SHEFFIELD AND ROTHERHAM CLEAN AIR ZONE FEASIBILITY STUDY

TRANSPORT MODELLING METHODOLOGY REPORT (T4)

21st June 2019

Sheffield City Council

Rotherham Metropolitan Borough Council

DOCUMENT CONTROL

Version	**Name**		**Position**	**Date**	**Changes**
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1. EXECUTIVE SUMMARY

1.1.1 {Will be prepared when the main text has been agreed with JAQU}

2. INTRODUCTION

2.1 Context

2.1.1 The UK Government has named Sheffield and Rotherham as one of 29 areas in England which contains locations where the annual average concentrations of Nitrogen Dioxide (NO_2) exceed statutory limits and are projected to continue to do so over and beyond the next 3-4 years.

2.1.2 The two Councils have therefore been legally directed to develop a strategy which will ensure that they become compliant with this statutory health based limit 'in the shortest possible time'.

2.2 Overview of this Document

2.2.1 This document is the Local Plan Transport Model Forecasting Report (T4[1]) which explains how the transport modelling to feed into the Sheffield and Rotherham CAZ scenarios has been undertaken. It also includes the 'Business as Usual' (Baseline)[2] modelling results and the methodology used for forecasting and scenario analysis.

2.2.2 This report includes:

- A description of the modelling methodology;
- The scope of the study;
- A presentation and discussion on the 'Business as Usual' forecasts;
- Results from the forecast scenario testing and the final shortlist of options to take forward to the Outline Business Case (OBC);
- An impact analysis on traffic demand; and
- Finally, a summary of key findings

2.2.3 The 'Business as Usual' (Baseline) forecasting and scenario testing contained in this document focusses on results from a 2021 forecast year. Most this work and scenario testing which fed into this document was undertaken prior to switching to a 2021 forecast year.

2.2.4 This report formed part of the **Initial Evidence Submission.** It has been updated to form part of the **Outline Business Case** and will then subsequently be updated to form part of **Full Business Case Submissions**.

2.3 Model Background and Version

2.3.1 The model being used to provide evidence for the Outline Business Case (OBC) is the latest version of the Sheffield and Rotherham Transport Model (SRTM3B). This was the best available model with which to undertaken the analysis required, as agreed with JAQU.

2.3.2 The SRTM3 model was originally developed by SYSTRA with a base year representation of travel movements of 2008, but has recently been updated (along with a limited recalibration and revalidation exercise) to a base year of 2015 to test the Sheffield Local (Land Use) Plan. This version of the transport model is referred to as SRTM3A and was approved by Highways

[1] Document numbering system is as per JAQU's CAZ Transport and Air Quality Guidance

[2] For forecast years, Baseline, 'Business as Usual' and Do Minimum are used interchangeably in this report. However, they are the same thing

England for the Sheffield Local (Land Use Plan) study. SRTM3A therefore, represented the best starting point model available for the CAZ assessment work, as agreed with JAQU.

2.3.3 SRTM3A was then updated again in early 2018 to make modest improvements to the calibration and validation and to update to a 2017 Base year to make it a better tool for undertaking the CAZ modelling. The updates to this version of the model SRTM3B are detailed in the **Local Plan Transport Model Validation Report (T2)** which was submitted as part of the **Evidence Methodology Submission** and has been updated for the **Outline Business Case Submission** (including in response to JAQU comments post OBC submission).

2.3.4 A new model of the Sheffield City Region (SCRTM1) is currently being developed, which will provide a more up to date modelling platform to assess schemes in Sheffield and Rotherham (and the wider SCR). However, that model was not available during the evidence gathering phase and was not completed in time for use on the development of the OBC. **Therefore, this new SCRTM1 model has not been used for any analysis contained in this report.** However, the 2017 base year of the new model is complete (Nov 2018) and a sensitivity test will be undertaken to ensure the Base Year Air Quality impacts are the same as in the SRTM3B model, this will be detailed in the air quality modelling documents.

2.4 Structure of this Document

2.4.1 The remainder of this document is structured as follows:

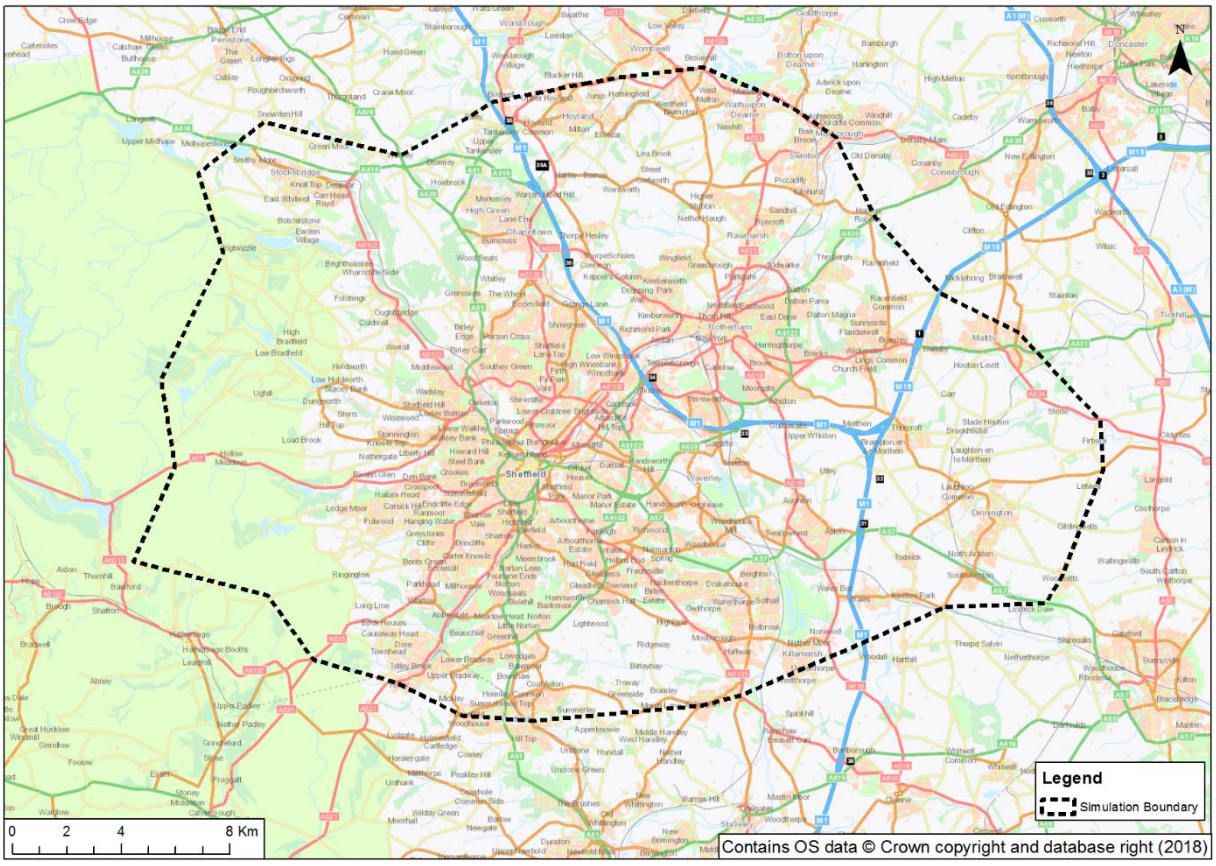
- Section 4 details the methodology used in the modelling;
- Section 3 details the scope of the study;
- Section 4 details the results from the 2017 Base Year Model;
- Section 6 includes the results from the 2021 'Business as Usual' modelling;
- Section 7 includes the results of the scenario testing which has been used to arrive at the **Preferred Option**;
- Section 8 includes analysis on the impact of traffic demand; and
- Section 9 provides a summary of the modelling to date.

3. STUDY SCOPE

3.1 Geographical Coverage of SRTM3B

3.1.1 The geographic scope of the detailed Traffic and Emissions modelling is illustrated in the figure below. The SRTM3B model covers the whole of Sheffield and Rotherham urban areas along with significant sections of the M1 and M18 motorways.

Figure 1. Area of detailed traffic and Emissions modelling



3.2 Time Periods

3.2.1 The modelled time periods included in the SRTM3B model are as follows:

- AM Peak Hour (08:00-09:00);
- Inter-Peak average hour (10:00-16:00); and
- PM Peak Hour (17:00-18:00)

3.3 Modelled Years

3.3.1 The modelled years included in the SRTM3B are as follows:

- 2017 Base Year;
- 2024 Forecast Year; and
- 2034 Forecast Year

3.3.2 To obtain the 2021 Modelled Year required for the assessment of Air Quality in Sheffield and Rotherham, an interpolation process was created which was used on a 2017 Base Year run including the 'scheme' and a 2024 Forecast Year run including the 'scheme' to obtain an idea of the impact of an option in 2021.

3.3.3 The 2021 Business as Usual (BaU) is a simple interpolation between the 2017 Base Year results and the 2024 BaU.

3.4 Outside the Scope

3.4.1 There are a couple of locations within Sheffield which fall outside the scope of this study. Firstly, the platforms at Sheffield railway station where there are known exceedances due to the relatively old diesel train fleet which forms most of the service at Sheffield. Secondly the taxi rank outside Sheffield station, which is not explicitly modelled in SRTM3B.

4. MODELLING METHODOLOGY

4.1 Introduction

4.1.1 This section details the modelling methodology used to undertake the forecast 'Business as Usual' (Baseline) transport model testing, the updates that have been made to the model to allow for the undertaking of scenario testing and the tools that have been developed to analyse the outputs from the model.

4.1.2 In addition to the model updates which have been included in SRTM3B and documented in the **Transport Model Validation Report (T2),** there were a further series of updates to the modelling setup to undertake forecast scenario testing.

4.2 ANPR Data

4.2.1 Detailed ANPR data representing a full 12-month period with extensive geographical coverage of Sheffield and Rotherham was used to establish the Base Year fleet profile for use in the Transport Model and the ENEVAL Emissions Model. This is detailed in the **T3 Transport Modelling Methodology Report** and in Section 5 of this report which describes the Base Year Model Results**.**

4.2.2 This local ANPR data was also then combined with DEFRA Emissions Factor Toolkit (EFTv8.0.1b) changes in fleet composition over time to establish a forecast view of the Sheffield and Rotherham fleet in each of the SRTM3B modelled years. This is set out in Section 6 of this report.

4.3 Forecasting

4.3.1 The forecasting methodology uses Uncertainty Logs in order to determine the likely schemes and developments which will be in place in the forecast years. The following sub-sections describe how these have been implemented in SRTM3B, to provide a modelling tool which can be used to predict future changes in annual traffic Emissions of NO_X.

Supply Side

4.3.2 The 'Business as Usual' forecasts made use of the scheme information provided in the Uncertainty Logs as provided by Sheffield, Rotherham and Highways England (dated November 2017). In summary, the information contained in the Uncertainty Logs was incorporated into the 'Business as Usual' models as follows:

- Only major/significant highway improvement schemes modelled;
- Major Public Transport schemes modelled (e.g. BRT North, Tram-Train Trial, additional Supertram vehicles, Park and Ride);
- No bus route / timetable changes were modelled (due to no information about future service changes);
- Category 1 & 2 Schemes (as defined by the DfT as 'near certain' – TAG Unit M4) from the 2024 and 2034 Sheffield and Rotherham Uncertainty Logs were included in the 2024 and 2034 'Business as Usual' Scenarios;
- Major committed schemes on the Strategic Road Network (SRN) within the modelled area were included in the 2024 and 2034 'Business as Usual' Scenario; and
- Update of values of time, vehicle operating costs, and PT fares to future year values.

4.3.3 Category 3 & 4 (which are hypothetical) Supply Side Schemes from the 2024 and 2034 Sheffield and Rotherham Uncertainty Logs are not included in the 'Business as Usual' forecasts.

Forecast Year 'Business as Usual' Transport Networks

4.3.4 Modelled changes to the Strategic Road Network and key changes to the local road network for 2024 are summarised in Table 1 and Table 2 respectively. For 2034, the changes in the road network are all located in Rotherham and are mainly party of the Bassingthorpe Farm development and junction improvements as part of the Community Infrastructure Levy.

Table 1. Modelled Network Changes – 'Business as Usual' 2024 - Strategic Road Network

PROJECT TITLE	DESCRIPTION
M1 J28-31 Managed Motorways	Hard shoulder permanently converted to an extra lane and variable speed limits.
M1 J32-J35a Managed Motorways	Hard shoulder permanently converted to an extra lane and variable speed limits.
M1 J31-J32 Extra Lane	Widening from three to four lanes.
IKEA	M1 J34 Junctions improvements.

Table 2. Modelled Network Changes – 'Business as Usual' 2024 - Local Road Network

PROJECT TITLE	DESCRIPTION
A630 Sheffield Parkway improvement	Widening to three lanes from two between Catcliffe and M1 Junction 33 and circulatory carriageway improvements.
BRT North	New link road from Meadowhall to A6178 Sheffield Road and signalisation of junctions.
Sheffield Retail Quarter	Changes to road layout in Sheffield city centre arising from development.
Bridgehouse Junction	Improvements to junction lay out
Waverley	Signalisation of two roundabouts and reinstating Highfield Lane Orgreave Road.
IKEA	A6138 junctions Improvements.
SAV Tram-Train	Tram-Train connection Sheffield city centre, Meadowhall, Rotherham Central and Parkgate.

Demand Side

4.3.5 The principle behind the 'Business as Usual' Development Assumptions is to include all development sites within the model boundary covering the Sheffield and Rotherham districts that already have planning permission and are considered "near certain" or "more than

likely" to be in place by 2024 and 2034. This information was obtained from Uncertainty Logs provided by Sheffield City Council and Rotherham Metropolitan Borough Council.

4.3.6 Trips associated with the Category 1 and 2 sites described above were added to the base year matrices, and the overall growth in trips controlled to match forecast growth from the National Trip End Model Version 7 (via the TEMPRO program) for cars and forecasts from the National Transport Model for goods vehicles.

4.3.7 This approach enabled us to account for differential growth between zones resulting from the location of individual developments whilst maintaining consistency with the overall expectations of population and economic growth in the area.

4.3.8 The cut-off decisions made as to which developments contained in the Uncertainty Log should be explicitly modelled were a little different for the forecast years from those made in updating the Base Year. As there were many small sites in the Uncertainty Log, a low cut-off had to be set to model the impact of the many small sites. The cut-off was therefore only applied to residential developments and set to 20 dwellings, which is equivalent to approximately 70 daily arrivals. The cut-off removed 1100 dwellings, or 2.5% of all new dwellings in the Uncertainty Log.

Forecast Year 'Business as Usual' Development Assumptions

4.3.9 The 'Business as Usual' scenario includes all developments identified in the Uncertainty Logs as either Category 1 or 2 – "near certain" or "more than likely". Table 3 shows the level of residential and commercial developments modelled explicitly in the 2024 and 2034 'Business as Usual' forecasts (relative to the 2016 base model) for the Rotherham and Sheffield districts.

Table 3. 'Business as Usual' Scenario – Residential and Commercial Development

DISTRICT	YEAR	RESIDENTIAL (DWELLINGS)	COMMERCIAL (FLOORSPACE)
Rotherham	2024	3,900	276,000
Sheffield	2034	18,800	688,000
Rotherham	2034	5,500	328,000
Sheffield	2034	24,400	766,000

4.3.10 Trip end estimates for demand generated by each of the sites contained in the Uncertainty Logs were prepared using trip rates taken from the industry standard TRICS database for appropriate development types.

4.3.11 The total scale of the development in terms of 12-hour person arrivals included in the 'Business as Usual' Scenario is summarised in Table 4.

Table 4. 12-hour Trip Ends by Land Use Type

LAND USE TYPE	2024 12H PERSON ARRIVALS	2034 12H PERSON ARRIVALS
A1 Shops	88,000	95,000
B1 Business	50,000	63,000
B2 General Industry	7,000	8,000
C3 Dwelling Houses	53,000	75,000

4.3.12 The figure below the table summarises the same trip end information by mode and hourly time period.

Table 5. Development Trips by Mode and Time Period

PERIOD	2024 CAR	2024 PT	2024 WALK/ CYCLE	2034 CAR	2034 PT	2034 WALK/ CYCLE
Morning peak hour	12,200	2,600	4,600	14,600	3,400	5,800
Average Inter peak hour	11,600	2,800	6,000	13,100	3,300	7,500
Evening peak hour	13,800	3,100	6,300	16,400	3,800	7,700
12Hr Weekday Total	140,000	33,000	66,000	166,000	40,000	83,000

4.3.13 The figure below illustrates the 12-hour weekday total person trip arrivals by the two main motorised modes.

Figure 2. 12-hour Car and PT person trip end arrivals for developments in 2024 'Business as Usual' Scenario

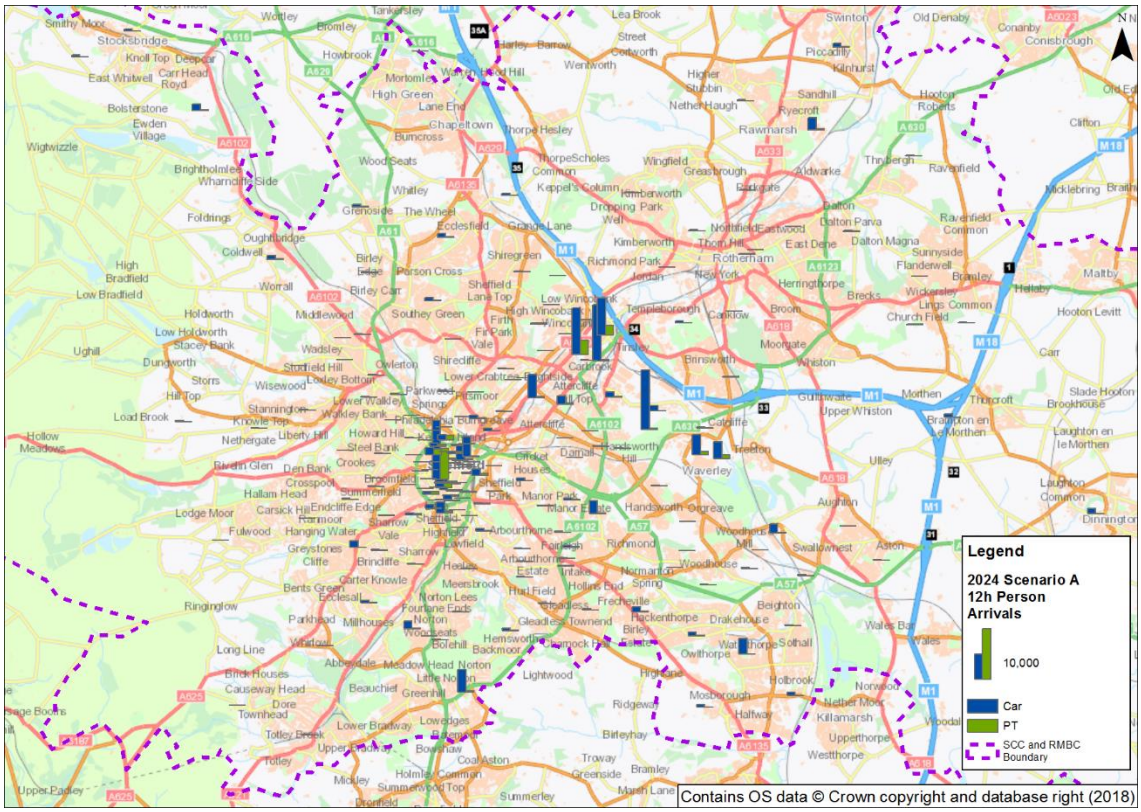
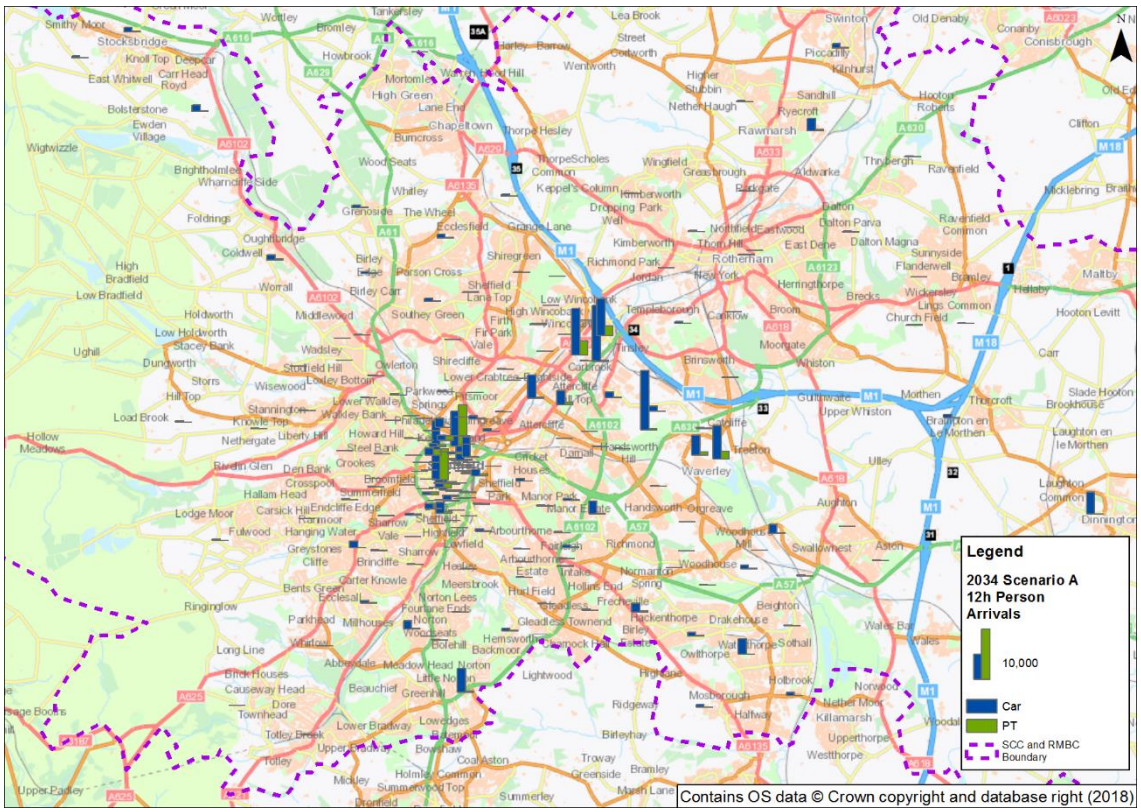


Figure 3. 12-hour Car and PT person trip end arrivals for developments in 2034 'Business as Usual' Scenario



4.4 Assignment Matrix Segmentation

4.4.1 An update was incorporated into the forecast version of the model to enable differential affects to be tested between CAZ-Compliant and Non-Compliant vehicles in the assignment models. This was undertaken by expanding the user classes from 6 to 12 in the assignment model, where 1 to 5 are the CAZ-compliant vehicle types for Car Business, Car Commute, Car Other, LGV and OGV and 6-10 are the non-compliant equivalents.

4.4.2 The setup of the assignment model is otherwise the same as in the base year with each non-compliant user class having the same parameters as it's CAZ-compliant equivalent.

4.4.3 The matrices for assignment were split using a combination of ANPR data from 2017 combined with data from the emission factor toolkit. The former allowed the compliant / non-compliant splits to be determined at four different key geographic areas (Sheffield, Rotherham, Parkway and the M1 Motorway) in the base year. Changes over time from EFT were then applied to these to obtain forecast year compliant / non-compliant splits. These are shown in the tables below.

4.4.4 The table below also show the compliant split proportions including for bus, coach, 'black cabs' and car-based Private Hire Vehicles (PHV), which are included in the traffic assignment model as preloads. These are presented for the Base Year and the 2024 Forecast Year. The table also shows the compliant splits applied to the preload vehicle types included in the assignment model.

Table 6. CAZ-Compliant Splits in the Modelled Area (by geography)

	SHEFFIELD		ROTHERHAM		PARKWAY		MOTORWAY	
	2017	2024	2017	2024	2017	2024	2017	2024
User Classes								
Car Commute	54%	72%	52%	71%	57%	75%	55%	73%
Car Business	54%	72%	52%	71%	57%	75%	55%	73%
Car Other	54%	72%	52%	71%	57%	75%	55%	73%
LGV	15%	60%	14%	60%	17%	61%	15%	60%
OGV	46%	67%	45%	66%	48%	68%	47%	68%
Preloads								
Black Cab	*83%*	*93%*	*83%*	*93%*	*83%*	*93%*	*83%*	*93%*
PHV	*14%*	*50%*	*14%*	*50%*	*15%*	*51%*	*14%*	*50%*
Bus	*18%*	*43%*	*17%*	*41%*	*22%*	*49%*	*20%*	*46%*
Coach	*18%*	*43%*	*17%*	*41%*	*22%*	*49%*	*20%*	*46%*

4.5 Charging CAZ Areas

4.5.1 The ability to introduce charging 'cordon' / area schemes into the model is already present within the SATURN assignment software. However, to apply charges like those expected in CAZ schemes they have been included in the model where necessary in one of two ways:

- **Cordon-charging** – 50% of the charge on any link which crosses the cordon in the inbound direction; and
- **Trips originating within the cordon** – 50% of the charge on zone centroid connectors in the direction of zone to network only.

4.5.2 This was required as applying 100% of the charge on the inbound cordon crossing would not charge those who drive entirely within the area at all and would double the charge on those who drove through the area, but with an origin and a destination outside the cordon.

4.5.3 This allows all the possible combinations of charging to be modelled in a reasonably accurate fashion, but does require the assumption that all trips in the model will make an equivalent return trip. The following table shows all the combinations.

Table 7. Charging Methodology Application of Charge

ORIGIN	DESTINATION	HOW CHARGE IS APPLIED IN THE TRAFFIC MODEL
Inside Cordon	Inside Cordon	50% on origin zone centroid on outbound trip and 50% on destination zone centroid on return trip
Inside Cordon	Outside Cordon	50% on origin zone centroid on outbound trip and 50% on inbound cordon crossing on return trip
Outside Cordon	Inside Cordon	50% on cordon crossing on outbound trip and 50% on destination zone centroid on return trip
Outside Cordon	Outside Cordon[3]	50% on cordon crossing on outbound trip and 50% on cordon crossing on return trip

4.5.4 There are three situations in which the currently applied methodology is not as effective:

- If one half of an outbound and return trip pair with origin and destination zones outside the cordon charging area routes through the cordon but the opposite does not. In this case, these vehicles will only pay half of the daily charge;
- If residents inside a cordon were to get a discount – this is not currently taken into consideration by this methodology and it is assumed they would pay the full charge; and
- If one vehicle makes multiple return trips through the charging area in a given day these assumptions will mean they pay for every return trip rather than just once per day as would be the case. This means that the modelling will overestimate the impact of a CAZ charging zone in a 24hr period, but it is expected that this is a relatively small number of trips (except for LGVs). Because of the risk of overestimation, the charge on the zone centroid was reduced to 30% in the later tests.

[3] For trips which choose to drive through the charging area

4.5.5 It is unnecessary to model the rerouting of taxis as they exist in the assignment as a preload. It is simply assumed they would pay the daily charge and route in a similar way as they would without the CAZ.

4.5.6 The proposed charges used in scenario testing (see Section 7) are **£10** for light vehicles and **£50** for heavy vehicles.

4.6 Through Trip Fleet Effects (TTFE)

4.6.1 Demand through the CAZ cordon will be influenced by the charge, thus a demand response would be expected here as well. From the baseline scenario, the demand that passes through the cordon was extracted from the SATURN highway model. For 50% of this demand, the same split between compliant and non-compliant was used as for demand to and from the CAZ Cordon. The remaining 50% of the demand has the default splits applied to it.

4.7 Interpolation

4.7.1 The above compliant splits were applied to both a base year and 2024 forecast year version of the model and a process to interpolate between these positions was created. This process interpolated between flows and speeds for each link in the model by time period, to produce a forecast of 2021 traffic flows and speeds.

4.7.2 The interpolation process assumes that the demand on new roads builds up linearly from the zero position in the base year to the 2024 value, with speeds assumed to be equal to the 2024 value in all years.

4.7.3 It is these values that are passed to the emission calculation software ENEVAL.

4.8 Behavioural Research

4.8.1 In addition to the updates to the transport model local Behavioural Research was undertaken to understand the likely response of different vehicle drivers to any CAZ charging scheme. The details of this Research are contained in **Supporting Document 1 (SD01)**.

4.8.2 The table below shows the outcome of the Research. Two different sets of values were concluded from the analysis – a pessimistic and a conservative set of values. It is the latter (highlighted) that have been used to feed into the transport modelling. These are shown against the JAQU values for comparison purposes.

Table 8. – Results from local Behavioural Research

	Local - Pessemistic			Local - Conservative			JAQU		
	Avoid zone or pay charge	Upgrade	Remove from highway matrix	Avoid zone or pay charge	Upgrade	Remove from highway matrix	Avoid zone or pay charge	Upgrade	Remove from highway matrix
Car	13%	68%	19%	8%	73%	19%	18%	64%	18%
PHV	6%	94%	0%	5%	95%	0%	N/A	N/A	N/A
Taxi	18%	82%	0%	16%	84%	0%	N/A	N/A	N/A
LGV	61%	39%	0%	43%	57%	0%	28%	64%	8%
HGV	N/A	N/A	N/A	N/A	N/A	N/A	13%	83%	4%

4.8.3 These responses have been included in the modelling by multiplying the segmented matrices by the relevant proportions in the table in any charging option. The full proportion split is

applied to trips originating or destination at a zone inside the CAZ charging area. Half of the trips passing through any CAZ area are subject to the proportions above.

4.9 Variable Demand Model

4.9.1 The Variable Demand Model (VDM) within the SRTM3B model has been upgraded to work with the segmented demand in the highway assignment. The VDM only operates on the car and public transport user classes. Goods vehicles are fixed matrices for the assignment and buses, coaches, black taxis and PHV are in the assignment model as preloads.

4.9.2 This means that the demand responses can be applied to compliant and non-compliant cars separately and that the charges to non-compliant private vehicles will therefore have an impact on the mode and destination choice models within SRTM3B. The VDM overrides the charge applied to trips to, from, within the cordon and applies the full charge to return trips and half charge to one-way trips.

4.9.3 The VDM update was only completed late in the OBC process and has therefore only been used for one of the options tested and described in Section 7.

4.10 ENEVAL

4.10.1 ENEVAL is SYSTRA's traffic Emissions modelling tool, which uses outputs from the traffic model. It is described in more detail in the **Local Plan Transport Model Validation Report (T2).**

4.10.2 As default this includes national UK data based on DEFRA's EFT tool (Emissions Factor Toolkit v8.01.b). The ANPR cameras at Sheffield's hotspot locations provide much more detailed local data and therefore the SCC/RMBC version of ENEVAL has been updated to use these local values. In particular, it was seen that Sheffield and Rotherham's vehicle fleets are generally older than the national average fleet assumed in the EFT.

4.10.3 The final update to the ENEVAL process, which needs to be noted, is that there has been a further update to accommodate the segmentation within the assignment. This simply works by passing the compliant user classes from the assignment to ENEVAL first and splitting those based on compliant vehicle splits in ENEVAL and calculating the Emissions from those. The same process is then also applied to non-compliant vehicles and the two sets of ENEVAL outputs are then combined.

4.11 Link to Air Quality Modelling

4.11.1 A combined GIS and SQL database process has been developed to convert straight-line link based outputs from the transport model and ENEVAL to links following a geographic based road network, which better reflect the individual paths taken on the ground by each link.

4.11.2 Essentially this process takes each B node of every A → B and B → C pair of links and snaps it to a set of links on the target geographic road network. Each pair of nodes forming a model link are routed through the target network using a shortest-path algorithm for all the combinations of the respective A node and B node points on the target. Final selection of the new geographically correct links is based on optimal criteria including the new length versus model length for the link to determine the best 'real world' link shape for each model link, such that connectivity is retained between adjacent links.

4.11.3 The target network used is Ordnance Survey's OS Open Roads, which is geographically suitable for representing model links in their appropriate ground position, but does not have detail on road section direction or any restrictions on general movements or those specific to any vehicle type.

4.11.4 Matched model links by their nature represent paths extending over multiple target road network links, but the road name and number of the most significant link (within the path) can be assigned to the geo-rectified model link.

4.11.5 Some preparatory cleaning of the target network was required to correctly route links along appropriate paths in the target network and avoid detours through this network via much longer paths.

4.11.6 This set of outputs is also vital in providing the interface between the transport and the Emissions model and between the Emissions model and the air quality dispersal modelling suite, Airviro.

5. 2017 BASE YEAR RESULTS

5.1 Introduction

5.1.1 This section of the note details 2017 Base Year modelling results for the base year (2017). It includes a description of the fleet composition put together from the local ANPR data (representing a full 12 months of observations) along with the Base Year compliance splits.

5.2 ANPR Data

5.2.1 The local detailed fleet splits which have been used in Emissions modelling have been put together from the ANPR data. The following charts show how the local (Sheffield and Rotherham combined) fleet splits at Euro standards level compare to the defaults contained in DEFRA's Emissions Factor Toolkit (EFT).

5.2.2 The charts show that for most vehicle types the Sheffield and Rotherham fleet is older than the expected national fleet, with a larger proportion of vehicles in older Euro classifications compared to the National picture.

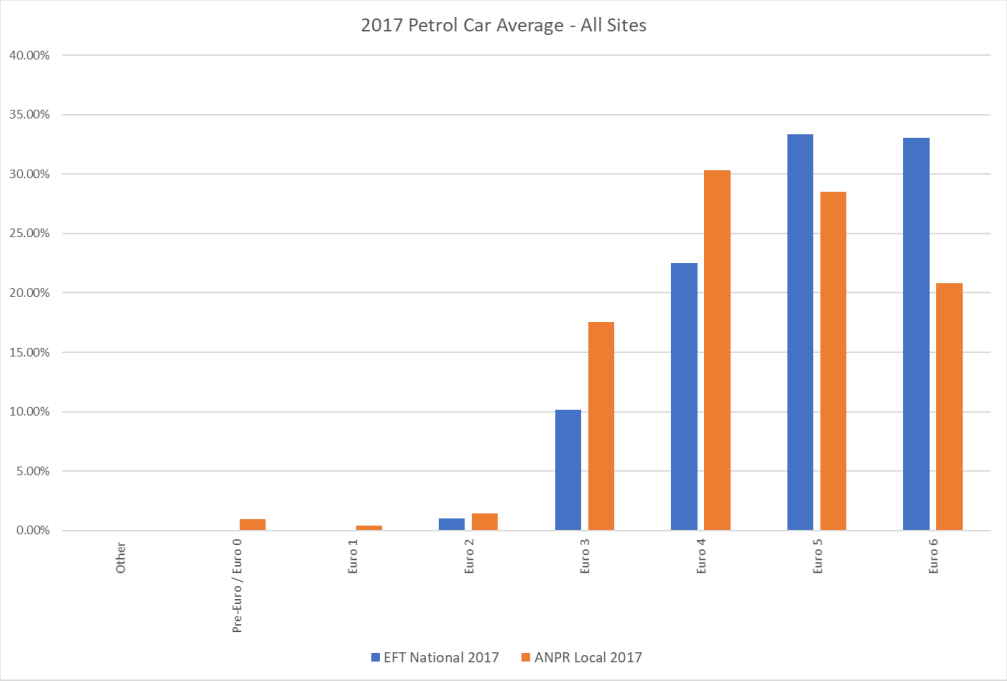


Figure 1 – Sheffield and Rotherham 2017 Petrol Car Fleet Split

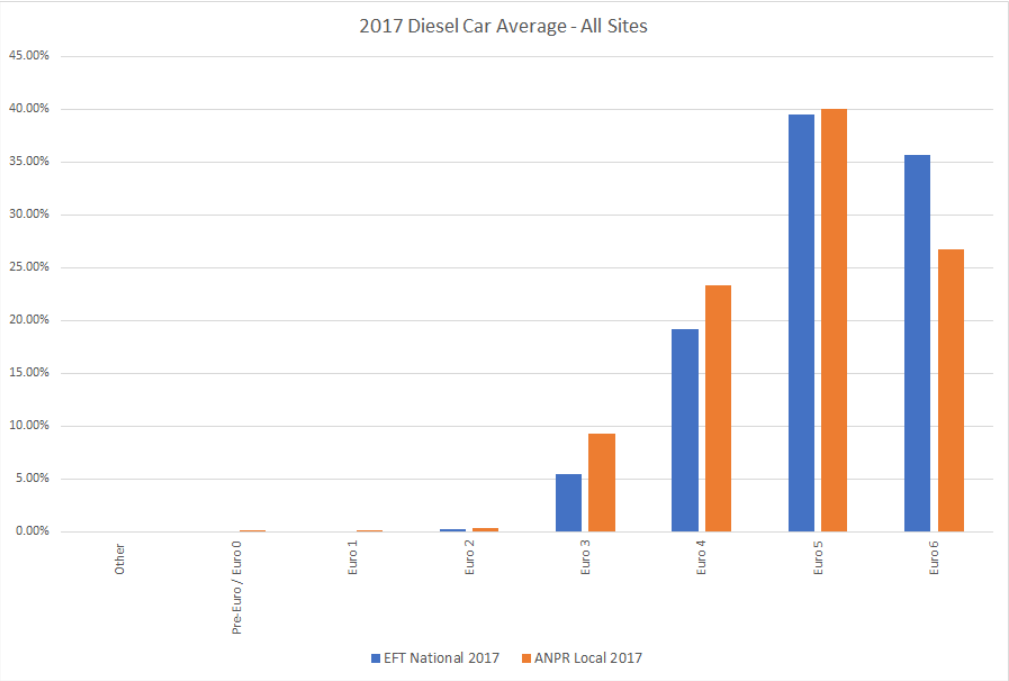


Figure 2 – Sheffield and Rotherham 2017 Diesel Car Fleet Split

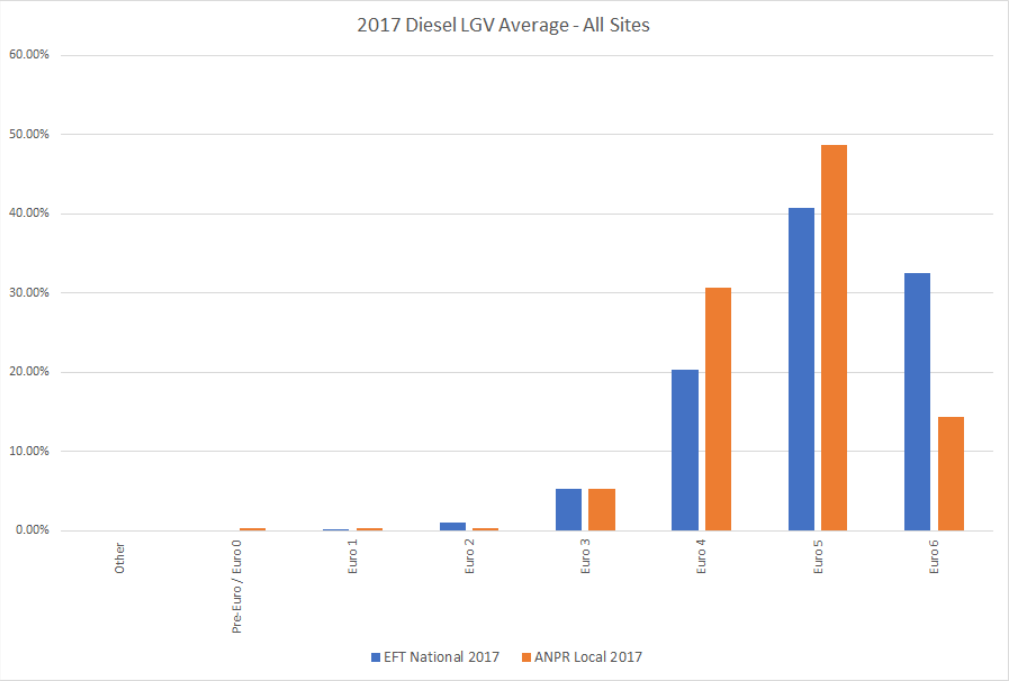


Figure 3 – Sheffield and Rotherham 2017 Diesel LGV Fleet Split

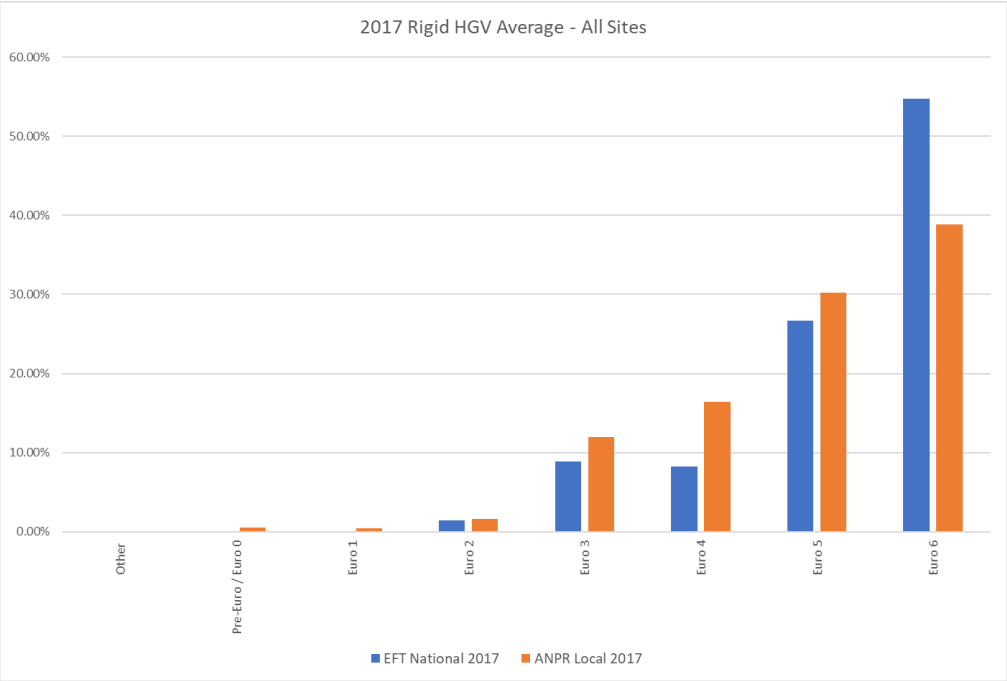


Figure 4 – Sheffield and Rotherham 2017 Rigid HGV Fleet Split

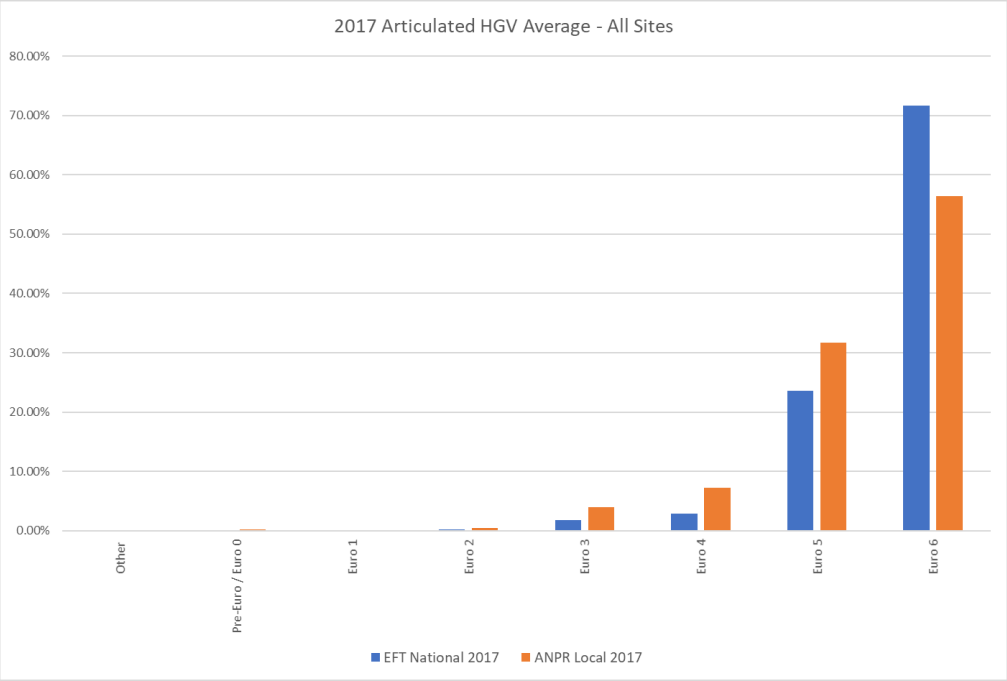


Figure 5 – Sheffield and Rotherham 2017 Articulated HGV Fleet Split

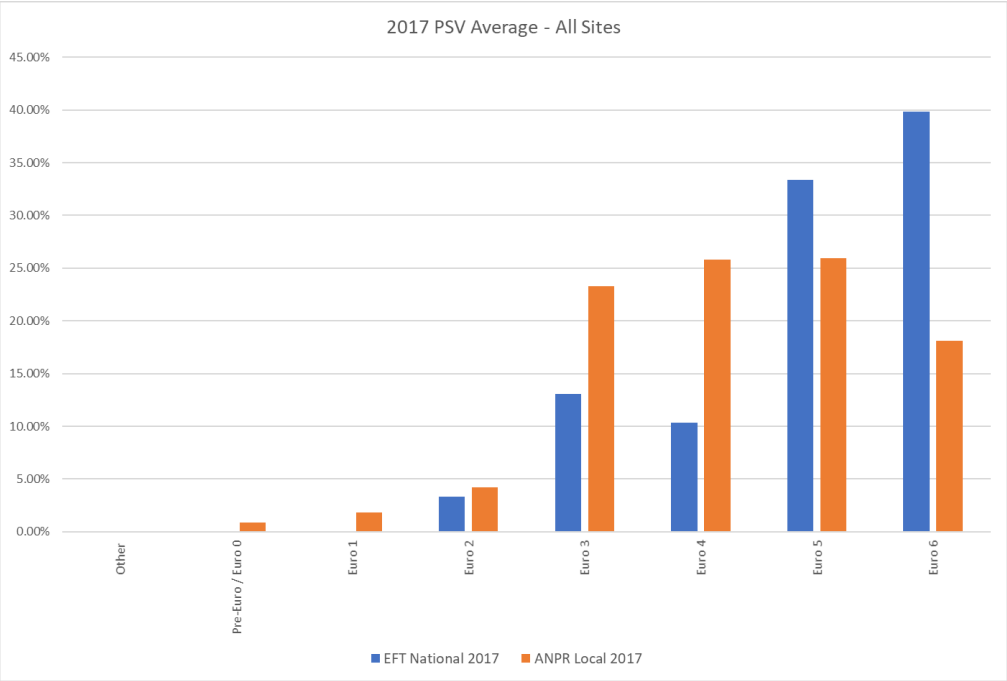


Figure 6 – Sheffield and Rotherham 2017 Passenger Service Vehicle (PSV) Fleet Split

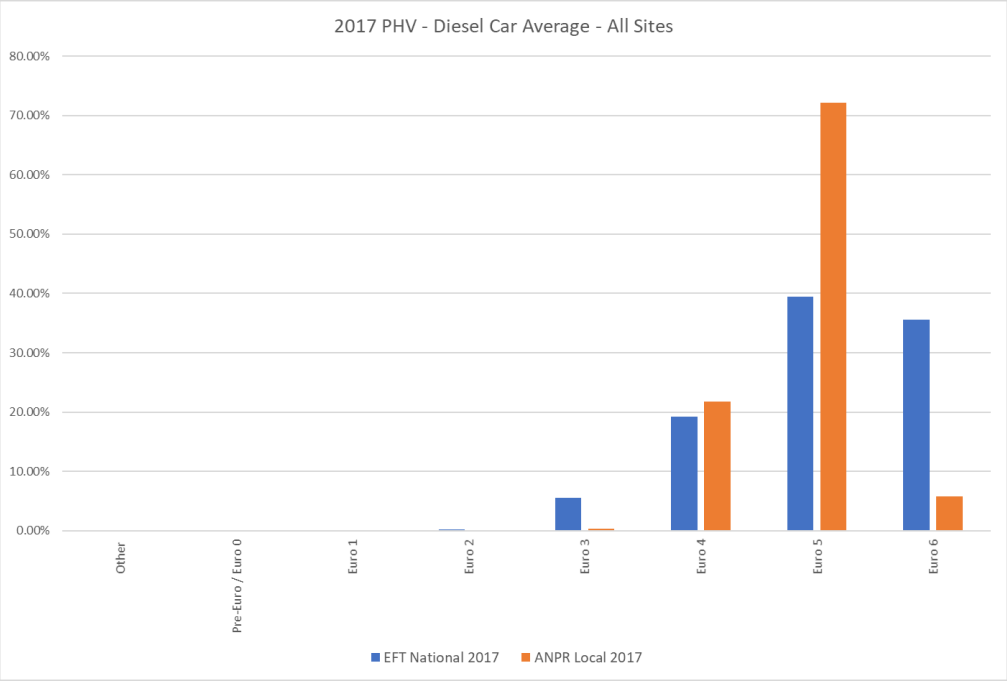


Figure 7 – Sheffield and Rotherham 2017 Private Hire Vehicle (PHV) Fleet Split

5.3 Compliant / Non-Compliant Splits

5.3.1 The compliant / non-compliant splits in the transport modelling have also been constructed from the ANPR data. The table below shows the compliance levels for each of the vehicle types included in the emissions modelling.

Table 1 – 2017 Base Year Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	20%	80%
Diesel Car	73%	27%
Petrol LGV	51%	49%
Diesel LGV	86%	14%
Rigid HGV	61%	39%
Articulated HGV	44%	56%
PSV	82%	18%
Black Cab	81%	19%
PHV	94%	6%

5.4 Base Year Results

5.4.1 The figures below show the levels of NO_X Emissions as predicted by the outputs of the 2017 Base Year transport model being passed through the ENEVAL process. The thicker lines represent higher annual NO_X Emissions in g/km. The first image shows modelled link Emissions with coloured dots denoting the annual average NO_2 concentrations observed at the various AQ monitoring sites in 2017. The second image shows the same link Emissions against the Defra's estimated background NO_2 Emissions.

Figure 4. Emissions in the 2017 Base Year model output AQ monitoring sites across study area.

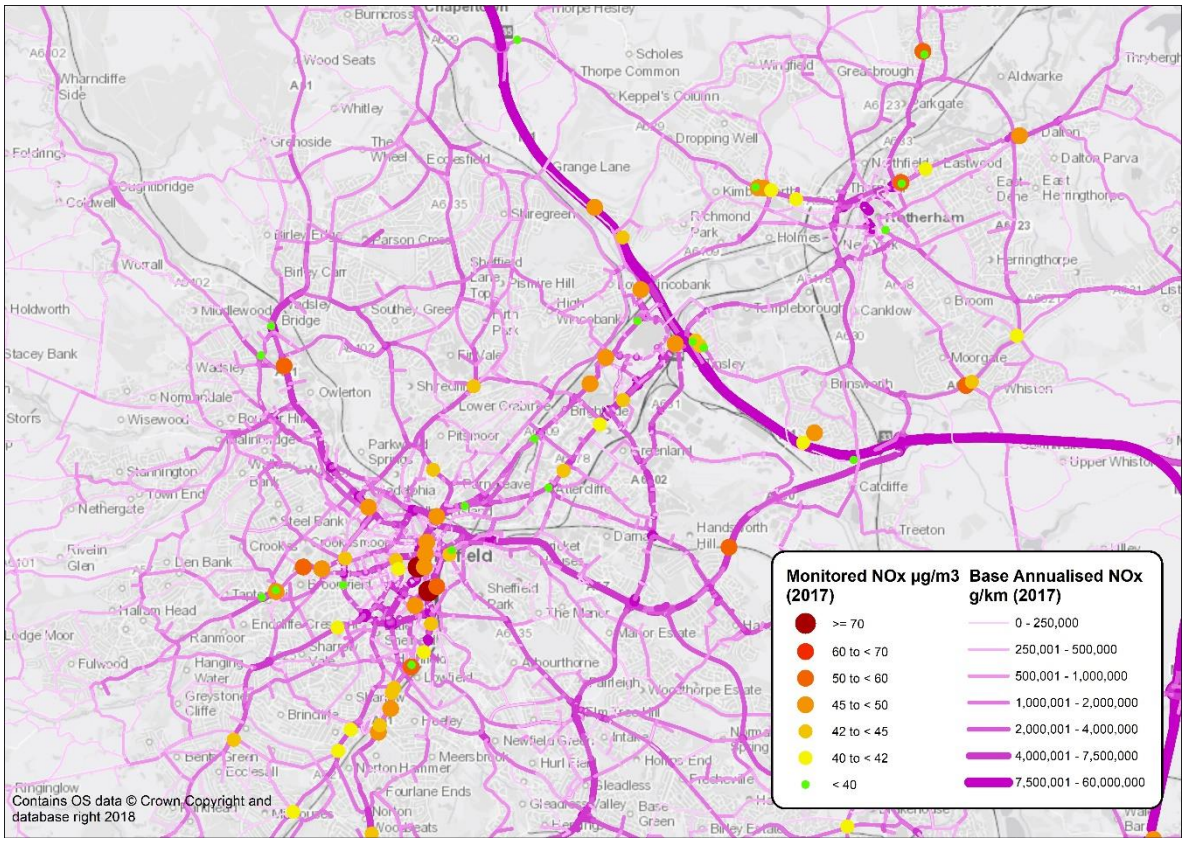
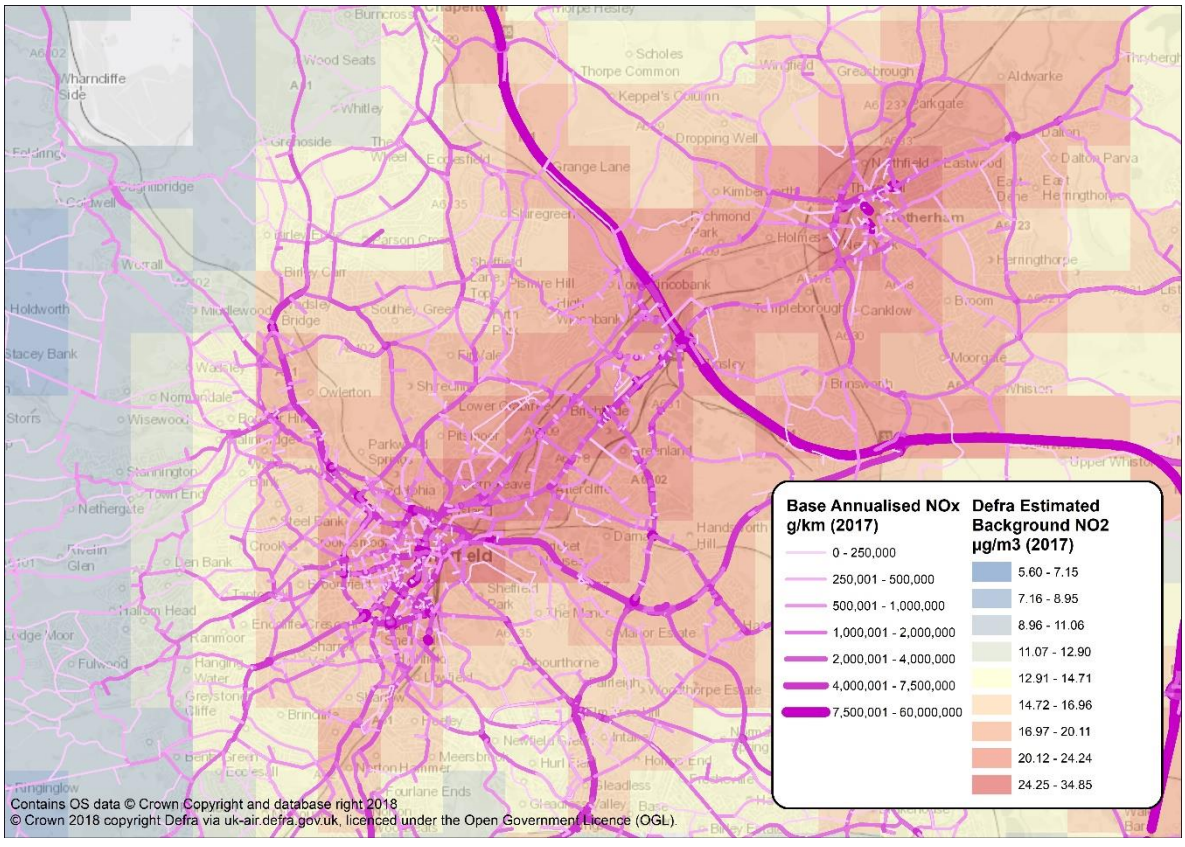


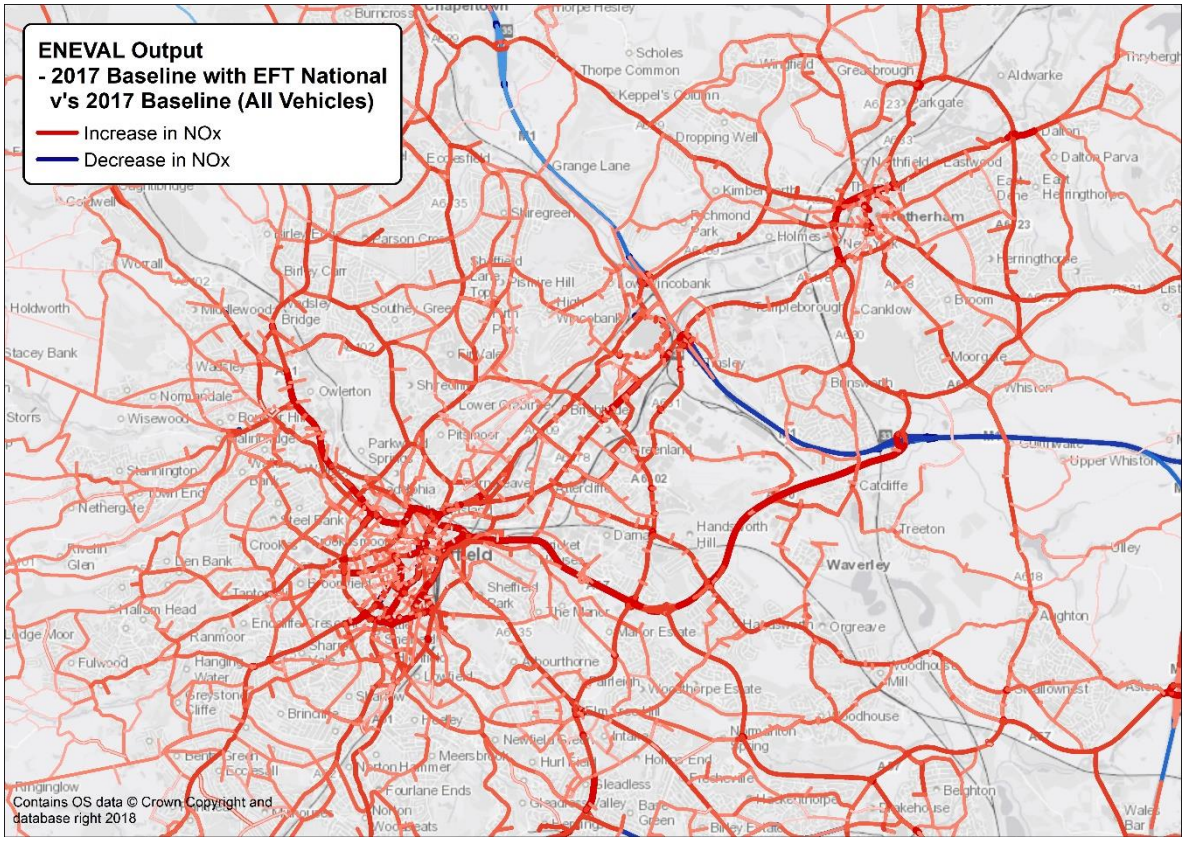
Figure 5. Emissions in the 2017 Base Year model output against Defra's estimated NO_2 background levels.



5.4.2 In the Emissions model the various fleet profiles are further adjusted to reflect observed differences between the base-year fleets observed in Sheffield, Rotherham, on the A630 Sheffield Parkway and on the M1 Motorway.

5.4.3 The figure below shows the difference in Emissions in the 2017 base year when comparing the run of ENEVAL with the EFT National Fleet projections and the fleets based on the local ANPR data. This demonstrates the older fleet with more Emissions in both Sheffield and Rotherham.

Figure 6. Difference in 2017 Base Emissions when using the EFT National Fleet Assumptions compared to local fleet data from ANPR



5.4.4 The figure above shows a reduction of NO_X Emissions on the M1 motorway when moving from the national average motorway fleet used in the EFT to the local observed fleet. This reduction is due to this section of the M1 having more petrol vehicles than the 'typical' UK motorway traffic (presumably due to higher-than-average proportions of short-distance local traffic).

5.4.5 The process to forecast forward from this revised 2017 Base Year data has been undertaken using year on year growth factors for each fleet type. We have applied the same change over time as the DFT, but applied to the local fleet, rather than to the national average fleet assumed in the EFT. New vehicles which enter the fleet composition in EFT beyond 2017 are input into the fleet at the same point in the new local data set, with the proportions all adjusted to ensure for each vehicle type the split adds to 100%.

6. 2021 'BUSINESS AS USUAL'

6.1.1 This section details the results from the forecast year Business as Usual (BaU) modelling. The modelled forecast years (2024 and 2034) were used to create interpolated intermediate years, the most important of which is 2021 in which compliance is to be achieved.

6.1.2 The forecasting methodology for arriving at the 'Business as Usual' values presented in this section is as discussed in section 3 of this report and in the **Local Plan Transport Model Validation Report (T2).**

6.2 Forecast Fleet Composition

6.2.1 The following figures show how the Business as Usual fleet composition is expected to look in Sheffield and Rotherham in 2021. These have been created to use in the emission modelling, by taking the local Base Year fleet built from the ANPR data and applying DEFRA Emissions Factor Toolkit (EFT) changes over time. The local fleet is compared to the expected average national fleet as predicted by EFT in each of these figures and this demonstrates that the local fleet is generally older in terms of Euro Standards. There are very small changes in the Euro splits in the OBC Clarification work, but the main difference is the proportion of diesel and petrol in the fleet. This change is described in detail in the Appendix to the OBC Clarification note.

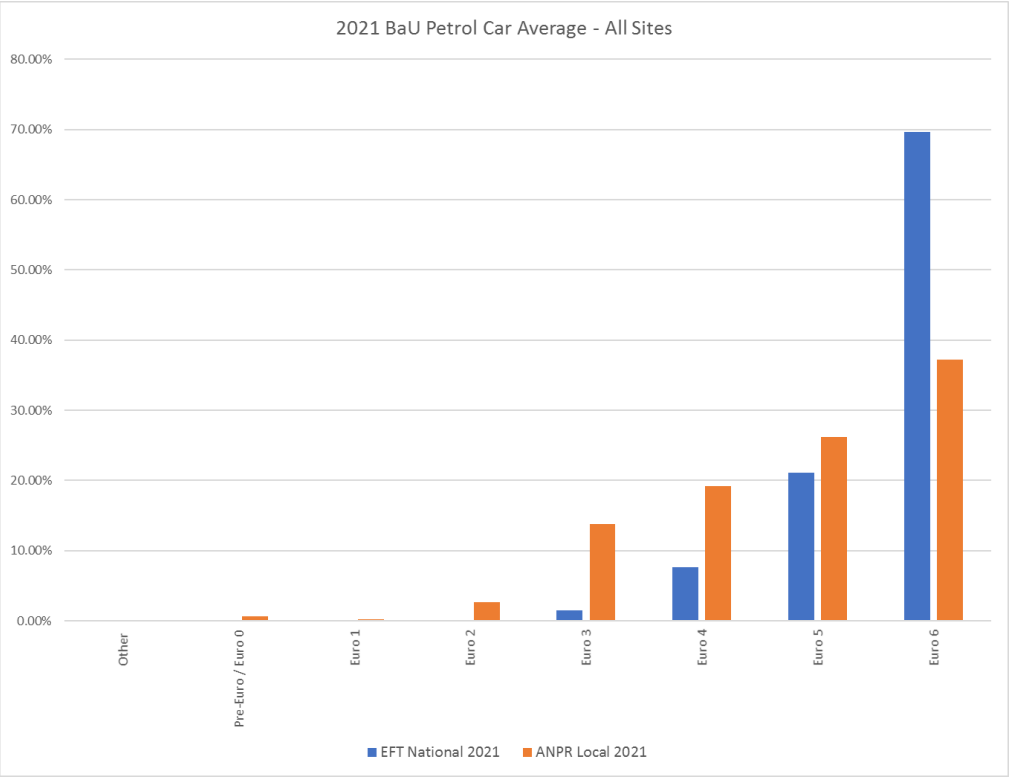


Figure 8 - Sheffield and Rotherham 2021 Petrol Car Fleet Split

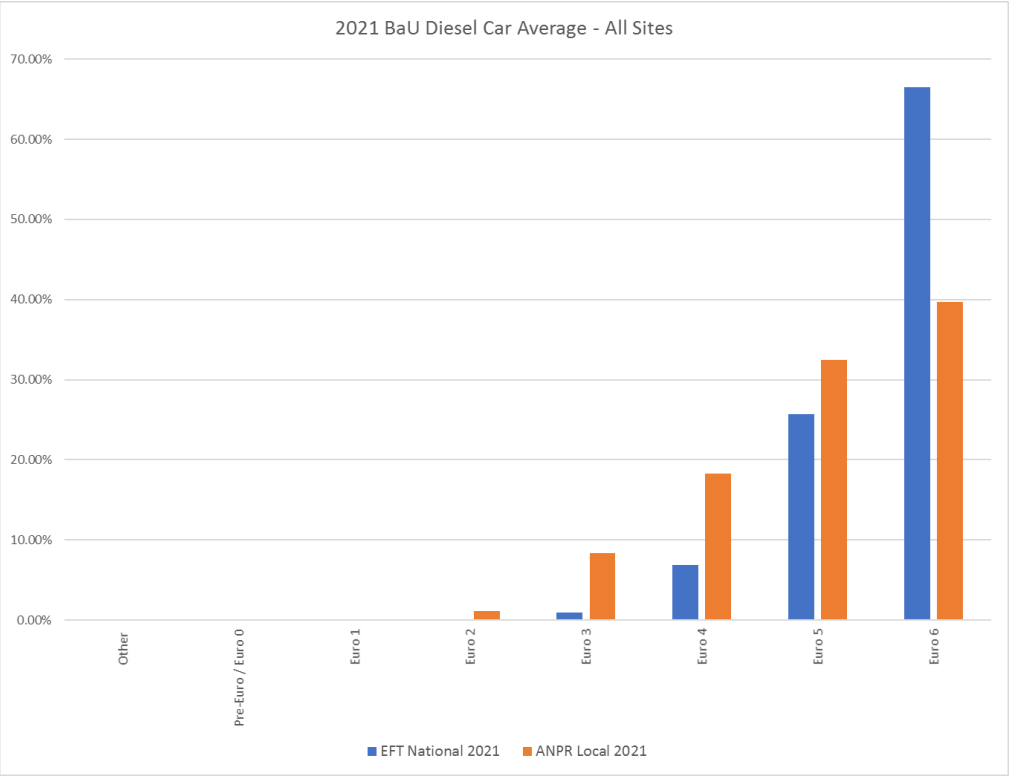


Figure 9 - Sheffield and Rotherham 2021 Diesel Car Fleet Split

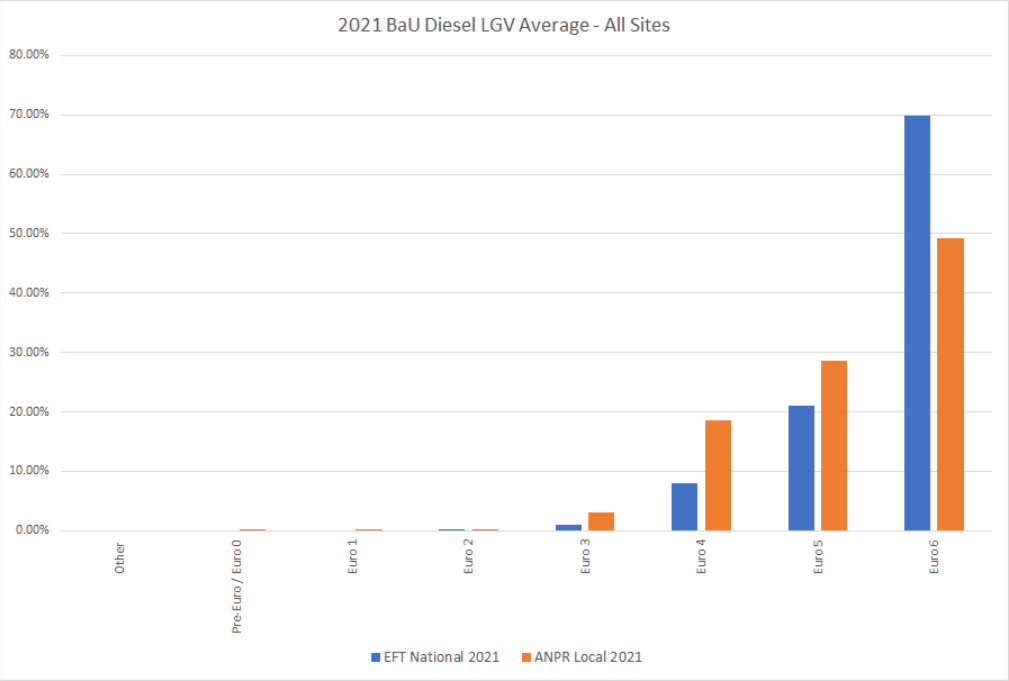


Figure 10 - Sheffield and Rotherham 2021 Diesel LGV Fleet Split

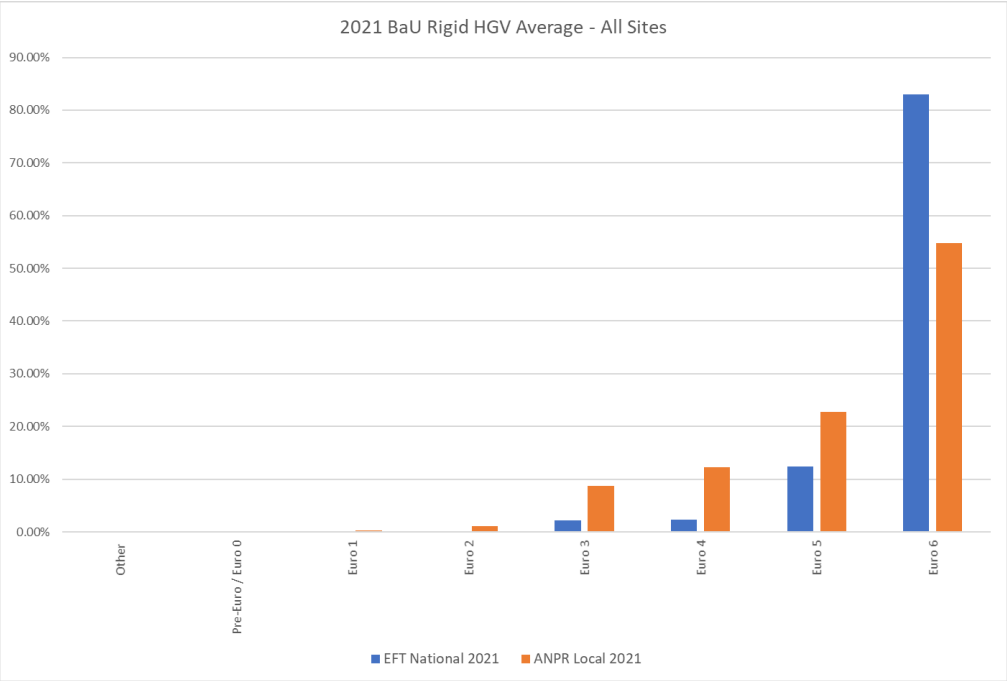


Figure 11 - Sheffield and Rotherham 2021 Rigid HGV Fleet Split

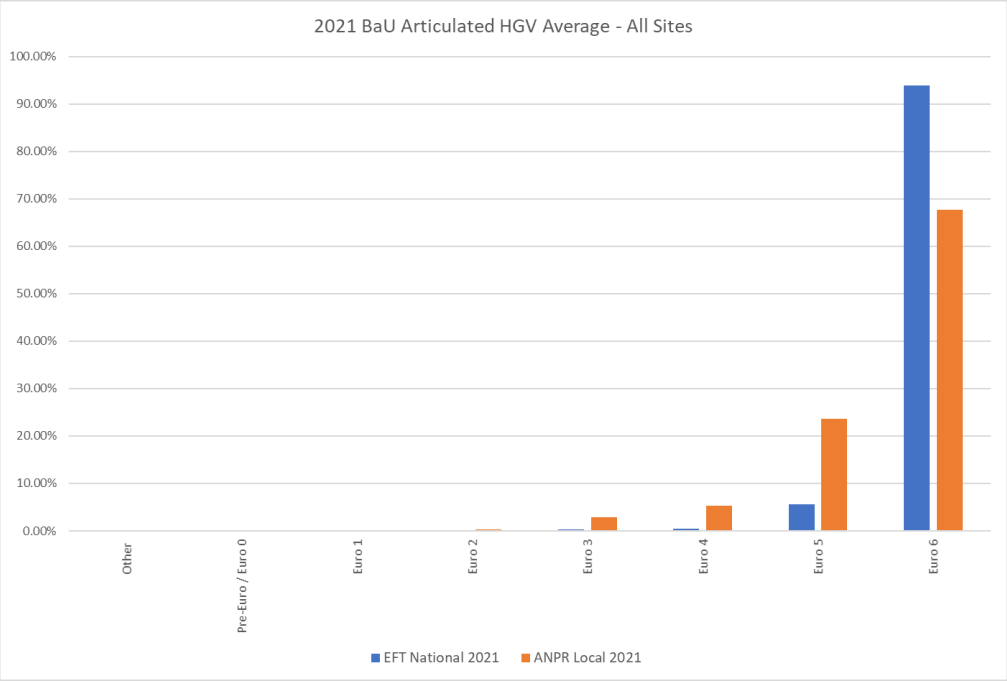


Figure 12 - Sheffield and Rotherham 2021 Articulated HGV Fleet Split

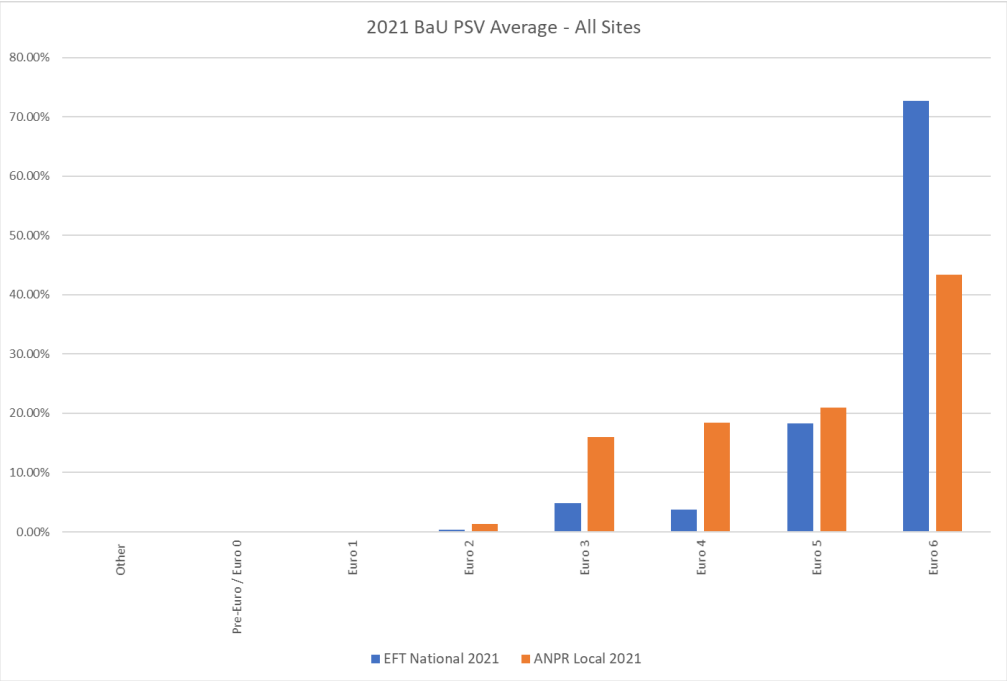


Figure 13 - Sheffield and Rotherham 2021 Passenger Service Vehicle (PSV) Fleet Split

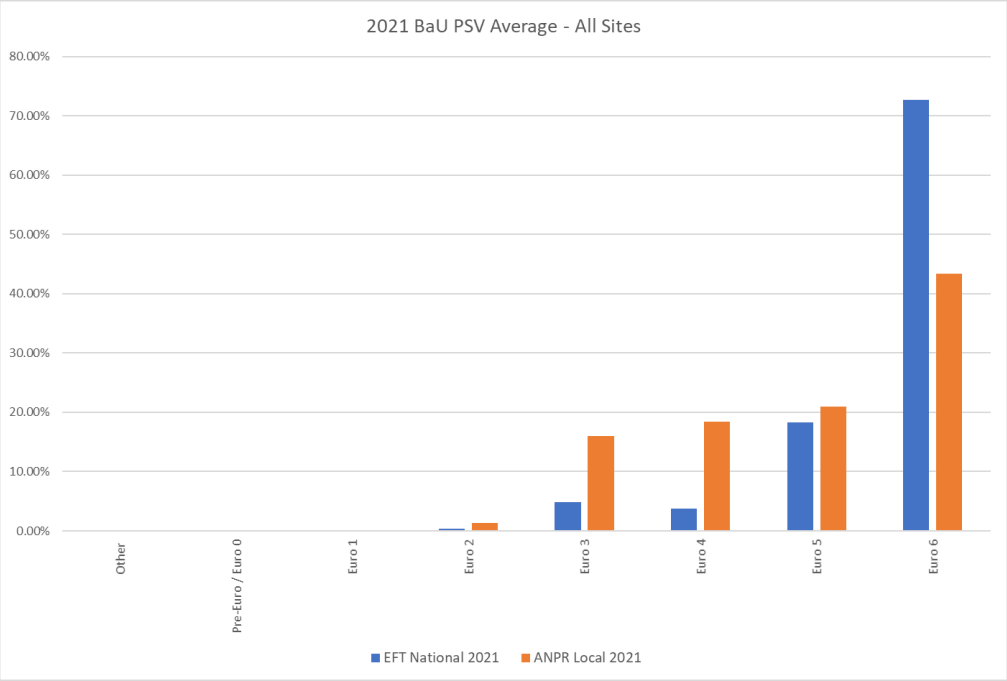


Figure 14 - Sheffield and Rotherham 2021 Private Hire Vehicle (PHV) Fleet Split

6.3 Forecast Compliance Splits

6.3.1 The following figures show how the 2021 BaU compliance splits are expected to look in Sheffield and Rotherham by applying the EFT fleet changes to the 2017 local Base Year fleet.

Table 2 – 2021 BaU Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	17%	83%
Diesel Car	60%	40%
Petrol LGV	27%	73%
Diesel LGV	51%	49%
Rigid HGV	45%	55%
Articulated HGV	32%	68%
PSV	46%	54%
Black Cab	78%	22%
PHV	69%	31%

6.4 Goods Vehicle Growth

6.4.1 No Goods vehicle growth has been applied in the modelling because trends over the last 10 years in the Sheffield and Rotherham area are that HGV vehicle kms have been declining by ~1% per annum but LGV vehicle kms have been increasing by ~1.5% per annum.

6.4.2 The combined effect of this is that in emissions terms these two trends almost exactly offset one another. A sensitivity test has been undertaken to demonstrate that this has no impact on the conclusions. This is described in more detail in the sensitivity testing section.

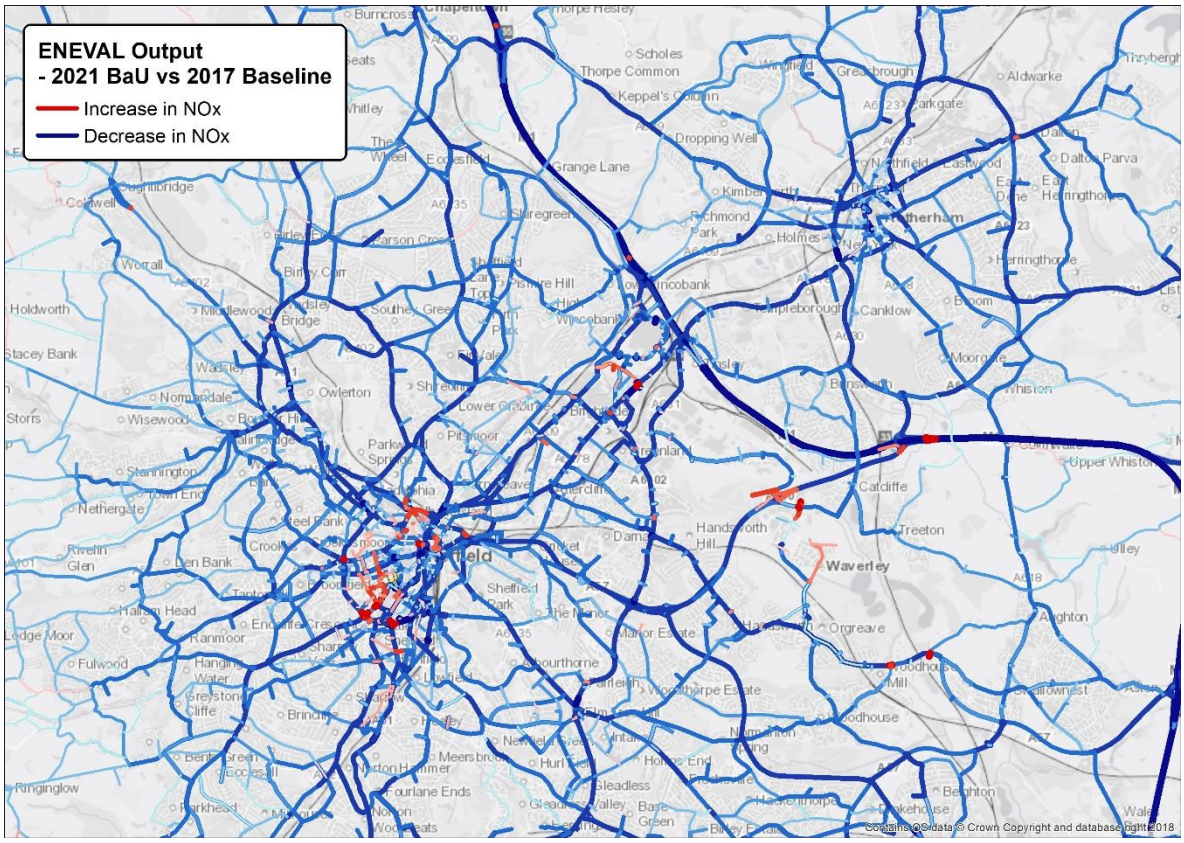
6.5 2021 Business as Usual Results

6.5.1 The following figures show how the Business as Usual fleet composition is expected to look in Sheffield and Rotherham.

6.5.2 The 2021 'Business as Usual' has then been arrived at by forecasting to 2024 in the transport model and interpolating between the 2017 and 2024 years to obtain traffic flows and speeds in 2021, which have then been passed through the ENEVAL process.

6.5.3 The image below shows the results of that 'Business as Usual' test as changes from the 2017 Base Year. Except around several development sites (noticeably in Sheffield Centre) there are predicted to be significant reductions in NO_X Emissions by 2021. This is due to the 'Business as Usual' changes in the fleet over time, as described in Section 3 of this report.

Figure 7. Change in NO_X between 2021 'Business as Usual' (Baseline) and the 2017 Baseline



6.5.4 The following table shows the percentage changes as introduced in section 3 for the 2021 'Business as Usual' scenario compared to the 2017 Base Year. This is restricted to the sites identified as still having an Air Quality Issue in 2021 through the target determination process. This shows reductions of between 12% and 21% due to improvement in the background fleet except on Derek Dooley Way where there is a slight increase due to development traffic in that area.

Table 3 – 2021 Business as Usual - Changes in Tailpipe NO_X Emissions from 2017 Base Year

SITE	BUSINESS AS USUAL – NO_X REDUCTIONS
Sheffield Sites	
Arundel Gate Interchange	-22%
Derek Dooley Way	-3%
Sheaf Street	-24%
Sheffield Parkway	-24%

SITE	BUSINESS AS USUAL – NO_X REDUCTIONS
Sheffield Road	-18%
Rotherham Sites	
A629 Wortley Road	-22%
A630 Fitzwilliam Road	-23%
A630 Parkway Rotherham	-21%
A633 Rawmarsh Hill	-25%

6.6 2021+ 'Business as Usual' Results

6.6.1 As 2024 was modelled, it is possible to estimate future changes in emissions. All intermediate years between 2021 and 2024 are interpolated and a linear continuation is assumed for the next few years after 2024.

6.6.2 The table below shows the results of this analysis as percentage reductions in NO_X Emissions. By 2025 / 2026 it is expected that the changes of over 40% will be enough to achieve compliance but this will need to be confirmed by the air quality modelling.

Table 4 – 2021+Baseline NO_X Emission Reductions

SITE	2021	2022	2023	2024	2025	2026
Sheffield Sites						
Arundel Gate Interchange	-22%	-27%	-32%	-37%	-42%	-47%
Derek Dooley Way	-3%	-6%	-8%	-11%	-13%	-15%
Sheaf Street	-24%	-29%	-35%	-40%	-46%	-51%
Sheffield Parkway	-24%	-29%	-34%	-39%	-44%	-49%
Sheffield Road	-18%	-22%	-26%	-31%	-35%	-40%

SITE	2021	2022	2023	2024	2025	2026
Rotherham Sites						
A629 Wortley Road	-22%	-28%	-33%	-38%	-44%	-49%
A630 Fitzwilliam Road	-23%	-29%	-34%	-40%	-46%	-51%
A630 Parkway Rotherham	-21%	-25%	-29%	-33%	-38%	-42%
A633 Rawmarsh Hill	-25%	-30%	-35%	-41%	-46%	-51%

7. SCENARIO FORECASTS

7.1 Introduction

7.1.1 This section presents the outputs from the scenario testing that has been undertaken using the SRTM3B version of the model. This included undertaking tests in which the full modelled area (i.e. all of Sheffield and Rotherham were considered as a CAZ) through to cordon testing resulting in a shortlist of options to take forward, as submitted to JAQU recently.

7.1.2 For the CAZ charging options, the same charge as the London ULEZ has been applied in the first instance. This is **£10** per day for light vehicles (cars / black cabs & PHVs / LGVs) driving within the zone and **£50** per day for heavy vehicles (buses / coaches / HGVs).

7.1.3 The three cordons in the figure below have been considered in the option testing.

- **Cordon 1** covers Sheffield City Centre, the Lower Don Valley and the parts of Rotherham which contain areas where exceedances are expected in 2021;
- **Cordon 2** covers Sheffield City Centre and the Lower Don Valley, but no parts of Rotherham; and
- **Cordon 3** covers Sheffield City Centre and the Inner Ring Road only.

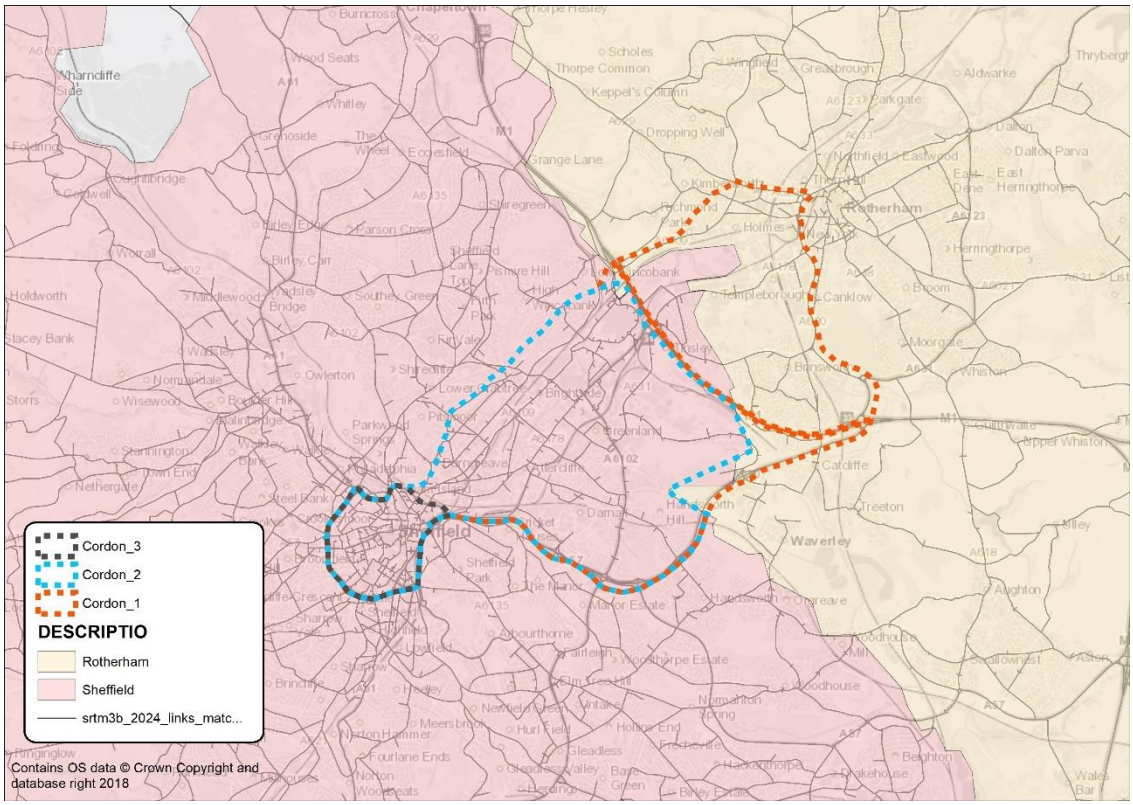


Figure 15 – Sheffield and Rotherham Cordons Used in Option Testing

7.1.4 This section details the options tested with the cordons described in the previous section. This starts with the largest cordon tested and works through the options to the final one with the minimum impact on the area that still achieves compliance by 2021.

7.2 2021 Cordon 1 CAZ D

Description

7.2.1 This option uses the largest cordon size and assumes no changes to the compliance mix and the underlying fleet in 2021. It uses the default behavioural responses as presented by JAQU and described in the previous section, which apply to all trips entering the cordon area. As this is a CAZ D all vehicle types are charged for entering the cordon area.

Compliance Splits

7.2.2 These are the same as the 2021 BaU, however those trips starting in the CAZ area or destinating in the CAZ charge area are subject to JAQU Behavioural research proportions resulting in the compliance proportions in the table below.

Table 5 – 2021 Cordon 1 CAZ D Area Wide Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	7%	93%
Diesel Car	43%	57%
Petrol LGV	13%	87%
Diesel LGV	40%	60%
Rigid HGV	24%	76%
Articulated HGV	25%	75%
PSV	67%	33%
Black Cab	9%	91%
PHV	68%	32%

Matrix Totals

7.2.3 The following table shows the Assignment Matrix totals for this option in each time period, for each assigned vehicle type and separately for compliant and non-compliant vehicle types

Table 6 – 2021 Cordon 1 CAZ D Matrix Totals

VEHICLE	CORDON 1 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 1 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
TYPE	2021	2024	2021	2024	2021	2024	2021	2024
AM Peak								
Car Commute	44,968	50,618	7%	2%	16,123	13,015	-21%	-14%
Car Business	9,982	11,243	8%	3%	3,341	2,755	-25%	-17%
Car Other	19,829	22,683	4%	0%	7,915	6,553	-13%	-5%
LGV	6,909	8,875	31%	14%	5,840	3,940	-24%	-24%
HGV	3,505	3,822	21%	14%	1,452	1,141	-31%	-31%
Inter Peak								
Car Commute	8,948	9,905	8%	3%	3,065	2,410	-24%	-18%
Car Business	11,854	13,201	9%	3%	3,911	3,178	-26%	-18%

VEHICLE	CORDON 1 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 1 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
Car Other	39,860	45,407	6%	2%	14,540	11,819	-19%	-13%
LGV	6,970	8,859	34%	16%	5,587	3,770	-26%	-26%
HGV	4,160	4,509	24%	16%	1,592	1,251	-35%	-35%
PM Peak								
Car Commute	41,442	46,592	7%	2%	14,519	11,696	-22%	-16%
Car Business	7,760	8,746	8%	3%	2,591	2,127	-25%	-18%
Car Other	37,179	42,819	6%	2%	13,553	11,185	-19%	-13%
LGV	5,532	7,185	28%	13%	4,930	3,326	-22%	-22%
HGV	1,570	1,738	15%	10%	776	610	-22%	-22%

Results

7.2.4 The following table shows the reductions in NO_X Emissions predicted by ENEVAL because of this scenario. The 2021 BaU values are also presented as comparator and the table is restricted to those sites which are expected to not be in compliance in 2021.

7.2.5 As can be seen this wide area CAZ D option results in significant reductions in NO_X Emissions, all of which are expected to be large enough to bring each site into compliance

Table 7 – 2021 Cordon 1 CAZ D Scenario - Changes in Tailpipe NO_X Emissions from 2017 Base Year

SITE	BAU	CORDON 1 CAZ D
Sheffield Sites		
Arundel Gate Interchange	-22%	-30%
Derek Dooley Way	-3%	-47%
Sheaf Street	-24%	-53%
Sheffield Parkway	-24%	-62%
Sheffield Road	-18%	-49%
Rotherham Sites		
A629 Wortley Road	-22%	-70%
A630 Fitzwilliam Road	-23%	-56%
A630 Parkway Rotherham	-21%	-60%
A633 Rawmarsh Hill	-25%	-22%

7.3 2021 Cordon 2 CAZ D

Description

7.3.1 This option uses the medium cordon size and assumes no changes to the compliance mix and the underlying fleet. It uses the default behavioural responses as presented by JAQU and

described in the previous section, which apply to all trips entering the cordon area. As this is a CAZ D all vehicle types are charged.

7.3.2 The cordon in this case is entirely within Sheffield City Council area, so to mitigate the non-compliant sites in Rotherham some additional measures are included in the RMBC area, which are:

- A full HGV Ban on Wortley Road (Northbound / Uphill direction only). This is intended to prevent HGV's using this route to access the M1 from Rotherham Town Centre, but rather use the alternative route to M1 J34;
- Reduction in number of buses using Rawmarsh Hill, with 50% of buses currently on this route re-routed to using Barbers avenue. Alongside this junction changes will be made to allow for re-prioritisation of bus routes; and
- Improvements to Bus Fleet in areas where compliance is an issue. For the modelling, all buses using these routes (including Rawmarsh Hill and Barbers Avenue) have assumed to upgrade to Euro 6 or Retrofitted to Euro 6 equivalent.

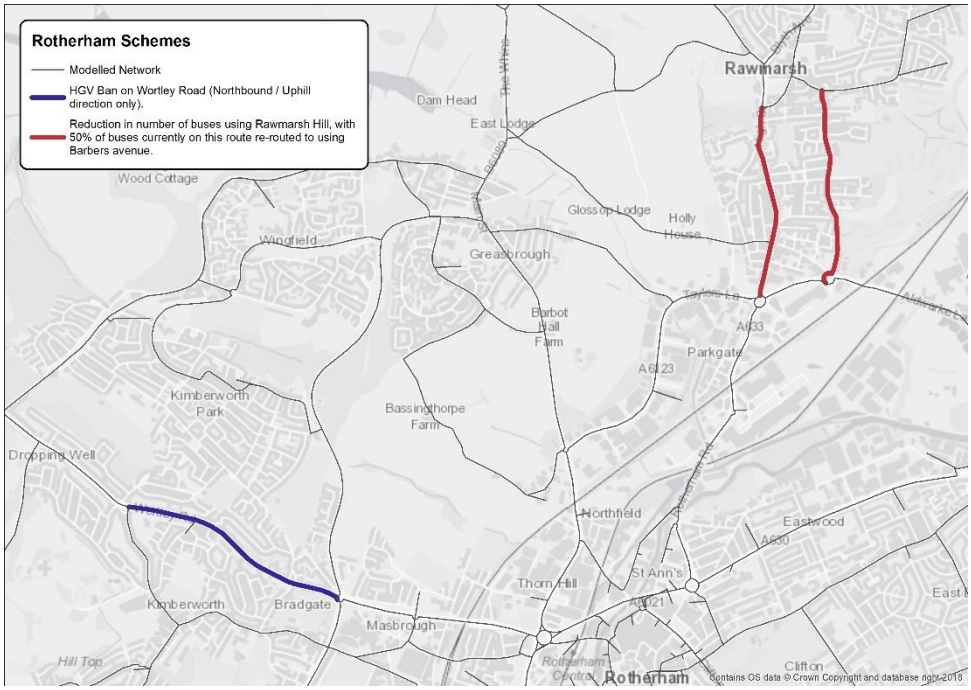


Figure 16 – Rotherham Schemes

Compliance Splits

7.3.3 These are the same as the 2021 BaU, however those trips starting in the CAZ area or destinating in the CAZ charge area are subject to JAQU Behavioural research proportions resulting in the compliance proportions in the table below.

Table 8 – 2021 Cordon 2 CAZ D Area Wide Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	7%	93%
Diesel Car	46%	54%
Petrol LGV	14%	86%
Diesel LGV	43%	57%
Rigid HGV	26%	74%
Articulated HGV	28%	72%
PSV	67%	33%
Black Cab	9%	91%
PHV	69%	31%

Matrix Totals

7.3.4 The following table shows the Assignment Matrix totals for this option in each time period, for each assigned vehicle type and separately for compliant and non-compliant vehicle types

Table 9 – 2021 Cordon 2 CAZ D Matrix Totals

VEHICLE	CORDON 2 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 2 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
TYPE	2021	2024	2021	2024	2021	2024	2021	2024
AM Peak								
Car Commute	44,047	49,801	5%	0%	17,303	14,063	-15%	-7%
Car Business	9,820	11,090	6%	1%	3,548	2,951	-20%	-11%
Car Other	19,525	22,409	2%	-1%	8,304	6,904	-9%	0%
LGV	6,568	8,645	25%	11%	6,223	4,199	-19%	-19%
HGV	3,344	3,696	16%	11%	1,621	1,274	-23%	-23%
Inter Peak								
Car Commute	8,754	9,740	6%	1%	3,314	2,621	-18%	-10%
Car Business	11,664	13,028	7%	2%	4,154	3,399	-21%	-13%

VEHICLE	CORDON 2 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 2 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
Car Other	39,197	44,824	4%	0%	15,390	12,566	-14%	-7%
LGV	6,678	8,662	28%	13%	5,915	3,991	-22%	-22%
HGV	3,955	4,348	18%	12%	1,806	1,419	-26%	-26%
PM Peak								
Car Commute	40,543	45,805	5%	1%	15,670	12,705	-16%	-8%
Car Business	7,624	8,623	6%	1%	2,766	2,285	-20%	-12%
Car Other	36,617	42,322	4%	0%	14,274	11,821	-14%	-8%
LGV	5,228	6,980	21%	10%	5,271	3,557	-16%	-16%
HGV	1,506	1,688	10%	7%	843	663	-15%	-15%

Results

7.3.5 The following table shows the reductions in NO_X Emissions predicted by ENEVAL because of this scenario. The 2021 BaU values are also presented as comparator and the table is restricted to those sites which are expected to not be in compliance in 2021.

7.3.6 As can be seen this Sheffield and Lower Don Valley area CAZ D option results in significant reductions in NO_X Emissions, all of which are expected to be large enough to bring each site into compliance

Table 10 – 2021 Cordon 2 CAZ D Scenario - Changes in Tailpipe NO_X Emissions from 2017 Base Year

SITE	BAU	CORDON 2 CAZ D
Sheffield Sites		
Arundel Gate Interchange	-22%	-31%
Derek Dooley Way	-3%	-48%
Sheaf Street	-24%	-52%
Sheffield Parkway	-24%	-64%
Sheffield Road	-18%	-53%
Rotherham Sites		
A629 Wortley Road	-22%	-19%
A630 Fitzwilliam Road	-23%	-27%
A630 Parkway Rotherham	-21%	-64%
A633 Rawmarsh Hill	-25%	-23%

7.4 2021 Cordon 3 CAZ D

Description

7.4.1 This option uses the smallest cordon size (Cordon 3) which covers Sheffield City Centre and the Inner Ring Road (including the Inner Ring Road).

7.4.2 Additionally to the cordon, the measures listed in Appendix F are applied, which includes all the additional schemes in Rotherham which were included in the Cordon 2 CAZ D option, and are summarised below:

- The bus upgrades to Euro 6 or Euro 6 equivalent retrofit are extended to the full bus fleet in Sheffield and Rotherham;
- New taxi licencing regulations modelled as:
  - 60% of black cabs which have come up for renewal by 2021 have upgraded to ULEV (40% LPG and 20% Electric); and
  - 60% of PHV's which have come up for renewal by 2021 have upgraded to ULEV (either petrol hybrid and electric);
- Improved signal timings on the Derek Dooley Way section of the Sheffield Inner Ring Road to reduce delays particularly in the peak periods;
- Increased Parking Charges in Sheffield City Centre (all locations bounded by the Inner Ring Road) equivalent on average across all sites to an increase in Generalised Journey Time of 5 mins;
- A 'Hearts and Minds' campaign to encourage diesel car owners to upgrade to compliant petrol;
- A630 Sheffield Parkway widening scheme excluded (as not scheduled to be delivered until late 2021 at the earliest); and
- Speed limit on the Parkway assumed to be reduced from 70mph to 50mph, to achieve a more efficient distribution of vehicle speeds (from an emissions perspective).

7.4.3 The default JAQU behavioural response proportions were replaced by the corresponding values derived from the local behavioural research. This is described in more detail in **Supporting Document 1 (SD01)**.

7.4.4 The full VDM was used to determine the mode and destination choice responses on a cell-by-cell basis, replacing the model-wide average variable demand responses implied by the local behavioural research (which we use when not using the VDM).

Compliance Splits

7.4.5 These are the same as the 2021 BaU, however those trips starting in the CAZ area or destinating in the CAZ charge area are subject to local conservative Behavioural Research proportions (excluding the remove from highway matrix ones) resulting in the compliance proportions in the table below.

Table 11 – 2021 Cordon 3 CAZ D Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	14%	86%
Diesel Car	64%	36%
Petrol LGV	22%	78%
Diesel LGV	56%	44%

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Rigid HGV	39%	61%
Articulated HGV	41%	59%
PSV	1%	99%
Black Cab	4%	96%
PHV	11%	89%

Matrix Totals

7.4.6 The following table shows the Assignment Matrix totals for this option in each time period, for each assigned vehicle type and separately for compliant and non-compliant vehicle types

Table 12 – 2021 Cordon 3 CAZ D Matrix Totals

VEHICLE	CORDON 3 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 3 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
TYPE	2021	2024	2021	2024	2021	2024	2021	2024
AM Peak								
Car Commute	42,180	48,983	0%	-1%	19,922	15,506	-2%	3%
Car Business	9,358	10,856	1%	-1%	4,349	3,458	-2%	4%
Car Other	19,089	22,396	0%	-1%	9,103	7,250	0%	5%
LGV	5,555	7,962	5%	2%	7,398	4,991	-4%	-4%
HGV	2,944	3,382	2%	1%	2,040	1,603	-3%	-3%
Inter Peak								
Car Commute	8,369	9,617	1%	0%	3,927	2,984	-3%	2%
Car Business	11,084	12,751	2%	0%	5,227	4,102	-1%	5%

VEHICLE	CORDON 3 CAZ D – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 3 CAZ D – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
Car Other	37,695	44,279	0%	-1%	17,753	13,949	-1%	3%
LGV	5,570	7,914	7%	3%	7,208	4,863	-5%	-5%
HGV	3,431	3,936	2%	1%	2,356	1,851	-3%	-3%
PM Peak								
Car Commute	38,484	44,639	0%	-2%	18,336	14,223	-2%	3%
Car Business	7,186	8,344	0%	-2%	3,431	2,719	0%	5%
Car Other	35,055	41,500	0%	-2%	16,467	13,162	-1%	3%
LGV	4,492	6,483	4%	2%	6,121	4,130	-3%	-3%
HGV	1,384	1,592	1%	1%	971	763	-2%	-2%

Results

7.4.7 The following table shows the reductions in NO_X Emissions predicted by ENEVAL because of this scenario. The 2021 BaU values are also presented as comparator and the table is restricted to those sites which are expected to not be in compliance in 2021.

7.4.8 The reductions in this case are larger in some areas such as Arundel Gate in Sheffield than the previous options. This is due to the area-wide improvements in the bus fleet. In other areas, the reductions are more modest. However, the air quality modelling as presented in the AQ3 Local Air Quality Modelling Report shows that compliance is achieved in all locations.

As can be seen Table 13 – 2021 Cordon 3 CAZ D Scenario - Changes in Tailpipe NOX Emissions from 2017 Base Year

SITE	BAU	CORDON 3 CAZ D
Sheffield Sites		
Arundel Gate Interchange	-22%	-66%
Derek Dooley Way	-3%	-66%
Sheaf Street	-24%	-72%
Sheffield Parkway	-24%	-39%
Sheffield Road	-18%	-25%
Rotherham Sites		
A629 Wortley Road	-22%	-39%
A630 Fitzwilliam Road	-23%	-35%
A630 Parkway Rotherham	-21%	-26%
A633 Rawmarsh Hill	-25%	-43%

7.5 2021 Cordon 3 CAZ C+

Description

7.5.1 As with the previous option, this option uses the smallest cordon size (Cordon 3) which covers Sheffield City Centre and the Inner Ring Road (including the Inner Ring Road). However, in this case only a CAZ C scheme is in operation, meaning that private car owners have not been subjected to the charge. The through trip fleet effects (TTFE) was applied to LGV and HGV demand.

7.5.2 This option contains all the supplementary measures included in the Cordon 3 CAZ D option and are listed in Appendix F, with a 'Hearts and Minds' campaign in Sheffield that is expected to reach 4% switch from non-compliant diesel to compliant petrol over and above the BaU predictions.

7.5.3 Because of all the other measures included in this test it is referred to a CAZ C +.

Compliance Splits

7.5.4 These start from the same values as the 2021 BaU, however those trips starting in the CAZ area or destinating in the CAZ charge area, as well as 50% of the trips in BaU that traverse the cordon, are subject to local conservative Behavioural Research proportions resulting in the compliance proportions within the CAZ charging area in the table below.

Table 14 – 2021 Cordon 3 CAZ C+ Compliance Splits

VEHICLE TYPE	NON-COMPLIANT SPLIT	COMPLIANT SPLIT
Petrol Car	17%	83%
Diesel Car	60%	40%
Petrol LGV	5%	95%
Diesel LGV	23%	77%
Rigid HGV	8%	92%
Articulated HGV	5%	95%
PSV	0%	100%
Black Cab	7%	93%
PHV	2%	98%

Matrix Totals

7.5.5 The following table shows the Assignment Matrix totals for this option in each time period, for each assigned vehicle type and separately for compliant and non-compliant vehicle types

Table 15 – 2021 Cordon 3 CAZ C+ Matrix Totals

VEHICLE	CORDON 3 CAZ C+ – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 3 CAZ C+ – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
TYPE	2021	2024	2021	2024	2021	2024	2021	2024
AM Peak								
Car Commute	42,160	49,880	0%	0%	20,004	14,648	-1%	-3%
Car Business	9,242	10,991	0%	0%	4,367	3,228	-1%	-3%
Car Other	19,106	22,813	0%	0%	8,999	6,699	-1%	-3%
LGV	5,703	8,058	8%	4%	7,250	4,895	-6%	-6%
HGV	2,990	3,416	3%	2%	1,992	1,567	-5%	-5%
Inter Peak								
Car Commute	8,297	9,698	0%	1%	3,974	2,848	-1%	-3%
Car Business	10,938	12,903	0%	1%	5,202	3,789	-1%	-3%

VEHICLE	CORDON 3 CAZ C+ – COMPLIANT MATRICES		DIFFERENCE FROM BAU		CORDON 3 CAZ C+ – NON-COMPLIANT MATRICES		DIFFERENCE FROM BAU	
Car Other	37,593	44,837	0%	0%	17,722	13,167	-1%	-3%
LGV	5,727	8,023	10%	5%	7,051	4,755	-7%	-7%
HGV	3,484	3,978	4%	3%	2,300	1,807	-5%	-5%
PM Peak								
Car Commute	38,664	45,721	0%	0%	18,352	13,427	-1%	-3%
Car Business	7,175	8,532	0%	0%	3,391	2,505	-1%	-3%
Car Other	35,083	42,213	0%	0%	16,421	12,396	-2%	-3%
LGV	4,551	6,523	5%	2%	6,062	4,090	-4%	-4%
HGV	1,393	1,599	2%	1%	962	756	-3%	-3%

Results

7.5.6 The following table shows the reductions in NO_X Emissions predicted by ENEVAL because of this scenario. The 2021 BaU values are also presented as comparator and the table is restricted to those sites which are expected to not be in compliance in 2021.

7.5.7 The reductions in this case are more modest than in the CAZ D option, but Air Quality modelling has shown that the CAZ C+ is sufficient to reach compliance in all locations.

Table 16 – 2021 Cordon 3 CAZ C+ Scenario - Changes in Tailpipe NO_X Emissions from 2017 Base Year

SITE	BAU	CORDON 3 CAZ C+
Sheffield Sites		
Arundel Gate Interchange	-22%	-60%
Derek Dooley Way	-3%	-37%
Sheaf Street	-24%	-49%
Sheffield Parkway	-24%	-38%
Sheffield Road	-18%	-25%
Rotherham Sites		
A629 Wortley Road	-22%	-31%
A630 Fitzwilliam Road	-23%	-30%
A630 Parkway Rotherham	-21%	-30%
A633 Rawmarsh Hill	-25%	-39%

7.5.8 As this test reaches compliance at all sites required with the minimum charging area and number of vehicles charges, this is the **Preferred Option**

8. SENSITIVITY TESTS

8.1 Introduction

8.1.1 After testing the options detailed in the previous section, several sensitivity tests were undertaken to determine the robustness of the results already obtained. These sensitivity tests fall into several categories:

- Calibration and Validation Impacts;
- Behavioural Responses;
- Fleet Changes over time;
- Bus Fleet Sensitivity Changes;
- Infrastructure Changes; and
- Qualitative sensitivity tests.

8.1.2 The following sections describe these sensitivity tests that have been undertaken. It should be noted that due to the run times of the Air Quality Model none of these sensitivity tests have been put through the AIRVIRO model.

8.2 Calibration and Validation Impacts - Sheffield Parkway Sensitivity Test

8.2.1 At the request of Rotherham MBC, a sensitivity test was undertaken with an extra 1,000 vehicles per hour using the Parkway4. The result of this was that, whilst the reductions in NO_X Emissions on the Parkway between 2017 and the 2021 'Business as Usual' were slightly lower than without this, the reductions were still sufficient that compliance would be achieved.

8.3 Behavioural Responses Sensitivity Tests

8.3.1 A sensitivity test was undertaken on the Cordon 3 CAZ C+ test, using the original JAQU default responses rather than the values derived from the local Behavioural Research.

8.3.2 The results suggested little or no net change to the emissions on the links closest to the various target determination sites within Sheffield and Rotherham.

8.3.3 We therefore conclude that the use of the local Behavioural Research values (rather than the JAQU defaults) will not significantly impact the level of compliance with the required NO_2 Air Quality standards.

8.3.4 A 2nd test was undertaken using the 'pessimistic' behavioural responses, in which no vehicle trips get priced off the network and instead this demand continues to be met by a fleet whose trade-off between upgrading and 'paying to pollute' is the same as for the non-suppressed demand. More details are contained in **Supporting Document 1 (SD01)**. This test failed to reach compliance with the required air quality standards at several locations, suggesting that, if the trip suppression impacts have been over-stated in the JAQU & local Behavioural Research then there is a risk that the Preferred Option may need to be supplemented by other measures, if compliance is to be achieved in 2021.

[4] This test was undertaken for two reasons: Firstly, RMBC data shows modelled Base Year flows on the parkway are generally low, although this is largely corrected by the annualisation factors but as a result better represents Base Year Congestion; Secondly it has been undertaken as a sensitivity if the SRTM3B model underestimates traffic associated with the developments along the Parkway corridor

8.4 Fleet Changes - Goods Vehicle Growth Sensitivity Test

8.4.1 As indicated earlier, the current version of the SRTM3B model includes no changes in Goods Vehicle matrices over time. This has fed through into all the option tests reported in this document, The HGV vehicle kms in the Sheffield and Rotherham area have been reducing by around 1%v per annum over the last ten years and the LGV vehicle kms have been increasing by around 1.5%. These values have been extrapolated forward to a new 2024 forecast version of the Cordon 3 CAZ C+ test and then interpolated to get a new set of 2021 results, as shown in Table 9 below.

8.4.2 The results from this sensitivity test suggest that the increases in LGV emissions are almost exactly offset by the reduction in HGV emissions, resulting in little net change to the predicted reductions in NO_X on all the key roads as in the corresponding no-goods-growth version of the Preferred Option.

Table 9. 2021 Goods Vehicle Growth Sensitivity Test - Changes in Tailpipe NO_X Emissions from 2017 Base Year

SITE	CORDON 3 CAZ C+ (PREFFERED OPTION)	GOODS VEHICLE GROWTH SENSITIVITY
Sheffield Sites		
Arundel Gate Interchange	-61%	-61%
Derek Dooley Way	-42%	-41%
Sheaf Street	-52%	-52%
Sheffield Parkway	-37%	-36%
Sheffield Road	-28%	-27%
Rotherham Sites		
A629 Wortley Road	-39%	-39%
A630 Fitzwilliam Road	-36%	-35%
A630 Parkway Rotherham	-29%	-28%
A633 Rawmarsh Hill	-43%	-42%

8.5 Bus Fleet - Arundel Gate Sensitivity Test

8.5.1 A sensitivity test was undertaken to determine the proportion of buses required to make Arundel Gate compliant in either Cordon 1 or Cordon 2 CAZ D scenarios (ie before the bus fleet improvements were included in testing). From this analysis, it was found that around 45% of buses using that link would be needed to achieve a tailpipe reduction in NO_X equivalent to the NO_2 concentration required.

8.5.2 As the amount of upgrade required to achieve compliance on Arundel Gate is lower than that included in the **Preferred Option** it implies there is some 'wiggle room' in the target and compliance should still be achieved.

8.6 Bus Fleet - Rawmarsh Hill Sensitivity Test

8.6.1 This was very similar to the Arundel Gate sensitivity test and was undertaken to determine what proportion of buses on Rawmarsh Hill would need to upgrade to achieve a tailpipe NO_X

reduction which should achieve compliance. This was found to be around 70%. A further test was undertaken to see what would happen if Rawmarsh Hill could be made to move at free flow speed in the peak hours rather than the congested state it is currently in. This was also found to produce NO_X reductions which should be sufficient to achieve compliance.

8.6.2 As the amount of upgrade required to achieve compliance on Rawmarsh Hill is lower than that included in the **Preferred Option** it implies there is some 'wiggle room' in the target and compliance should still be achieved.

8.7 Infrastructure - Parkgate Link Road Sensitivity Test

8.7.1 The Parkgate Link Road is a test connecting A6123 Aldwarke Lane at the roundabout with Barber's Avenue with the Parkgate Retail Centre, which is a committed scheme but it is unclear whether this will be complete in time for 2021 and will also not form part of the **Preferred Option** CAZ strategy.

8.7.2 A sensitivity test was undertaken where this was included on top of the Cordon 3 CAZ C+ test and it was found to make further slight improvements to NO_X emissions over and above the **Preferred Option**. As a conclusion, it was deemed that this would therefore only result in improvements to the scheme.

8.8 Infrastructure – Parkway Widening and Speed Tests

8.8.1 Sensitivity tests were undertaken on the committed scheme of Parkway Widening on the A630, which is not due to be opened until 2022. This sensitivity test suggested that the extra capacity successfully reduces the amount of queuing traffic on the Parkway approaching J33 of the M1, but in doing so releases some of the suppressed demand which is currently using other routes to avoid this congestion. The net effect is a reduction in the emissions on these alternative routes and a mixture of emissions reductions and emission increases along the Parkway itself.

8.8.2 Given the importance of the Parkway in determining the overall NO_2-based compliance of the SCC/RMBC area, these results suggest that the Parkway Widening scheme and/or any developments which relate to it are designed and modelled carefully, to ensure that air quality compliance achieved in 2021 is then not jeopardised in later years.

8.9 Qualitative Sensitivity Impacts

Impact on / of Nearby Cities

8.9.1 The impact on other cities of a CAZ scheme in Sheffield and Rotherham is likely to be negligible if they have their own CAZ schemes. However, those that do not, are liable to become 'dumping grounds' for older bus and goods vehicle fleets and in those cases, it could have an adverse effect. Care also needs to be taken to ensure these fleets do not get placed in Rotherham, where there is no charge, and therefore threaten the success of the scheme in Rotherham. This is not expected to happen through close co-operation with local fleet managers and because of the joint SCC / RMBC 'Hearts and Minds' campaign.

8.9.2 The impact on the CAZ scheme itself on other nearby CAZ schemes is only likely to improve the NO_X emission reductions as fleets in those areas improve and hence if they drive into the Sheffield and Rotherham area there will be a higher number of compliant vehicles. It is unlikely that a higher number of non-compliant vehicles drive into the area.

8.9.3 These effects are either outside the geographical scope of SRTM3B or out with its modelling capability and therefore have not been tested.

Second Hand Car Market

8.9.4 No sensitivity test has been undertaken on the impact of this CAZ scheme on the second-hand car market. It is however, likely that it means that the market in surrounding areas may be flooded with non-compliant diesel cars. In Rotherham, in particular it is hoped the 'Hearts and Minds' campaign will mitigate against this.

8.9.5 The impacts on surrounding areas are outside the geographical scope of the model and have therefore not been tested.

Long Term Impacts of the Scheme

8.9.6 The long-term impacts of the scheme have not been tested as the research suggest that compliance should be achieved by 2025 / 2026 anyway. After that the fleet mix in Sheffield and Rotherham is expected to achieve compliance anyway due to the natural churn in the fleet.

Alternative CAZ Charges

8.9.7 The current modelled values for the various charges have been chosen to be consistent with other nearby proposed CAZ schemes, particularly Leeds and Birmingham.

8.9.8 The local Behavioural Research provides some evidence regarding the elasticity of the various responses to the CAZ charging level, but the time available to produce the OBC has not permitted any significant testing of alternative charging regimes.

8.9.9 We hope to include a sensitivity test in which the daily charge for LGVs is increased, when time permits. This variation will (presumably) reduce emissions and therefore increase the likelihood that the Preferred Option will achieve compliance in 2021. This may therefore provide an additional back-up option, if the ANPR-based monitoring suggests that less-than-expected amount of fleet upgrades have taken place in response to the introduction of the Preferred Option CAZ and the local Hearts and Minds campaign.

Daily Frequency of 1-Way Trips Within the Charging Area

8.9.10 No sensitivity tests have been undertaken on the assumed average number of trips made within the charging area per day by individual vehicles. The impact of these parameters will primarily be on the amount of revenue generated by the modelled travel demand (which does not affect the level of emissions)

8.9.11 We do not expect that changes to these parameters will significantly alter any of the decisions being informed by the OBC.

8.10 Additional Sensitivity Tests

8.10.1 Several further sensitivity tests were undertaken post OBC, including, but not limited to, through trips, taxi and hearts and mind, have been undertaken and are documented in the OBC Clarification Modelling Report.

9. IMPACT ANALYSIS ON TRAFFIC DEMAND

9.1 Introduction

9.1.1 This section details the impact on the highway network of the four options tested including the **Preferred Option.** A series of high level analyses have been done to inform the impact on the wider road network of introducing a CAZ Charging scheme.

9.2 Network Statistics

9.2.1 **Appendix A** contains tables of network statistics for each of the four options detailing:

- Average Journey Time per vehicle;
- Average Journey Distance per vehicle;
- Average Speed; and
- Average Delay per vehicle.

9.2.2 This is presented for all vehicle types in the assignment model and is split by compliant and non-compliant vehicle types.

9.2.3 From these network statistics, in general the introduction of a CAZ means that compliant vehicles travel shorter distances, whereas non-compliant vehicles travel longer distances due to the rerouting they undertake. The other network statistics are a bit of a mixture, where in many cases compliant vehicles experience more delay and lower speeds. However, this reflects the fact that non-compliant vehicles are often choosing longer distance routes but on faster routes (e.g. M1) with limited junctions. It is also the case that the number of compliant vehicles increases whilst the number of non-compliant vehicles decreases.

9.3 Changes in Demand / Routing

9.3.1 The changes in routing and demand on the road network of Sheffield and Rotherham is shown in **Appendix B**. This shows the network wide changes between the 2021 BaU and the four options presented in the AM Peak and PM Peak hours, along with a detailed picture of the Parkway in the PM when it is at its most busy.

9.3.2 The figures in the appendix show that:

- There are decreases in traffic demand within the cordon charging area for each option;
- In all options, there are increases in flows to the south and south west of Sheffield City Centre, particularly around Highfield, Sharrow, Broomhall and Crookes. This is because of non-compliant vehicles rerouting around the CAZ;
- Increases in traffic through the Wincobank area, particularly in the Cordon 1 and Cordon 2 options;
- Increased traffic through the north of Rotherham in the C Cordon 1 and Cordon 2 tests on an east-west axis to avoid the charging area. This affects Greasborough and Rawmarsh (but doesn't add to issues on Rawmarsh Hill except where east-west traffic crosses this route); and
- Increases in demand on the Sheffield outer ring road in the Cordon 3 options particularly around Prince of Wales Road.

9.4 Changes in Volume / Capacity

9.4.1 **Appendix C** shows the changes in Volume / Capacity in the Sheffield and Rotherham area as a proxy for looking at congestion. These are shown for the same areas and time periods as the demand and routing analysis.

9.4.2 What can be seen from these images is that congestion improves inside the CAZ cordon areas, which would be expected due to reductions in traffic flows, but that there is some worsening of congestion around the CAZ area as non-compliant vehicles reroute to avoid the scheme. These affects are very much geographically consistent with the traffic demand and rerouting analysis.

9.5 Changes in Junction Delays

9.5.1 Changes in the junction delays within transport model are shown in **Appendix D**. These are shown for the same areas and time periods as the demand and routing analysis.

9.5.2 Similarly, to the other analysis decrease in junction delays occur within the area of the CAZ scheme but with increases in some of the areas around the CAZ where traffic increases.

9.6 Changes in NO_X Tailpipe Emissions

9.6.1 Changes in the NO_X tailpipe emissions (predicted by ENEVAL) coming out of the transport model are shown in **Appendix E**. These are shown for the same areas and time periods as the demand and routing analysis.

9.6.2 This shows a very similar analysis to the demand and routing analysis (and indeed the Air Quality modelling covered in **AQ3** that there are reductions in NO_X Emissions inside the CAZ areas and along much of the strategic road network, but increases in NO_X emissions along some of the routes where traffic ins increasing to avoid the scheme.

10. SUMMARY OF KEY FINDINGS

10.1 Introduction

10.1.1 This section summarises the previous chapters and discusses some of the caveats around the results (these are a summarised version of those presented in the **Analytical Assurance Statement**) along with a description of the next steps.

10.2 Key Findings

10.2.1 The list below summarises some of the main components of the modelling and the conclusions from the Traffic Assignment and Emissions modelling:

- We have a traffic model (SRTM3B) which can predict the impact of measures which affect traffic flow (volume and/or speed) in the Sheffield and Rotherham area. This includes demand matrices split by compliant and non-compliant vehicle types to allow for rerouting due to CAZ schemes;
- We have an EFT-compatible[5] tailpipe Emissions model version of ENEVAL, calibrated to match observed local fleet profiles and capable of predicting the Emissions-related impacts of changes in traffic (from SRTM3B) and/or fleet proportions, on a link-by-link basis; and
- The output analysis from the tests undertaken, based on the percentage reduction in tailpipe NO_X, has suggested that:
    - a 'Business as Usual' scenario is unlikely to achieve compliance at all the monitored AQ hot-spot sites in Sheffield and Rotherham until 2025 (based on tailpipe NOX reductions);
    - as a minimum, a charging-CAZ C is required in Sheffield City Centre (including the Inner Ring Road) along with small schemes in Rotherham and soft measure across the whole area to achieve compliance by 2021. This is the **Preferred Option** by SCC and RMBC; and
    - a CAZ D charging scheme in the same area with similar measures in Rotherham or a CAZ D covering a wider area including west Rotherham and the lower Don Valley will also achieve compliance by 2021.

10.3 Caveats

10.3.1 The following caveats should be borne in mind when considering the transport modelling undertaken to date and presented in this report:

- The tailpipe NO_X Emissions changes have been presented throughout and used to give an indication as to whether compliance may be achieved. More detailed air quality responses can be found in the **Local Plan Air Quality Modelling Report (AQ3)** which is also released as part of the **Initial Evidence Submission**;
- The local Behavioural Research used in the modelling is based on a Stated Preference survey rather than a Revealed Preference survey. Although no empirical evidence exists to provide alternative values and sensitivity tests have been undertaken using the JAQU specified values;
- The traffic model has some known deficiencies in the Base Year validation, these are described in **T2 Transport Model Validation Report**, but whilst with more time further

[5] Compatible with the latest version of EFT v8.0.1b

analysis would be undertaken to mitigate these issues it is not expected that this would change the conclusions included in the **Preferred Option**; and

- It is considered that the **Emissions Factor Toolkit (EFTv8.0.1b)** is a very conservative estimate of the changes over time. In particular, the EFT predicts peak diesel car has not yet been achieved whereas evidence from the DFT suggests that diesel sales are already reducing as a proportion of total car sales. As EFT changes in fleet over time have been applied to the local fleet split it is expected that this possibly overestimates the emissions in forecast years.

10.4 Conclusion

10.4.1 From this round of modelling a **Preferred Option** has been settled on. This is being used in the **Outline Business Case (OBC)** for which this updated document is part of the submission.

10.4.2 It is understood although time scales were tight to reach this point and several caveats surrounding the modelling exist significant further research is not expected to change the conclusions or the scheme put forward as the **Preferred Option**.

10.4.3 This document will be further refined and updated for the **Full Business Case Submission** in 2019.

APPENDIX A – NETWORK STATISTICS

This appendix shows the high-level network statistics for each of the options considered compared to the 2021 Business as Usual (BaU) test. Times are in hours, speeds are in kph and distances are in km.

2021 Cordon 1 CAZ D

Table 17 – 2021 Cordon 1 CAZ D AM Peak Highway Network Statistics

MEASURE	COMPLIANT			NON - COMPLIANT		
	BaU	TEST	DIFF	BaU	TEST	DIFF
Average Travel Time						
Car Commute	0.23	0.24	1%	0.23	0.24	1%
Car Business	0.24	0.24	1%	0.24	0.23	-3%
Car Other	0.20	0.20	1%	0.20	0.20	0%
LGV	0.22	0.22	0%	0.22	0.23	5%
HGV - Rigid	0.24	0.24	1%	0.24	0.24	2%
HGV - Artic	0.24	0.24	1%	0.24	0.24	2%
Black Cab	0.21	0.20	-1%	0.21	0.20	-1%
PHV	0.18	0.18	-2%	0.18	0.18	-2%
Bus	0.63	0.62	0%	0.63	0.62	0%
Coach	0.24	0.24	1%	0.24	0.24	2%
Average Travel Distance						
Car Commute	8.91	9.03	1%	8.91	9.06	2%

MEASURE	COMPLIANT			NON - COMPLIANT		
Car Business	10.73	10.76	0%	10.73	10.86	1%
Car Other	7.86	7.91	1%	7.86	8.07	3%
LGV	9.34	9.16	-2%	9.34	9.87	6%
HGV - Rigid	11.33	11.08	-2%	11.34	12.32	9%
HGV - Artic	11.33	11.08	-2%	11.34	12.32	9%
Black Cab	7.28	7.26	0%	7.28	7.26	0%
PHV	4.81	4.79	0%	4.81	4.79	0%
Bus	16.87	16.79	0%	16.87	16.79	0%
Coach	11.33	11.08	-2%	11.34	12.32	9%
Average Speed						
Car Commute	38.07	38.13	0%	38.07	38.29	1%
Car Business	44.39	44.21	0%	44.39	46.37	4%
Car Other	39.57	39.34	-1%	39.57	40.46	2%
LGV	41.76	40.90	-2%	41.76	42.14	1%
HGV - Rigid	47.59	46.09	-3%	47.89	51.09	7%
HGV - Artic	47.59	46.09	-3%	47.89	51.09	7%
Black Cab	35.01	35.00	0%	35.01	35.00	0%

MEASURE	COMPLIANT			NON - COMPLIANT		
PHV	29.24	29.54	1%	29.24	29.54	1%
Bus	26.91	26.89	0%	26.91	26.89	0%
Coach	47.59	46.09	-3%	47.89	51.09	7%
Average Delay						
Car Commute	0.04	0.04	2%	0.04	0.04	-5%
Car Business	0.04	0.04	2%	0.04	0.03	-17%
Car Other	0.03	0.03	3%	0.03	0.03	-7%
LGV	0.04	0.04	5%	0.04	0.04	-2%
HGV - Rigid	0.03	0.04	6%	0.03	0.03	-11%
HGV - Artic	0.03	0.04	6%	0.03	0.03	-11%
Black Cab	0.05	0.05	-1%	0.05	0.05	-1%
PHV	0.05	0.05	-5%	0.05	0.05	-5%
Bus	0.17	0.17	0%	0.17	0.17	0%
Coach	0.03	0.04	6%	0.03	0.03	-11%

2021 Cordon 2 CAZ D

Table 18 – 2021 Cordon 1 CAZ D AM Peak Highway Network Statistics

MEASURE	COMPLIANT			NON - COMPLIANT		
	BaU	TEST	DIFF	BaU	TEST	DIFF
Average Travel Time						
Car Commute	0.23	0.24	1%	0.23	0.22	-7%
Car Business	0.24	0.24	1%	0.24	0.23	-6%
Car Other	0.20	0.20	1%	0.20	0.19	-5%
LGV	0.22	0.23	1%	0.22	0.22	-1%
HGV - Rigid	0.24	0.24	2%	0.24	0.22	-5%
HGV - Artic	0.24	0.24	2%	0.24	0.22	-5%
Black Cab	0.21	0.20	-2%	0.21	0.20	-2%
PHV	0.18	0.18	-3%	0.18	0.18	-3%
Bus	0.63	0.61	-3%	0.63	0.61	-3%
Coach	0.24	0.24	2%	0.24	0.22	-5%
Average Travel Distance						
Car Commute	8.91	9.02	1%	8.91	8.65	-3%
Car Business	10.73	10.74	0%	10.73	10.73	0%
Car Other	7.86	7.91	1%	7.86	7.78	-1%

MEASURE	COMPLIANT			NON - COMPLIANT		
LGV	9.34	9.23	-1%	9.34	9.56	2%
HGV - Rigid	11.33	11.23	-1%	11.34	11.73	3%
HGV - Artic	11.33	11.23	-1%	11.34	11.73	3%
Black Cab	7.28	7.25	0%	7.28	7.25	0%
PHV	4.81	4.78	-1%	4.81	4.78	-1%
Bus	16.87	16.43	-3%	16.87	16.43	-3%
Coach	11.33	11.23	-1%	11.34	11.73	3%
Average Speed						
Car Commute	38.07	38.13	0%	38.07	39.66	4%
Car Business	44.39	44.11	-1%	44.39	47.17	6%
Car Other	39.57	39.39	0%	39.57	41.40	5%
LGV	41.76	40.79	-2%	41.76	43.11	3%
HGV - Rigid	47.59	46.23	-3%	47.89	52.21	9%
HGV - Artic	47.59	46.23	-3%	47.89	52.21	9%
Black Cab	35.01	35.31	1%	35.01	35.31	1%
PHV	29.24	29.72	2%	29.24	29.72	2%
Bus	26.91	26.95	0%	26.91	26.95	0%

MEASURE	COMPLIANT			NON - COMPLIANT		
Coach	47.59	46.23	-3%	47.89	52.21	9%
Average Delay						
Car Commute	0.04	0.04	1%	0.04	0.03	-18%
Car Business	0.04	0.04	1%	0.04	0.03	-20%
Car Other	0.03	0.03	1%	0.03	0.03	-16%
LGV	0.04	0.04	6%	0.04	0.03	-13%
HGV - Rigid	0.03	0.04	7%	0.03	0.03	-24%
HGV - Artic	0.03	0.04	7%	0.03	0.03	-24%
Black Cab	0.05	0.04	-5%	0.05	0.04	-5%
PHV	0.05	0.05	-7%	0.05	0.05	-7%
Bus	0.17	0.16	-3%	0.17	0.16	-3%
Coach	0.03	0.04	7%	0.03	0.03	-24%

2021 Cordon 3 CAZ D

Table 19 – 2021 Cordon 1 CAZ D AM Peak Highway Network Statistics

MEASURE	COMPLIANT			NON - COMPLIANT		
	BaU	TEST	DIFF	BaU	TEST	DIFF
Average Travel Time						
Car Commute	0.23	0.23	0%	0.23	0.23	0%
Car Business	0.24	0.24	0%	0.24	0.24	0%
Car Other	0.20	0.20	0%	0.20	0.20	0%
LGV	0.22	0.22	-2%	0.22	0.23	3%
HGV - Rigid	0.24	0.24	0%	0.24	0.24	2%
HGV - Artic	0.24	0.24	0%	0.24	0.24	2%
Black Cab	0.21	0.20	-2%	0.21	0.20	-2%
PHV	0.18	0.18	-3%	0.18	0.18	-3%
Bus	0.63	0.63	0%	0.63	-	-
Coach	0.24	0.24	0%	0.24	0.24	2%
Average Travel Distance						
Car Commute	8.91	8.88	0%	8.91	9.14	3%
Car Business	10.73	10.63	-1%	10.73	11.08	3%
Car Other	7.86	7.84	0%	7.86	8.15	4%

MEASURE	COMPLIANT			NON - COMPLIANT		
LGV	9.34	9.01	-4%	9.34	9.63	3%
HGV - Rigid	11.33	11.28	0%	11.34	11.54	2%
HGV - Artic	11.33	11.28	0%	11.34	11.54	2%
Black Cab	7.28	7.11	-2%	7.28	7.11	-2%
PHV	4.81	4.73	-2%	4.81	4.73	-2%
Bus	16.87	16.87	0%	16.87	-	-
Coach	11.33	11.28	0%	11.34	11.54	2%
Average Speed						
Car Commute	38.07	37.89	0%	38.07	39.10	3%
Car Business	44.39	44.00	-1%	44.39	45.80	3%
Car Other	39.57	39.33	-1%	39.57	41.10	4%
LGV	41.76	40.97	-2%	41.76	41.69	0%
HGV - Rigid	47.59	47.51	0%	47.89	48.01	0%
HGV - Artic	47.59	47.51	0%	47.89	48.01	0%
Black Cab	35.01	35.04	0%	35.01	35.04	0%
PHV	29.24	29.51	1%	29.24	29.51	1%
Bus	26.91	26.91	0%	26.91	-	-

MEASURE	COMPLIANT			NON - COMPLIANT		
Coach	47.59	47.51	0%	47.89	48.01	0%
Average Delay						
Car Commute	0.04	0.04	0%	0.04	0.04	-6%
Car Business	0.04	0.04	0%	0.04	0.03	-8%
Car Other	0.03	0.03	0%	0.03	0.03	-6%
LGV	0.04	0.04	0%	0.04	0.04	1%
HGV - Rigid	0.03	0.03	0%	0.03	0.03	-1%
HGV - Artic	0.03	0.03	0%	0.03	0.03	-1%
Black Cab	0.05	0.04	-4%	0.05	0.04	-4%
PHV	0.05	0.05	-6%	0.05	0.05	-6%
Bus	0.17	0.17	0%	0.17	-	-
Coach	0.03	0.03	0%	0.03	0.03	-1%

2021 Cordon 3 CAZ C+

Table 20 – 2021 Cordon 1 CAZ D AM Peak Highway Network Statistics

MEASURE	COMPLIANT			NON - COMPLIANT		
	BaU	TEST	DIFF	BaU	TEST	DIFF
Average Travel Time						
Car Commute	0.23	0.23	0%	0.23	0.23	0%
Car Business	0.24	0.24	0%	0.24	0.24	0%
Car Other	0.20	0.20	0%	0.20	0.20	0%
LGV	0.22	0.22	-2%	0.22	0.23	2%
HGV - Rigid	0.24	0.24	0%	0.24	0.24	1%
HGV - Artic	0.24	0.24	0%	0.24	0.24	1%
Black Cab	0.21	0.20	-1%	0.21	0.20	-1%
PHV	0.18	0.18	-2%	0.18	0.18	-2%
Bus	0.63	0.63	0%	0.63	-	-
Coach	0.24	0.24	0%	0.24	0.24	1%
Average Travel Distance						
Car Commute	8.91	8.88	0%	8.91	9.03	1%
Car Business	10.73	10.72	0%	10.73	10.84	1%
Car Other	7.86	7.84	0%	7.86	8.02	2%

MEASURE	COMPLIANT			NON - COMPLIANT		
LGV	9.34	9.00	-4%	9.34	9.62	3%
HGV - Rigid	11.33	11.28	0%	11.34	11.54	2%
HGV - Artic	11.33	11.28	0%	11.34	11.54	2%
Black Cab	7.28	7.17	-2%	7.28	7.17	-2%
PHV	4.81	4.77	-1%	4.81	4.77	-1%
Bus	16.87	16.86	0%	16.87	-	-
Coach	11.33	11.28	0%	11.34	11.54	2%
Average Speed						
Car Commute	38.07	38.11	0%	38.07	38.74	2%
Car Business	44.39	44.33	0%	44.39	44.89	1%
Car Other	39.57	39.56	0%	39.57	40.41	2%
LGV	41.76	40.83	-2%	41.76	41.93	0%
HGV - Rigid	47.59	47.51	0%	47.89	48.30	1%
HGV - Artic	47.59	47.51	0%	47.89	48.30	1%
Black Cab	35.01	35.05	0%	35.01	35.05	0%
PHV	29.24	29.43	1%	29.24	29.43	1%
Bus	26.91	26.97	0%	26.91	-	-

MEASURE	COMPLIANT			NON - COMPLIANT		
Coach	47.59	47.51	0%	47.89	48.30	1%
Average Delay						
Car Commute	0.04	0.04	-1%	0.04	0.04	-3%
Car Business	0.04	0.04	-1%	0.04	0.04	-3%
Car Other	0.03	0.03	-1%	0.03	0.03	-3%
LGV	0.04	0.04	1%	0.04	0.03	-2%
HGV - Rigid	0.03	0.03	0%	0.03	0.03	-4%
HGV - Artic	0.03	0.03	0%	0.03	0.03	-4%
Black Cab	0.05	0.04	-3%	0.05	0.04	-3%
PHV	0.05	0.05	-4%	0.05	0.05	-4%
Bus	0.17	0.16	-1%	0.17	-	-
Coach	0.03	0.03	0%	0.03	0.03	-4%

APPENDIX B – TRAFFIC ANALYSIS – FLOW DIFFERENCES

This appendix shows the changes in demand flow in each of the four options presented in this document compared to the 2021 BaU. For each option an indication of the AM and PM peaks is presented along with a zoomed in view of the Parkway in the PM Peak (when it is at its most congested).

2021 Cordon 1 CAZ D

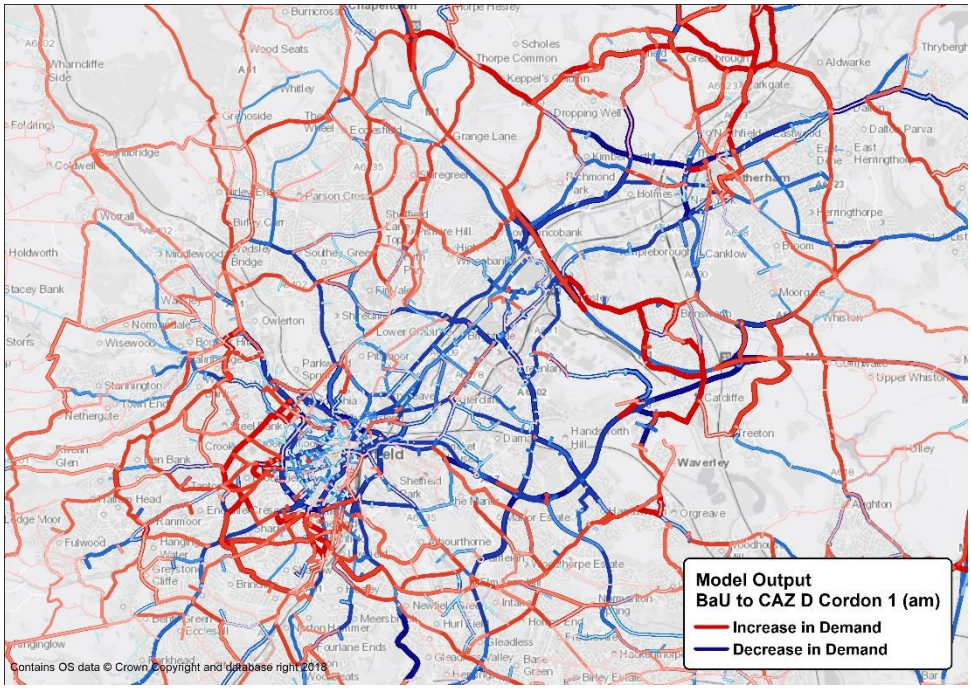


Figure 17 - 2021 Cordon 1 CAZ D – AM Peak Demand Flow Changes

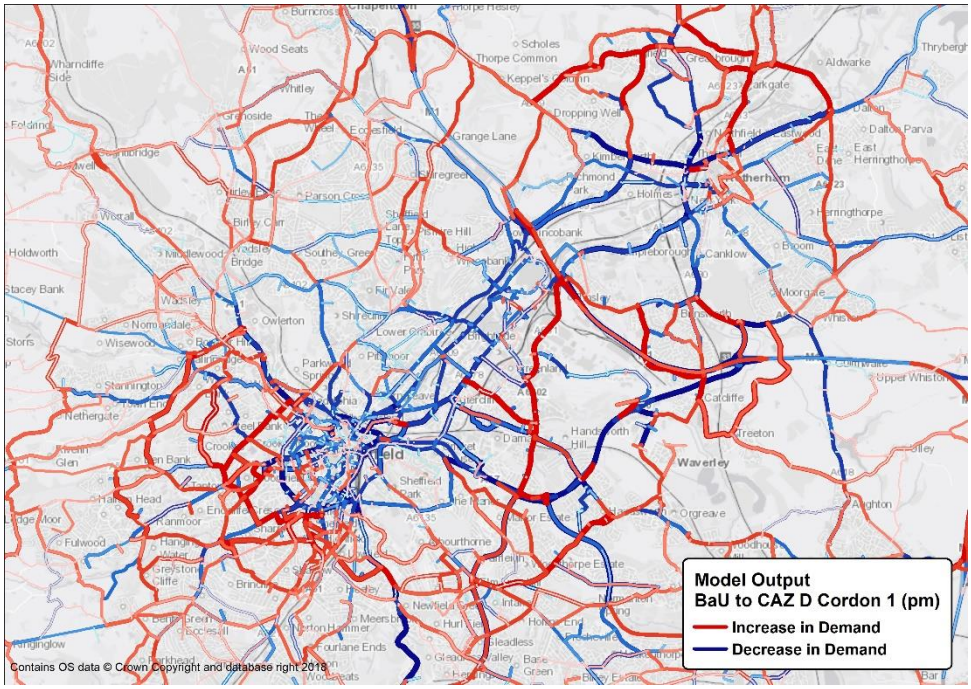


Figure 18 - 2021 Cordon 1 CAZ D – PM Peak Demand Flow Changes

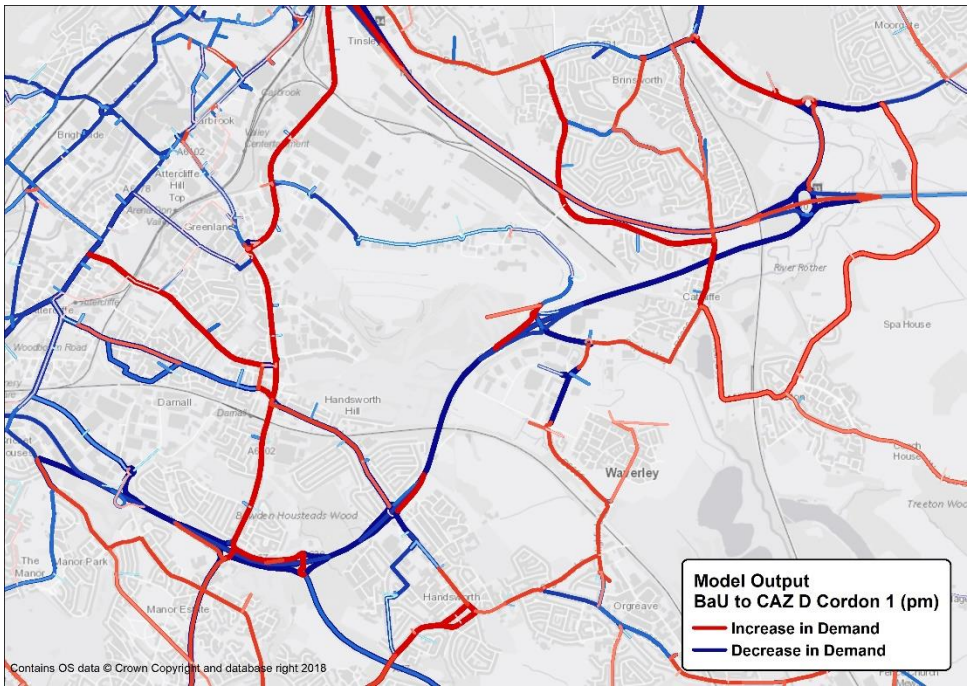


Figure 19 - 2021 Cordon 1 CAZ D – PM Peak Demand Flow Changes – Sheffield Parkway Area

2021 Cordon 2 CAZ D

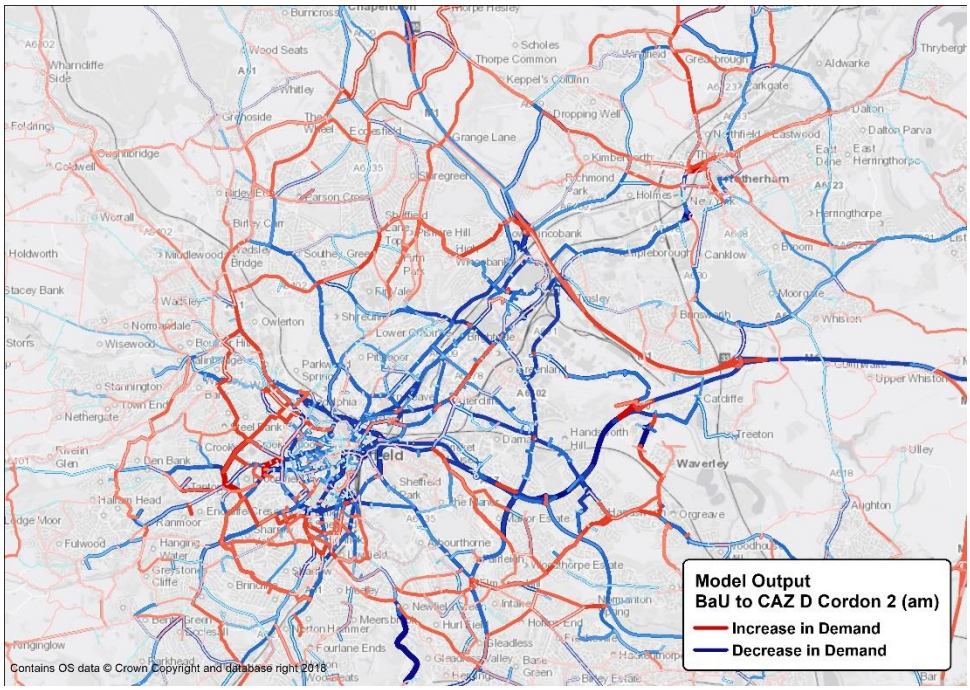


Figure 20 - 2021 Cordon 2 CAZ D – AM Peak Demand Flow Changes

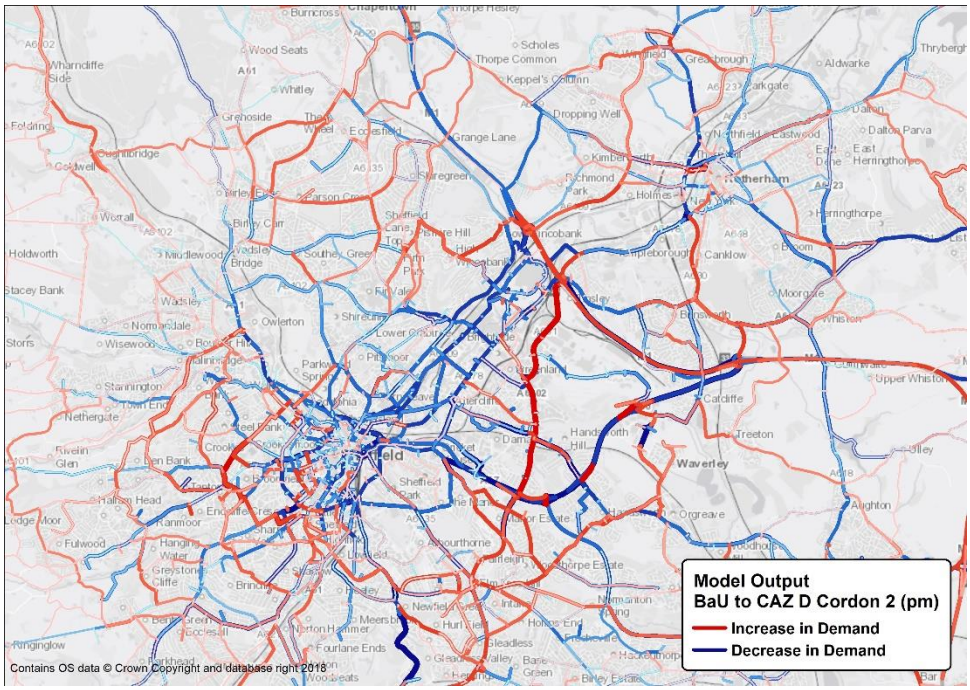


Figure 21 - 2021 Cordon 2 CAZ D – PM Peak Demand Flow Changes

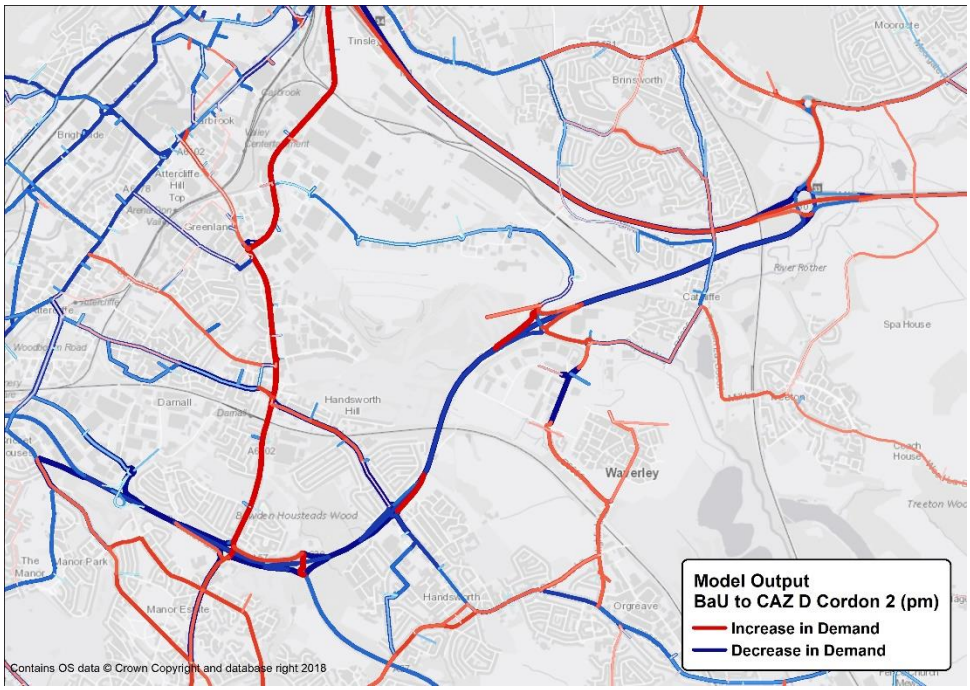


Figure 22 - 2021 Cordon 2 CAZ D – PM Peak Demand Flow Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ D

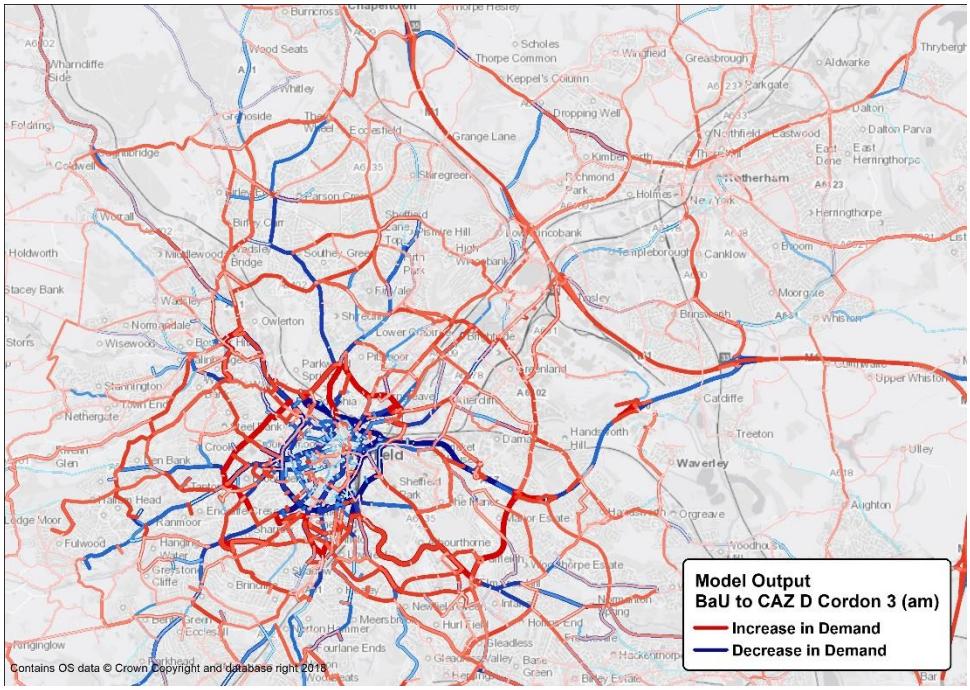


Figure 23 - 2021 Cordon 3 CAZ D – AM Peak Demand Flow Changes

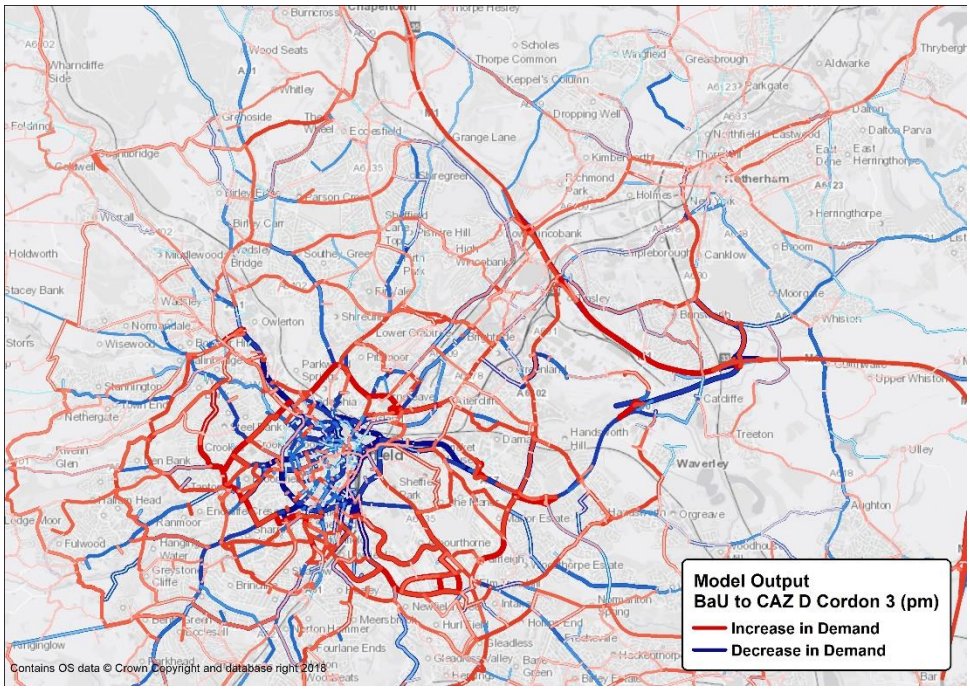


Figure 24 - 2021 Cordon 3 CAZ D – PM Peak Demand Flow Changes

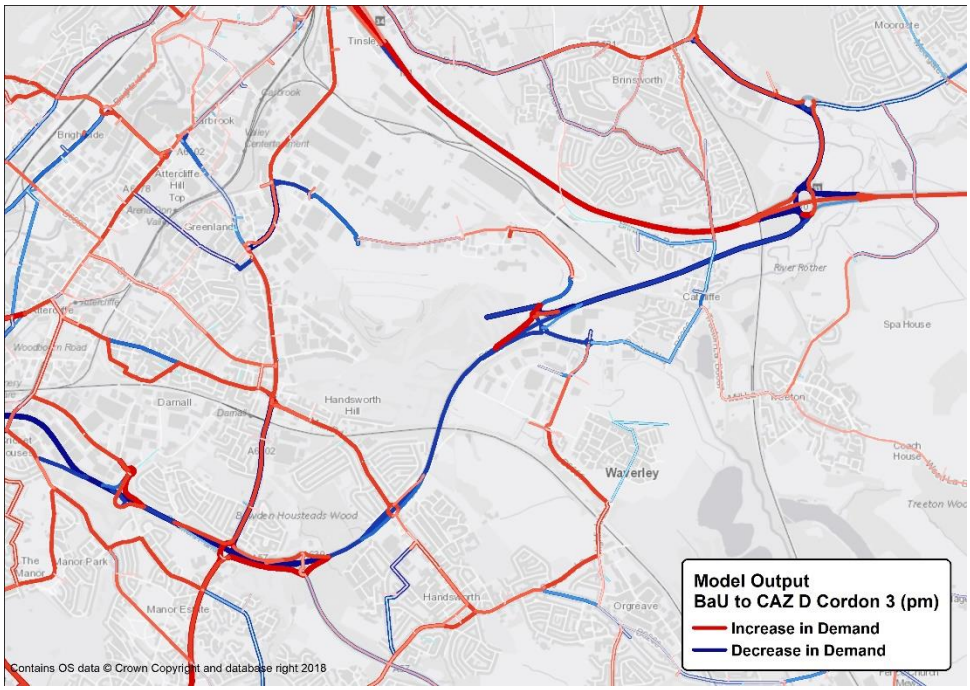


Figure 25 - 2021 Cordon 3 CAZ D – PM Peak Demand Flow Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ C+

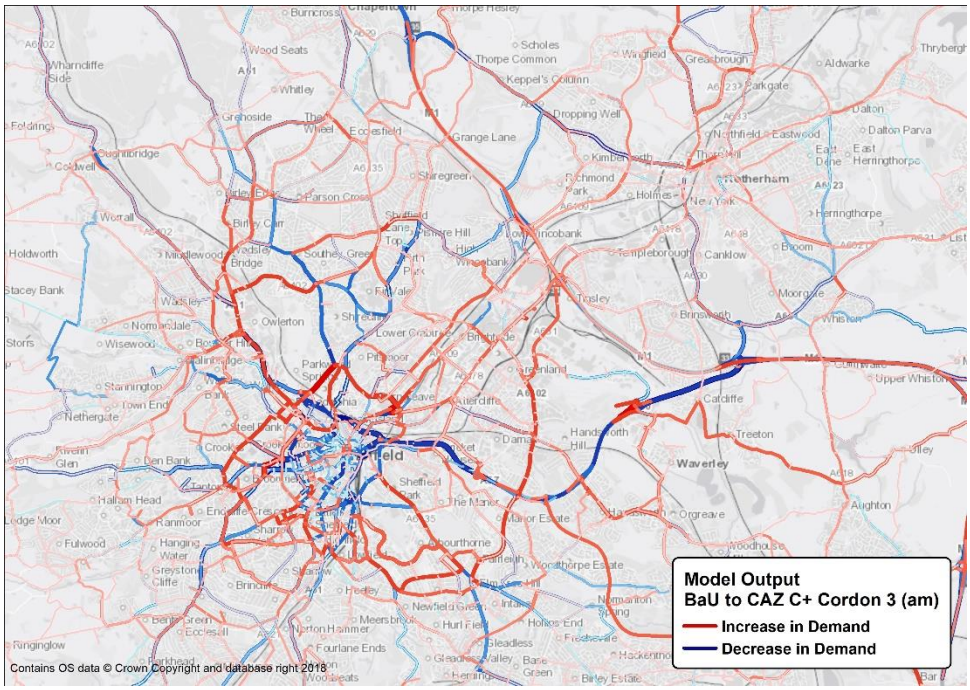


Figure 26 - 2021 Cordon 3 CAZ C+ – AM Peak Demand Flow Changes

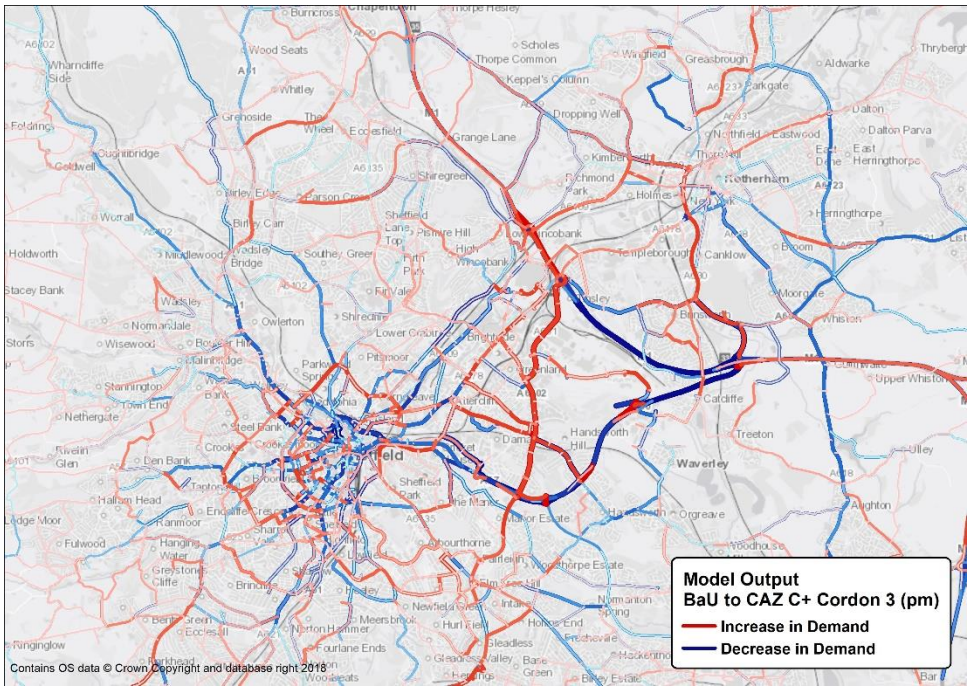


Figure 27 - 2021 Cordon 3 CAZ C+ – PM Peak Demand Flow Changes

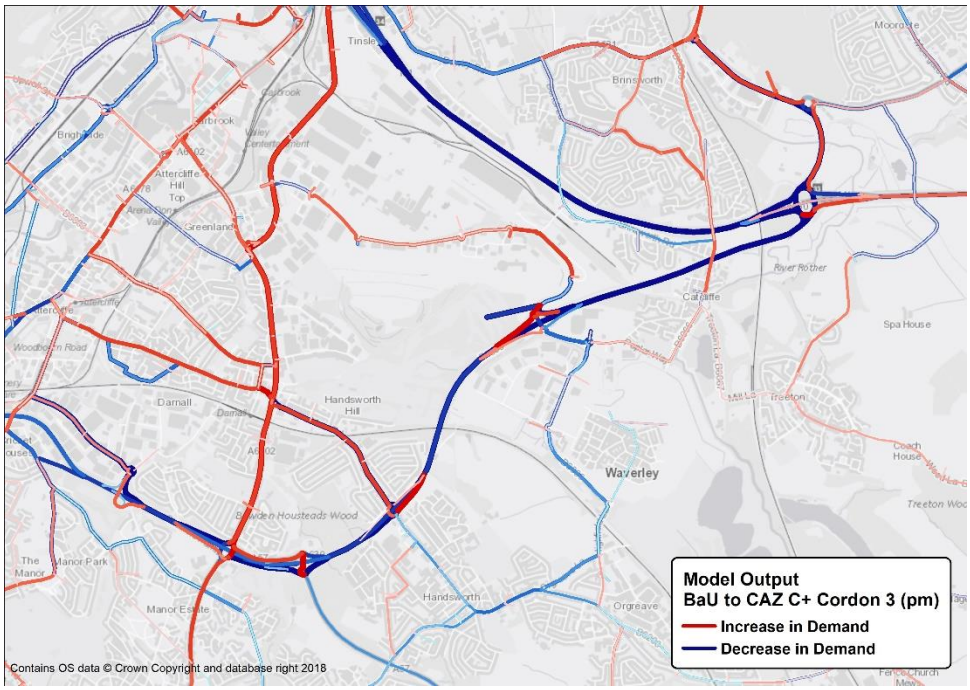


Figure 28 - 2021 Cordon 3 CAZ C+ – PM Peak Demand Flow Changes – Sheffield Parkway Area

APPENDIX C – TRAFFIC ANALYSIS – VOL / CAPACITY DIFFERENCES

This appendix shows the changes in volume divided by capacity in each of the four options presented in this document compared to the 2021 BaU. For each option an indication of the AM and PM peaks is presented along with a zoomed in view of the Parkway in the PM Peak (when it is at its most congested).

2021 Cordon 1 CAZ D

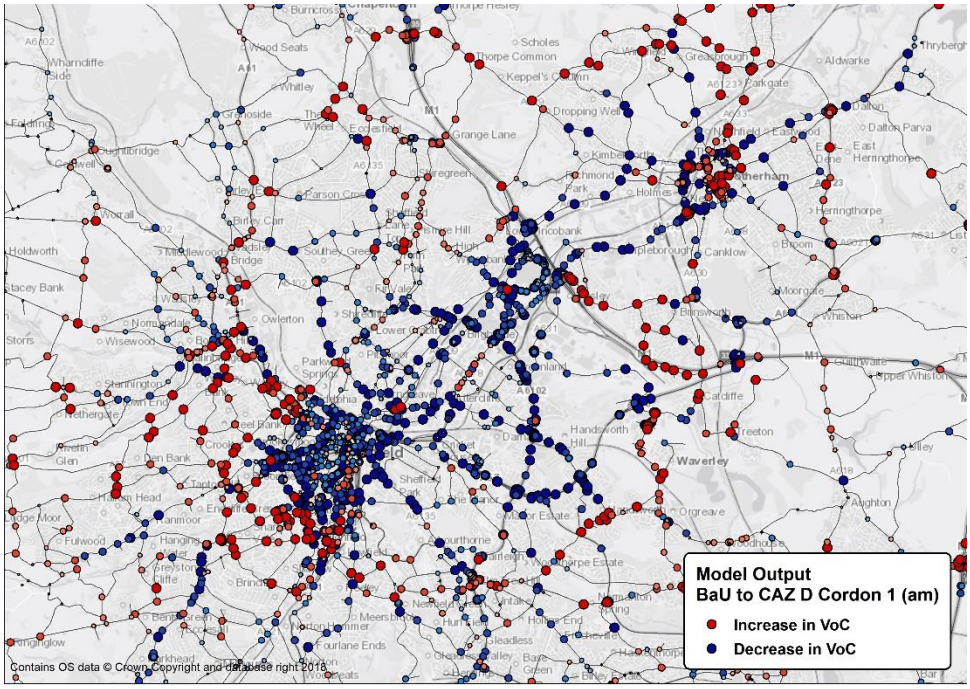


Figure 29 - 2021 Cordon 1 CAZ D – AM Peak Volume / Capacity Changes

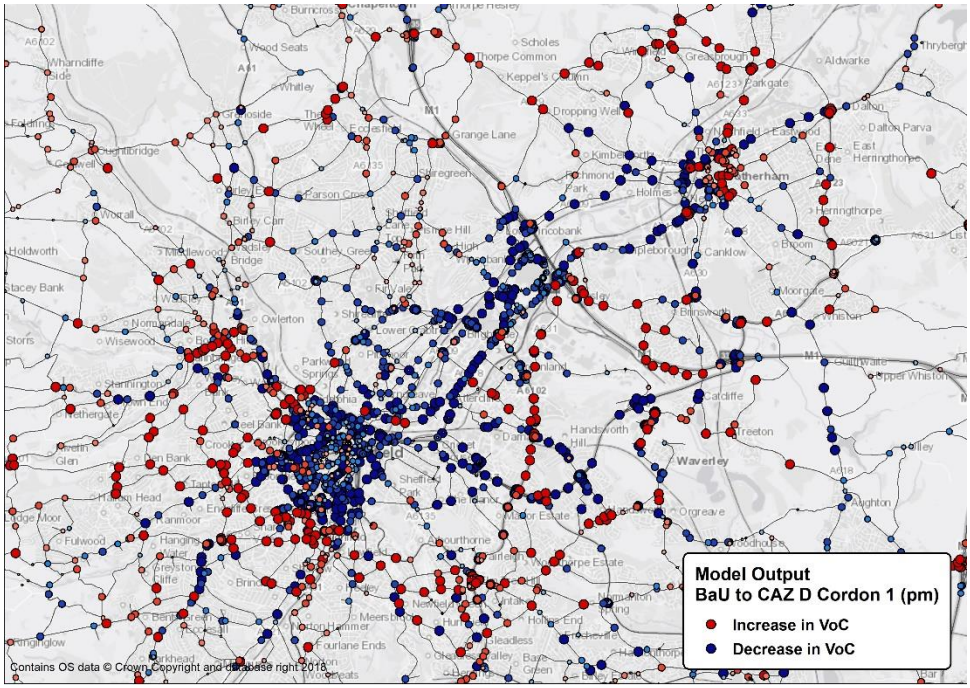


Figure 30 - 2021 Cordon 1 CAZ D – PM Peak Volume / Capacity Changes

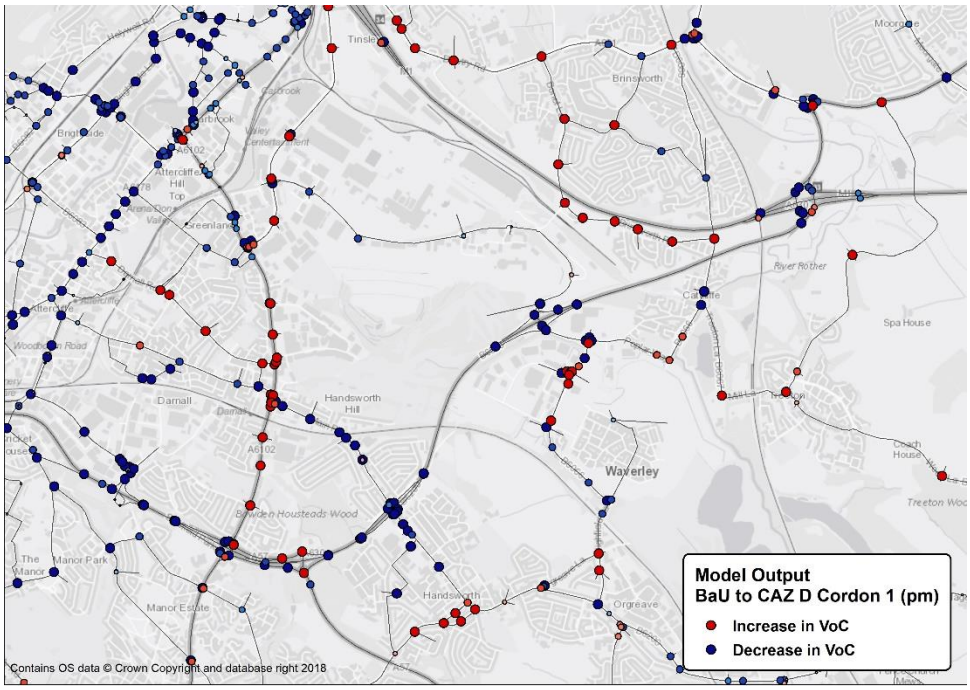


Figure 31 - 2021 Cordon 1 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 2 CAZ D

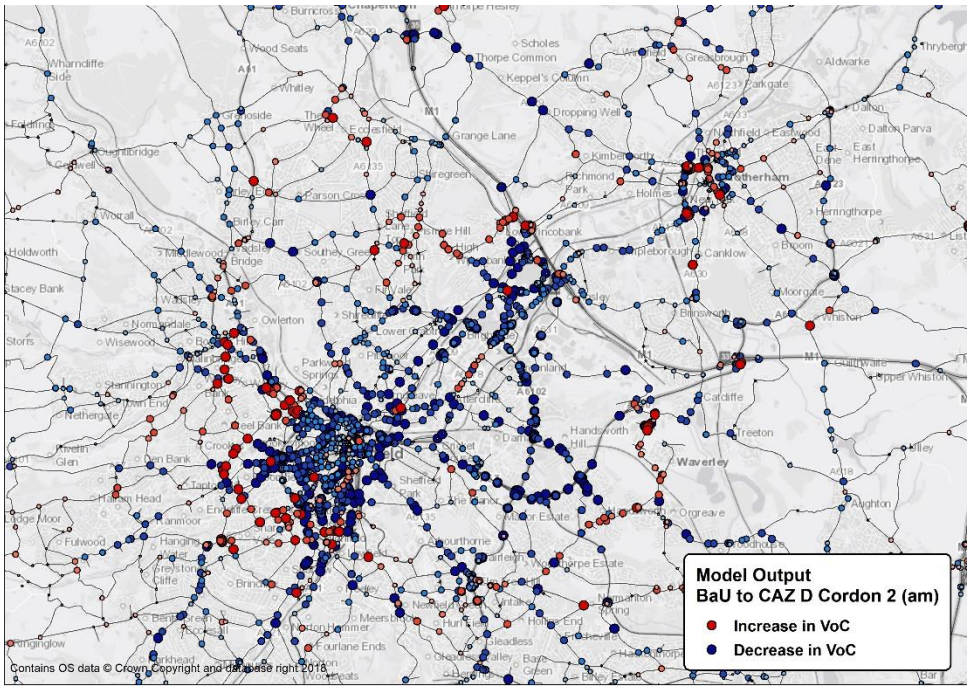


Figure 32 - 2021 Cordon 2 CAZ D – AM Peak Volume / Capacity Changes

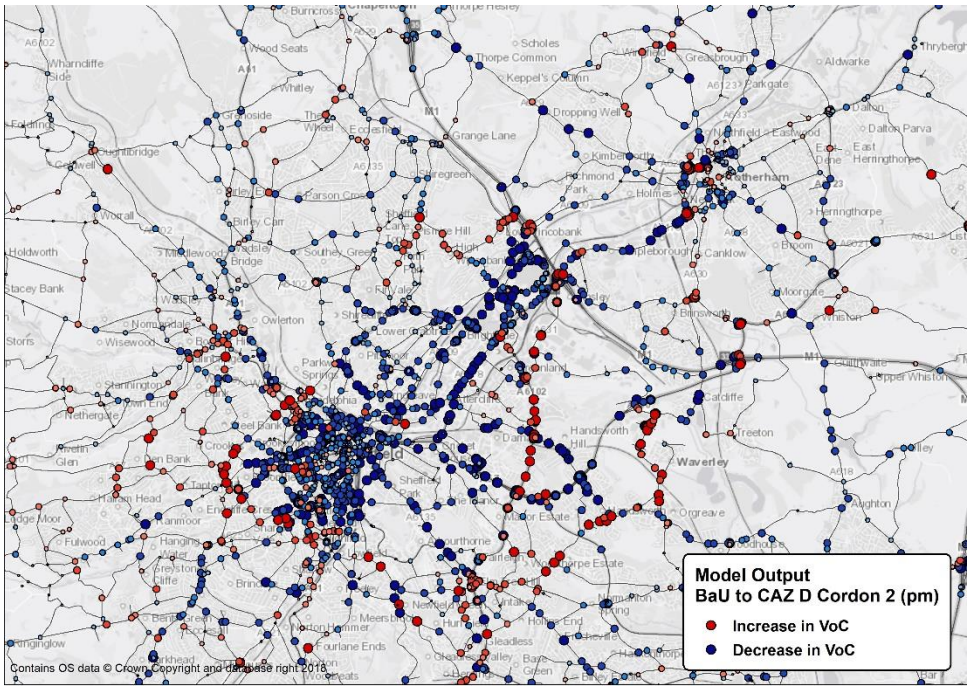


Figure 33 - 2021 Cordon 2 CAZ D – PM Peak Volume / Capacity Changes

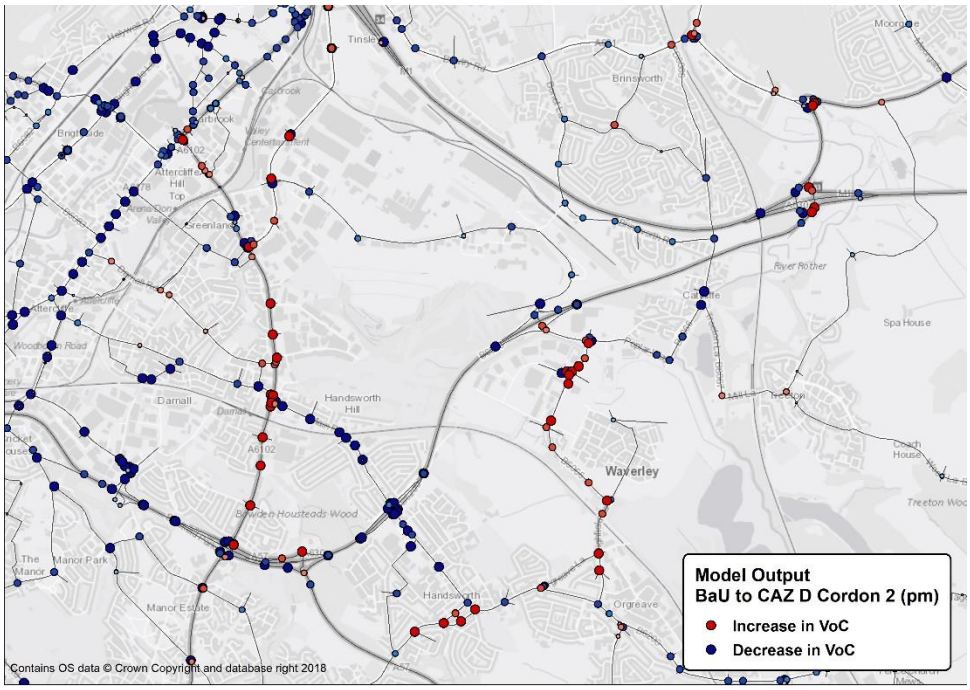


Figure 34 - 2021 Cordon 2 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ D

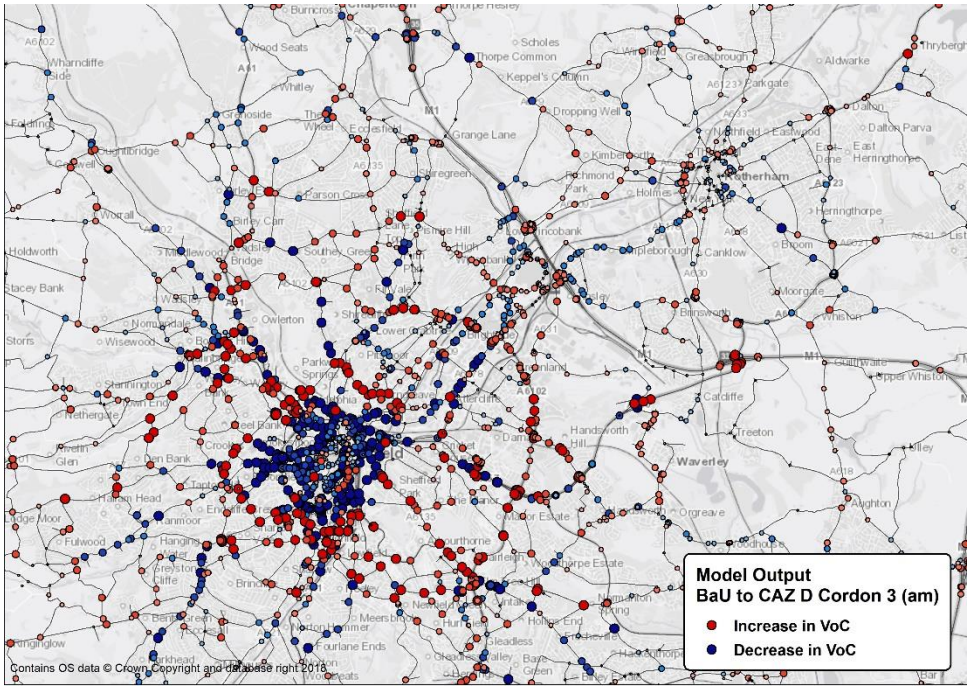


Figure 35 - 2021 Cordon 3 CAZ D – AM Peak Volume / Capacity Changes

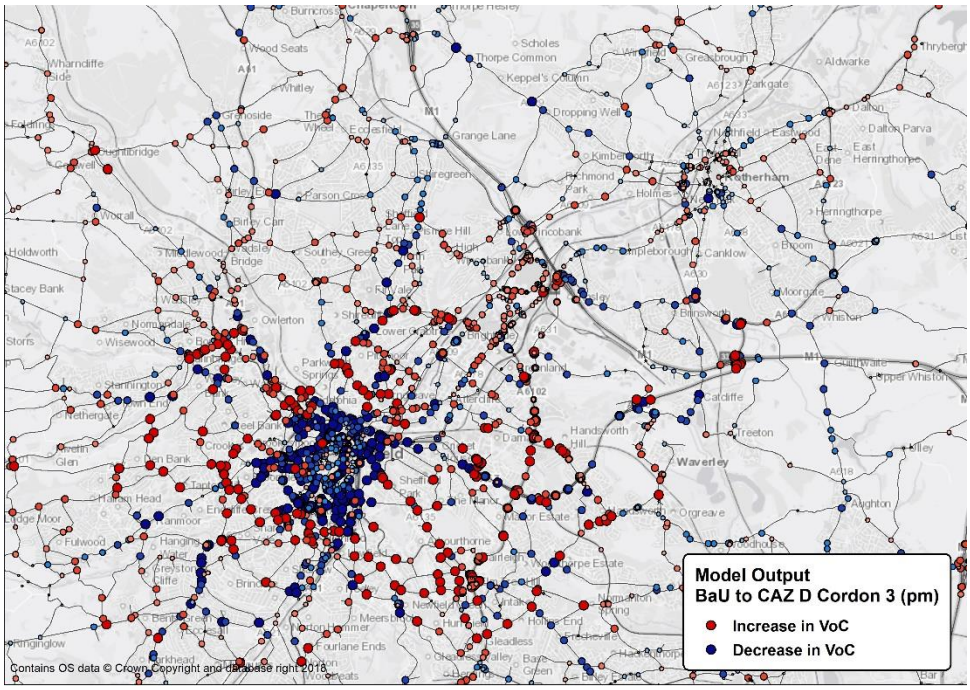


Figure 36 - 2021 Cordon 3 CAZ D – PM Peak Volume / Capacity Changes

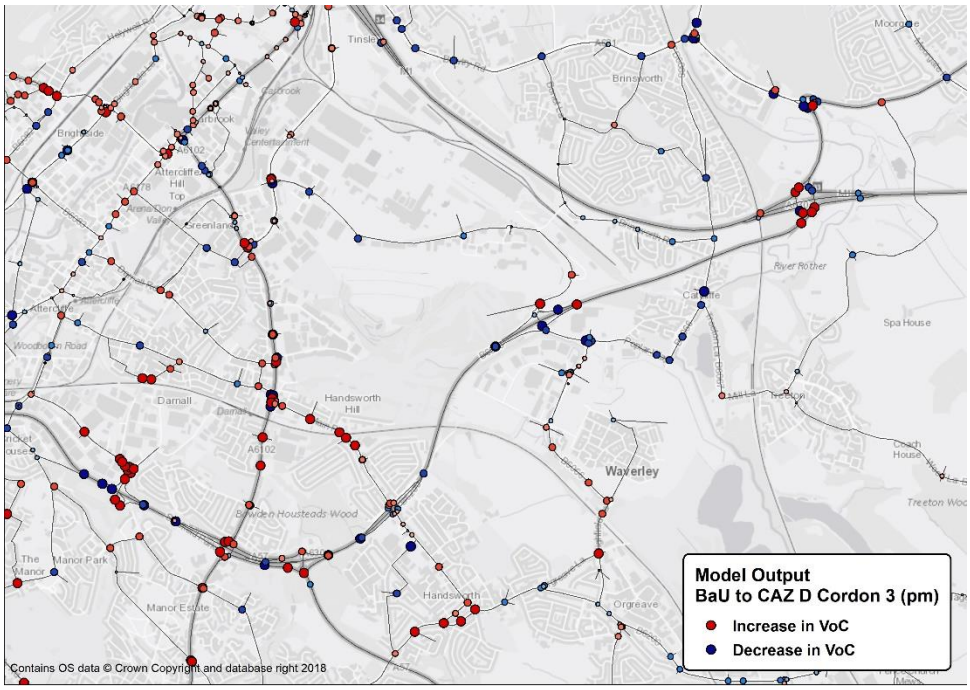


Figure 37 - 2021 Cordon 3 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ C+

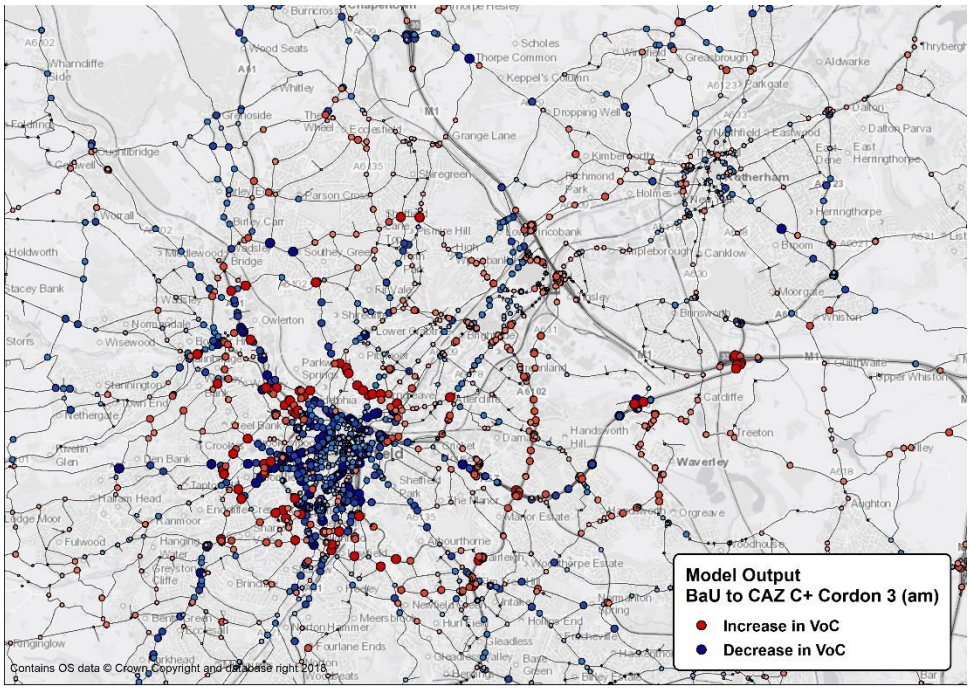


Figure 38 - 2021 Cordon 3 CAZ C+ – AM Peak Volume / Capacity Changes

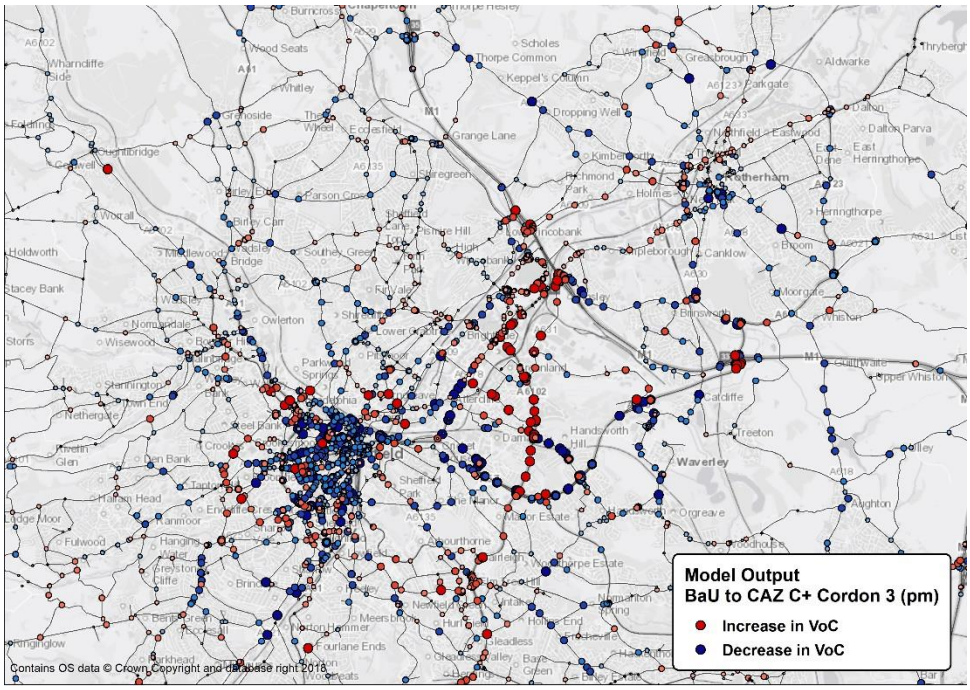


Figure 39 - 2021 Cordon 3 CAZ C+ – PM Peak Volume / Capacity Changes

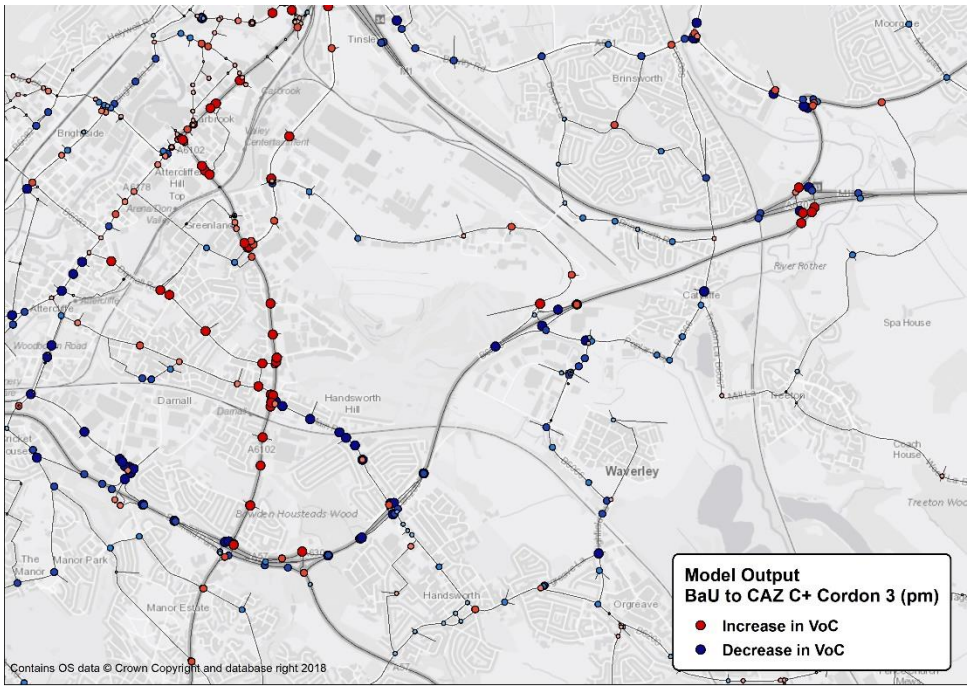


Figure 40 - 2021 Cordon 3 CAZ C+ – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

APPENDIX D – TRAFFIC ANALYSIS – JUNCTION DELAY DIFFERENCES

This appendix shows the changes in junction delay in each of the four options presented in this document compared to the 2021 BaU. For each option an indication of the AM and PM peaks is presented along with a zoomed in view of the Parkway in the PM Peak (when it is at its most congested).

2021 Cordon 1 CAZ D

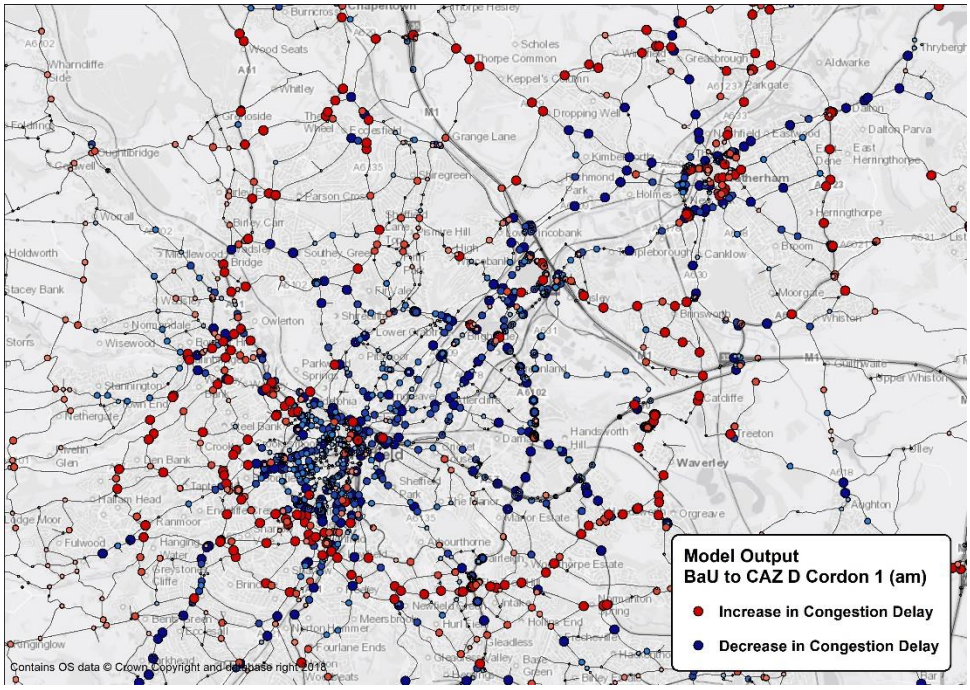


Figure 41 - 2021 Cordon 1 CAZ D – AM Peak Volume / Capacity Changes

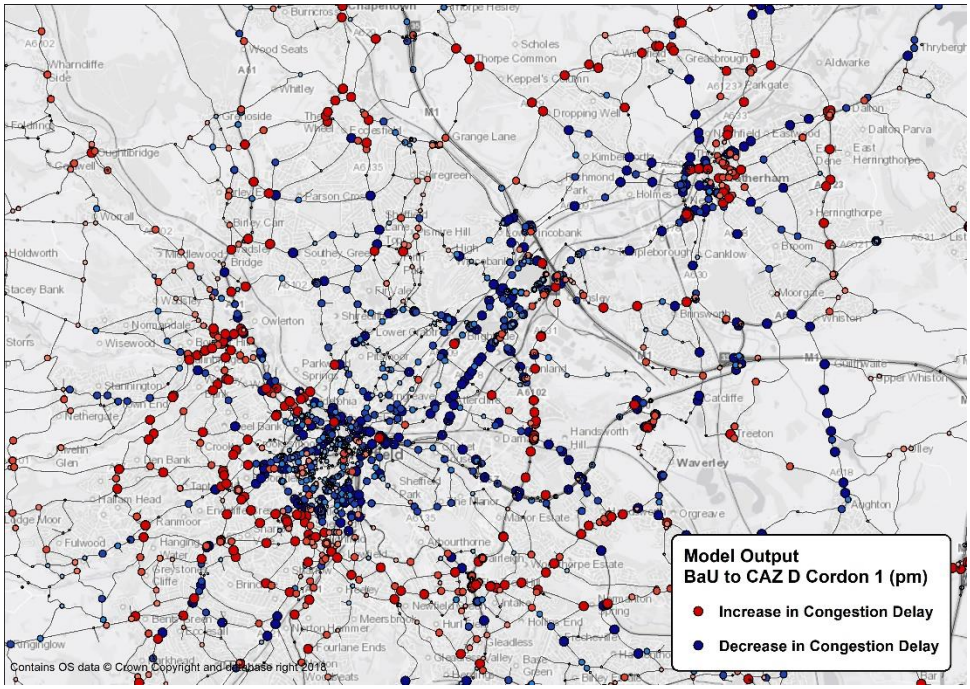


Figure 42 - 2021 Cordon 1 CAZ D – PM Peak Volume / Capacity Changes

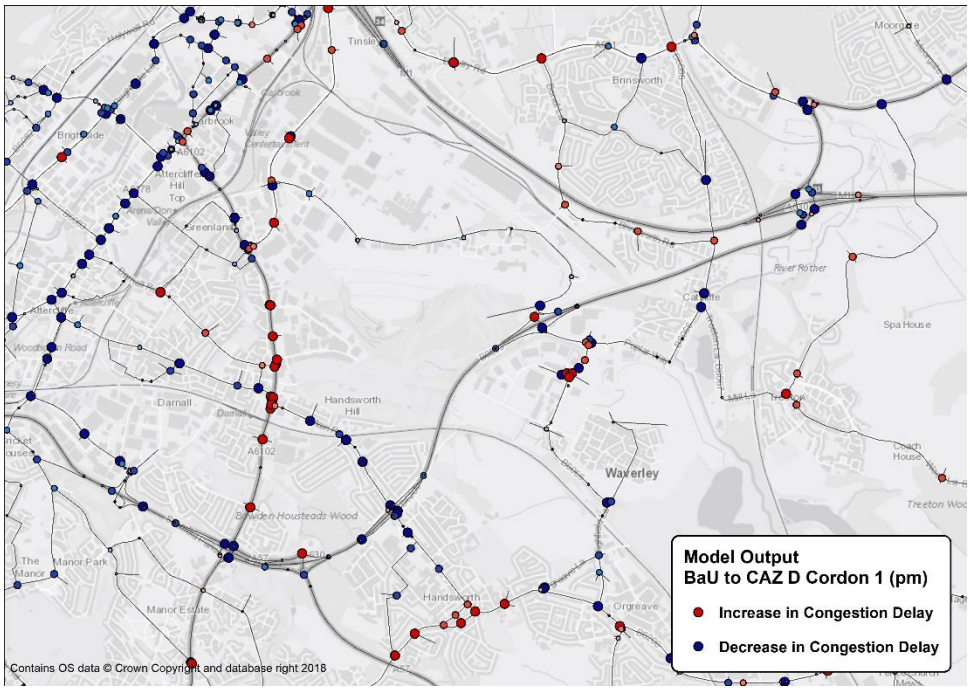


Figure 43 - 2021 Cordon 1 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 2 CAZ D

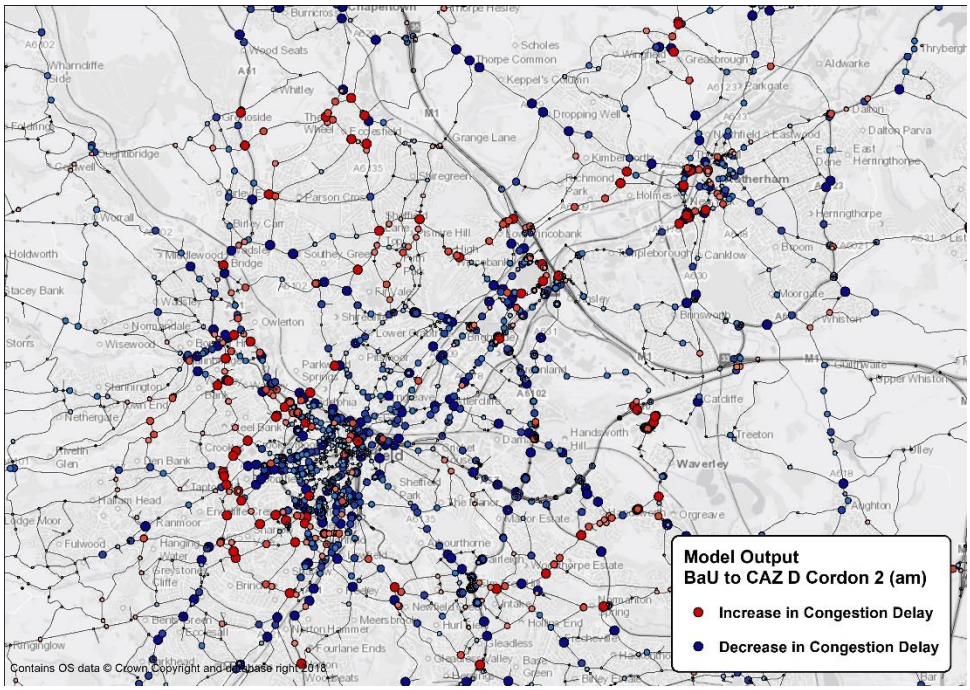


Figure 44 - 2021 Cordon 2 CAZ D – AM Peak Volume / Capacity Changes

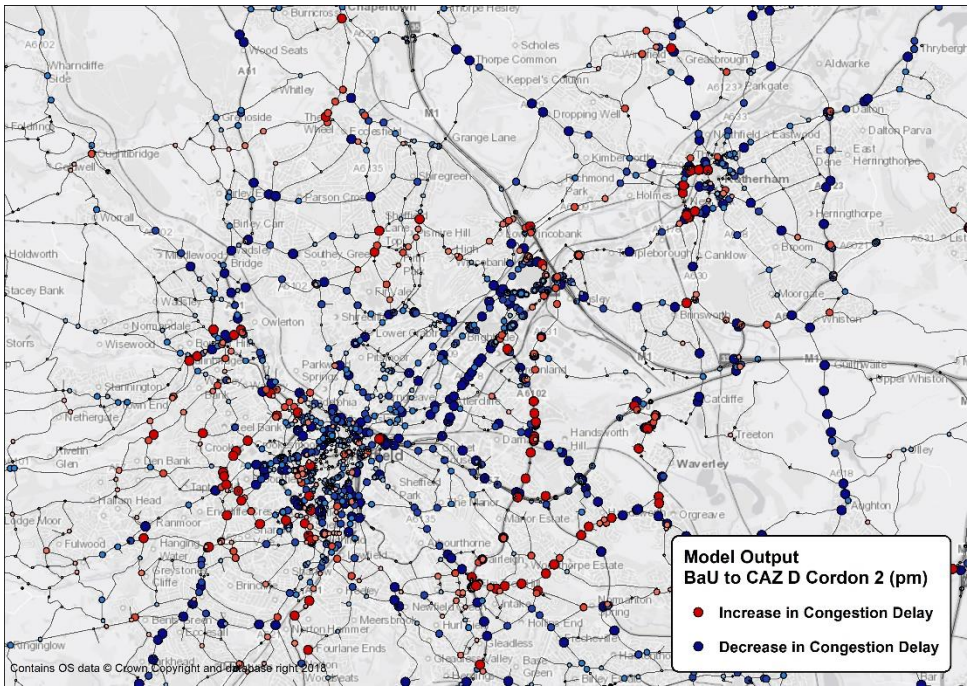


Figure 45 - 2021 Cordon 2 CAZ D – PM Peak Volume / Capacity Changes

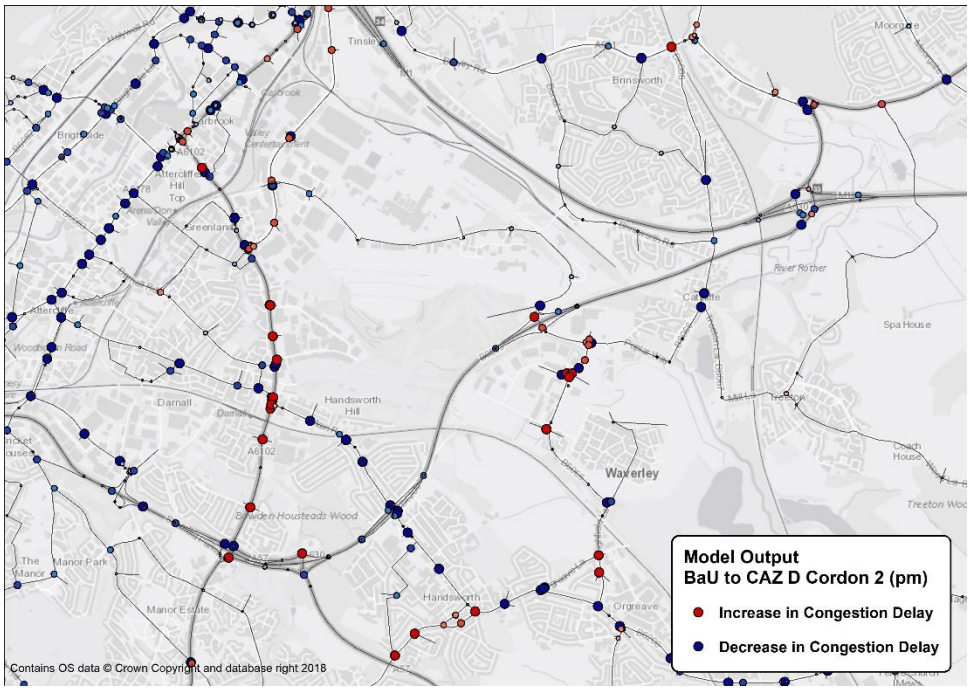


Figure 46 - 2021 Cordon 2 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ D

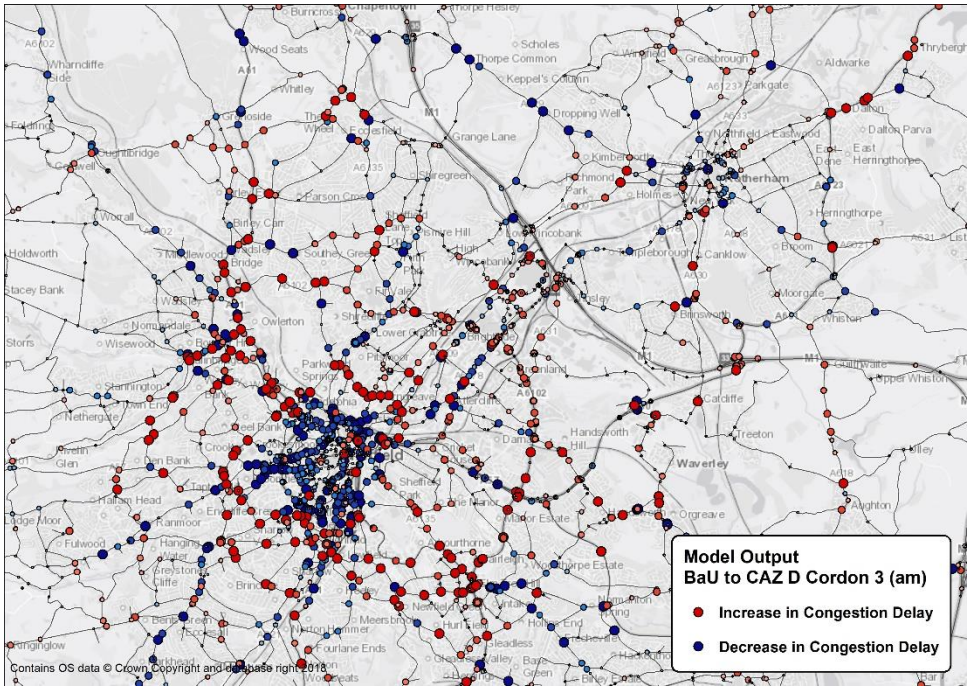


Figure 47 - 2021 Cordon 3 CAZ D – AM Peak Volume / Capacity Changes

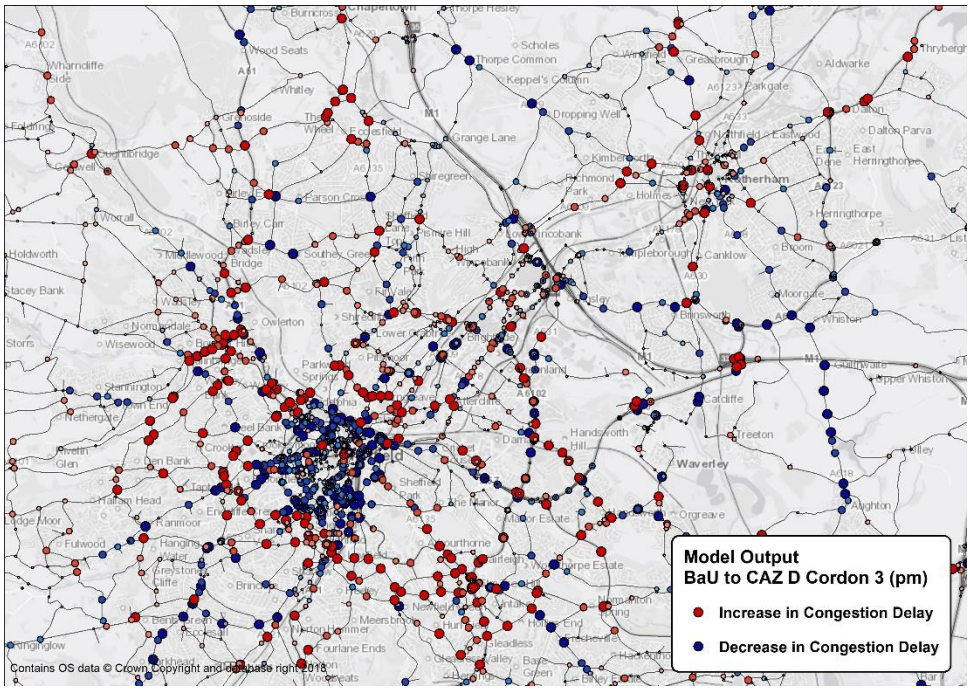


Figure 48 - 2021 Cordon 3 CAZ D – PM Peak Volume / Capacity Changes

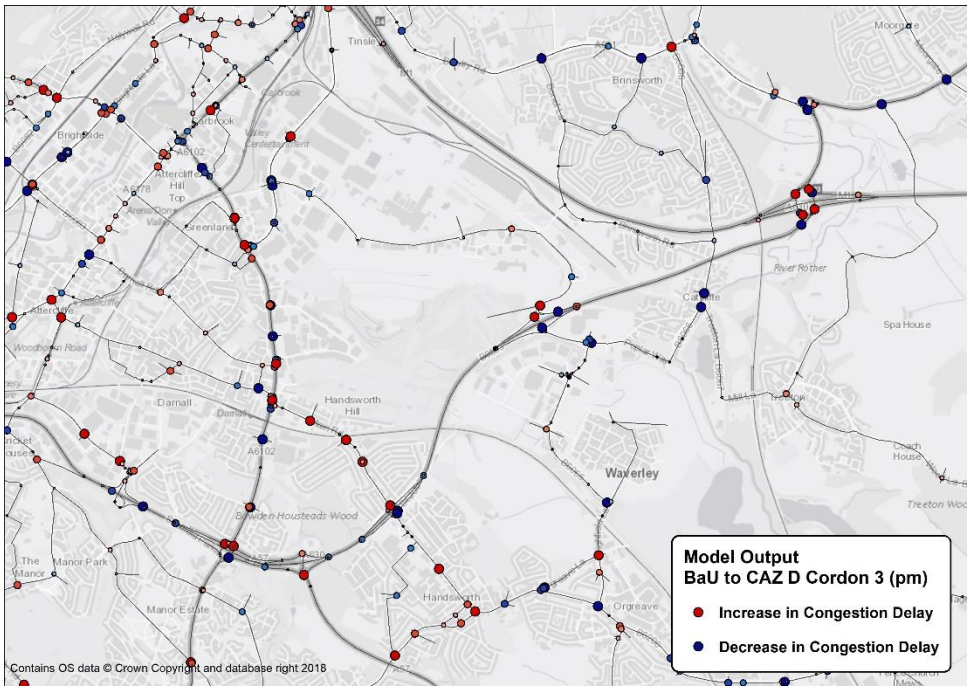


Figure 49 - 2021 Cordon 3 CAZ D – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ C+

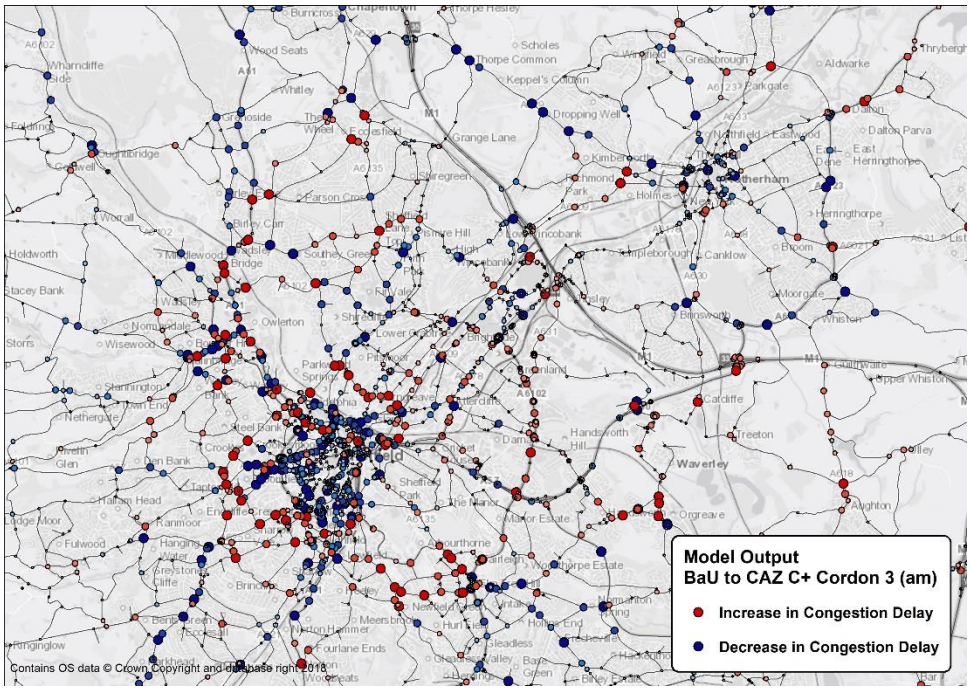


Figure 50 - 2021 Cordon 3 CAZ C+ – AM Peak Volume / Capacity Changes

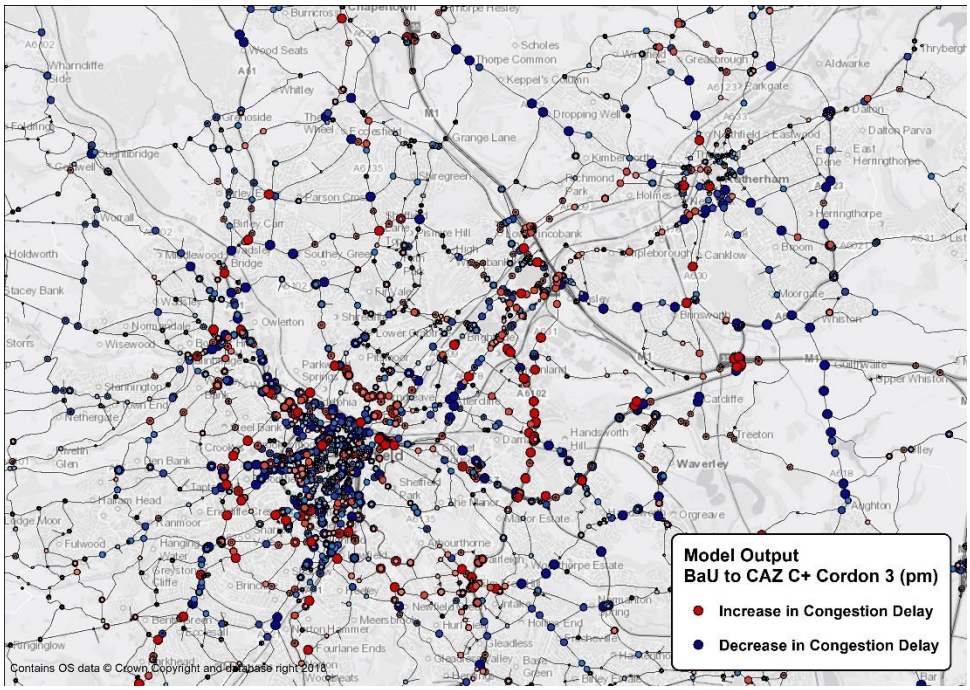


Figure 51 - 2021 Cordon 3 CAZ C+ – PM Peak Volume / Capacity Changes

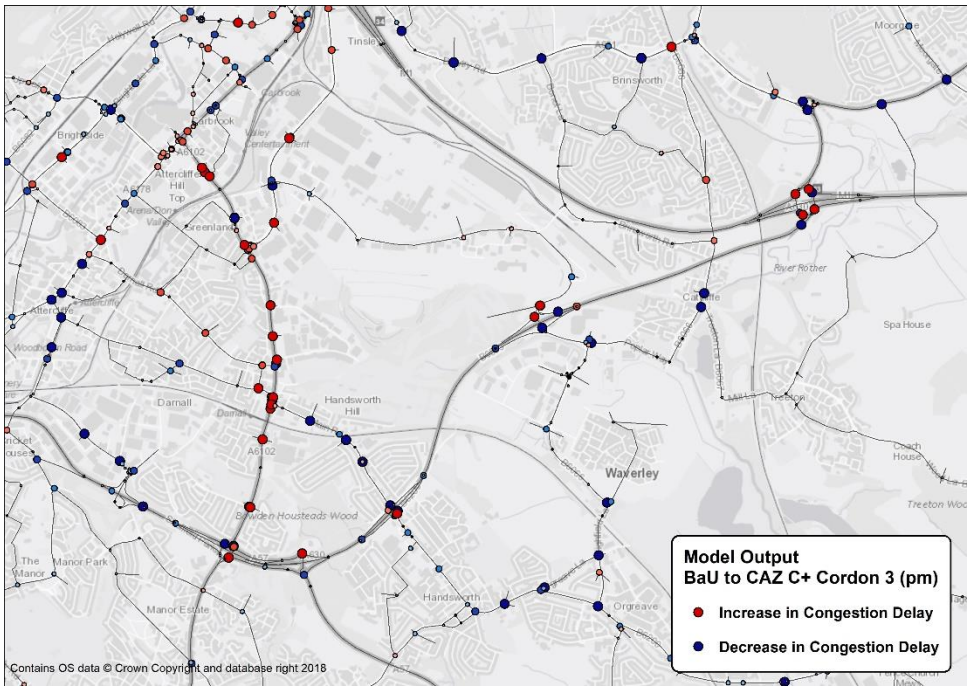


Figure 52 - 2021 Cordon 3 CAZ C+ – PM Peak Volume / Capacity Changes – Sheffield Parkway Area

APPENDIX E – TRAFFIC ANALYSIS – NO_X EMISSION DIFFERENCES

This appendix shows the changes in NO_X Emissions in each of the four options presented in this document compared to the 2021 BaU. For each option an indication of the AM and PM peaks is presented along with a zoomed in view of the Parkway in the PM Peak (when it is at its most congested).

2021 Cordon 1 CAZ D

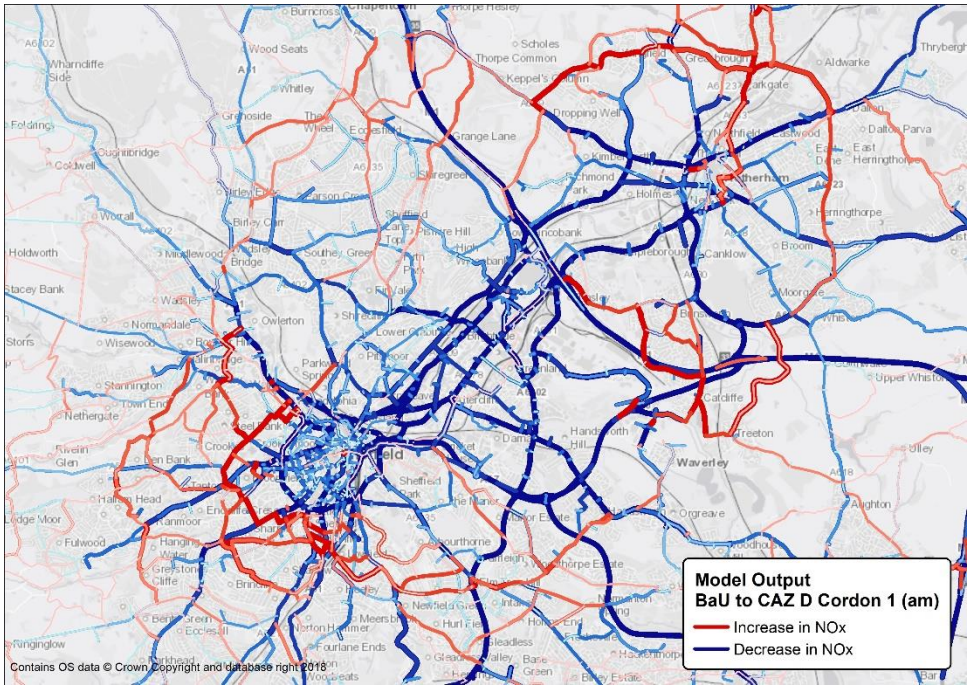


Figure 53 - 2021 Cordon 1 CAZ D – AM Peak NO_X Emissions Changes

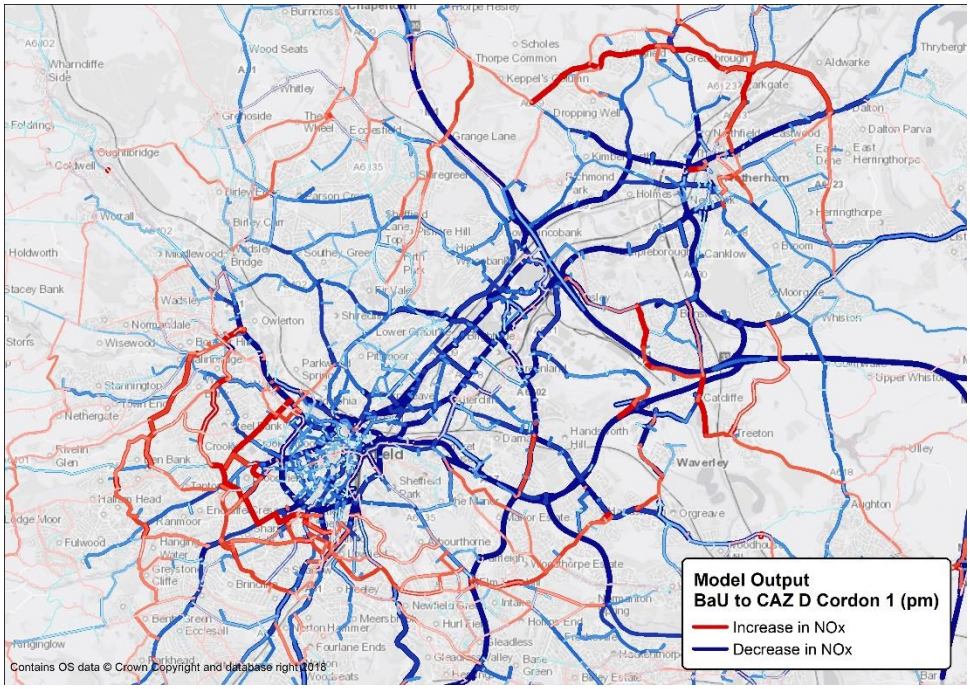


Figure 54 - 2021 Cordon 1 CAZ D – PM Peak NO_X Emissions Changes

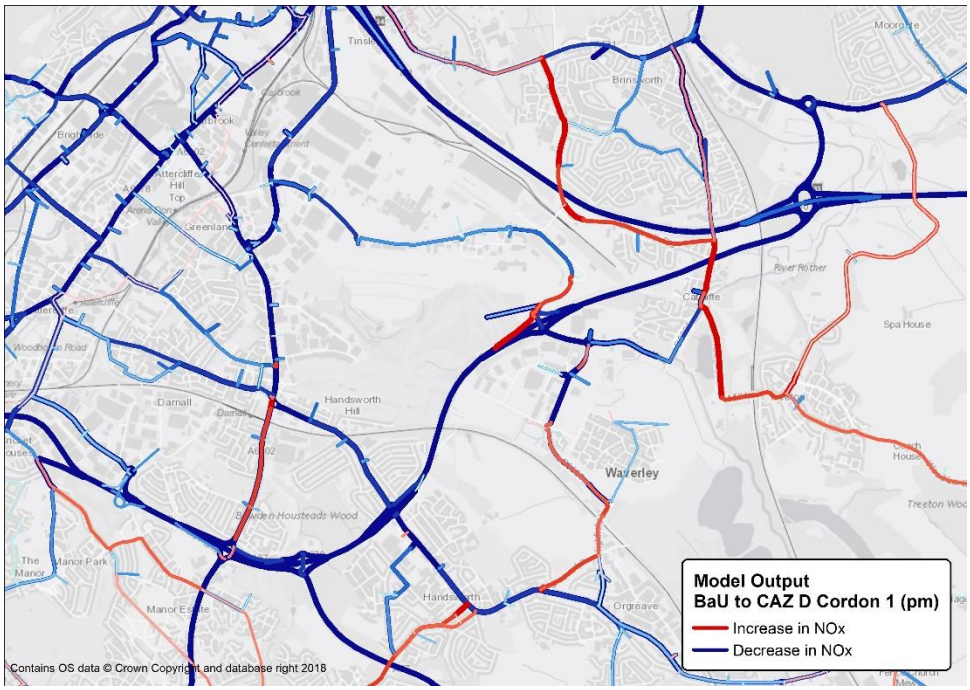


Figure 55 - 2021 Cordon 1 CAZ D – PM Peak NO_X Emissions Changes – Sheffield Parkway Area

2021 Cordon 2 CAZ D

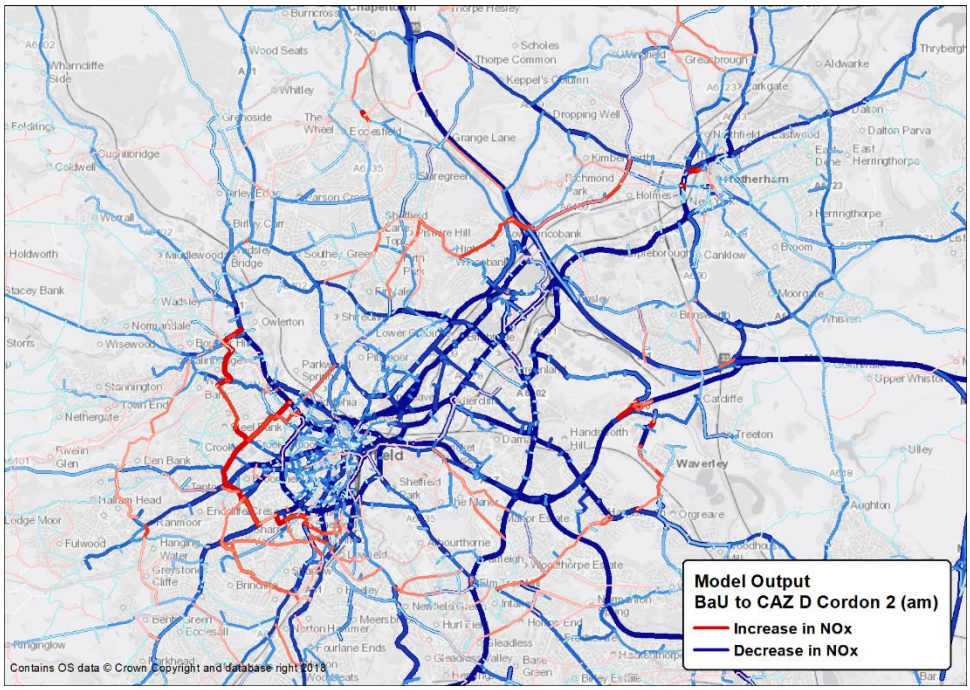


Figure 56 - 2021 Cordon 2 CAZ D – AM Peak NO_X Emissions Changes

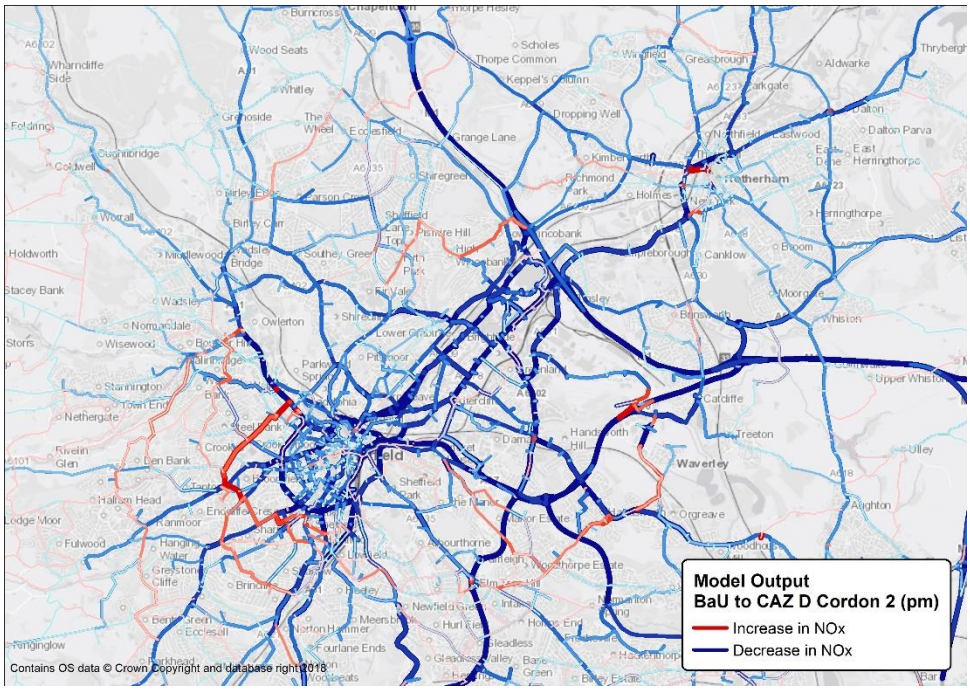


Figure 57 - 2021 Cordon 2 CAZ D – PM Peak NO_X Emissions Changes

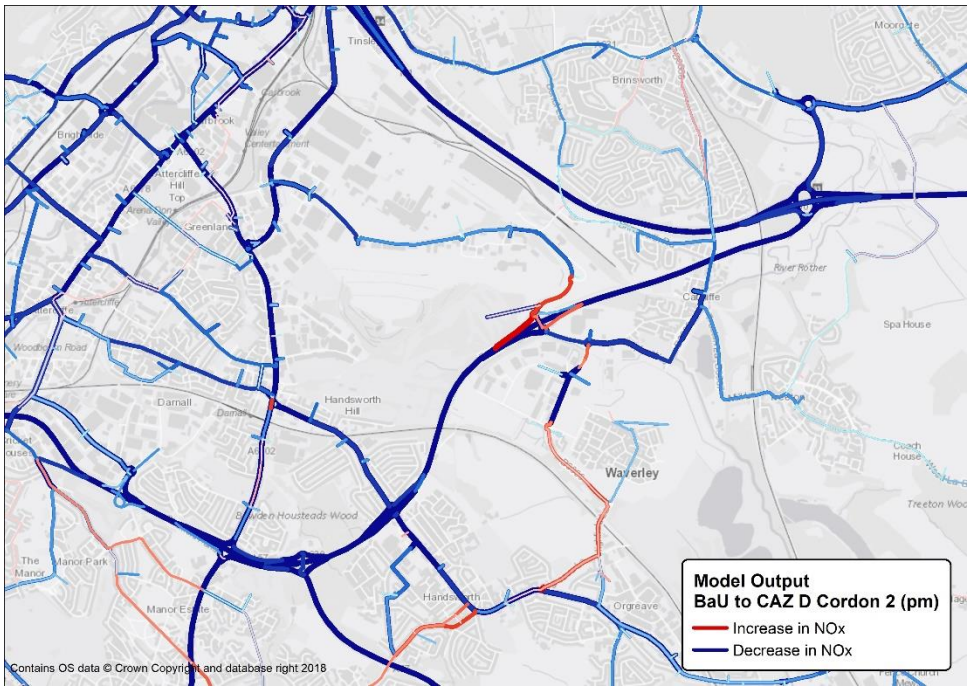


Figure 58 - 2021 Cordon 2 CAZ D – PM Peak NO_X Emissions Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ D

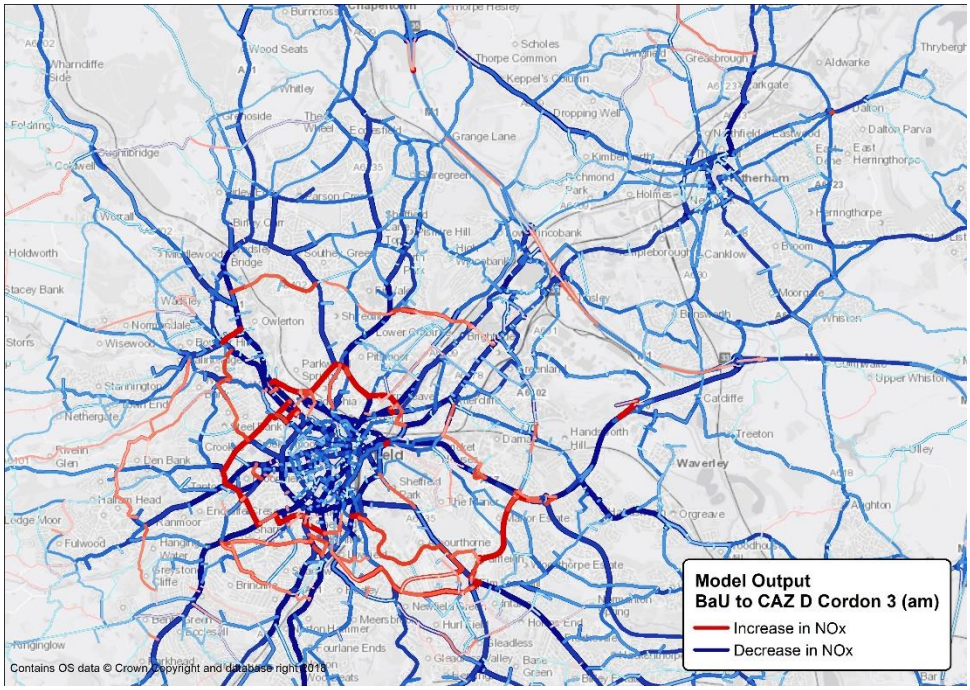


Figure 59 - 2021 Cordon 3 CAZ D – AM Peak NO_X Emissions Changes

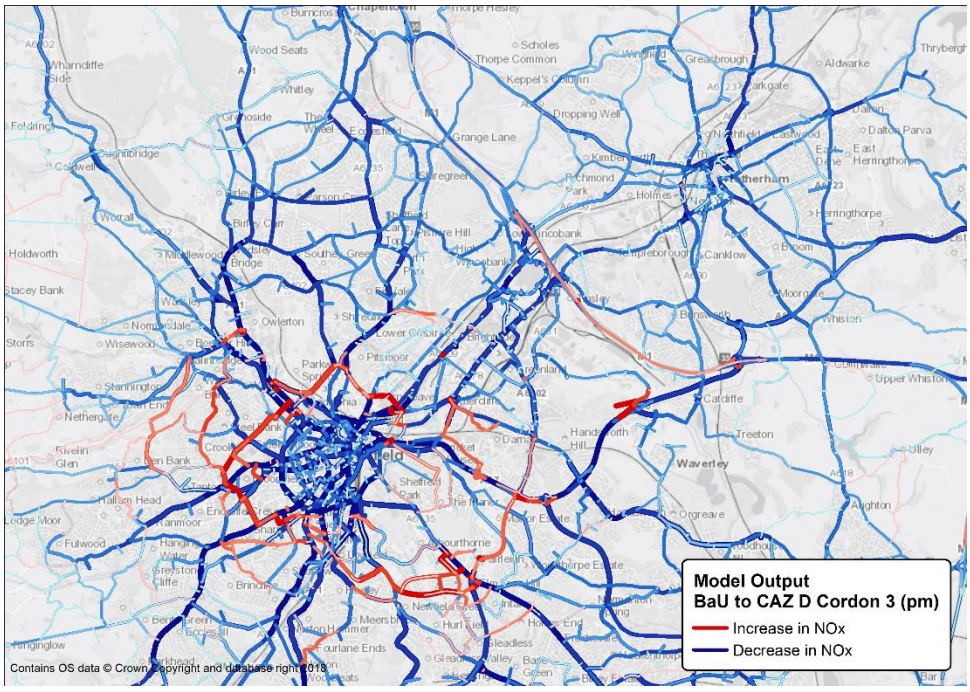


Figure 60 - 2021 Cordon 3 CAZ D – PM Peak NO_X Emissions Changes

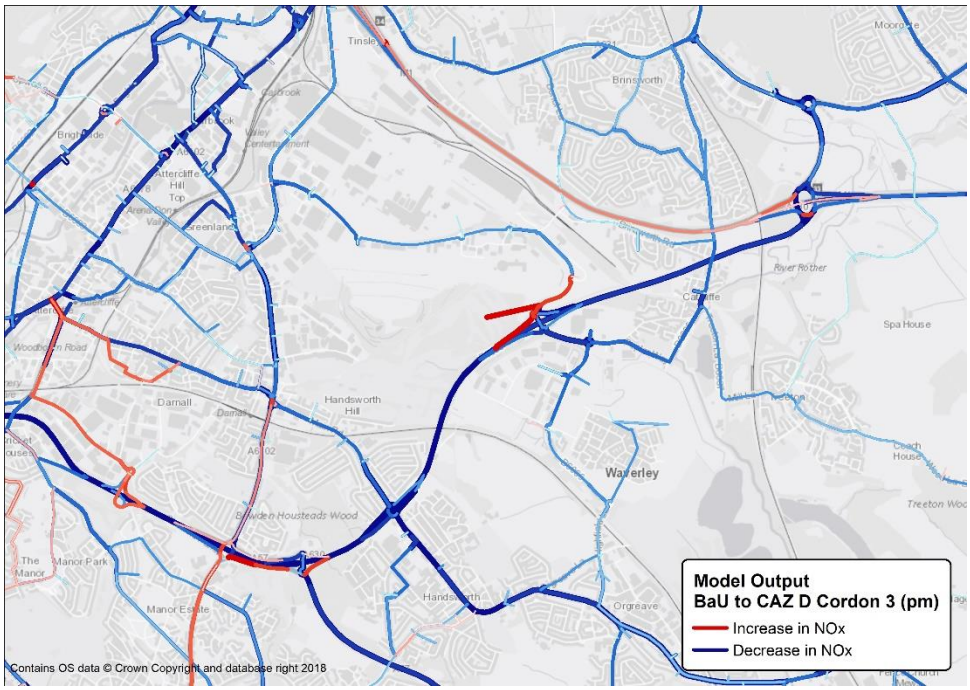


Figure 61 - 2021 Cordon 3 CAZ D – PM Peak NO_X Emissions Changes – Sheffield Parkway Area

2021 Cordon 3 CAZ C+

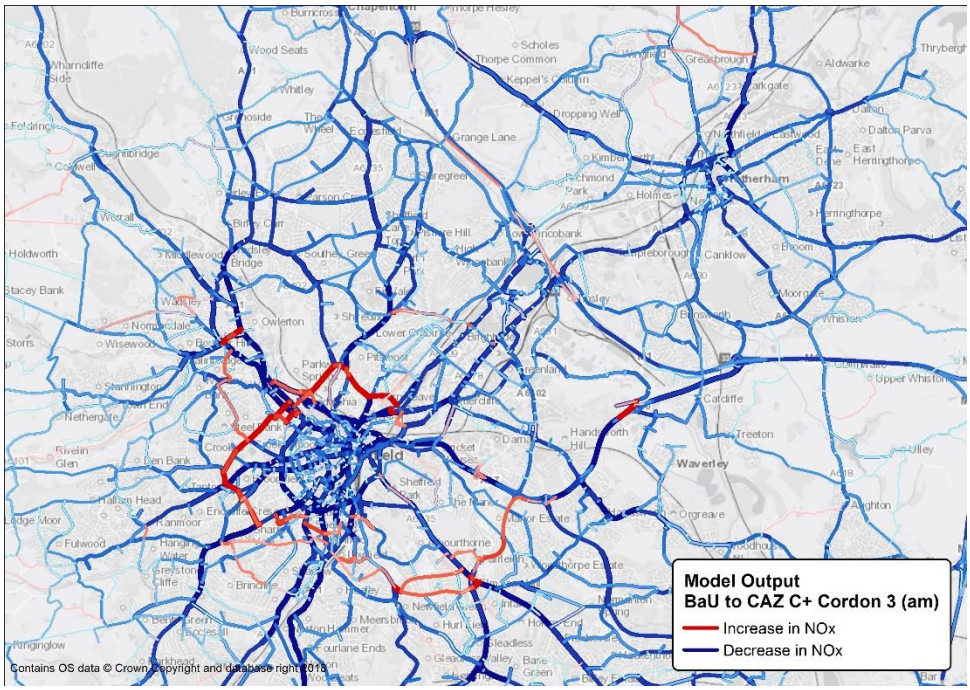


Figure 62 - 2021 Cordon 3 CAZ C+ – AM Peak NO_X Emissions Changes

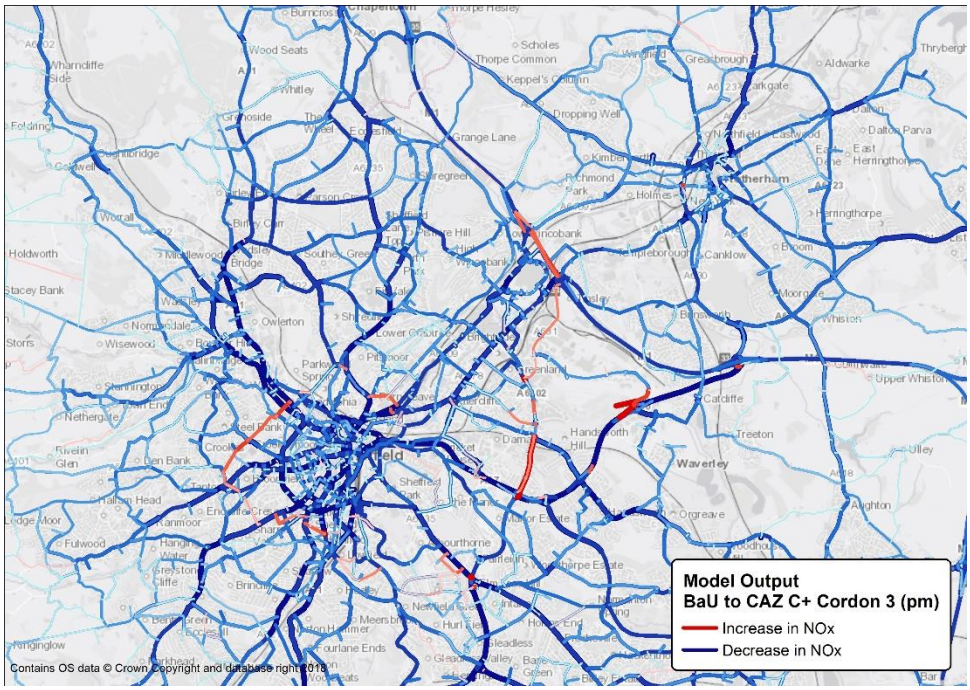


Figure 63 - 2021 Cordon 3 CAZ C+ – PM Peak NO_X Emissions Changes

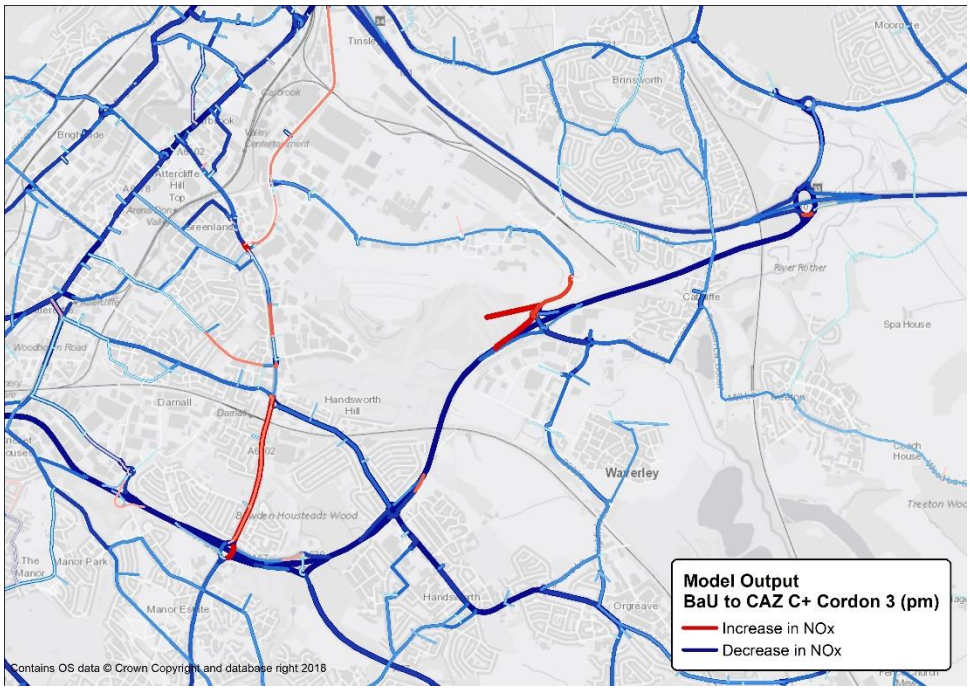


Figure 64 - 2021 Cordon 3 CAZ C+ – PM Peak NO_X Emissions Changes – Sheffield Parkway Area

APPENDIX F – ADDITIONAL MEASURES IN CORDON 3 CAZ D AND C+

This appendix shows the additional measures implemented in the cordon 3 CAZ D and Cordon 3 CAZ C+ scenarios. Table 21 lists all of these measures.

Table 21 – Additional Measures in Cordon 3 CAZ D And CAZ C+

MEASURE	DESCRIPTION
50 mph on Parkway	Reduction from national speed limit to 50 mph on section between M1 junction 33 to intersection with Handsworth Road on A630 Sheffield Parkway. West of this junction, a speed limit of 50 mph is already in place. The free flow speed in SATURN was set to the speed limit and the speed flow curve set to the same one as the rest of the Parkway. A planned widening to three lanes is not included as it is not scheduled to be in place until the end of 2021 at the earliest.
Bus upgrade/retrofit to Euro 6	The full bus fleet in Sheffield and Rotherham is upgraded or retrofitted to Euro 6, the impact of which is shown in Figure 65 below. Those which are still Euro 5 have been retrofitted so that their emissions are Euro 6 equivalent or better. This has been implemented within the ENEVAL (EFTv8.01b / COPERT5 consistent) inputs.
Hearts and Minds campaign	The Hearts and Minds campaign has been modelled as a percentage shift from diesel to petrol cars in the ENEVAL input files for the model run (noting ENEVAL is consistent with COPERT5). The ENEVAL inputs have different splits for different geographical areas, so where the impact of the Hearts and Minds campaign was different between Rotherham and Sheffield this was reflected in the inputs.
HGV ban on Northbound A629 Wortley Road	A full (100%) HGV ban on Northbound/Uphill direction only A629 Wortley Road between junction with Wilton Gardens and junction with Old Wortley Road as highlighted in Figure 66 below. This is intended to prevent HGVs using this route to access the M1 from Rotherham Town Centre, but rather use the alternative route to M1 J34. Although the full length of the road has not been banned in modelling terms it will have this impact. This has been modelled in SATURN by banning access by the user classes representing HGV's from this link in the relevant direction.
Parking charges	Increased Parking Charges in Sheffield City Centre (all locations bounded by the Inner Ring Road) equivalent on average across all sites to an increase in generalised journey time of 5 mins. This affects car user classes in assignment.

MEASURE	DESCRIPTION
	The parking charges are implemented in the SRTM3B variable demand model (VDM) where the full charge is applied to return trips with their destination in the city centre and one-way trips are have half the charge if it originates or ends in the city centre. As the VDM is run, the demand changes to reflect increase in cost, resulting in a decrease in car demand to and from the city centre of about 5%.
Rawmarsh Hill bus rerouting	Reduction in number of buses using Rawmarsh Hill, with 50% of buses currently on this route re-routed to using Barbers Avenue as shown in Figure 66 below. Alongside this junction changes will be made to allow for re-prioritisation of bus routes. Buses in the SATURN model are reflected by preloads on the highway network. This change has been reflected by halving those preloads on Rawmarsh Hill itself and adding them to Barbers Avenue. These preloads effect capacity for other vehicles on these links and feed through into the ENEVAL emissions calculations.
Taxi licencing regulations	Sixty percent of black cabs which have come up for renewal by 2021 have upgraded to ULEV (40% LPG and 20% Electric) and 60% of PHV's which have come up for renewal by 2021 have upgraded to ULEV (either petrol hybrid and electric). These changes have been reflected in the ENEVAL inputs.
Traffic signals on Derek Dooley Way	Improved signal timings on the Derek Dooley Way section of the Sheffield Inner Ring Road to reduce delays and slow moving traffic particularly in the peak periods at the Bridgehouses Roundabout. This update has been implemented by optimising the signal timings along Derek Dooley Way in SATURN. This has resulted in different timings in different time periods through an iterative process of adjustments.
Demand changes due to application of cordon charge	This only applies to CAZ D as CAZ C+ only charges LGVs and HGVs and its demand is fixed and thus origin and destination does not change because of changes in generalised costs. Return trip to or from the city centre have the full charge applied to them in the variable demand model (VDM) which overrides the costs acquired in the highway model. For one way trips have half the charge has already been applied in the highway model and is kept in the VDM. As the VDM is run, the demand changes to reflect increase in cost,

MEASURE	DESCRIPTION
	resulting in a decrease in car demand to and from the city centre of about 5%.

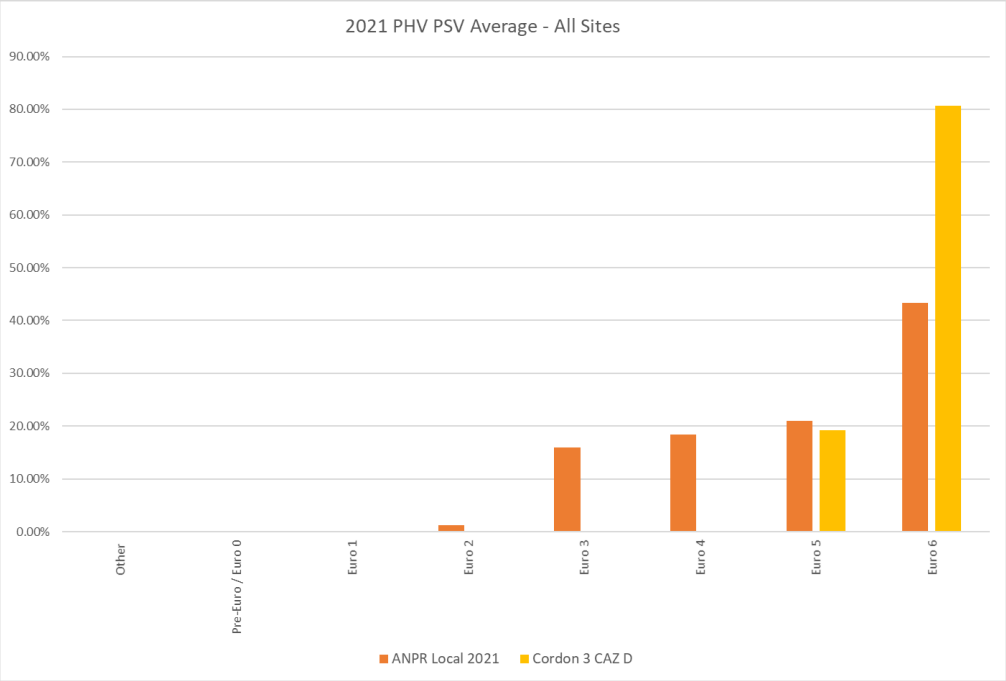


Figure 65 – Changes to 2021 Bus Fleet as part of scheme (Sheffield and Rotherham areas combined)

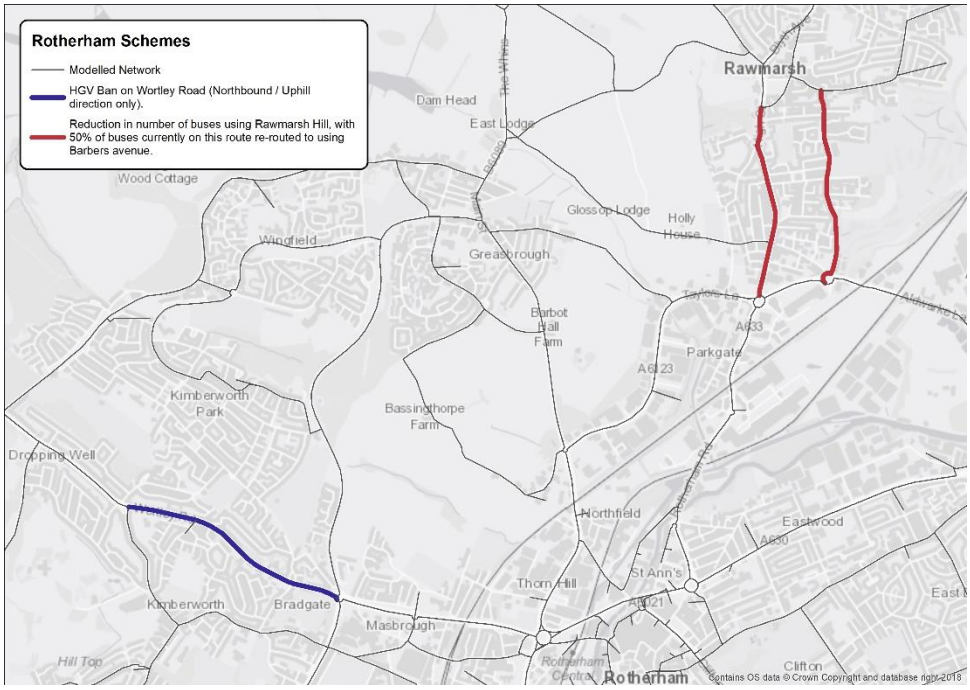


Figure 66 – Rotherham Schemes