holburn St SB (S of Fonthill Road)	1791	1801	10	1%
Great Southern Rd NB	2548	2451	-98	-4%
Hutcheon St WB	2975	2839	-137	-5%
Holburn St NB (S of Fonthill Road)	1169	996	-173	-15%
Fonthill Rd EB	877	744	-134	-15%
Westburn Dr SB	3371	2853	-518	-15%
Westburn Dr NB	3873	3231	-642	-17%
Regent Quay WB	1185	936	-250	-21%
Palmerston Pl WB	1505	1113	-392	-26%
Albyn Place EB	1969	1456	-514	-26%
Ashley Rd SB	627	444	-183	-29%
Kings St SB	2328	1473	-856	-37%
Ferryhill Road NB	863	506	-357	-41%
Kings St NB	1982	908	-1075	-54%
Bon-Accord St SB	791	360	-432	-55%
Ashley Rd NB	996	446	-550	-55%
Bon-Accord St NB	540	223	-318	-59%
Regent Quay EB	174	56	-118	-68%
Union St EB	2487	348	-2140	-86%
Union St WB	2355	299	-2056	-87%

Legend

Decrease in Model Traffic Flow from ACCPM24 Reference Case

Increase in Model Traffic Flow from ACCPM24 Reference Case

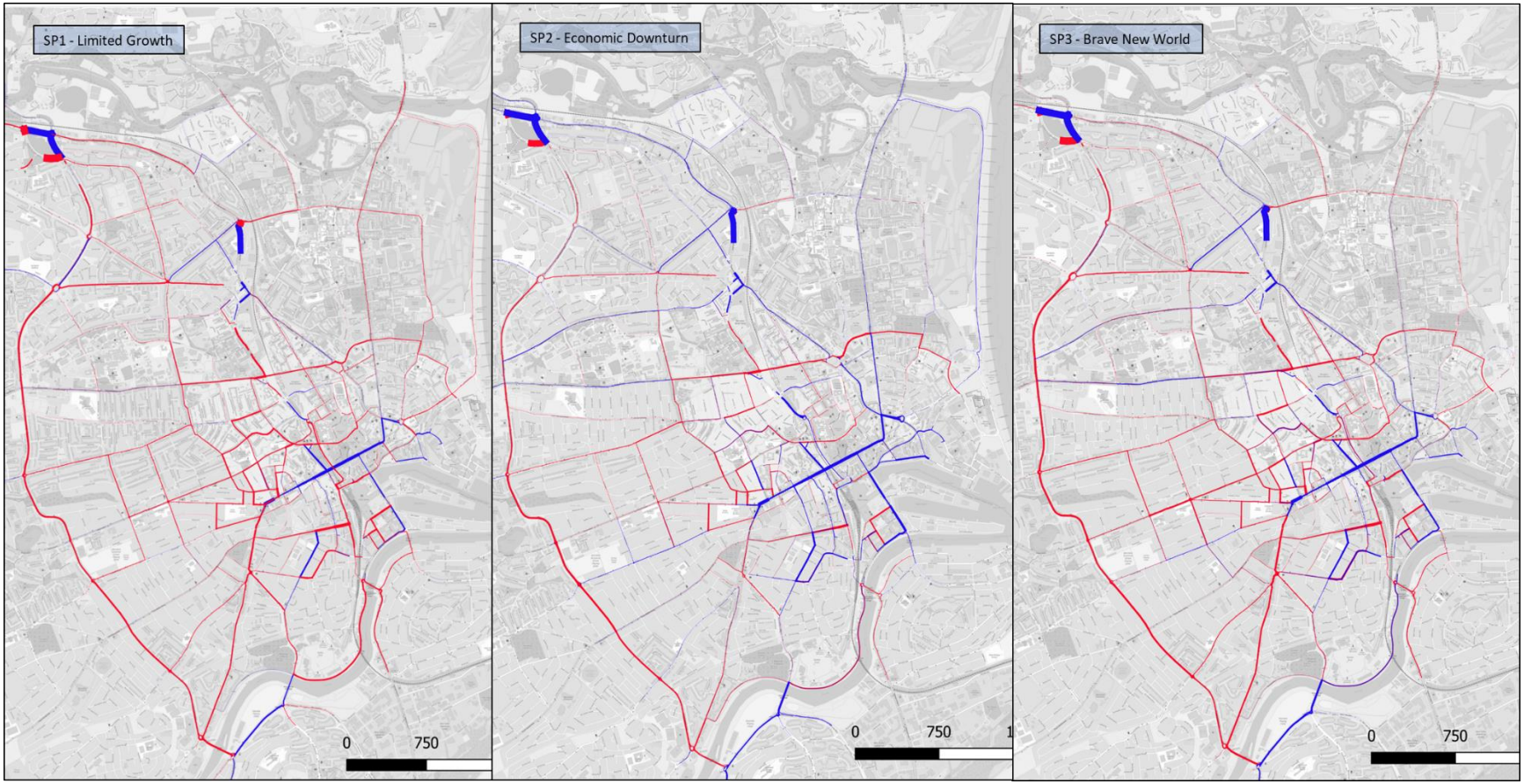


Final LEZ Scheme – PM Peak (16:00-19:00)

Final LEZ Scheme – PM Peak (16:00-19:00)

Location	Ref Case Flow at 95% Demand (Vehicle)	Test Flow (Vehcle)	Flow Change (Vehicle)	Percentage Change
Springbank Terrace EB	597.5	1553.5	956	160%
Chapel St SB	912.5	1866	953.5	104%
Albyn Place WB	838	1476.5	638.5	76%
Willowbank Road EB	519	908.5	389.5	75%
Ferryhill Road SB	897.5	1542	644.5	72%
Albert Street NB	618	1033	415	67%
Bon-Accord St NB	217	321.5	104.5	48%
Willowbank Road WB	465	653	188	40%
Westburn Dr SB	1401.5	1908	506.5	36%
Holburn St SB (S of Fonthill Road)	1333.5	1746.5	413	31%
Back Hilton Rd EB	957	1210	253	26%
Hutcheon St EB	1461	1801.5	340.5	23%
Hutcheon St WB	1612	1962.5	350.5	22%
Fonthill Rd WB	1047.5	1275	227.5	22%
Seaforth Rd WB	800	970.5	170.5	21%
Anderson Dr NB	2945.5	3508	562.5	19%
Great Southern Rd SB	1702	1991	289	17%
Palmerston Pl WB	991	1135.5	144.5	15%
Back Hilton Rd WB	1585.5	1813.5	228	14%
Albert Street SB	631.5	712	80.5	13%
Seaforth Rd EB	737	808	71	10%
Springbank Terrace WB	669	717	48	7%
Anderson Dr SB	3174.5	3361	186.5	6%
Great Southern Rd NB	1905.5	1997	91.5	5%
Holburn St NB (S of Fonthill Road)	638	629.5	-8.5	-1%
Westburn Dr NB	2158	2029	-129	-6%
Ashley Rd SB	544	507.5	-36.5	-7%
Albyn Place EB	1466.5	1230	-236.5	-16%
Fonthill Rd EB	746	601	-145	-19%
Ashley Rd NB	566.5	454	-112.5	-20%
Regent Quay WB	916	534	-382	-42%
Palmerston Pl EB	282.5	150	-132.5	-47%
Kings St SB	1402.5	722	-680.5	-49%
Kings St NB	1390	626.5	-763.5	-55%
Bon-Accord St SB	927.5	359.5	-568	-61%
Regent Quay EB	126.5	46.5	-80	-63%
Ferryhill Road NB	836.5	301.5	-535	-64%
Union St EB	1501.5	182	-1319.5	-88%
Union St WB	1473	157.5	-1315.5	-89%

APPENDIX E: MODEL TRAFFIC FLOWS – ALTERNATIVE FUTURES (PM PEAK: 16:00-19:00)



Legend

Decrease in Model Traffic Flow from ACCPM24 Reference Case

Increase in Model Traffic Flow from ACCPM24 Reference Case

Note: Flow changes at Haudagain Rdbt and Berryden Rd to be ignored as this is the impact of the infrastructure measures applied in the future year models.

Final LEZ Scheme Under Alternative Futures – PM Peak (16:00-19:00)

Location	Number of Vehicles				% Flow Change		
	2019 Base	SP1 LEZ+CCMP	SP2 LEZ+CCMP	SP3 LEZ+CCMP	SP1 LEZ+CCMP	SP2 LEZ+CCMP	SP3 LEZ+CCMP
Willowbank Road EB	405	909	813	910	124%	101%	125%
Back Hilton Rd EB	593	1210	1137	1161	104%	92%	96%
Holburn St SB (S of Fonthill Road)	935	1747	1449	1842	87%	55%	97%
Seaforth Rd EB	440	808	931	830	84%	112%	89%
Seaforth Rd WB	530	971	1147	1001	83%	117%	89%
Hutcheon St EB	1032	1802	1886	1839	75%	83%	78%
Great Southern Rd SB	1149	1991	1815	1885	73%	58%	64%
Broomhill Road WB	776	1323	964	1310	70%	24%	69%
Willowbank Road WB	384	653	545	618	70%	42%	61%
Anderson Dr NB	2109	3508	3567	3566	66%	69%	69%
Fonthill Rd WB	784	1275	1184	1328	63%	51%	69%
S College St NB (N of Palmerston Pl)	1595	2589	2486	2571	62%	56%	61%
Back Hilton Rd WB	1133	1814	1622	1898	60%	43%	68%
Hutcheon St WB	1232	1963	2087	2232	59%	69%	81%
Denburn Rd NB	1686	2678	2265	2525	59%	34%	50%
Virginia St WB	1513	2266	1839	2151	50%	22%	42%
Great Southern Rd NB	1338	1997	1961	1905	49%	47%	42%
Bon-Accord St NB	230	322	323	373	40%	40%	62%
Anderson Dr SB	2421	3361	3895	3419	39%	61%	41%
S College St SB (N of Palmerston Pl)	1188	1643	1288	1559	38%	8%	31%
W N St NB	1593	2145	1851	1996	35%	16%	25%
Broomhill Road EB	804	1078	1057	1081	34%	32%	34%
Holburn St NB (S of Fonthill Road)	475	630	579	691	33%	22%	46%
Virginia St EB	2489	3272	3034	3247	31%	22%	30%
Market St SB	2548	3247	3038	3145	27%	19%	23%
Denburn Rd SB	1295	1648	1486	1585	27%	15%	22%
Ashley Rd SB	404	508	493	685	26%	22%	70%
W N St SB	885	1110	926	1085	25%	5%	23%
E N St SB	1632	1916	1532	1878	17%	-6%	15%
Market St NB	2361	2612	2249	2574	11%	-5%	9%
Fonthill Rd EB	562	601	613	614	7%	9%	9%
E N St NB	1612	1687	1268	1636	5%	-21%	2%
Ashley Rd NB	441	454	604	449	3%	37%	2%
Regent Quay WB	671	534	327	522	-20%	-51%	-22%
Kings St SB	987	722	640	744	-27%	-35%	-25%
Regent Quay EB	66	47	29	43	-29%	-56%	-34%
North Anderson Dr NB (Haudagain)	3897	2629	2543	2664	-33%	-35%	-32%
Kings St NB	959	627	584	601	-35%	-39%	-37%
North Anderson Dr SB (Haudagain)	3615	2353	2279	2419	-35%	-37%	-33%
Bon-Accord St SB	737	360	299	356	-51%	-59%	-52%
Union St EB	1020	182	179	188	-82%	-82%	-82%
Union Terrace NB	488	87	85	82	-82%	-83%	-83%
Union St WB	1071	158	144	156	-85%	-87%	-85%
Union Terrace SB	621	75	85	79	-88%	-86%	-87%

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Abidjan, Douala, Johannesburg, Kinshasa, Libreville, Nairobi

Latin America:
Lima, Mexico, Rio de Janeiro, Santiago, São Paulo

North America:
Little Falls, Los Angeles, Montreal, New-York, Philadelphia, Washington

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