Sheffield & Rotherham Clean Air Zone Feasibility Study Transport Model Forecasting Report (T4)

April 2022

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Revision History

Version	Nature of Revision
V0_01	Draft for FBC
FBC Final	Final formatted version for FBC submission

Contents

Section 1 Introduction

1.1 Context

1.1.1 In 2017, the UK Government named Sheffield and Rotherham as one of 29 areas in England which contained locations where the annual average concentrations of Nitrogen Dioxide (NO_2) exceeded statutory limits and was projected to continue to do so beyond a 3-4 year horizon.

1.1.2 The two councils have therefore been developing a strategy which will help ensure that the two areas will become compliant with this statutory limit 'in the shortest possible time'.

1.2 Overview of this Document

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

1.2.2 The Baseline forecasting and scenario testing contained in this document focusses on results from a 2022 forecast year.

1.2.3 This report formed part of the Initial Evidence Submission and the Outline Business Case. It has been updated to form part of the Full Business Case Submission (FBC).

1.3 Model Background and Version

1.3.1 The model being used to provide evidence for the Full Business Case (FBC) is the newly available Sheffield City Region Transport Model (SCRTM1). This was the best available model with which to undertake the analysis required and represents a change in modelling platform from OBC at which point this model was not ready and the Sheffield and Rotherham Transport Model (SRTM3B) was used.

1.3.2 The PT model of SCRTM1 model was developed by SYSTRA while the highway model was developed by AECOM with a base year representation of travel movements of 2016. For the modelling the 2016 base year has been used as a pseudo-2017 year to match the base year of the Air Quality modelling, and the demand has been updated to match. From this point on the Base Year is referred to as 2017. The highway assignment model is built within the SATURN software version 11.04.07H and was developed through merging models from five existing models covering different parts of the SCR area. The trip matrix was developed from a new set of mobile phone data and was merged with synthetic data and then adjusted using matrix estimation in order to achieve a reasonable fit against observed traffic flows. This was completed in late 2019. SCRTM1 therefore, represented the best model available for the CAZ assessment work for the FBC.

1.4 Structure of this Document

1.4.1 The remainder of this document is structured as follows:

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

1.4.2 The Baseline forecasting and scenario testing contained in this document focusses on results from a 2022 forecast year.

1.4.3 This report formed part of the Initial Evidence Submission and the Outline Business Case. It has been updated to form part of the Full Business Case Submission (FBC).

- Section 2 details the scope of the study;
- Section 3 details the methodology used in the modelling;
- Section 4 details the results from the 2017 Base Year Model;
- Section 5 details the results from the 2022 ‘Baseline’ modelling;
- Section 6 details the results of the 2022 Preferred Option;
- Section 7 includes analysis on the impact of traffic demand; and
- Section 8 provides a summary and conclusions.

Section 2 Study Scope

2.1 Geographical Coverage of SCRTM1

2.1.1 The geographic scope of the detailed Traffic and Emissions modelling is illustrated in the figure below. The SCRTM1 model covers the whole of Sheffield and Rotherham urban areas along with significant sections of the M1 and M18 motorways. This is not the full area of SCRTM1 but the area in which detailed consideration has occurred within the modelling of the CAZ scheme.

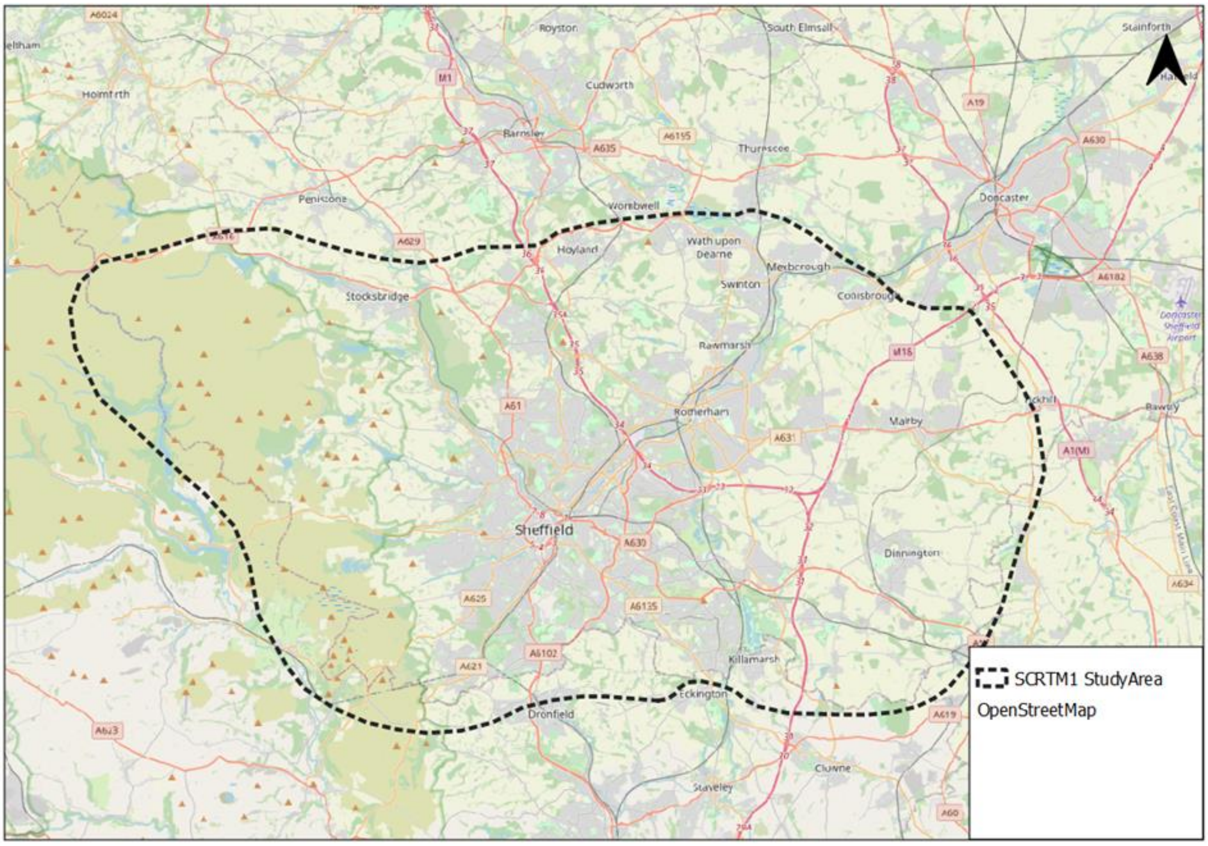

Figure 1. Area of Detailed Traffic and Emissions Modelling

2.2 Time Periods

2.2.1 The modelled time periods included in the SCRTM1 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)

2.3 Modelled Years

2.3.1 The modelled years included in the SCRTM1 are as follows:

- 2017 Base Year; and
- 2024 Forecast Year.

2.3.2 To obtain the 2022 Modelled Year required for the assessment of Air Quality in Sheffield and Rotherham, an interpolation process was created which was used on a 2017 Baseline 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 2022. The two highway networks (2017 & 2024) are then passed through a Saturn assignment which includes a split to the 6 user classes into 12 (complaint and non-complaint) by specifying the proportion of vehicle that could be compliant by the model year. These splits were calculated from the 2019 ANPR data.

2.4 Outside the Scope

2.4.1 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 SCRTM1 anyway.

Section 3 Modelling Methodology

3.1 Introduction

3.1.1 This section briefly details the modelling methodology used to undertake the forecast 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.

3.1.2 This is covered in more detail in the **Transport Modelling Methodology Report (T3)**. In addition to the model updates which have been included in SCRTM1 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.

3.2 ANPR Data

3.2.1 Detailed 2019 ANPR data collected over a full month in February 2019 with extensive geographical coverage of Sheffield and Rotherham was used to establish the Forecast 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. (2017 ANPR data used to underpin the OBC modelling was retained to represent the Base Year fleet).

3.2.2 This local ANPR data was also then combined with DEFRA Emissions Factor Toolkit (EFTv9.1) changes in fleet composition over time to establish a forecast view of the Sheffield and Rotherham fleet in each of the SCRTM1 modelled years. This is set out in Section 6 of this report.

3.3 Forecasting

3.3.1 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 SCRTM1, to provide a modelling tool which can be used to predict future changes in annual traffic Emissions of NO_x. This is set out in Section 5 of this report.

3.4 Assignment Matrix Segmentation

3.4.1 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 6 are the CAZ-compliant vehicle types for Car Business, Car Commute, Car Other, LGV, MGV and HGV and 7 to 12 are the non-compliant equivalents.

3.4.2 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.

3.4.3 The matrices for assignment were split using a combination of ANPR data from 2019 combined with data from the emission factor toolkit.

3.4.4 The forecast assumptions were based on forecast fleet modelling which for car used a fleet forecasting model to allows us to forecast in detail the local changes in the car fleet between 2019 and 2022 (and beyond). In particular that model allows the recent rapid changes in the proportions of petrol, diesel, hybrid, and battery electric vehicles in new car sales to be taken fully into account. For other vehicle types, changes over time were taken from EFT and applied to the base year compliancy to obtain forecast year compliant / non-compliant splits. These are shown in the tables below.

3.4.5 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. The compliant splits for 2017 and 2024 Forecast Year are the same but they vary for baseline and do something (PO) tests. The table also shows the compliant splits applied to the preload vehicle types included in the assignment model.

Table 1. CAZ-Compliant Splits in the Modelled Area (by geography)

User Class	Baseline	PO (CAZ C)
Car	83.1%	84.3%
LGV	61.6%	76.6%
MGV	76.9%	96.1%
HGV	92.7%	98.8%
Black Cab	21.0%	90.3%
Bus	79.3%	100.0%
Coach	79.3%	79.3%
PHV	65.7%	97.9%

3.5 Charging CAZ Areas

3.5.1 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.

3.5.2 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.

3.5.3 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 2. 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[2]	50% on cordon crossing on outbound trip and 50% on cordon crossing on return trip

3.5.4 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.

3.5.5 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.

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

3.6 Through Trip Fleet Effects (TTFE)

3.6.1 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.

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

3.6.2 The proportion of trips in the Baseline which travel through part of the proposed charging zone which are through-trips are shown in the table below.

Table 3. Proportion of Baseline trips in the proposed charging zone which are through trips

	% of Baseline Entering Charging Zone which are Through Trips
LGV	34%
Rigid HGV	62%
Artic HGV	75%

3.6.3 The key point to note however is that for the HGV's over 90% are compliant in the Baseline, so whilst the proportion of through trips is large the impact of the CAZ, and rerouting impacts, on these through trips will be small.

3.6.4 Clearly a large proportion of goods vehicle trips which have a origin or destination in the zone cannot reroute and a number of the non-compliant through trips in the Baseline choose to upgrade – in line with the behavioural research in T4 section 3.8. The total number of non-compliant through trips which therefore end up rerouting around the zone is shown in the table below.

Table 4. Non-compliant rerouting around the Charging Zone

	% of Baseline N-C Trips which Enter CAZ in Baseline which Reroute
LGV	8.3%
Rigid HGV	5.6%
Artic HGV	0.7%

3.6.5 Further details on the Through Trips methodology can be found in **Appendix F**.

3.7 Interpolation

3.7.1 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 2022 traffic flows and speeds.

3.7.2 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.

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

3.8 Behavioural Research

3.8.1 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).**

3.8.2 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 5. 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%

3.8.3 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.

3.8.4 The overall response of the goods vehicle trips to CAZ by those with a trip end within the charging area and those which are through trips are shown in the table below.

Table 6. Behavioural response of non-compliant trips entering the CAZ (rounding means not all add up to 100%)

	To / From / Within CAZ				Through CAZ			
	Upgrade	Divert	Pay	Cancel	Upgrade	Divert	Pay	Cancel
LGV	57%	0%	43%	0%	29%	24%	47%	0%
Rigid HGV	87%	0%	13%	0%	44%	9%	46%	0%
Artic HGV	87%	0%	13%	0%	44%	1%	55%	0%

3.8.5 For the purpose of this model it is assumed a 0% trip cancellation rate. This contains some additional nuance however which is that we assume some non-compliant goods vehicles will cancel there trip, but the business related to that trip will not go away so it will be replaced by a compliant trip. This is contained in the local values for LGV and the JAQU HGV values are adjusted accordingly.

3.9 Variable Demand Model

3.9.1 The Variable Demand Model (VDM) within the SCRTM1 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.

3.9.2 This means that the demand responses are not split by compliant and non-compliant vehicles separately and that the charges to non-compliant private vehicles will therefore not have an impact on the mode and destination choice models within SCRTM1. 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.

3.10 ENEVAL

3.10.1 ENEVAL is SYSTRA's traffic Emissions Evaluation software, which uses outputs from the traffic model combined with the latest DfT, EFT and COPERT figures to calculate tailpipe emissions.

3.10.2 As default this includes national UK data based on DEFRA's EFT tool (Emissions Factor Toolkit v9.1). 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.

3.10.3 The ENEVAL process has also been updated, compared to the standard version, 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.

3.11 Link to Air Quality Modelling

3.11.1 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.

3.11.2 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.

3.11.3 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.

3.11.4 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.

3.11.5 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.

3.11.6 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.

Section 4 2017 Base Year Results

4.1 Introduction

4.1.1 This section of the note details 2017 Base Year modelling results. It includes a description of the fleet composition put together from the local ANPR data along with the Base Year compliance splits.

4.2 ANPR Data

4.2.1 The local detailed fleet splits which have been used in Emissions modelling have been put together using detailed ANPR data that was collected for use in this project with extensive temporal and spatial coverage. For the OBC data from 2017 ANPR surveys was used in the Base Year and Forecast Year modelling, but for FBC modelling 2019 data was used to inform forecasting as it was more up to date. As the model remained at 2017, to be consistent with the Air Quality modelling, the 2017 data was retained for that purpose.

4.3 Compliant / Non-Compliant Splits

4.3.1 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 7. 2017 Base Year Compliance Splits

Vehicle Type	Non-Compliant Split	Compliant Split
Car	70%	30%
LGV	80%	20%
Rigid HGV	84%	16%
Articulated HGV	76%	24%
Black Cab	100%	0%
PHV	57%	43%
Bus	83%	17%

4.4 Base Year Results

4.4.1 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 NOx Emissions in g/km. The first image shows modelled link Emissions with coloured dots denoting the annual average NO2 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.

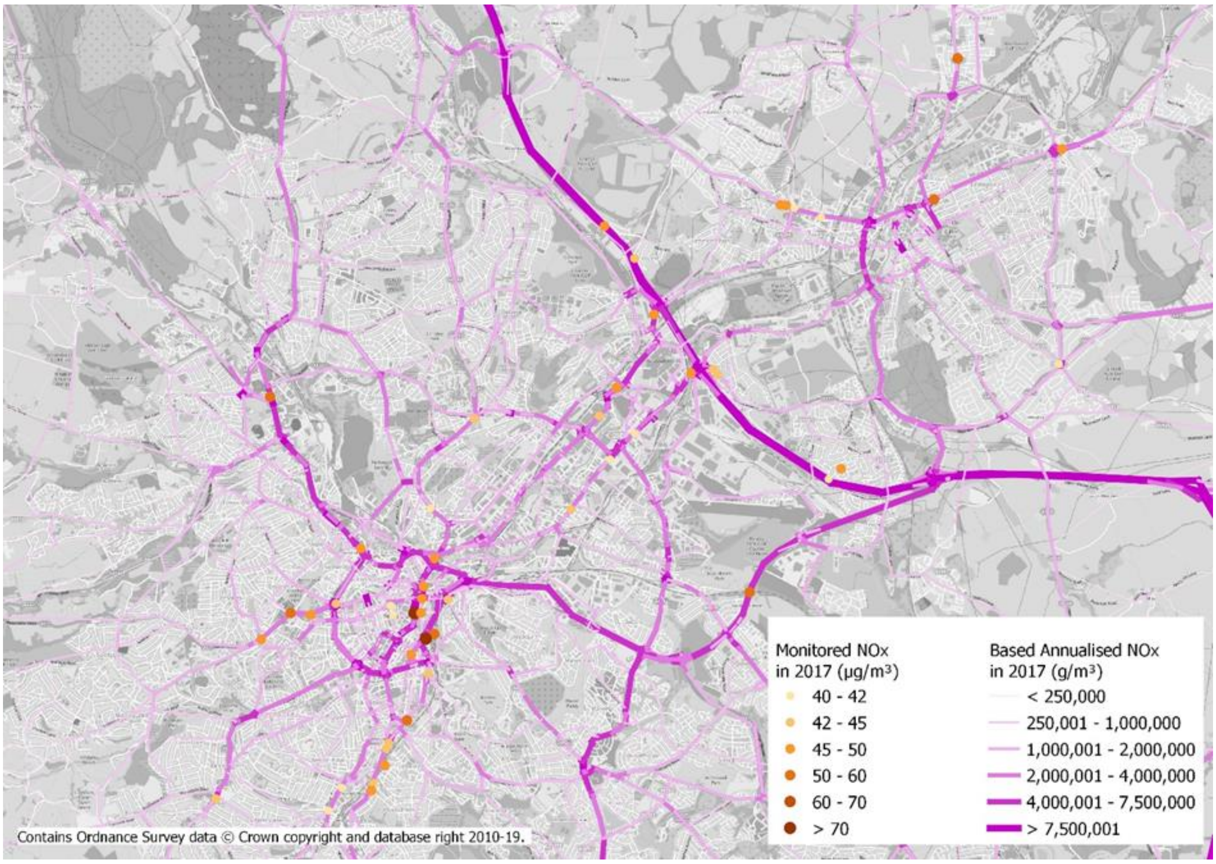

Figure 2. Emissions in the 2017 Base Year model output AQ monitoring sites across study area.

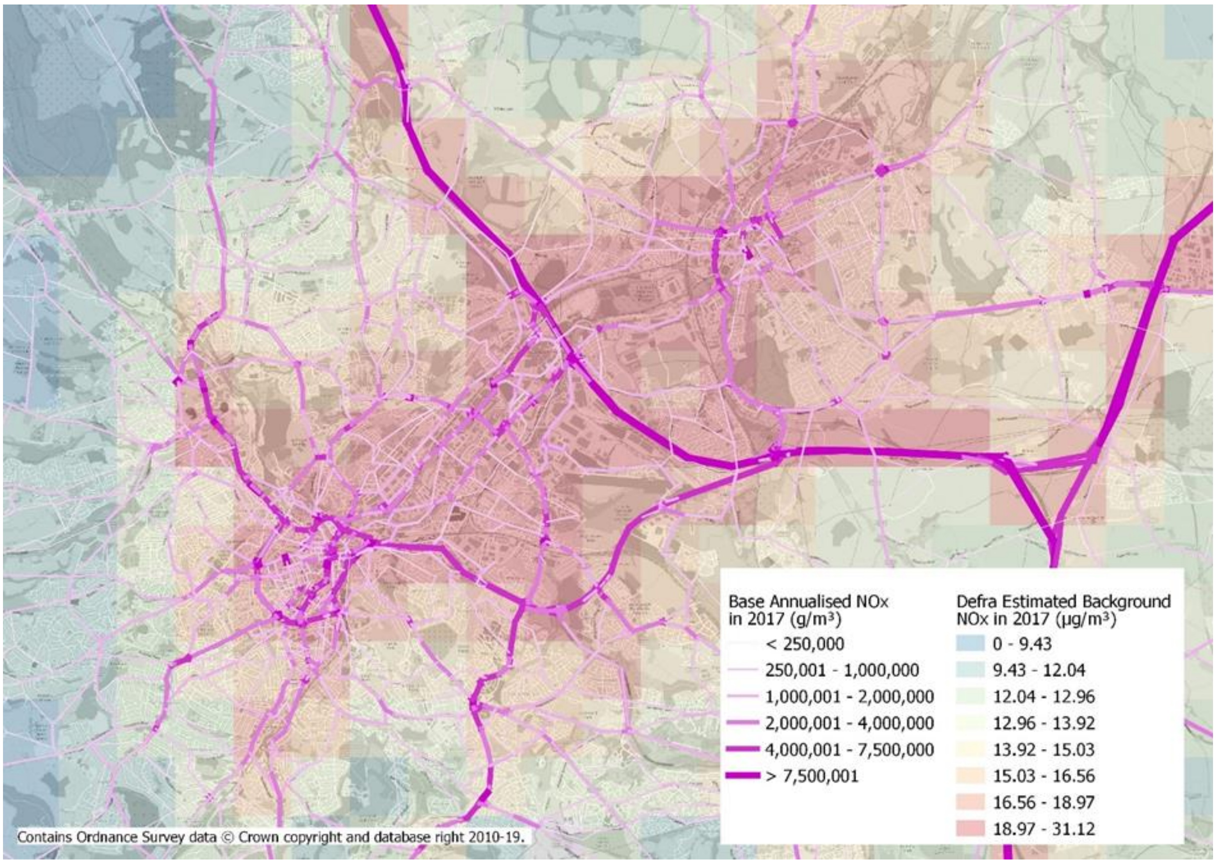

Figure 3. Emissions in the 2017 Base Year model output against Defra's NO_2 background levels.

4.4.2 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.

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

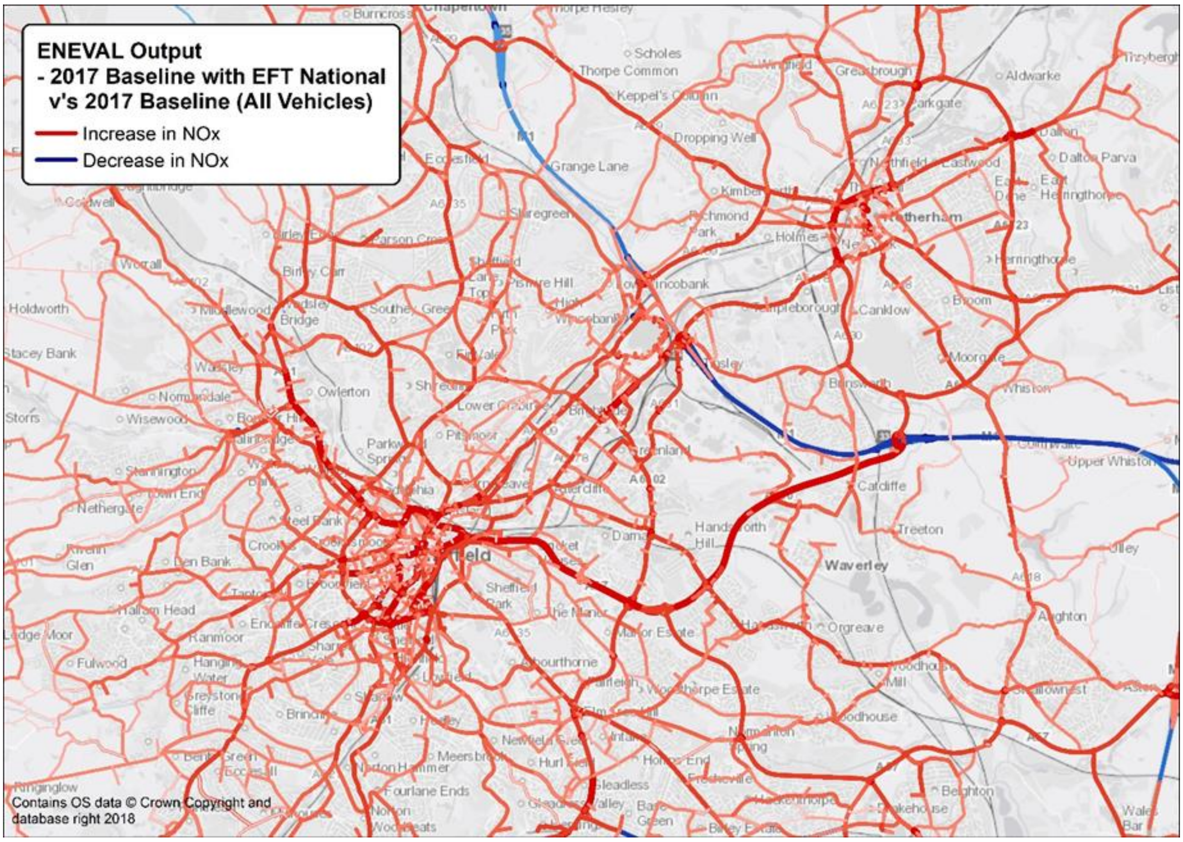

Figure 4. Difference in 2017 Base Emissions when using the EFT National Fleet Assumptions compared to local fleet data from ANPR

4.4.4 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).

4.4.5 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%.

Section 5 2022 Baseline

5.1 Introduction

5.1.1 This section details the results from the forecast year Baseline (Baseline) modelling. The modelled forecast years (2017 and 2024) are used to create interpolated intermediate years, the most important of which is 2022 in which compliance is to be achieved.

5.1.2 The forecasting methodology for arriving at the 'Baseline' values presented in this section is as discussed in section 3 of this report and in the **Local Plan Transport Modelling Methodology Report (T3).**

5.2 Schemes included in the Baseline Test

5.2.1 The following table shows the schemes included in the Baseline modelling.

Table 8. List of Schemes included in the Baseline Test

Scheme ID	Description
S010	A61 inbound at Heeley bottom - significant widening to provide bus lane
S011	Greenhill Parkway/Greenhill Ave, signalise junction
S012	Meadowhead roundabout - extra lane arising from development
S026	Barnsley Road (Norwood road - Toll Bar)road widening to provide bus lane
S033	Blackstock Road / Gleadless Road - bus lane + junction imp.
S041	Broad Lane / Rockingham St junction - signalisation
S043	SRQ traffic management changes
S056	Castlegate downgraded through G2G2
S080	new signalised all-movements junction
S107	SCRIF Bridgehouses
S108	IKEA junction improvements between A6178 / A6102 and Tinsley Roundabout, plus Meadowhall Roundabout.
TCF9	Cross city bus (Bus Gates on Furnival Gate and Arundel Gate are not included)
TCF15	Sheffield to Burngreave via Kelham Island - Housing zone north Scheme – Have only included Alma street Closure
TCF18 & 19	Parkgate Link Road scheme (TCF)
College Road Roundabout	Road widening into the roundabout
B6089 Main Street/Coach Road/Potter Hill, Greasborough;	To remove the eastern island on Main Street whilst retaining traffic signal control

A630 Sheffield Parkway improvement	Widening to three lanes from two between M1 Junction 33 and Catcliffe.
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.
SAV Tram-Train	Tram-Train connection Sheffield city centre, Meadowhall, Rotherham Central and Parkgate.
M1 J31-J32 Extra Lane	Widening from three to four lanes.
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.

5.3 Planning Data Summary

5.3.1 The Planning data for forecast year (2024) is calculated based on the base year (2017) and TEMPRO v72 Growth factors. The tables below show the changes in jobs and dwelling by local authority in 2024 from the trip end process.

5.3.2 The 'Baseline' scenario includes all developments identified in the Uncertainty Logs as either Category 1 or 2 – "near certain" or "more than likely". Table 6 and Table 7 shows the level of residential and commercial developments modelled explicitly in the 2024 'Baseline' forecasts (relative to the 2016 base model) for the Rotherham and Sheffield districts.

Table 9. Jobs in 2024 (noting base year for trip end model is 2016)						
Local Authority	**Jobs in by (2016)**	**New Jobs forecast for the FY (Employment developments)**	**Growth in Jobs for the FY based on TEMPRO V72**	**Employment Developments / TEMPRO Growth**	**TEMPRO Growth Constraint Factor (On top of developments)**	**Actual No of Jobs in the FY**
Barnsley	83,347	1,915	2,337	82%	0.005	85,684
Doncaster	127,783	12,320	4,919	250%	-0.058	132,702
Rotherham	**108,694**	**567**	**3,514**	**16%**	**0.027**	**112,208**
Sheffield	**264,310**	**27,966**	**8,609**	**325%**	**-0.073**	**272,919**
Bassetlaw	53,232	3,809	1,836	207%	-0.037	55,069
Bolsover	30,234	5,410	934	579%	-0.148	31,168
Chesterfield	52,331	1,180	1,867	63%	0.013	54,198
Derbyshire Dales	37,304	-	1,089	0%	0.029	38,393
NE Derbyshire	32,861	1,219	1,041	117%	-0.005	33,902
Rest of UK	29,969,918	-	936,612	0%	0.031	30,906,529

Table 10. Dwellings in 2024 (note base year for trip end model)						
Local Authority	**Dwellings in by (2016)**	**New Dwellings Forecast for the FY (Housing developments)**	**Growth in Dwellings for the FY based on TEMPRO V72**	**Housing Developments / TEMPRO Growth**	**TEMPRO Growth Constraint Factor (On top of Developments)**	**Actual No of Households in the FY**
Barnsley	105,090	3,410	6,845	50%	0.033	111,934
Doncaster	130,523	7,322	6,226	118%	-0.008	136,749
Rotherham	**110,233**	**3023**	**4,739**	**64%**	**0.016**	**114,973**
Sheffield	**240,160**	**11,199**	**12,212**	**92%**	**0.004**	**252,372**
Bassetlaw	49,223	2,679	2,431	110%	-0.005	51,654
Bolsover	33,758	1,795	1644	109%	-0.004	35,402
Chesterfield	48,007	2,973	2,216	134%	-0.016	50,223
Derbyshire Dales	31,020	2953	1,121	263%	-0.059	32,141
NE Derbyshire	43,406	3,441	4,870	71%	0.033	48,276
Rest of UK	25,827,259	-	1,884,389	0%	0.073	27,711,649

5.3.3 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. The total scale of the development in terms of 12-hour person arrivals included in the 'Baseline' Scenario is summarised in Table 8.

Table 11. 12-hour Trip Ends by Land Use Type

Land Use Type	2024 12H Person Arrivals
A1 Shops	95,735
B1 Business	15,257
B2 General Industry	3,306
C3 Dwelling Houses	81,741

5.3.4 The figure below Table 12 summarises the same trip end information by mode and hourly time period.

Table 12. Development Trips by Mode and Time Period

Mode	2024 Car	2024 PT	2024 Walk/Cycle
Total	115,295,068	18,102,448	40,610,115

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

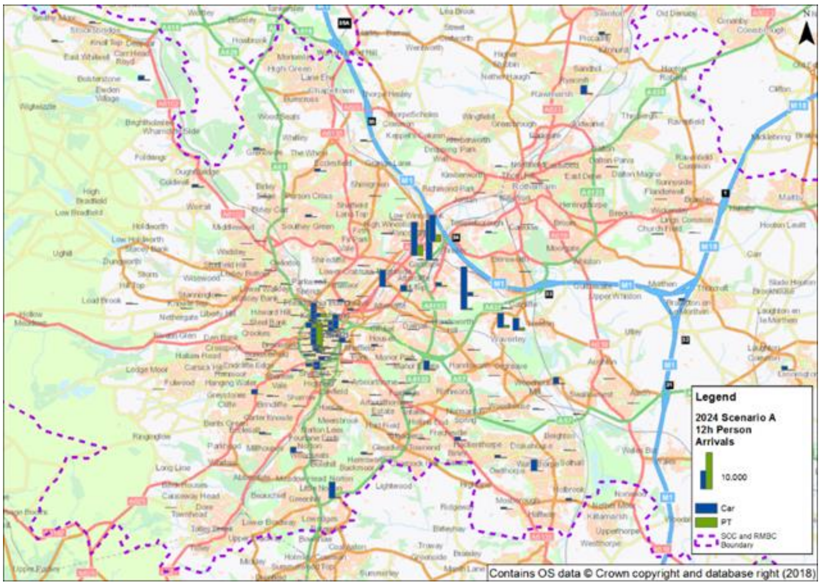

Figure 5. 12-hour Car and PT person trip end arrivals for developments in 2024 'Baseline' Scenario

5.4 Forecast Fleet Composition

5.4.1 The following figures show how the Baseline fleet composition is expected to look in Sheffield and Rotherham in 2022. These have been created to use in the emission modelling, by taking the local Base Year fleet built from the ANPR data and applying a combination of DEFRA Emissions Factor Toolkit (EFT) changes over time and local changes to car modes as predicted by the car forecasting spreadsheet model.

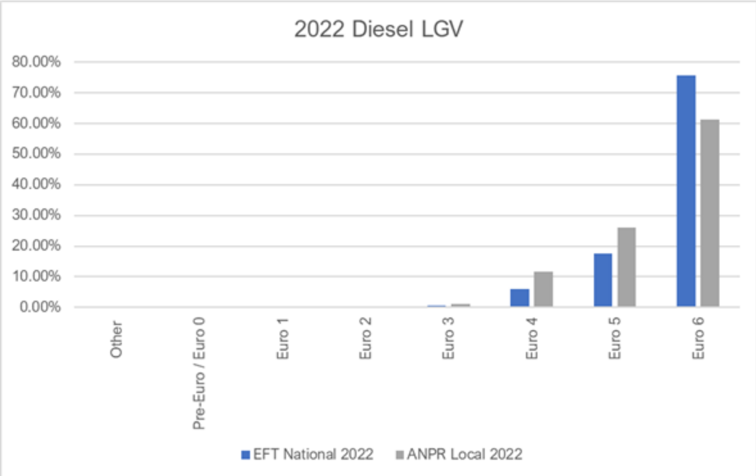

Figure 6. LGV Fleet Mix 2022 Baseline (EFT and Local)

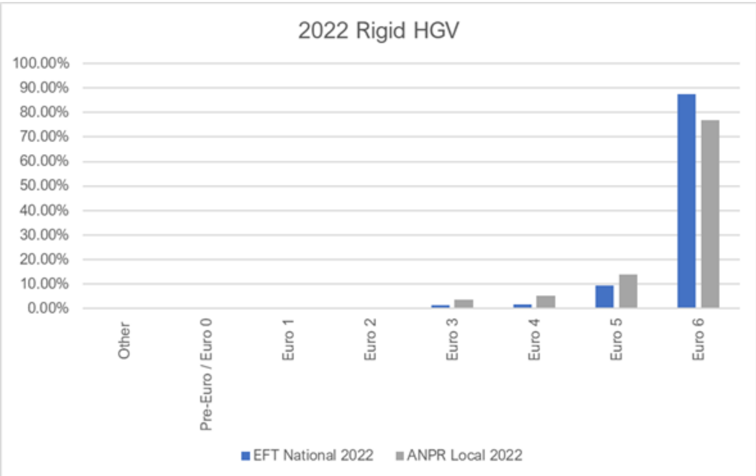

Figure 7. Rigid HGV Fleet Mix 2022 Baseline (EFT and Local)

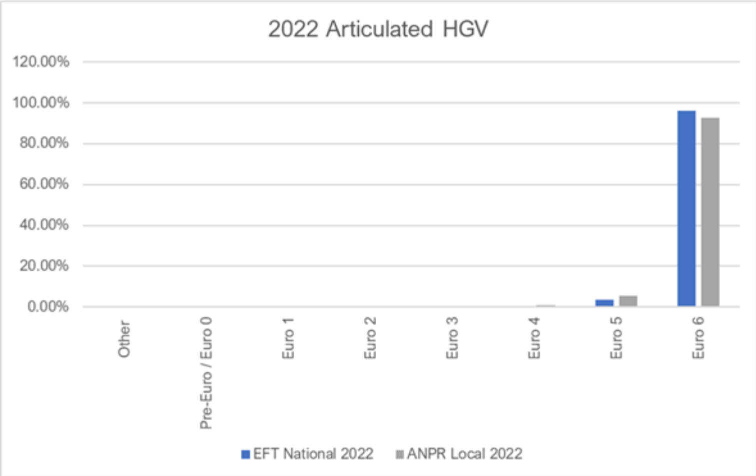

Figure 8. Articulated HGV Fleet Mix 2022 Baseline (EFT and Local)

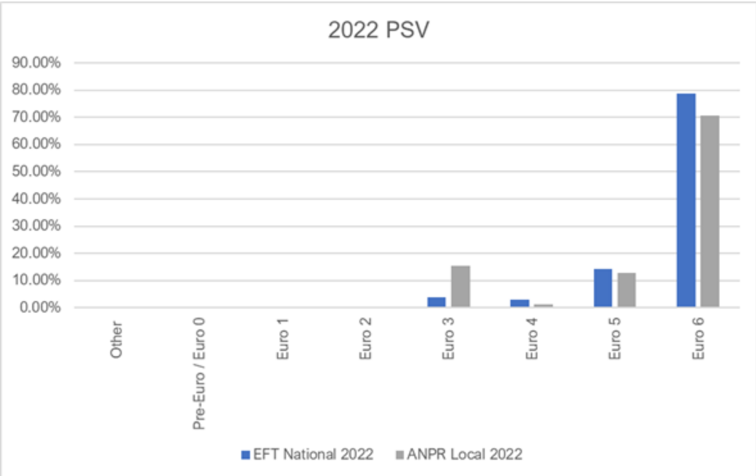

Figure 9. PSV and Bus Fleet Mix 2022 Baseline (EFT and Local)

5.5 Forecast Compliance Splits

5.5.1 The following figures show how the 2022 Baseline compliance splits are expected to look in Sheffield and Rotherham by applying the EFT fleet changes and local projections to the 2019-based ANPR local fleet.

Table 13. Compliance splits in the Baseline 2022 Model

Vehicle	Baseline
Car	79.0%
LGV	61.6%
MGV	76.9%
HGV	92.7%
Black Cab	21.0%

PHV	65.7%
Bus	79.3%

5.6 Trip End Model

5.6.1 In the trip end Model process the base year ratio of each population and car ownership segment over the total number of households in 2016 (E02 category in IXIE table) and multiplies that with a) the total no of households in the forecast year as predicted by the specific planning scenario and b) the respective TEMPROv72 Growth in that ratio between the base and the future year at a district level. The output of the process will be the generation of the forecast year population and car ownership tables. However, the base year David Simmonds Planning data did not include all the different NTEM population and car ownership categories, but aggregations of some categories instead. As a result, the same applied to the forecast year matrices.

5.6.2 To correct for that, we used the relevant NTEM v72 splits for the specific forecast year at an MSOA level. The E15 employment type was also infilled straight from the NTEM v72 forecast data. Thus, we came up with the Final IXI pop, IXI car own and IXIE tables for the forecast year. The additional number of students generated in Sheffield as a result of the new developments of type C4 (students' accommodation) are added to the forecast year student's population (if the planning scenario includes new developments in Sheffield).

5.7 2022 Baseline Results

5.7.1 The 2022 Baseline has been calculated by running the transport model for 2017 and 2024. This is then interpolated between the 2017 and 2024 years to obtain traffic flows and speeds in 2022, which have then been passed through the ENEVAL process.

5.7.2 The image below shows the results of that Baseline 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 2022. This is largely due to the Baseline changes in the fleet over time.

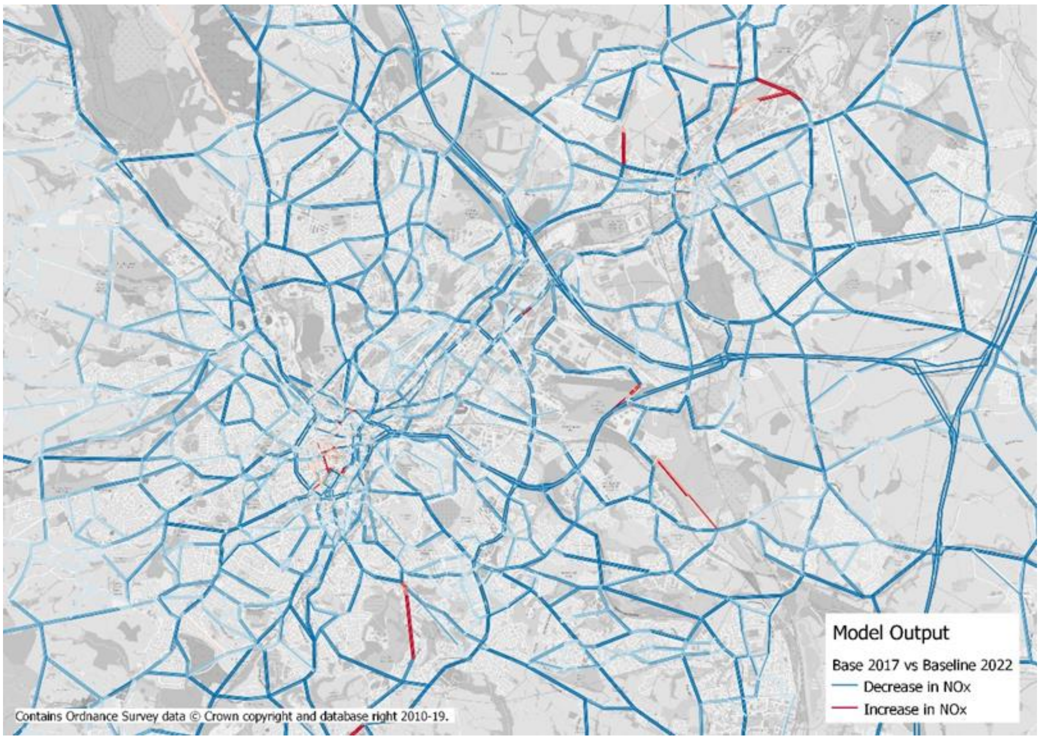

Figure 10. Change in NO_x between 2022 Baseline and the 2017 Base

5.7.3 The following table shows the percentage changes in NO_x for the 2022 Baseline scenario compared to the 2017 Base Year. This is restricted to the sites identified as still having an Air Quality Issue in 2022 through the target determination process. This shows an average reductions about 32% due to improvement in the background fleet.

Table 14. 2022 Baseline – Changes in Tailpipe NO_x Emissions from 2017 Base Year	
Site	**Baseline – NO_x Reductions**
Sheffield Sites	
Arundel Gate Interchange	-45%
Derek Dooley Way	-10%
Sheaf Street	-34%
Sheffield Parkway	-32%
Rotherham Sites	
A629 Wortley Road	-26%
A630 Fitzwilliam Road	-29%
A630 Parkway Rotherham	-30%
A633 Rawmarsh Hill	-24%

Section 6 Preferred Option

6.1 Introduction

6.1.1 This section presents the outputs from the Preferred Option scenario testing that has been undertaken using the SCRTM1 version of the model. A full series of option tests were undertaken at OBC stage to arrive at the requirement for a CAZ C and the extent of the charging district. That was not repeated for the FBC, but rather the Preferred Option as established at OBC stage assessed through the new model framework and the results from that modelling are presented in this section.

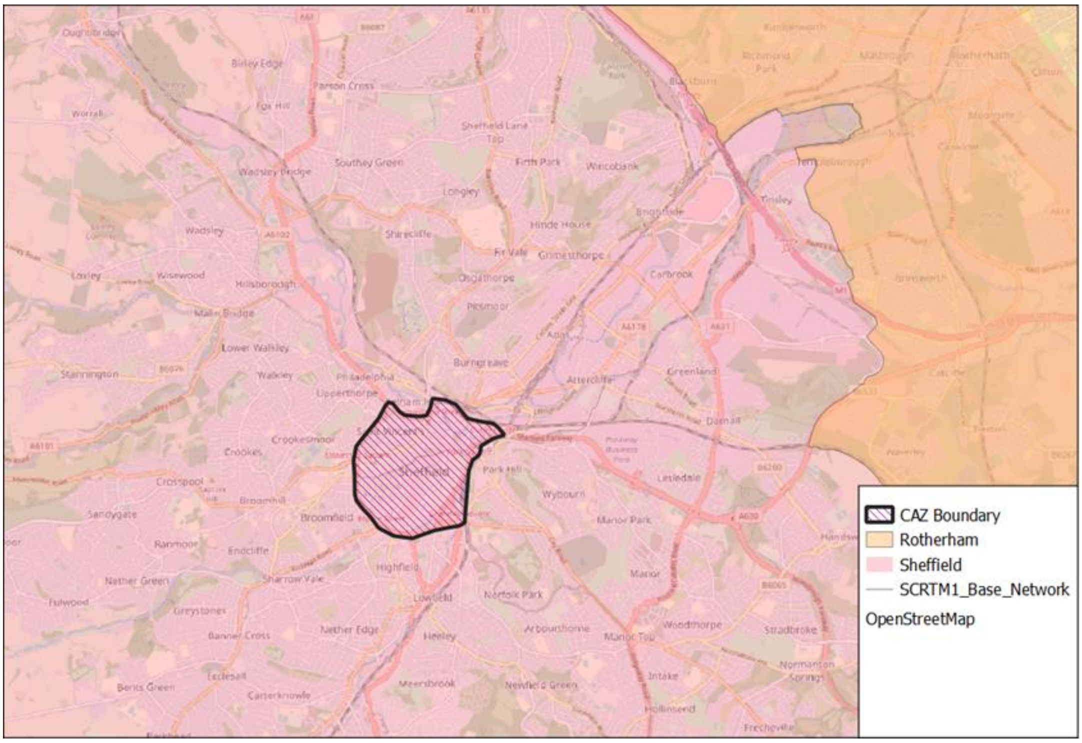

Figure 11. Map Representing CAZ cordon in SCRTM1

6.2 Schemes included in the Preferred Option Test

6.2.1 In addition to the list of schemes included in Table 10 the list of schemes included in the Baseline, Table 15 show the additional schemes included for the Preferred Option Test.

Table 15. List of Schemes included in the Preferred Option Test		
Scheme ID	**Description**	**Changes on Model Compared to Baseline**
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. In 2022 both the Baseline and the Preferred Option are modelled with roadworks on the Parkway (which will be in place due to widening works). From 2023 onwards the completed Parkway widening scheme will be in place.
Rawmarsh Hill bus rerouting	Reduction in number of buses using Rawmarsh Hill to ensure no more than 26 in-service buses/hr (12 hour weekday average) [3] are on this route with the rest re-routed to using Barbers Avenue. 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 reducing 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. See Figure 9.
Bellow's Road	Rerouting is via Bellows Road is to get to Barbers Avenue	These bus changes have been run through the VDM to ensure demand changes as a result of this rerouting has been picked up.
Bus upgrade/retrofit to Euro 6	The full bus fleet in Sheffield and Rotherham is upgraded or retrofitted to Euro 6. Those which are pre-Euro 6 have been retrofitted so that their emissions are Euro 6 equivalent or better.	This has been implemented within the ENEVAL inputs.

[3] In the modelling this was included as a 50% reduction which came out as ~22 buses/hr, but subsequent interpolation of the results shows that 26 buses/hr will achieve compliance with sufficient headroom and hence that is the scheme being taken forward.

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. 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. See Figure 9. Local HGV traffic is still able to access businesses on Wortley Road.
TCF9 (Arundel Gate Bus Gate Partial Scheme)	Cross city Bus associated Bus Gates on Arundel Gate is included in the model bringing it forward from 2023.	The highway network on SATURN has been adjusted to improve bus connectivity in central Sheffield locations according to Transforming Cities Fund TCF 9 scheme.
Taxi Upgrades	Black cabs in Sheffield upgrade from 21% (Baseline) to 90% compliant and Private Hire Vehicles (PHV) across Sheffield and Rotherham upgrade to be 98% compliant. This is as a result of mitigation / incentives and behavioural responses to the charging scheme. These upgrades are covered in more detail in the Management Case delivery plan.	These changes have been reflected in the ENEVAL inputs.
Sheffield Inner Ring Road Charging Area	See section 6.3 below	
Anti-Idling Measures on Arundel Gate	Measures to combat bus-idling on Arundel Gate, in particular to increase compliance with a maximum 2 minute idling rule.	Post-model calculations described below

6.2.2 Maps of the specific highway schemes are shown in the figures below.

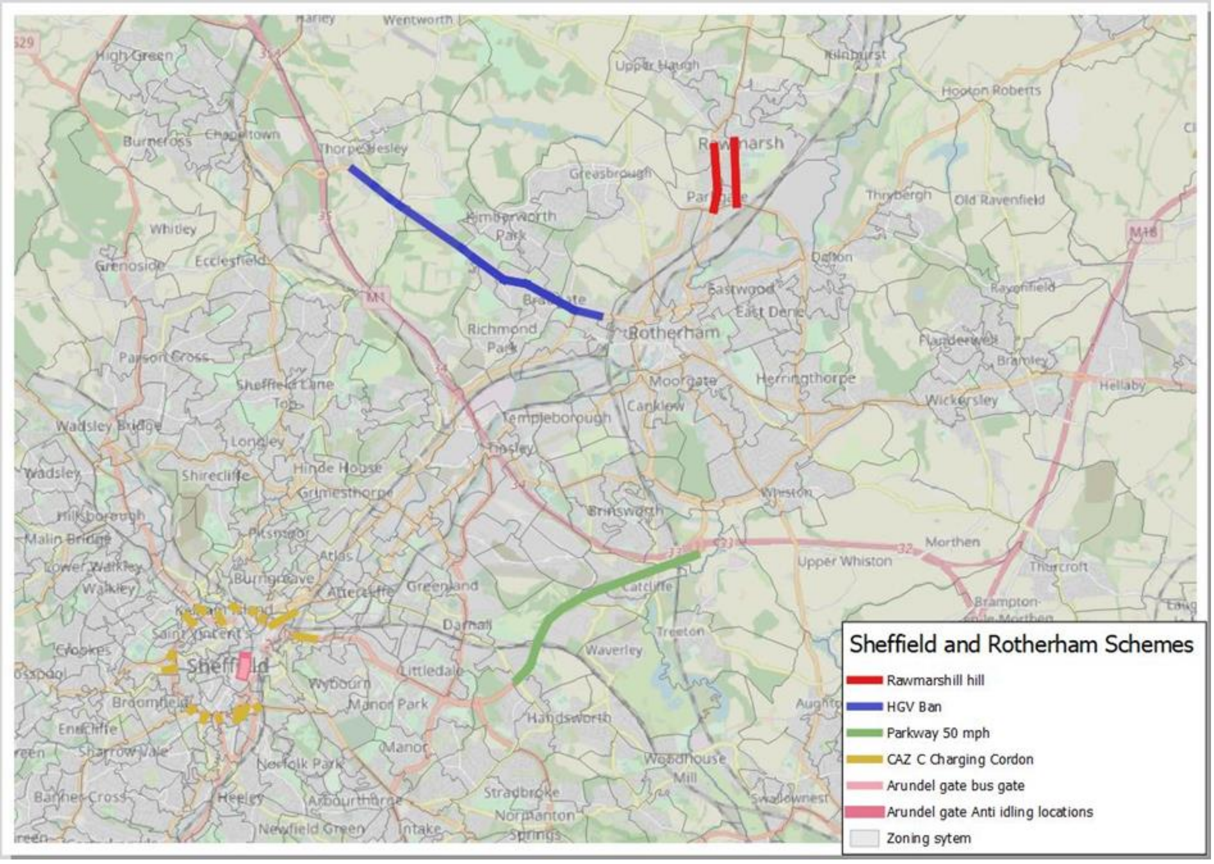

Figure 12. Highway Schemes across Rotherham and Sheffield

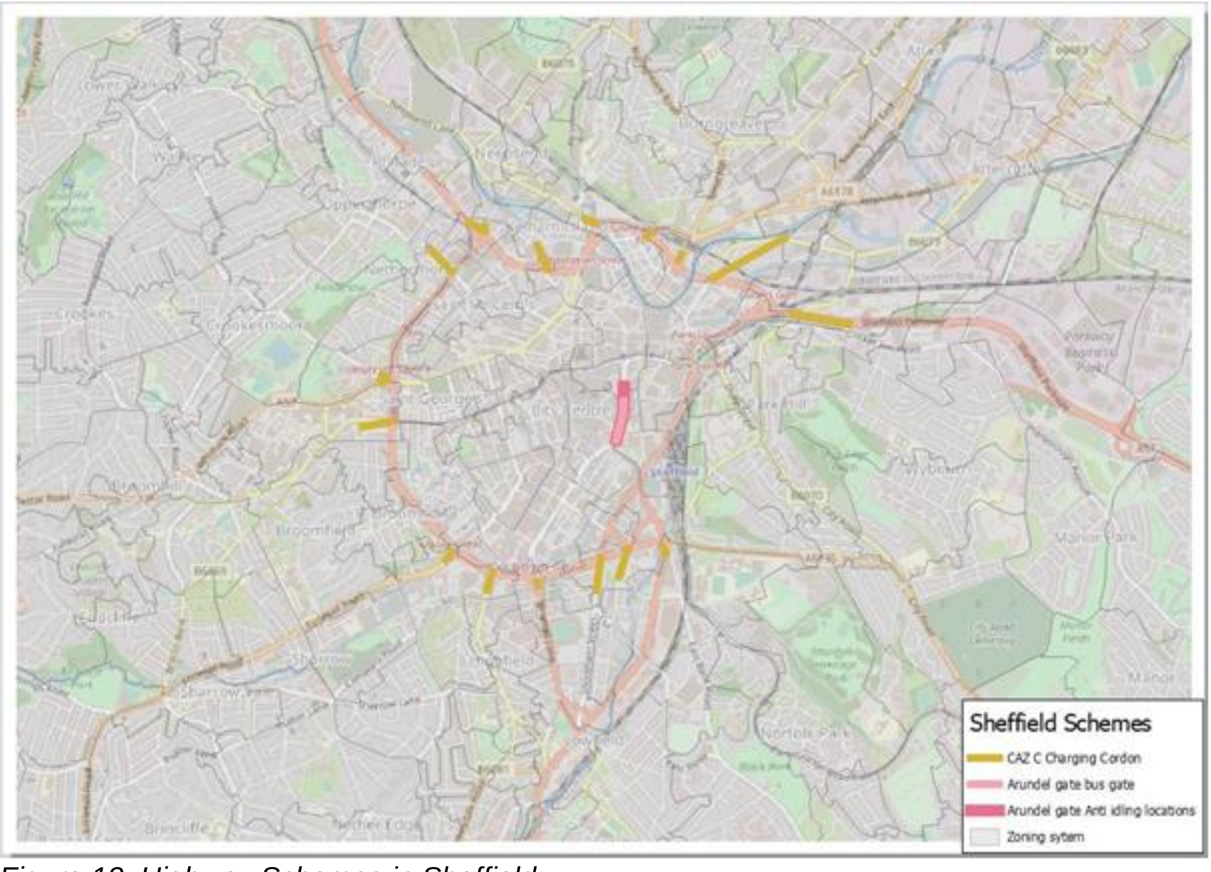

Figure 13. Highway Schemes in Sheffield

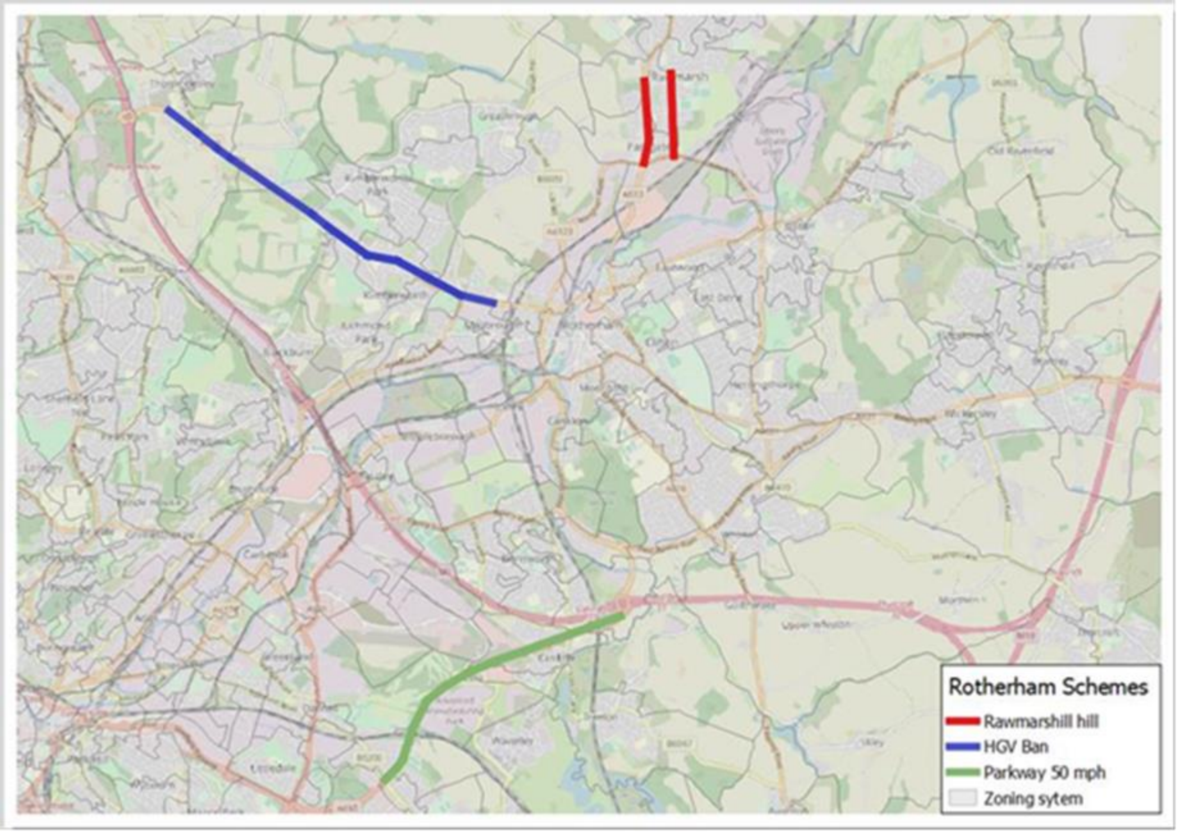

Figure 14. Highway Schemes in Rotherham

6.3 Charges in the Preferred Option Test

6.3.1 In the CAZ C Preferred option (PO) test, charges are being to LGV's, MGV's, HGV's, Black cabs, PHV's and Coach.

Table 16. CAZ C Charges

Daily Charge	CAZ C Charges
Car	£0
LGV	£10
MGV	£50
HGV	£50
Black Cab	£10
PHV	£50
Coach	£50

6.4 Through Trips

6.4.1 The through trips are taken from base year assignments. The origin, destination and demand are extracted from the links that enters the CAZ Cordon. It is then assumed that 50% of this demand will have the same behavioural response as trips to/from/within the CAZ Cordon and the upgrade proportions are applied likewise to 50% of the though trip demand. This assumption was agreed with JAQU at OBC stage.

6.4.2 For non-compliant through trips which do not upgrade and continue to drive through the charging zone, they will only experience the 50% one way charge. This will not result in underestimating the diversion impact as the frequency analysis has shown that each unique vehicle is identified by ANPR cameras making on average over 2 trips per day in the charging area. Indeed, there may be a slight overestimate of the number of trips rerouting.

6.5 Fleet Upgrade

6.5.1 The fleet for the Do Something (CAZ C) is assumed to be the same as the Baseline except for the following

- Second hand effects around diesel car sales go away which make fleet slightly cleaner;
- There will be a response to charge which is based on local behavioural research (LGV's, MGV, HGV, Black Cab, PHV and Coach) and JAQU guidance (HGV);
- PHV's have higher compliance splits as compared to a non-charging scheme;
- Buses will achieve 100% compliance through upgrade or retrofitting; and
- Black cabs will upgrade partly based on a response to any charge, partly as a result of incentives and partly through licensing changes at both Sheffield and Rotherham Councils.

6.5.2 The upgrades included in the model are based on assumptions taken from the Emissions Factor Toolkit. For example, the diesel LGV fleet the Baseline fleet split is the Base Year fleet, based on ANPR data, grown to 2022 using EFT changes over time. Those LGV's that are expected to upgrade in response to the scheme are simply pro-rata allocated to the compliant fleet types in the same proportions as the Baseline fleet. No switching between petrol and diesel in response to the scheme is modelled, as the majority vehicles included in this scheme (ie LGV, HGV, Bus) can only really use diesel.

6.5.3 A summary of the resultant upgrade (including behavioural) responses included in the modelling of the non-compliant vehicle classes is as follows:

- LGV – 43% do not upgrade, 57% upgrade (behavioural change underpinned by incentives);
- HGV – 13% do not upgrade, 87% upgrade (behavioural change underpinned by incentives)
- Taxi – 16% do not upgrade, 84% upgrade (behavioural change plus licencing changes);
- Private Hire Vehicle – 5% do not upgrade,95% upgrade (behavioural change plus licencing changes); and
- Bus – 100% upgrade

6.6 Preferred Option Compliant Splits

6.6.1 In the CAZ C Preferred option (PO) test, charges are applied to Cars, LGV's and HGV's and Taxi's/Private Hire vehicle's (PHV) which is represented by a higher compliancy split.

Table 17. Compliance splits in the Preferred option 2022 model

Vehicle	Baseline
Car	79.0%
LGV	76.6%
MGV	96.1%
HGV	98.8%
Black Cab	90.3%
PHV	97.9%
Bus	100.0%

6.7 Matrix Totals

6.7.1 Prior to running ENEVAL to calculate the tailpipe emissions, the highway network of the transport model is passed through an assignment so as to split the user classes into complaint and non-complaint i.e. 6 user classes get split into 12 user classes. This process is done for both 2017 and 2024 so that the resulting 2022 year can be interpolated with the splits. The matrix totals for the base year and forecast year by time period are as follows:

Table 18. Matrix totals – Preferred option

Model Year	Vehicle Type	AM	IP	PM
2017	Commute Car-Compliant	471,407	75,342	416,398
2017	Business Car-Compliant	193,142	155,562	215,422
2017	Other Car - Compliant	305,041	343,542	386,406
2017	LGV - Compliant	55,217	47,299	52,428
2017	MGV - Compliant	18,747	22,222	5,742
2017	HGV - Compliant	57,182	60,661	24,592
2017	Commute Car-Non Compliant	95,870	15,322	84,683
2017	Business Car- Non Compliant	39,279	31,637	43,810

2017	Other Car – Non Compliant	62,036	69,866	78,583
2017	LGV - Non Compliant	87,307	74,765	82,962
2017	MGV - Non Compliant	5,617	6,659	1,721
2017	HGV – Non Compliant	4,498	4,771	1,935
2024	Commute Car-Compliant	503,526	80,277	444,366
2024	Business Car-Compliant	211,633	170,586	235,769
2024	Other Car - Compliant	346,278	386,637	434,977
2024	LGV - Compliant	63,868	54,713	60,622
2024	MGV - Compliant	18,256	21,675	5,578
2024	HGV - Compliant	56,699	60,274	24,439
2024	Commute Car-Non Compliant	102,402	16,326	90,370
2024	Business Car- Non Compliant	43,040	34,692	47,948
2024	Other Car – Non Compliant	70,422	78,630	88,461
2024	LGV - Non Compliant	101,010	86,510	95,940
2024	MGV - Non Compliant	5,470	6,495	1,672
2024	HGV – Non Compliant	4,460	4,741	1,923

6.8 2022 Preferred Option Results

6.8.1 In section 3 for the 2022 'PO' scenario compared to the 2017 Base Year. This is restricted to the sites identified as still having an Air Quality Issue in 2022 through the target determination process. This shows an average reduction about 38% due to improvement in the background fleet. *Note: these values are higher in magnitude than those presented at OBC stage partly because of the change in model used but mainly as a result of the extra years' worth of vehicle churn.*

Table 19. 2022 CAZ C Scenario – Changes in Tailpipe NO_x Emissions from 2017 Base Year

Site	BAU	CAZ C
Arundel Gate Interchange	-45%	-75%
Hatherley Road, Rotherham	-30%	-33%
Rawmarsh Hill	-24%	-37%
Sheffield Parkway (A630)	-32%	-44%

A630 Parkway - Rotherham	-30%	-38%
ASDA A630	-30%	-34%
A631 East Bawtry Road, Whiston Crossroads	-29%	-30%
Wortley Road (227), Rotherham	-26%	-34%
Kirkstead Road, Rotherham	-27%	-28%
Fullwood Rd Post Office (Broomhill Forum)	-30%	-40%
463 Queens Road - A61	-35%	-43%
Winster Road (A61 Hillsborough)	-33%	-33%
R60 (152 Fitzwilliam Road)	-29%	-32%
Wicker (Kelham Island)	-29%	-62%
Shoreham Street	-38%	-58%
Wales (Wales Roadside Automatic)	-27%	-30%
Western Bank/Clarkson Road	-21%	-40%
Pond Street Interchange	-69%	-88%
A61 - Chesterfield Road - Meersbrook Park	-34%	-43%
Derwent Crescent (Brinsworth and Catcliffe)	-27%	-28%
Brightside Lane (Jenkin Road) (LSTF)	-31%	-35%
Droppingwell Road, Rotherham	-30%	-32%
Duke Street	-37%	-63%
Fenton Road, Rotherham	-50%	-49%
Derek Dooley Way	-10%	-27%
Sheaf Street	-34%	-43%
Sheffield Road (M1 34S)	-24%	-22%
St Mary's Rd	-40%	-38%
Attercliffe common	-33%	-31%
Shalesmoor	-37%	-49%
St Mary's Rd	-25%	-38%
Derek Dooley Way	-28%	-43%

Arundel Gate	-51%	-76%
Bellows road	-45%	-25%
Barber's avenue	-35%	-34%
(A61) Penistone Road	-31%	-36%

6.9 Bus Anti-Idling

6.9.1 Following the core modelling work and after the transport model outputs had been put through the Air Quality modelling processes, it was found that the Preferred Option achieved compliance in all locations except on Arundel Gate. In order to deal with that a further scheme was introduced into the modelling to implement anti-idling measures for buses stopping at the interchange location on Arundel Gate. This additional element to the scheme brought Arundel Gate into compliance. This was modelled as a post ENEVAL adjustment for which the methodology is covered in supporting document **SD02**.

Section 7 Impact Analysis on Traffic Demand

7.1 Introduction

7.1.1 This section details the impact on the highway network of the 2 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.

7.2 Network Statistics

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

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

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

7.2.3 From these network statistics, in general the introduction of a CAZ means that 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.

7.3 Changes in demand / Routing

7.3.1 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 2022 Baseline 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.

7.3.2 The figures in the appendix show that:

- There are decreases in traffic demand within the charging area;
- There are increases in flows to the south and south east of Sheffield City Centre, particularly around Highfield, Broomhall and Moorfoot. This is because of non-compliant vehicles rerouting around the CAZ;
- Increased traffic through the north of Sheffield City Centre as non-compliant vehicles reroute around Rotherham; and
- Decreased demand on Sheffield Parkway.

7.3.3 In addition to that the image below shows the impact on the Preferred Option of the switch from the situation with roadworks on the Rotherham Parkway to the situation with the Parkway widening in place. This increases traffic on the parkway itself, but as per the 2023 sensitivity test (see sperate sensitivity test note) has no impact on compliance. In addition, the opening of the Parkway widening scheme is likely to improve Air Quality along parallel routes particularly through the Lower Dona Valley and along the A57.

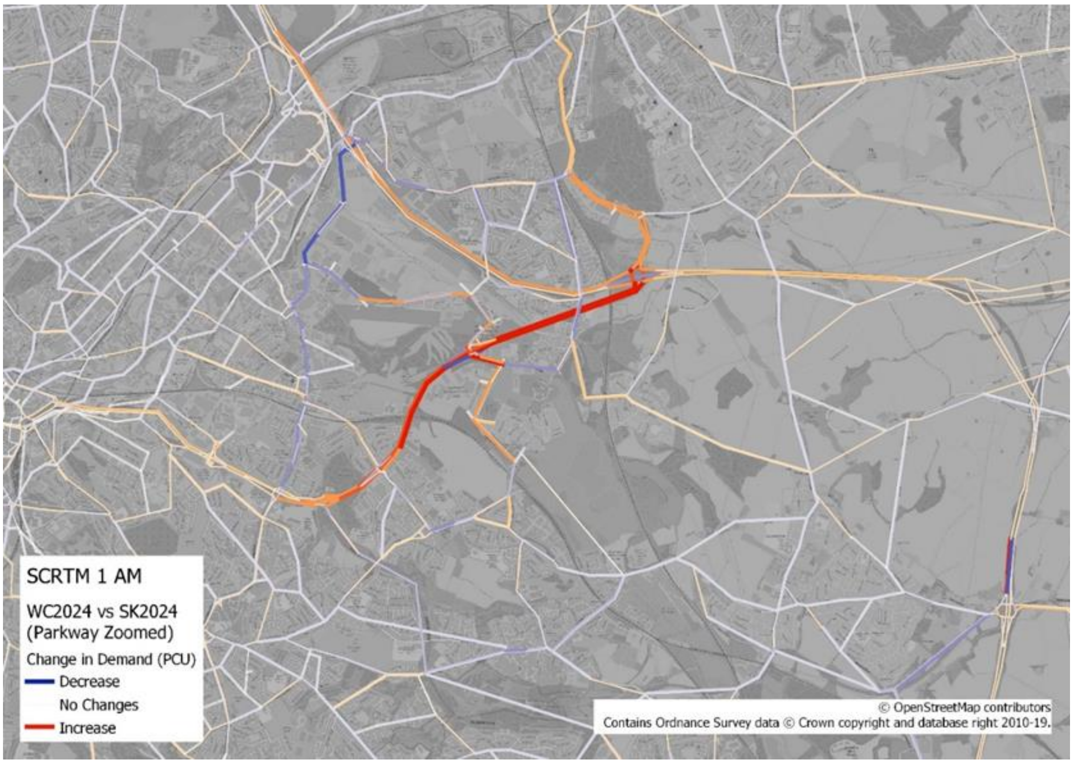

Figure 15. Rerouted Traffic as a Result of the Scheme

7.3.4 The table below describes the various elements of the scheme which cause rerouting and describe the impact that element of the scheme has.

Table 20. Scheme Elements which cause rerouting				
Scheme Element Causing Rerouting	**Details**	**Vehicles Effected**	**Where to they go**	**Additional Effects**
CAZ Charging	CAZ C for non-compliant vehicles, inside and including Sheffield Inner Ring Road	Through trip HGV, LGV, Coach (no rerouting assumed for taxi or bus)	Rerouted traffic switches to other orbital routes around Sheffield. Mainly impacts LGV as 90%+ HGV are compliant anyway. Coaches tend to have a origin or destination in the City Centre.	Some slight increases in car traffic through the centre of Sheffield which infill the small amount of capacity left behind by reduced LGV / HGV

A630 / A57 Speed limit change	Speed reduced from 70mph to 50mph but increase in capacity from 2 lanes to 3 lanes. Between Handsworth junction and M1.	All vehicles	Speed reduced on Parkway from 70mph to 50mph. Traffic attempting to reach M1 diverts onto A6102 Prince of Wales Road and then A631 Sheffield Rd as a faster way of reaching the M1. This is the cause of the minor reductions on the M1 as northbound trips join at J34. Southbound trips continue to use the Parkway access to the M1.	
Wortley Road HGV ban	HGV ban in uphill / northbound direction north of junction with Meadowbank Road	HGV only	HGV's divert from Wortley Road to Meadowbank Road and then the M1. only in northbound direction.	Some slight car traffic increase - very small!
Rawmarsh Hill Bus Rerouting	50% of buses on Rawmarsh Hill rerouted via Barbers Avenue	Bus	Buses divert from Rawmarsh Hill to Barbers Avenue.	Small increase in non-bus traffic on Rawmarsh Hill
Arundel Gate - Bus Gate	Bus Gate on Arundel Gate northbound (positioned to the south of Charles Street)	All vehicles except bus	Some rerouting of non-bus vehicles around the City Centre to access desired zone centroid connectors. This includes some increases on the Inner Ring Road. This effect is likely overstated due to lack of parking model within the SCRTM1 setup ie many of these car trips are likely to simply change their parking location rather than drive all the way round the City Centre to access a specific zone.	

7.3.5 Furthermore on the diversion impacts, there are a number of caveats to the responses predicted by the model:

- SCRTM1 is a strategic model and therefore doesn't have full road coverage, some of the orbital rerouting close to the city centre may be on roads not actually included in the model. In some areas the roads included in the model are 'valves' in order to allow trip movements contained within the matrix to occur. In some cases, one road included in the model may actually represent 2 or 3 roads so any dispersal is likely to be spread across several roads;

- In SCRTM1 there is more rerouting going on to the West of the city. However the SRTM3B model (used at OBC stage) suggested more would occur to the east. Some of the more minor orbital routes are not very well represented in the strategic models so it introduces a higher level uncertainty in these responses. We know that traffic will reroute but the exact routings are of higher uncertainty than other modelled impacts; and
- As already mentioned in a previous section of this document, it is likely that the rerouting predicted by the model is a slight overestimate (see section 6.4.2 for details).

7.3.6 In addition the next table shows the change in vehicle kilometres by geography and compliance category. This demonstrates effects which are expected within the Clean Air Plan, in particularly a reduction non-compliant vehicle kilometres within the charging area. There is also a reduced level of car kilometres across the modelled area due to more direct routes becoming slightly less congested (ie good vehicles trips have diverted elsewhere)

Table 21. Change in Vehicle kms (by compliance and geography)

Area	Vehicle Type	Compliant	Non-compliant	Total
Rotherham	Car	-0.60%	-0.60%	-0.60%
	LGV	-0.02%	-1.06%	-0.66%
	HGV	-0.59%	-2.80%	-0.89%
	Taxi	55.73%	-92.96%	0.00%
	Bus	15.87%	-61.98%	-0.24%
	Total	1.13%	-6.12%	-0.60%
Sheffield	Car	-0.23%	-0.23%	-0.23%
	LGV	2.31%	3.06%	2.77%
	HGV	1.03%	0.92%	1.01%
	Taxi	73.62%	-91.37%	0.00%
	Bus	22.56%	-85.90%	0.11%
	Total	1.35%	-3.74%	0.18%
Charging Area	Car	1.91%	1.91%	1.91%
	LGV	12.93%	-36.61%	-17.44%
	HGV	5.33%	-60.96%	-5.47%
	Taxi	87.35%	-90.60%	0.00%
	Bus	24.16%	-94.18%	-0.34%

	Total	5.28%	-20.91%	-1.08%
Total Modelled Area	**Car**	**-0.38%**	**-0.38%**	**-0.38%**
	LGV	**1.17%**	**-0.13%**	**0.37%**
	HGV	**0.28%**	**-1.10%**	**0.10%**
	Taxi	**63.03%**	**-92.19%**	**0.00%**
	Bus	**16.62%**	**-63.46%**	**0.05%**
	Total	**1.03%**	**-4.36%**	**-0.24%**

7.3.7 The table above shows that there is in total a reduction in vehicle kilometres across the modelled area and within Sheffield City Centre.

7.3.8 Finally, in this section the table below shows the daily vehicle trips within the cordon area in the Baseline and the Preferred Option. It is worth noting the very slight increase in car trips which has been noted elsewhere drawn in by reduction in goods vehicles.

Table 22. AADT vehicle flows in the CAZ area by compliance type / vehicle type (2022)

Vehicle Type	Compliance	Baseline	Preferred Option
Car	Compliant	174,814	178,154
	Non-Compliant	35,553	36,232
LGV	Compliant	11,167	15,565
	Non-Compliant	15,843	7,874
Rigid HGV	Compliant	2,426	2,442
	Non-Compliant	289	112
Artic HGV	Compliant	1,968	1,963
	Non-Compliant	51	24

7.4 Changes in Volume / Capacity

7.4.1 **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.

7.4.2 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.

7.5 Changes in Junction Delays

7.5.1 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.

7.5.2 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.

7.6 Changes in NO_x Tailpipe Emissions

7.6.1 Changes in the NO_x tailpipe emissions (predicted by ENEVAL) from the transport model are shown in **Appendix E.**

7.6.2 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 outside those areas including along some of the routes where traffic increasing to avoid the scheme.

7.6.3 In addition, the image below shows this clipped to a grid system which allows visualization of all the tailpipe emissions within a given area.

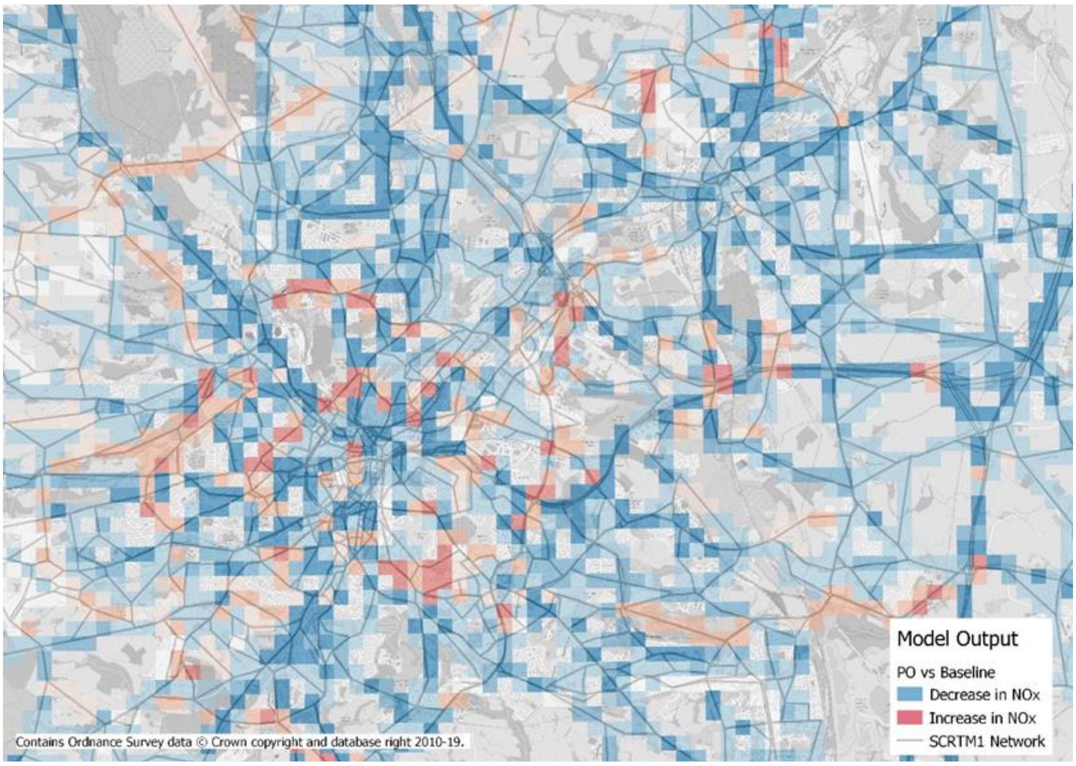

Figure 16. Change in NO_x Tailpipe Emissions between the Preferred Option and the Baseline

Section 8 Summary of Key Findings

8.1 Introduction

8.1.1 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.

8.2 Key Findings

8.2.1 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 (SCRTM1) 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[4] 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 SCRTM1) 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 Baseline scenario is unlikely to achieve compliance at all the monitored AQ hot-spot sites in Sheffield and Rotherham until 2025 (based on tailpipe NO_x reductions);
  - a charging-CAZ C is required in Sheffield City Centre (including the Inner Ring Road) along with additional schemes in Rotherham is expected to achieve compliance in 2022. This is the **Preferred Option** by SCC and RMBC.
- The behavioural (and other) responses to the introduction of a charging zone would see the following proportions of the non-compliant fleet in the Baseline upgrade in response to the CAZ – 57% LGV; 83% HGV; 84% Black Cab; 95% Private Hire Vehicles; and 100% of buses. *For LGV and HGV this relates only to those who have a trip end in the zone. Trips by these vehicle categories which pass through the charging zone upgrade at 50% of the rate and trips which do not interact with the charging zone remain as per the Baseline.*
- In addition to the charging zone additional non-charging measures are required to achieve compliance in other parts of the study area, notably:
  - A ban on uphill HGV's on Wortley Road in Rotherham;
  - Bus rerouting away from Rawmarsh Hill and onto the parallel Barbers Avenue (modelled as a 50% switch but a smaller proportion would achieve compliance);
  - Speed limit reduction of Rotherham Parkway (from 70mph to 50mph) to ensure traffic travels at a more efficient level and hence with lower emissions;
  - Upgrades to buses, Black cabs and Private Hire Vehicles across Sheffield and Rotherham. These are particularly important in helping to achieve compliance at Rawmarsh Hill, Fitzwilliam Road (in Rotherham) and on Arundel Gate (in Sheffield); and
- Some rerouting occurs around the charging area. This is on orbital routes around Sheffield, is relatively low in volume and is mainly by non-compliant LGV trips. Monitoring this rerouting will form part of the Monitoring and Evaluation plan.

[4] Compatible with the latest version of EFT v9.1b

8.3 Caveats

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

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Appendix T4-1

Traffic Analysis – Network Statistics

This appendix shows the high-level network statistics for each of the options considered compared to the 2022 Baseline (Baseline) test. Times are in hours, speeds are in kph and distance are in km.

Table 23. 2022 Cordon CAZ C AM Peak Highway Network Statistics						
Measure	**Compliant**			**Non-Compliant**		
	Baseline	CAZ C	DIFF	Baseline	CAZ C	DIFF
Average Travel Time (mins)						
Car Commute	47.341	47.346	0.005	47.366	47.358	-0.008
Car Business	47.469	47.471	0.001	47.412	47.416	0.004
Car Other	47.480	47.494	0.014	47.465	47.459	-0.006
LGV	47.525	47.534	0.009	47.538	47.551	0.013
HGV - Rigid	47.526	47.549	0.023	47.098	47.236	0.138
HGV - Artic	47.469	47.509	0.040	47.057	47.202	0.145
Black Cab	46.810	47.299	0.489	47.290	46.333	-0.956
PHV	47.446	47.455	0.010	47.311	46.105	-1.206
Bus	43.097	43.079	-0.019	43.097	0.000	-43.097
Coach	47.117	47.172	0.054	46.534	46.534	-0.001
Average Travel Distance (km)						
PHV	47.446	47.455	0.010	47.311	46.105	-1.206
Car Commute	23.952	23.959	0.000	23.985	23.988	0.000
Car Business	24.032	24.046	0.000	24.021	24.026	0.000
Car Other	24.009	24.037	0.000	24.017	24.025	0.000
LGV	24.175	24.196	0.000	24.168	24.173	0.000
HGV - Rigid	24.163	24.179	0.000	23.967	24.007	0.000
HGV - Artic	24.140	24.166	0.000	24.004	24.040	0.000
Black Cab	23.683	23.914	0.000	23.914	23.441	0.000
PHV	23.993	23.993	0.000	23.926	23.360	-0.001
Bus	20.761	20.760	0.000	20.761	0.000	20.761
Coach	24.023	23.997	0.000	23.775	23.716	0.000

Average Speed (kph)						
Car Commute	30.357	30.362	0.005	30.382	30.391	0.009
Car Business	30.376	30.392	0.016	30.399	30.402	0.003
Car Other	30.340	30.366	0.026	30.360	30.374	0.014
LGV	30.521	30.542	0.021	30.503	30.501	-0.002
HGV - Rigid	30.505	30.510	0.005	30.532	30.494	-0.037
HGV - Artic	30.513	30.520	0.007	30.606	30.558	-0.048
Black Cab	30.356	30.335	-0.021	30.341	30.356	0.014
PHV	30.342	30.336	-0.006	30.343	30.400	0.057
Bus	28.904	28.915	0.011	28.904	0.000	-28.904
Coach	30.591	30.523	-0.068	30.655	30.579	-0.075

Table 24. 2022 Cordon CAZ C PM Peak Highway Network Statistics

Measure	**Compliant**			**Non-Compliant**		
	Baseline	CAZ C	DIFF	Baseline	CAZ C	DIFF
Average Travel Time (mins)						
Car Commute	47.961	47.992	0.031	47.992	48.013	0.020
Car Business	48.015	48.033	0.018	47.946	48.029	0.083
Car Other	48.057	48.095	0.038	48.049	48.096	0.046
LGV	48.061	48.087	0.026	48.103	48.163	0.060
HGV - Rigid	47.981	48.042	0.061	47.272	47.452	0.181
HGV - Artic	47.832	47.918	0.086	47.063	47.336	0.272
Black Cab	47.574	47.912	0.338	47.885	46.833	-1.052
PHV	47.983	48.010	0.027	47.933	46.872	-1.061
Bus	43.238	43.255	0.017	43.238	0.000	-43.238
Coach	47.221	47.324	0.103	45.415	45.366	-0.049
Average Travel Distance (km)						

Car Commute	47.961	47.992	0.031	47.992	48.013	0.020
Car Business	48.015	48.033	0.018	47.946	48.029	0.083
Car Other	48.057	48.095	0.038	48.049	48.096	0.046
LGV	48.061	48.087	0.026	48.103	48.163	0.060
HGV - Rigid	47.981	48.042	0.061	47.272	47.452	0.181
HGV - Artic	47.832	47.918	0.086	47.063	47.336	0.272
Black Cab	47.574	47.912	0.338	47.885	46.833	-1.052
PHV	47.983	48.010	0.027	47.933	46.872	-1.061
Bus	43.238	43.255	0.017	43.238	0.000	-43.238
Coach	47.221	47.324	0.103	45.415	45.366	-0.049
Average Speed (kph)						
Car Commute	30.137	30.135	-0.002	30.169	30.162	-0.007
Car Business	30.153	30.150	-0.003	30.171	30.165	-0.007
Car Other	30.137	30.135	-0.002	30.145	30.140	-0.005
LGV	30.342	30.345	0.003	30.335	30.296	-0.039
HGV - Rigid	30.348	30.331	-0.017	30.408	30.330	-0.078
HGV - Artic	30.383	30.365	-0.018	30.472	30.438	-0.033
Black Cab	30.123	30.092	-0.030	30.109	30.070	-0.039
PHV	30.098	30.081	-0.017	30.105	30.142	0.036
Bus	28.648	28.635	-0.013	28.648	0.000	-28.648
Coach	30.450	30.350	-0.100	30.640	30.531	-0.109

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Appendix T4-2

Traffic Analysis – Flow Differences

This appendix shows the changes in demand flow in the Preferred Option compared to the 2022 Baseline. The AM and PM peaks are presented along with a zoomed in view of the Parkway in the PM interpolation and show Preferred Option minus Baseline.

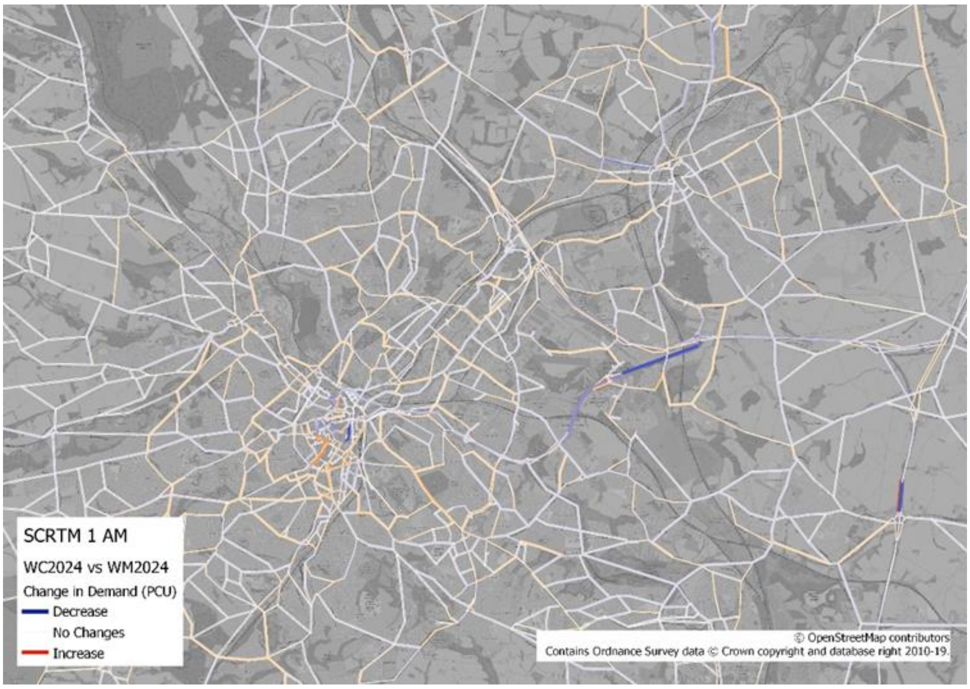

Figure 17. 2022 Cordon CAZ C – AM Peak Demand Flow Changes

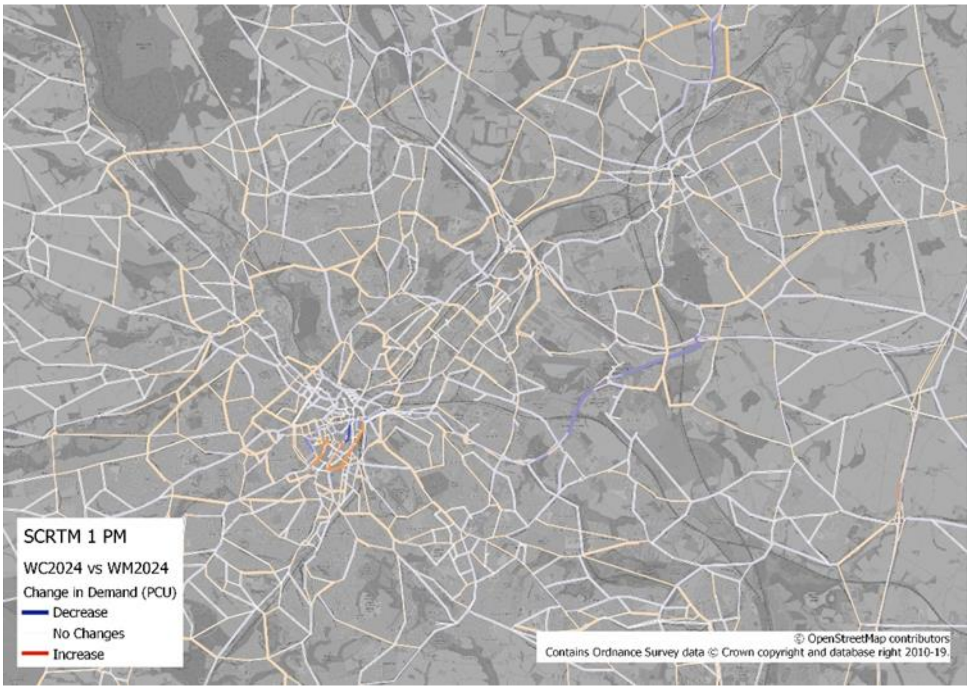

Figure 18. 2022 Cordon Caz C – PM Peak Demand Flow Changes

Figure 19. 2022 Cordon CAZ C – AM Peak Demand Flow Changes – Sheffield Parkway Area

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Appendix T4-3

Traffic Analysis – Vol / Capacity Differences

This appendix shows the changes in volume divided by capacity in the Preferred Option compared to the 2022 Baseline. The AM and PM peaks are presented. These plots are based on 2024 assignments ie without interpolation and show Preferred Option minus Baseline.

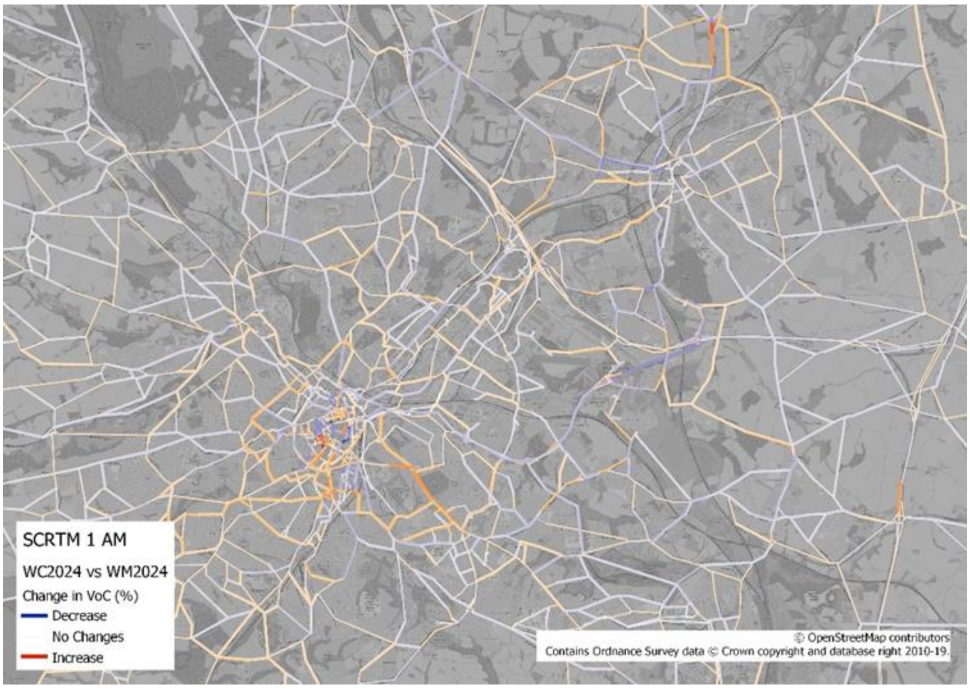

Figure 20. 2022 Cordon CAZ C – AM Peak Volume / Capacity Changes

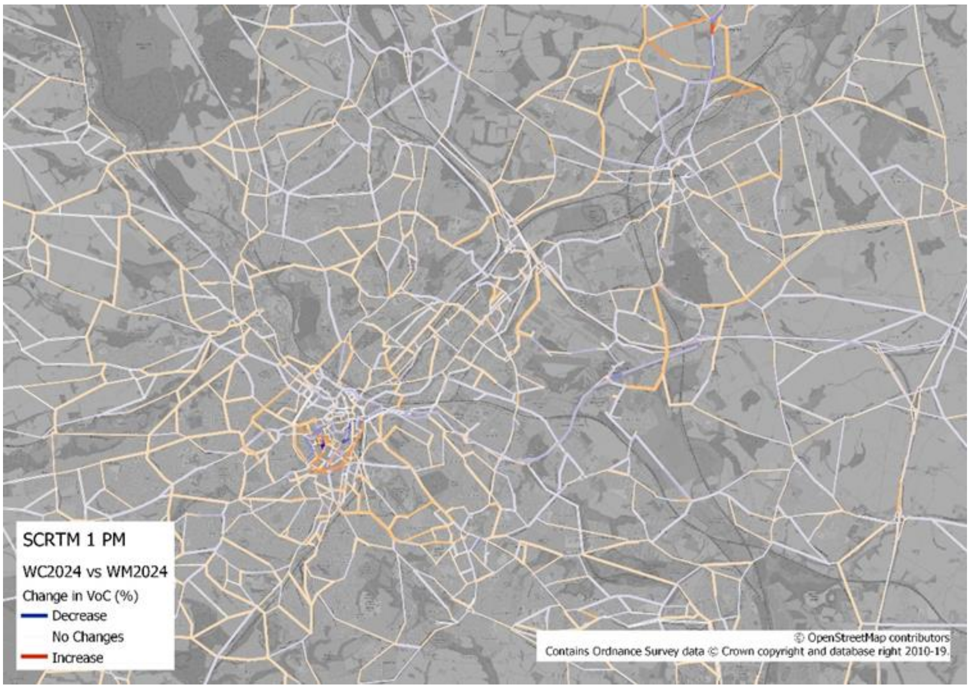

Figure 21. 2022 Cordon CAZ C – PM Peak Volume / Capacity Changes

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Appendix T4-4

Traffic Analysis – Junction Delay Differences

This appendix shows the changes in junction delay in the Preferred Option compared to the 2022 Baseline. The AM and PM peaks are presented. These plots are based on 2024 assignments ie without interpolation and show Preferred Option minus Baseline.

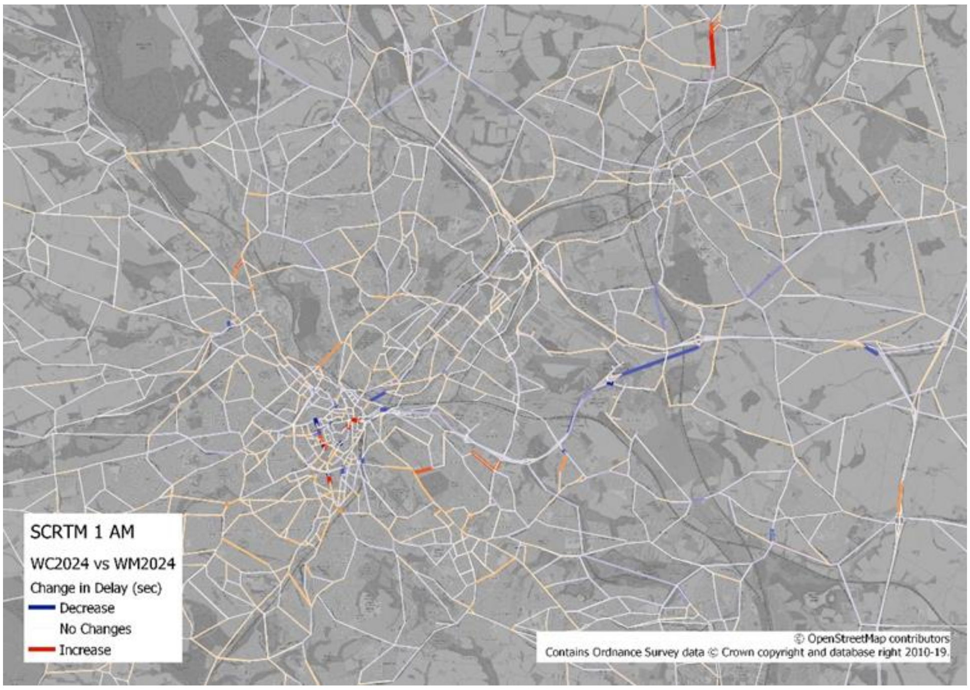

Figure 22. 2022 Cordon CAZ C – AM Peak Junction Delay Changes

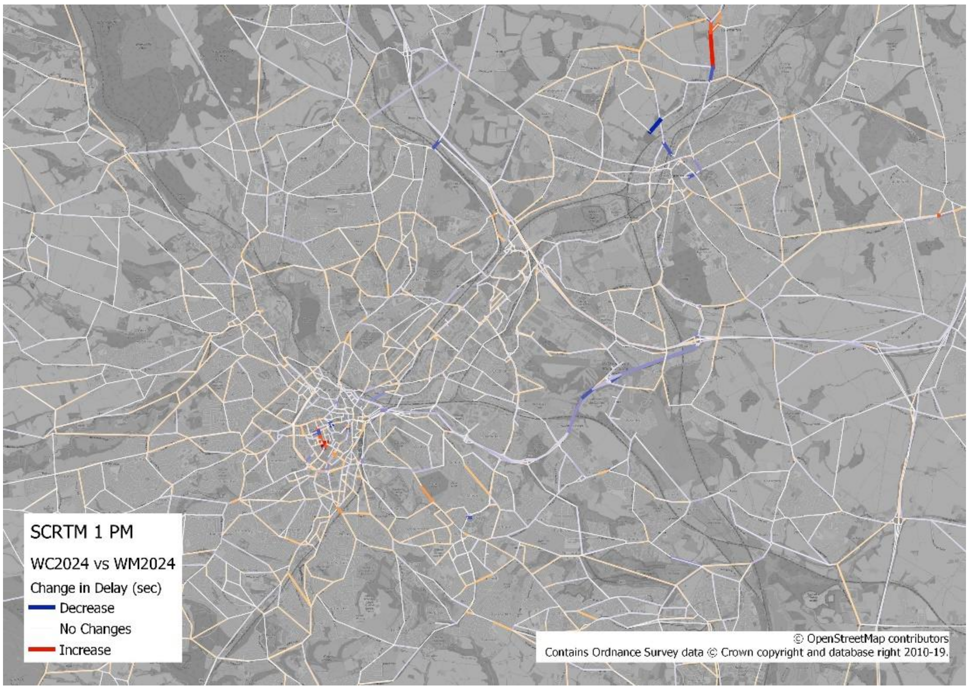

Figure 23. 2022 Cordon CAZ C – PM Peak Junction Delay Changes

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Appendix T4-5

Traffic Analysis – NO_X Emission Differences

This appendix shows the changes in NO_x Emissions in the Preferred Option compared to the 2022 Baseline. This shows the 24hour change in NO_x across Sheffield and Rotherham. Blues are decreases in NO_x and red increase.

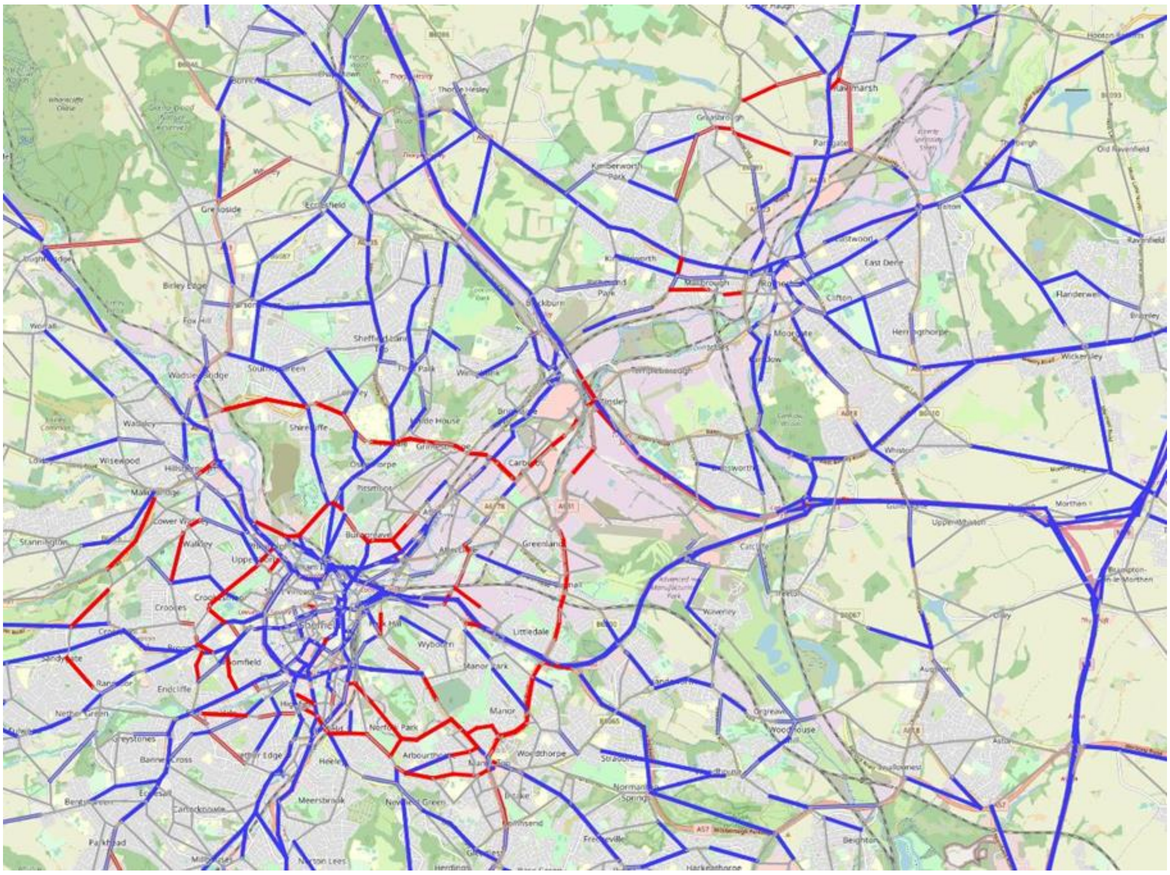

Figure 24. 2022 Cordon CAZ C – NO_x Emission Changes

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Appendix T4-6

Through Trips Methodology

Introduction

Our local behavioural research (supplemented by JAQU Guidance) has provided estimates of the likelihood of fleet upgrades by those travelling to/from a proposed charging area, but not any/much evidence regarding the likely fleet upgrade responses of those making trips which pass through the charging area.

Non-compliant vehicles that travel through a proposed CAZ area in a Baseline scenario will be impacted by the introduction of the charging scheme within that CAZ area. The owners of these vehicles have four choices – reroute to avoid the charge, pay the charge and continue to drive through the CAZ, abandon the trip (or change its origin or destination) or upgrade the non-compliant vehicle to a compliant one. This is one more choice that is available to the owners of vehicles making trips which start &/or finish inside the CAZ, who do not have the option to simply reroute to avoid the charge.

In the previous (December 2018) version of our Preferred Option, we made what we-believed at the time to be a conservative ‘worst case’ assumption, namely that the fleet upgrade responses for non-compliant through trips could/should be ignored and that doing so would generally over-estimate future Do Something emissions, by ignoring these additional Do Something fleet improvements.

However, JAQU have asked us to revisit this assumption, to determine the potential benefits (and disbenefits) from assuming that some or all of the owners of the non-compliant through-trip vehicles might also consider upgrading their vehicles.

The methodology which SCC/RMBC/SYSTRA have discussed and agreed with JAQU for incorporating these additional fleet upgrade effects is described below.

Extraction of through trips

To extract the through trips, a list of links on sections that would be used by traffic inside the CAZ cordon was created.

The 2022 forecast year is created by interpolating between 2017 base year and a 2024 forecast year, thus for each of the 2017 and 2024 unsegmented assignments and the three time periods (morning peak hour, interpeak average hour, and evening peak hour), the routing and demand information was extracted from the model.

This data contains, for each user class, the demand from origin to destination and the exact routing information from origin to destination and all intermediate nodes in the future Baseline (ie prior to the introduction of the CAZ) model.

From this dataset, the routes that passes through any links inside the charging area was extracted for each affected user class. The portion of this demand whose origin and/or destination lies inside the proposed CAZ charging area was then removed, to leave an origin-destination matrix of ‘through trips’.

Note that this through-trip matrix will only include the proportion of the original demand which chooses to travel through the proposed CAZ area in the future-year Baseline. For example, if an OD pair has two equally good routes, one through the proposed CAZ and the other around it, then we would expect the through trip matrix to only include around 50% of the original OD demand of non-compliant vehicles (ie just the subset which chooses to route through the CAZ-area in the Baseline traffic assignment).

Note also that we use the travel pattern before the introduction of the charge, not after, so that the matrix of through trips is the full set of those who would be affected by the introduction of the CAZ charging, not just those who opt to pay the charge to continue to drive through the CAZ area in the Do Something scenario.

Applying demand response to through trips

When creating the compliant/non-compliant segmented OD-matrix to highway input, it is initially done using the same methodology as without through trips, splitting the demand by its origin and destination. From the through trips OD-matrix, two matrices are created, one multiplied by absolute difference in compliance between trips to/from the CAZ cordon and other trips which is added to the compliant part of the highway matrix, and one multiplied by absolute difference in non-compliance between trips to/from the CAZ cordon and other trips which is removed from the non-compliant part of the highway matrix. For 50% through trips, the factors above are reduced by 50%. The new matrix is then assigned to the highway network.