SHEFFIELD AND ROTHERHAM CLEAN AIR ZONE (CAZ) FEASIBILITY STUDY - ANALYTICAL ASSURANCE STATEMENT

1. Introduction

This document is the Analytical Assurance Statement for the Transport and Air Quality Modelling work undertaken to support the Sheffield and Rotherham Clean Air Zone (CAZ) Feasibility Study. This document has been put together in accordance with JAQU guidance and feedback on the Initial Evidence Submission (IES) to support the Outline Business Case (OBC) submission. This version of the document has been updated following clarifications required by JAQU in response to the OBC submission.

This document sets out the main limitations, risks, uncertainties and suitability for use of the Transport and Air Quality Modelling packages used to inform the Sheffield and Rotherham CAZ Preferred Option.

2. Limitations of the Analysis

- *Has the analysis been constrained by time or cost, meaning further proportionate analysis has not been undertaken?*

Timescales for the work have been very constrained in order to comply with the governmental Legal Directive; however despite this we have ensured that the impact on the quality of the work produced has been minimised and all of the key outputs have been thoroughly checked.

On the Transport Modelling side, we have used the latest available version of the Sheffield and Rotherham Transport Model (SRTM3B) to undertake the work which has supported the Strategic Outline Case (SOC) and also underpinned the Outline Business Case (OBC). The tight timescales available for this work has prevented us from waiting to use an emerging WebTAG compliant model of the Sheffield City Region (SCRTM1), which was being created, calibrated and tested during 2018 and is only now[1] becoming ready to test future-year scenarios. As a result, while the SRTM3B model has some known issues in terms of calibration and validation, JAQU have accepted that this was the best available model for the OBC and have approved its use in this situation.

Furthermore, for the initial option testing, a simplified traffic and fleet adjustment-based approach was used, to reduce the move the need for time-consuming runs of the full Variable Demand Model (VDM) on all of the numerous variants tested during the Study. The Preferred Option and its main alternative have, however, been tested using the full VDM, to ensure that we have a full understanding of all of the demand responses to these two main options.

Similarly, the Air Quality Modelling has been very constrained by the Legal Directive timescales and due to long run times associated with the AIRVIRO model. An annual time series run using hourly sequential meteorological data takes around 14 days to run.

[1] April / August 2019 – not yet signed off by DfT for Innovation Corridor scheme.

Therefore an annual 'scenario' of 'typical' meteorological data was created for the study by the Swedish Meteorological and Hydrological and Meteorological Institute reducing modelling run times to around 2-3 days. Not every scenario that has been run through the transport model has been fully evaluated in the Air Quality Model, and therefore it was not possible to fully assess every scenario considered at this level of detail. However, all scenarios leading up to and included in the final **Preferred Option** have been through the full Air Quality Modelling process. It was agreed with JAQU throughout the process that meeting the deadlines for submission was the most important factor in this work.

Limited further analysis was undertaken at OBC stage in order to minimise the effects of the key limitations identified and described above, including:

- Sensitivity Tests (described in T4) to determine the impacts of the main areas of uncertainty within the Transport Modelling;
- Use of both Local and National Behavioural responses (also covered in T4 and later in this document) to confirm the expected impacts on local road users of the Preferred Option, noting that the local socio-economic composition in Sheffield and Rotherham is different to the national picture; and
- Refinements to the Preferred Option within the Transport Modelling.

Further sensitivity tests were subsequently undertaken post OBC which are reported in this revised document. That additional work also changed the assumptions underpinning the final **Baseline** and final **Preferred Option**, but no changes in the definition of the scheme have been made.

- *Could this further analysis lead to a substantive change in the conclusions?*

  Given the Sensitivity Tests undertaken for OBC, the additional sensitivity tests following OBC and the teams experience in using the Transport and Air Quality models driving the conclusions, it is not anticipated that any further analysis would significantly change the conclusions of the CAZ study. There is no evidence to suggest that any additional work would alter the Preferred Option[2], which has been modelled or indeed any of the alternative scenarios being presented as part of the OBC. It could however, provide greater detail and understand on the medium-term impacts on travel patterns in Sheffield and Rotherham.

  The Transport Modelling also suggests that the expected Business as Usual fleet upgrades (ie retaining the current age profiles of the various fleets) will be sufficient to achieve compliance with the 40 µg/m^3 annual average limit value for NO_2 concentrations by 2025. This is based on the changes over time included in EFTv8, but this may change slightly based on the emerging evidence relating to the earlier than expected switch away from diesel cars. This therefore removes any risks associated with modelling assumptions that might only significantly affect the traffic forecasting beyond 2024 (e.g. assumptions concerning medium and long-term developments or changes in general mobility patterns, car ownership etc.).

- *Does the analysis rely on appropriate sources of evidence? (Rate the source of evidence high/moderate/low)*

  The Transport and Air Quality modelling work undertaken to inform the OBC has used the best models available at the time and also the best data sets available. The key data sets are discussed in detail in the table below and each source is rated based on our assessment of

[2] This has been borne out by the post-OBC sensitivity testing

its quality. This table covers both the input data sources used in the Transport Modelling and the Air Quality modelling and is ordered in terms of the highest ratings.

Data	Description	Rating (Rank)
ANPR Data	Comprehensive ANPR data has been used to establish a robust view of the local fleet. This data was collected over a full 12-month period between December 2016 and November 2017. This is significant data set and as such is considered to be a highly reliable piece of evidence describing the fleet composition within Sheffield and Rotherham. It is also important to stress that having a full year's data enables an analysis of the frequency of visits by a particular vehicle, which is essential for assessing the efficacy of any CAZ proposal, without this any study cannot establish outcomes of any CAZ proposal. Note that this data collection is continuous and will therefore, form a key part of our OBC Monitoring and Evaluation Plan.	Very high (1)
Local Meteorological Data	The meteorological data used in Airviro is either measured data from Sheffield CC's Met Mast or bought in and converted Met Office data from suitable local sites if there is insufficient data from the local mast for a particular year. It is essential to have good data capture for the weather data. A meteorological pre-processor routine within the AIRVIRO software tool analysed the local weather data obtained from the weather mast within the urban area of Sheffield. This is done for 360 different weather cases, representing the various possible combinations of wind direction and stability, including velocity and vertical temperature profile. Due to the location of the weather mast the data is deemed to be representative and a highly reliable source of evidence.	High (2)
Diffusion Tube Data	Diffusion Tube data has been collected from over 200 sites across Sheffield and Rotherham throughout the last 20 years of LAQM work. This gives very good coverage of the two urban areas and concentration trends. It also means that the two Councils have a very good understanding of the actual levels of nitrogen dioxide in their areas, as reported under LAQM since 2000. The collection of this data has been undertaken in line with guidance and is therefore, considered a very robust piece of evidence. This monitored data is key for validating model outputs as it has spatial coverage which cannot be achieved with a few automatic monitors, and can also monitor levels of nitrogen dioxide close to roadside where it may be impossible to site automatic equipment. Note that this data collection is on-going and will therefore, form a key part of our OBC Monitoring and Evaluation Plan.	High (3)

Local Behavioural Research	Local Behavioural Research was carried out to determine the likely response of residents, taxi drivers and goods vehicle operators to charging within Sheffield and Rotherham. This is a piece of primary research we understand has not been undertaken in other CAZ studies and as such is considered a very strong piece of evidence. The slight concern with this data set is that it represents a Stated Preference rather than a Revealed Preference response and may not fully reflect real life responses.	Medium / High (4)
Data used to build the Traffic Model	The underlying data used to build the original version of the WebTAG compliant 2008 Base Year SRTM3 model came from a variety of robust data sources including Roadside Interview (RSI) Data, various traffic count data sets and TrafficMaster journey times. This model was updated to a 2017 Base Year in SRTM3B by incorporating local schemes, development and traffic growth from RTF 2018. The model was built in line with WebTAG guidance and more detail can be found on this in the accompanying T2 Transport Model Validation Report.	Medium (5)
Traffic Flows	The traffic flows used in the emissions calculations and the Air Quality modelling are taken from the SRTM3B transport model. These traffic speeds have been validated using local count data taken from the DFT's count database. There are some known deficiencies in this validation as discussed in the accompanying T2 Transport Model Validation Report, but in large parts of the modelled area the validation reaches acceptable levels against the WebTAG criteria. In particular, there are some known shortcomings in the validation of goods vehicle flows at certain geographical locations. A modest recalibration exercise was undertaken at the start of this project which resulted in some minor improvements to the validation compared to the previous version of the model. It should be noted that the version of the Transport Model being used for the CAZ OBC i.e. SRTMB has been approved by Highways England in assessing Sheffield City Council's Local (Land Use) Plan.	Medium (6)
Traffic Speeds	The traffic speeds used in the emissions calculations and the Air Quality modelling are also taken from the SRTM3B model. These traffic speeds have been validated using local TrafficMaster data. There are some known issues, largely regarding the model being too fast, in this validation and this is discussed in the accompanying T2 Transport Model Validation Report. A small-scale recalibration exercise was undertaken at the start of this project which resulted in some modest improvements to the validation compared to the previous version of the model. It should be noted that the version of the Transport Model being used for the CAZ	Low / Medium (7)

	OBC i.e. SRTMB has been approved by Highways England in assessing Sheffield City Council's Local (Land Use) Plan.	
Emissions Factor Toolkit	The latest version of the Emissions Factor Toolkit (EFT), v8.0.1b, which feeds into the ENEVAL process[3] used to generate emissions from the outputs from the Transport Model has been reviewed and found to be very pessimistic in its future fleet development. This includes a very slow uptake of new vehicle technologies. It also predicts a continuing growth in diesel cars up to 2021, whereas evidence from DfT suggests that diesel car sales are already in decline (these have been included in the post-OBC modelling updates). The EFT also does not include the latest emerging versions of Euro 6 Black Cabs which are expected to be better than the existing Euro 6 vehicles available. The result of this is that it is quite possible that the assumptions in the EFT will overstate the scale of NOx emissions in the coming years and therefore, should be considered a very conservative estimate of the 'natural' fleet churn over the coming years. A separate technical note for JAQU review is being prepared on this point. However, on the flip side, the EFT makes several assumptions about the effectiveness of new technologies to reduce emissions and it is not yet clear whether these emissions reductions will be achieved in real life driving conditions.	Low / Medium (8)

- *How reliable are the underpinning assumptions? (Rate level of reliability high/moderate/low)*

  The CAZ study uses a wide range of assumptions in both the Transport and Air Quality models, most of these are either applied directly or have been derived from the JAQU guidance. However, a number of local assumptions have been made based on locally available data sets and primary research undertaken as part of the study.

  A full review of the key assumptions underpinning the Transport and Air Quality modelling has been undertaken to evaluate the level of reliability of each. These are detailed in the following table along with a rating and rank of the reliability, with those considered the most reliable first (and hence have a higher rank).

Assumption	**Description**	**Rating (Rank)**
Base Year Local Fleet	Based on local high quality ANPR data collected over a 12-month period. The Base year fleet assumptions derived from this are considered to be very reliable.	High (1)

[3]ENEVAL is SYSTRA's environmental assessment software which is designed to automate the estimation of link-based emissions from the outputs of our traffic models, using emissions factors derived from the values used in v8.0.1b of the Emissions Factors Toolkit

Meteorological Data	As this is based on locally collected data from the weather mast within the Sheffield urban area or purchased from the Met Office and converted by the Swedish Meteorological and Hydrological Institute when local data is not available. This data are considered highly reliable and has high levels of data capture.	High (2)
Local Development	Local Development data used to drive changes in traffic flows over time has been taken from the data developed in the Spring of 2018 for the Sheffield and Rotherham Local (Land Use Plan) modelling as agreed with Highways England. This data has been further reviewed as part of this CAZ modelling work, as well as for the development of SCRTM1, and as such the assumption derived from this is that it can be considered very reliable.	High (3)
Committed Schemes	As with the Development data above, the committed schemes which are likely to be delivered between now and the end of 2024 have been taken from the Sheffield and Rotherham Local (Land Use) Plan modelling version of SRTM3B. This list of assumed future developments has been reviewed as part of this CAZ modelling work (and the concurrent development of SCRTM1 during 2018). The reliability of these assumptions will be high for the early years (ie the period when the predicted traffic emissions are most-critical to this Study), but will then decrease over time	High (4)
Measured Roadside Concentrations	The two Councils both have automatic monitoring stations for nitrogen oxides and carry out large surveys annually using diffusion tubes. This data is bias-adjusted annually following LAQM(TG16) methodology. Outputs from the air quality modelling Base Year were validated and adjusted using base year monitored data. The monitoring is undertaken following LAQM(TG16) guidance. We measure average NO_2 using the diffusion tubes. The Defra NO_X:NO_2 diffusion tube tab has been used to convert between NO_X and NO_2 roadside concentrations, in line with LAQM (TG16) and JAQU Guidance.	High (5)
Air Quality Assumptions	Road emissions are not the only source of NO_X. Sheffield and Rotherham have worked with their Airviro model for over 20 years and have EDBs containing all known point and area sources. This EDB was used to establish the contributions from industrial, domestic, minor road sources etc. A regional background for nitrogen dioxide was obtained from Ladybower AURN site (situated in the Peak District to the west of the study area) The combined 'background' was made up of these sources and is regarded as good quality data.	High (6)

Forecast Year Local Fleet Data	This is based on the Base Year local fleet split derived from ANPR data with EFT changes over time applied to obtain the forecast fleet composition. Our review has noted some concerns with the EFT forecasts and in particular we feel that the national (non-London) values contained in the EFT may not be representative of the changes which will occur in Sheffield and Rotherham over time.	Medium (7)
Behavioural Responses to a Charging CAZ	The assumptions used in the Transport Modelling to describe how different groups will react to a Charging CAZ come from the Local Behavioural Research. This is described in T4 and as noted above is a robust data source, however the use of this Stated Preference data(rather than Revealed Preference) in the model is subject to the normal caveats surrounding this type of data. For example, the outturn responses of the population may be somewhat different. However, with the lack of any scheme in place, no outturn analysis has been undertaken so these assumptions are deemed to be the best available. Also, two different variants of the responses were produced a conservative estimate and a pessimistic estimate, it is the former that has been used in the modelling, to be confirmed by JAQU.	Medium (8)
Transport Model (flows and speeds)	The SRTM3B transport model has recently been rebased to 2017. This means that although there are some known issues with the model and the validation, as set out above and in the T2 Report, this recent update has used the best currently-available data.	Medium (9)
Emission Factors	Emissions factors (and associated scaling parameters) have been used as per the latest EFT (v8.0.1b). The assumptions included in the EFT, particularly for emerging vehicle types, are based on testing regimes and may not reflect real life driving conditions.	Medium (10)
Values of Time	Absolute and Changes in Values of Time have been applied as per the WebTAG Databook (WebTAG Databook Spring 2016 v1.5). No update has been made for local conditions.	Medium (11)
Car Occupancy Changes	Car Occupancy changes over time have been based on the default profiles provided in the WebTAG Databook, with no attempt to calibrate these to local conditions, such as current occupancy, local car ownership patterns, household size etc. This is unlikely to be a significant issue over the short-term timescales being considered in this Study	Medium (12)
Benefit Interpolation	The main SRTM3B transport model inputs and outputs are only available for 2017 and 2024. To model the step-change created by the assumed introduction of the various	Medium (13)

	CAZ schemes on 1st January 2021, we use linear interpolation between a (hypothetical) Do Something version of 2017 and the (predicted) Do Something version of 2024. This approach assumes that the various changes between 2017 and 2024 (including the Business as Usual fleet upgrades) occur linearly over this 7-year period.	
Number of Upgrades Required to the fleet of articulated HGVs	The default behavioural responses of the owners of non-compliant HGVs provided by JAQU would imply that a significant number of very low frequency[4] articulated HGVs will upgrade in response to the various SCC/RMBC CAZ schemes being tested here. While these 'artics' are likely to be affected by CAZ schemes elsewhere in the UK (and beyond) and may therefore upgrade in line with the JAQU guidance, the absence of any national modelling/ forecasting makes it difficult to confirm this. It is therefore not appropriate to assume the full cost of upgrading this large fleet of low frequency articulated HGV's within our economic appraisal. We propose to exclude the cost of upgrading these low frequency articulated HGV's from our economic analysis.	Medium (14)
Interpolation Process	The forecast year of the SRTM3B model is 2024, so to obtain traffic flows in 2021 we have interpolated the traffic flows and speeds from 2017. We have removed developments from the 2024 forecast which we know for certain will not be in place by 2021 (including the large West Bar development in Sheffield city centre) and assumed that other more-general developments will come on-stream 'linearly'(ie with 4/7ths of their traffic impacts affecting to the road network in 2021)	Medium (15)
Construction Traffic	The Transport modelling has not attempted to include the impacts of any roadworks or construction traffic which might affect the level of NO_X emissions at any key air quality 'problem' locations during 2021. In particular, the emissions-related impacts of the construction phase of the proposed widening of the A630 Parkway to the west of the M1 has not been included in our forecasting of 2021	Medium (16)
Taxi Emissions	The level of black cab emissions in the modelling is based on their emissions factors as set out in EFTv8. However, some Real Driving Emissions (RDE) data, collected for a previous study in Sheffield highlighted that local taxis were often emitting significantly more pollution than would be expected based on their age/EURO category, presumably due to the much-higher-than-average total mileage of these vehicles. This would be an underestimate more in the Base Year than in the forecast Baseline or Preferred Option	Medium (17)

[4] ie passing a given camera location less than once per month

Goods vehicle trip patterns	The goods vehicle component of the SRTM3B has been mainly calibrated using traffic counts and therefore, while it will provide a reasonable estimate of good vehicle traffic on individual links, there is less evidence supporting the underlying origin-destination travel pattern of goods vehicle movements. This needs to be borne in mind when considering the predicted rerouting impacts of any CAZ scheme which affects goods vehicles.	Low / Medium (18)
The number of different vehicles driving within the CAZ per day	The SRTM3B uses a tour-based representation of trip-making, with the set of 1-way trips split into a set of discrete home-based pairs and 1-way trips. The model does not provide any information about how many trips each individual vehicle makes in a given area per day. Assumptions are therefore required when converting from the set of 1-way or simple 2-way trips within the CAZ and the number of vehicles which would pay the daily charge. These 'average trips per day' factors are particularly important for light goods vehicles, many of which are likely to make multiple city centre trips per day. These assumptions do not affect the fleet upgrading or emissions modelling, but are needed in the Economic and Financial Cases, to predict the assumed amount of CAZ charges paid by a day's worth of 1-way trips by non-compliant vehicles. We propose to use values which are consistent with those used in modelling London's Congestion Charging scheme.	Low / Medium (19)
Bus Upgrades Achievable	All Buses operating on non-compliant roads can in theory upgrade to Euro 6, Euro 6 equivalent or better by 2021. This is an achievable assumption, but requires financial support packages (subject to State Aid issues), and may cause issues for smaller operators and will be slightly more difficult to achieve in Rotherham due to the geographical location of Air Quality issues in that authority.	Low / Medium (20)
Taxi Upgrades due to Licensing changes	It is assumed in the Transport Modelling that 60% of Black Cabs and Car based Private Hire Vehicles will have upgraded to ULEV by 2021 as a result of new Licensing obligations introduced by SCC This assumes a steady renewal rate for the fleet which may not be achieved and does not include any exemptions.	Low / Medium (21)
Hearts and Minds Campaign	The Hearts and Minds campaign to encourage local car drivers to upgrade to compliant petrol or ULEV vehicle when they next upgrade their car, assumes 20% switch in Sheffield and a 10% switch in Rotherham over and above the fleet projections in the EFT. These levels of upgrade have been included in the Transport modelling. This is ambitious, but as described above there is evidence that the EFT projections are fairly pessimistic and that this process is already happening. Also, when diesel cars were	Low / Medium (22)

	being strongly promoted for their efficiency changes of this magnitude were not uncommon in parts of the country. There is therefore evidence that this assumption can be achieved.	

Distributional Impacts Assumption	Analysis will be carried out on current population demographics assuming similar patterns will be in place in future.
	User benefits/disbenefits and affordability will be based on TUBA and it is assumed that all benefits and user charges will be modelled using TUBA.
	For impact on people benefits/disbenefits included are:
	• Trip purposes 'Commuting' and 'Other';
	  ○ AM home based (from zones);
	  ○ IP average to and from each zone;
	  ○ PM to zone trips;
	• For impact on businesses benefits/disbenefits included are:
	  ○ Trip purpose 'Business';
	  ○ AM,IP and PM average to/from each zone;
	• For impact on LGVs:
	  ○ User class 4;
	  ○ AM, IP and PM average to/from each zone;
	• Air quality benefits/disbenefits provided in georeferenced sensitive receptors will be distributed to population per LSOA
		Low / Medium (23)

Some of the above assumptions have been considered in the Sensitivity Testing which is detailed in the T4 Local Plan Transport Model Forecasting Report and the AQ3 Local Air Quality Modelling Report. These results align with the relative reliability of the assumptions, as presented above.

Overall, the reliability of the assumptions contained in the Transport and Air Quality modelling is considered to be High / Medium, which is as high as possible given the tight timescales available to undertake this work.

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3. Risk of Error / Robustness of the Analysis

- *Has there been sufficient time and space for proportionate levels of quality assurance to be undertaken?*

SYSTRA who are consultants on this project for Sheffield City Council (SCC) and Rotherham Metropolitan Borough Council (RMBC) have their own internal quality management process which is in line with international standards ISO9001. Quality Assurance (QA) procedures also form part of the standard SYSTRA project management systems and each project is subject to regular quality and risk review. The SYSTRA Project Manager and Project Director take the lead in ensuring these processes are adhered to and have substantial experience in doing so.

On the Transport Modelling side, despite the tight timescale there has been sufficient time allocated for QA and checking of the model runs, particularly those forming the Preferred Option and the other options included in the OBC. Throughout the process this has permitted some issues in the Baseline and Scenario tests to be captured and corrected, before the emissions outputs were provided to the Air Quality modelling.

For the Air Quality modelling time has been constrained even more due to the 2-3 day run time of the Airviro model. Therefore, there has been limited time for checking of the Air Quality Model runs, but for the key runs including the Preferred Option and the other scenarios presented in the OBC a proportionate level of QA has been undertaken to ensure the outputs are as robust as possible.

Time has been allocated so that the work and assumptions which have fed into the Business Case Appraisal and the Distributional Impacts of the OBC have been thoroughly reviewed at each stage in the process. Our proposed approach to the main economic appraisal of the options and the Distributional Impact analysis has been documented, discussed with JAQU experts and amended to reflect their comments.

- *Have sufficient checks been made on the analysis to ensure absence of errors in calculations?*

  On the Transport Modelling side, a sufficient amount of checking and analysis has been undertaken on the Baseline and Scenario tests to ensure there are no systematic errors in those Scenarios. Any errors in the underlying SRTM3B transport modelling suite may still be present but are likely to cancel out in all pairwise comparisons between the Scenarios and the Baseline. Furthermore, any minor errors which have been found in the checking process, but not incorporated into the final Scenarios due to time constraints, have been subject to appropriate Sensitivity Tests in the Transport Model which are subsequently documented within the T4 Local Plan Transport Model Forecasting Report.

  The Base Year Air Quality modelling outputs are compared with Air Quality monitoring results. Verification and adjustments are then undertaken. Model verification is the process by which uncertainties are minimised, however there will never be a modelled run which does not differ from reality in some respect. As per LAQM.TG16 a model ideally performs within +/-25% of measured values. As the main purpose is to establish in which year compliance is likely, absolute values are not as important as the difference between Baseline, Business as Usual (BaU) and scenarios.

  We believe all reasonable checks have been undertaken and that these checks are proportionate and appropriate given the timescales available.

- *Have sufficiently skilled staff been responsible for producing the analysis?*

  Experienced staff have undertaken and reviewed both the Transport and Air Quality modelling work. This has been supplemented by input from other senior members of staff or specialists where necessary.

  The key positions in the team have been held by skilled staff members, in particular:

  - The Project Management team is comprised of senior members of staff across SCC, RMBC and SYSTRA with significant experience in developing Business Case submissions and project delivery;

  - The modelling lead at SCC has many years of experience in Transport Monitoring, Strategic Transport Modelling, and evidence based Transport / Air Quality Policy and

Strategy Development. They were Project Manager for development of the 2008 Sheffield and Rotherham Strategic Transport Model (SRTM3) and have supported Sheffield City Region (SCR) with the development of the Sheffield City Region Transport Model (SCRTM1). They also led the 2010 City Centre Masterplan (Sheffield Transport Strategy) Review Study and the 2013 Sheffield Low Emission Zone (LEZ) Feasibility Study, which was subsequently presented to the House of Commons Environmental Audit Committee in September 2014;

- SYSTRA's transport modelling team is led by a Project Manager with over 15 years' experience of transport modelling and scheme appraisal, an MSc in Transport Planning and extensive experience of modelling traffic and transport in the Sheffield and Rotherham area. SYSTRA's Project Director has over 25 years' experience of transport-related behavioural research and modelling and traffic emissions-related modelling and appraisal, a 1st Class Honours in Mathematics and a PhD in Operational Research and was heavily involved in an earlier Defra-funded Low Emission Strategy Study for Sheffield City Council in 2012/13;

- The Sheffield and Rotherham Air Quality Officers have 40 years combined experience of working in air quality for Sheffield and Rotherham, covering a wide range of work such as Local Air Quality Management, air quality monitoring and modelling, development control, policy guidance development, and public health. As a result of this work, they have an in depth knowledge and understanding of air quality in their respective areas;

- The Local Behavioural Research was led by a SYSTRA expert with over 30 years' experience in Market Research; and

- The appraisal process for OBC was overseen by experts with relevant economics degrees as well as a supporting staff with several years of producing Business Case documents, scheme appraisal and distributional impact analysis.

Furthermore, where required, junior members of staff across SCC, RMBC and SYSTRA have had training in relevant packages where necessary, including in use of the transport model and the Emissions Factor Toolkit.

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4. Uncertainty

- *Is the level of uncertainty proportionate to the decision being made?*

There are many causes of uncertainty within both Transport and Air Quality models over and above which they are just models which try to mathematically represent real life responses. These uncertainties will be included in any modelling process and will no doubt be manifest in this process.

Despite these uncertainties, we believe the current level of uncertainty in the process followed is proportionate to the decisions being made in the OBC phase of the project. The development of the models and use of the models has followed WebTAG / JAQU guidance as best as possible (notwithstanding the known validation issues in the SRTM3B model being used).

In the following table, we have outlined the key sources of uncertainty in the Transport Modelling. All the following sensitivity tests were undertaken as part of the OBC work and have only been analysed at tail-pipe emissions level and not through the dispersal model.

Uncertainty	Description	Findings / Mitigation
Land Use Assumptions and Committed Schemes	The land use assumptions and committed schemes are uncertain in that they have not yet been delivered. However, only those labelled as certain or near-certain have been included.	If less development was included, compliance would be easier to achieve so no sensitivity testing undertaken.
Hearts and Minds Campaign	There is uncertainty around whether the Hearts and Minds campaign can achieve the required level of switch away from diesel to petrol / ULEV vehicles when drivers next upgrade that has been modelled for our Preferred Option. However, as suggested in the previous section there is precedence for this scale of change (given the EFT underestimating this etc.).	Sensitivity Tests have been undertaken to understand the impact of lower levels of 'Hearts and Minds' responses. A 10% switch from non-compliant cars to compliant cars in Sheffield were modelled compared to a 20% switch. At all but one location, Derek Dooley Way, the Preferred Option remains compliant.
Model Version	As described in an earlier section we have been unable to use the emerging Sheffield City Region Model Transport Model (SCRTM1).	This model is currently only available in the Base Year and has no forecast capability. Comparisons will be done between this and the SRTM3B model to ensure they tell the same story for 2017.
Forecast Year flows and speeds	Given the underlying uncertainties in the Base Year traffic model validation there will be similar uncertainties in the flows and speeds in forecast years.	Sensitivity Tests have been undertaken on Sheffield Parkway where the speed limit was varied between 40km/h and 90km/h with 10km/h intervals while maintaining the same traffic flow. The best results were achieved at 70km/h and lead to the suggestion of reducing the speed limit to 50mph at the Rotherham section. A Sensitivity Test was also undertaken where traffic on Sheffield Parkway was increased by 800 vehicles per day (or 1.3%). At all but one location, Derek Dooley Way, the

		Preferred Option would remain compliant.
Forecast Goods vehicle flows	A particular cause of uncertainty in the Base Year model validation is the goods vehicle validation which is poor in some areas, particularly Rotherham.	A Sensitivity Test has been undertaken with alternative goods vehicle growth. The test included a LGV growth of 13% to 2024 and HGV decrease of 10% to 2024. All sites are compliant in 2021 with this test.
Local Behavioural Responses	There is uncertainty as to how closely the vehicle owner responses reported and recorded in the local behavioural research will match the actual out-turn responses to the introduction of a charging CAZ	Sensitivity Test have been undertaken with JAQU prescribedBehavioural values for LGVs (HGVs are using JAQU values in the preferred option) and compliance is still met.
Emissions Factors	Uncertainty exists around whether the emissions factors for emerging vehicle technologies in the EFT will actually be realised in real life driving conditions.	No mitigation or Sensitivity Tests currently undertaken as EFT values only ones available.
Impact of CAZ schemes in nearby cities	The impact of CAZ schemes in nearby cities (e.g. Leeds, Derby, Manchester) will have an impact on the scheme in Sheffield and Rotherham. Without access to the detailed modelling work of those areas it is uncertain what the impact of this is likely to be.	It is likely that there will be upgrade effects on the fleet from other cities which will improve the situation in Sheffield and Rotherham. It is unlikely a CAZ elsewhere would worsen the situation in Sheffield due to the presence of a City Centre CAZ, but fall back positions may be required to prevent non-compliant vehicles (e.g. buses) from being operated in Rotherham if voluntary agreement is not reached to operate Euro VI buses on key routes.
Bus / Taxi Upgrades	There is uncertainty around the modelled assumption that all Buses and Taxis can be upgraded to compliant vehicle types by 2021, due to the capacity of the market to deliver the upgrades and the need for significant financial support packages.	The issue around bus upgrades has been referred to JAQU. A sensitivity test around taxi upgrades has subsequently been undertaken for the OBC Clarification work.

Exemptions	Vehicle exemptions have not been included in the Transport Modelling.	It is expected that this will only have a very small impact on model results and will not change the conclusions.
Parkgate Link Road	This is assumed to not be in the Preferred Option but may be in place by 2021.	A sensitivity test has been undertaken and reduces the emissions in at Rawmarsh Hill by a further 7% compared to the preferred option. Other locations are unaffected.

Following on from the OBC submission, further sensitivity tests were undertaken as part of a series of clarification work requested by JAQU. These sensitivity tests were run through both the transport model and the air quality dispersal model. The results of these tests are considered with the **shortest possible time** compliance in mind and set against the alternative of a CAZ D implementation.

Uncertainty	**Description**	**Findings / Mitigation**
Hearts and Minds Sensitivity Test	To determine a breaking point for the % shift which the Hearts and Minds campaign needs to achieve to achieve compliance.	All of the 4% Hearts and Minds impact is required to achieve compliance on Sheffield Inner Ring Road by mid-2021. A 2% Hearts and Minds effect would achieve compliance in advance of the ability to implement a CAZ D and therefore the Hearts and Minds approach represents the shortest possible time compliance.
Through Trip Fleet Effects Sensitivity Test	A test with 100% through trips experiencing fleet effects has been undertaken in order to to establish a breaking point for numbers of through HGV / LGV trips which are effected by the CAZ fleet effect proportions.	Results in some non-compliances on Sheffield's Inner Ring Road in mid-2021 due to additional (upgraded) goods vehicles using this route to travel through the CAZ, whereas in the OBC version of the Preferred Option these trips simply rerouted. As long as approx. 87% or less of the possible through good trips are effected in the same way as trips to / from the CAZ compliance will be achieved. Analysis of modelling suggests that approx. 50% will reroute regardless so this will be achieved. Even if all through trips upgrade in the same way as trips to / from the charging area compliance would still be achieved before a CAZ

		D could be implemented, but with slightly extended timescales.
Taxi Upgrade Sensitivity Test	To justify financial ask around taxi upgrades and establish a breaking point proportion of taxis (Black Cabs + PHV's) which we need to upgrade to achieve compliance.	The breaking point for taxis found to be around 97% of the Preferred Option assumptions. ie 90% of black cabs and 95% of PHVs need to upgrade to LPG / ULEV by mid-2021 in order to achieve compliance. Due to the current age profile of the current taxi fleet (Private Hire and Hackney) 60% will need to change their vehicle by 2021 Q1 as they become beyond the age at which they can be licensed. Changes to licencing in Sheffield and Rotherham are proposed post FBC approval and in conjunction with the CAZ incentive schemes, this is forecast to achieve compliance at the majority of locations. Even at this level alone compliance would be achieved before a CAZ D could go live.
Wortley Road HGV Ban Sensitivity Test	To establish two points on a line in order to undertake linear interpolation to determine the proportion of HGV's we need to remove from Wortley Rd to achieve compliance	HGV ban is required to achieve compliance by mid-2021 but only 10% are required to obey the ban (based on standard modelling). This is considered a significant underestimate due to gradient effects on that route which are not included in the modelling. These will be considered as part of the FBC work.
Rawmarsh Hill Bus Rerouting Sensitivity Test	To establish two points on a line to undertake linear interpolation to determine the proportion of buses we need to remove from Rawmarsh Hill to achieve compliance	TO FOLLOW

In the following table, we have outlined the key sources of uncertainty in the Air Quality Modelling.

Uncertainty	**Description**	**Findings / Mitigation**
Observed Fit	There will always be a difference between modelled (unadjusted) and monitored NO_X in any modelling.	The large number of monitoring sites in the SCC & RMBC area and the high quality of the post-

	However, once the adjustment process has been completed the Root Mean Square Error (RMSE) for observed v predicted (adjusted) NO_2 shows a good fit.	calibration fit between observed and modelled NO2 concentrations help minimise any concerns associated with this risk
Forecast Background Concentrations	There is a small amount of uncertainty in the level of background emission concentrations in the forecast years. The reduction has been assumed in line with the NAEI predictions.	No sensitivity tests or other mitigation measures are required for this one
Forecast Weather Conditions	We have used the same annual scenario typical weather for each model run so that we are comparing like with like for future years. Weather patterns from the Sheffield weather monitoring site.	No sensitivity tests undertaken (yet), but could be considered, if necessary
Gradient effects not included in modelling	These have not been included in the Transport modelling and hence the Air Quality modelling to date.	Capability was not available at Initial Evidence Submission and OBC stages but new version of EFT (released June 2019) now includes capability and can therefore be considered at FBC stage.
Canyon Modelling	Canyon modelling has not been included in the Air Quality modelling to date.	Canyon model could have improved the modelling but due to the time constraints around this work this has not been possible. Also the format in which the emissions data comes out of the transport model does not make it possible to run a canyon model in AIRVIRO. .
f-NO_2 factors	f-NO_2 factors are based on fleet composition in a particular test. There are uncertainties in the underlying f-NO_2 values themselves as well as the forecast year fleet uncertainties.	f-NO_2 factors are lower in Sheffield and Rotherham than the UK average because of a higher proportion of petrol vehicles than present nationally. For the final calculations using the NOx:NO_2 calculator, SYSTRA calculated route specific f-NO_2 values for each road in the study area, based on the predicted vehicle fleet using

		each link. This reduces the error/uncertainty associated with using an average derived for the whole of the UK, especially given the amount of local ANPR data which provides a detailed understanding of the local fleets at different locations within the SCC/RMBC area
Calculation of road NOx from NO_2 values	Difference between local and national default relationships between NO_X and NO_2 (incurred by our use of Defra's NOx:NO_2 calculator	Methodology is as per national guidance. No additional mitigation required

In the following table, we have outlined any other key sources of uncertainty in the process.

Uncertainty	**Description**	**Findings / Mitigation**
CAZ Camera Locations	Uncertainty over number of cameras required.	Roaming cameras or temporary cameras which move around.
Number of HGV / LGV Upgrades	Number of unique vehicles that need to be updated to achieve the targets is uncertain as it is unknown how many daily trips a particular goods vehicle makes.	This will not impact on the conclusions drawn from the modelling, but if the ask is too low it may mean compliance is not achieved.
Scheme Progression /Decommission	It is unknown how the scheme will develop over time or whether it will be decommissioned once compliance can be achieved without it.	This will also not affect the Preferred Option, but will be an uncertainty in the costs included in the Business Case.

Overall, whilst these uncertainties will cause some minor differences in results depending upon how they are dealt with in the transport modelling, the combination of our experience and the various sensitivity tests undertaken at each stage, (not all of which can be reported in detail in the time available to prepare the OBC), we are confident that these various uncertainties will not significantly affect the conclusions reached by this Study.

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5. Use of Analysis

- *Does the evidence provided support the business case?*

The evidence provided does support the Business Case and similar evidence is provided in the OBC covering each of the other options considered.

The Transport Modelling has provided evidence of the implications on traffic flows and tailpipe emissions for each Scenario on a consistent basis, whilst the Air Quality Modelling has provided the same information on the concentration of annual mean nitrogen dioxide at receptor locations.

The Air Quality Model predicts NO_2 concentrations on each key link across the domain in the Sheffield and Rotherham area for the Base Year, the Baseline Business as Usual option, the Preferred Option and each alternative Scenario option. Further, it provided the data for the Target Determination Process.

The level of robustness, quality of the data and the assumptions in the Transport and Air Quality Modelling is the same for all options considered and as such they have been compared on a 'like for like' basis. This allows us to conclude that the evidence suggests that:

- Nothing less than a CAZ C scheme on any level of geography will bring all links within Sheffield and Rotherham into compliance in the shortest possible time, as required by the Legal Directive;

- A wide-area CAZ D schemes (covering Sheffield City Centre and the Lower Don Valley) is predicted to achieve/over-achieve compliance at all locations by 2021;

- Restricting the wide-area CAZ D charging area to start/end at the Sheffield/Rotherham boundary results in a significant reduction in the number of vehicles which need to be upgraded or pay the charge, but requires the introduction of other local supporting measures (targeting emissions from buses and HGVs) at three locations in Rotherham – this option generally 'over-achieves' the required air quality standard within Sheffield;

- A CAZ D (with £10 daily charge for LGV and £50 for HGV) inside and including Sheffield Inner Ring Road, plus the local supporting measures in Rotherham mentioned above is predicted to achieve compliance (ie annual average concentrations below 40 $\mu g/m^3$ on all roads within the scope of this study) during 2021, but again 'over-achieves' this compliance;

- A CAZ C (with £10 daily charge for LGV and £50 for HGV) inside and including Sheffield Inner Ring Road, plus the local supporting measures in Rotherham mentioned above, a full upgrade (new &/or retrofitting) of the relevant bus fleets to Euro VI emission standards, a near-complete/significant upgrade of the respective black cab and car-based taxi fleets in Sheffield/Rotherham respectively and a Hearts and Minds campaign aimed at reducing the ownership and use of diesel private cars over time is predicted to achieve compliance (ie annual average concentrations below 40 $\mu g/m^3$ on all roads within the scope of this study[5]) during 2021, while incurring significantly less costs in terms of CAZ charging and/or the costs of the widespread upgrade of the private car fleet – this 'Preferred Option' also has significantly more cross-party political support than the other options on the short-list and is therefore more deliverable within the required timescales) than the various CAZ D options.

Given that it will not be possible to confirm compliance until the 2021 air quality data has been fully collated and analysed (ie in early/mid 2022), it will be necessary to use the local

[5] Ie excluding the M1 and M18 (which come under Highways England jurisdiction), taxi ranks, locations close to junctions, the interior of Sheffield Railway station etc. – in particular, as reported in the Target Determination documents, our modelling suggests that the 40ug/m^3 annual average limit value for NO_2 will continue to be exceeded in 2021 and beyond at a number of locations close to the M1, unless appropriate action is taken by Highways England

ANPR data to monitor how quickly the relevant fleets are being upgraded and the use of diesel vehicles is declining.

This monitoring and analysis of the local ANPR data should be undertaken continuously from early 2019 onwards, with particular focus on the changes that occur in the observed fleet following the introduction of the selected CAZ scheme (scheduled to be at the start of 2021).

If this ANPR analysis suggests that the predicted/required fleet changes are not taking place quickly enough (or at all), then Sheffield City Council should consider the need to upgrade the Preferred Option CAZ charging from a CAZ C^{+} to a CAZ D, with this decision taken as soon as it becomes apparent that the required compliance will not be achieved during 2021.

There has been no requirement to amend these conclusions as a result of the additional testing undertaken post-OBC.

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6. Summary

This Analytical Assurance statement for Sheffield and Rotherham has outlined the key limitations and assumptions made in the Transport and Air Quality modelling work to inform the CAZ OBC. Our methodology was agreed at each stage with JAQU. It has also described the reliability of the data sources underpinning the evidence presented in the accompanying documentation. Furthermore, it has covered the Sensitivity Testing which has been undertaken to give more confidence in the modelling outcomes. It has also been updated following additional sensitivity testing requested by JAQU post-OBC.

We believe that all questions and requirements set out by JAQU in the guidance have been covered here and in the documentation. Overall, we therefore, believe that the limitations described are within acceptable levels (given the time-constraints associated with the Legal Directive) and the evidence presented robustly supports the Business Case.
