# Sheffield & Rotherham Clean Air Plan Full Business Case
# AQ2 – The Air Quality Planning Methodology Report
# April 2022

## Document Controls

| Document Approval | | | |
| --- | --- | --- | --- |
| Version Number: | Final Version | | |
| Prepared by: | Ogo Osammor (SCC), Julie Kent (RMBC) | Date: | 08/04/2022 |
| Checked by: | Amanda Cosgrove (SCC) | Date: | 11/04/2022 |
| Approved by: | Tom Finnegan Smith (SCC) | Date: | 11/04/2022 |

**Revision History**

| Version | Nature of Revision |
| --- | --- |
| | |
| | |
| | |

**Acronyms and Abbreviations**

| | |
|---|---|
| ANPR | Automatic Number Plate Recognition |
| AQD | Air Quality Directive |
| AQMA | Air Quality Management Area |
| BaU | Business as Usual |
| CAP | Clean Air Plan |
| CAZ | Clean Air Zone |
| COPERT | Computer Programme to calculate Emissions from Transport |
| Defra | Department for Environment Food & Rural Affairs |
| DfT | Department for Transport |
| EDB | Emissions Database |
| EFT | Emission Factor Toolkit |
| f-$NO_2$ | Primary $NO_2$ |
| FBC | Full Business Case |
| HGV | Heavy Goods Vehicle |
| JAQU | Joint Air Quality Unit (Defra and DfT) |
| LAQM | Local Air Quality Management |
| LGV | Light Goods Vehicle |
| LV | Limit Value |
| $\mu g/m^3$ | micrograms per cubic metre |
| Met | Meteorology |
| $NO_2$ | Nitrogen Dioxide |
| NOx | Nitrogen Oxides |
| PCM | Pollution Climate Mapping |
| PO | Preferred Option |
| SCRTM1 | Sheffield City Region Transport Model |
| TCF | Transforming Cities Fund |

## 1. Introduction

In 2017 the government published a UK Air Quality Plan for Nitrogen Dioxide setting out how compliance with the EU Limit Value for annual mean $NO_2$ would be reached across the UK in "the shortest possible time". Sheffield City Council and Rotherham Metropolitan Borough Council, along with 27 other Local Authorities, were directed by Minister Therese Coffey (Defra) and Minister Jesse Norman (DfT) in 2017 to produce a Clean Air Plan (CAP). The Plan is expected to set out how the Councils will achieve sufficient air quality improvements in the shortest possible time. In line with Government guidance Sheffield City Council and Rotherham Metropolitan Borough Council are working towards implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, to achieve sufficient improvement in air quality and attendant public health.

Systra and the Councils have jointly produced a Full Business Case for the delivery of the CAP; a package of measures which is predicted to bring about compliance with the Limit Value for annual mean $NO_2$ in the shortest time possible in Sheffield and Rotherham. The OBC assessed the shortlist of options set out in the Strategic Outline Case and proposed a preferred option including details of delivery. The FBC develops the preferred option set out in the OBC, detailing the strategic, commercial, economic, financial and management requirements to implement and operate the scheme. The OBC and FBC form a bid to central government for funding to implement the CAP.

### 1.1 The Proposed Measures

It is proposed to introduce a charging Class C Clean Air Zone in the centre of Sheffield, including the inner ring road, Park Square and the A61/Parkway junction. Rotherham MBC is developing targeted schemes on the Parkway (A630), Fitzwilliam Road, Wortley Road and Rawmarsh Hill, Rotherham to address non-compliance with limits on concentrations of nitrogen dioxide. The Councils are directed by the Secretary of State to implement these schemes pursuant to air quality compliance in the shortest possible time.

### 1.2 Overview of this document

This document is the Air Quality Modelling Methodology Report (AQ2) which explains in detail how dispersion modelling was used to assess the air quality implications of the intervention options tested. This report provides information covering the key requirements as listed in the JAQU guidance for the "Evidence Package":

- A description of the methods used, including: the choice of model, the choice of modelling domain, the years modelled and details of the $NO_2$ from NOx calculations.
- Details of locations and types of monitoring data (automatic and diffusion tubes) used for the model validation (provided in Supporting Document SD04 – Air Quality Monitoring Data and Site Locations).
- Details of how outputs from the transport model were input into the air quality model.
- A description of the methods used to assess the impacts of changes in primary $NO_2$ emission fraction (f-$NO_2$) between the model base year, projection years and projection years with measures. f-$NO_2$ has been calculated for each road link for each relevant future year.

## 2. Section 1 – The Dispersion Model

Air dispersion modelling of pollutants from roads, points and diffuse sources within the Rotherham and Sheffield domain was carried out using the Airviro v5.01 dispersion model (Estonian Environmental Research Centre (EERC), Eesti Keskkonnauuringute Keskus OU and Apertum IT AB). The years modelled were the baseline year of 2017 and earliest year for compliance of 2022.

The Airviro dispersion modelling system has been continuously developed since 1990 and has many users all over the world. It has been used in a number of intra-urban exposure studies in recent years (Korek et al., 2016; Jadaanet et al., 2016; Jerrett et al., 2004; Pierse et al., 2006). Its main advantage is being a web-based environmental management tool with embedded Geographical Information System (GIS) features which enables its application at urban and regional levels. In addition, it contains a dynamic emission database which allows for storage of static as well as dynamic emission characteristics for a large number of pollution sources, the latter is mainly used to characterise time-varying emissions from road, area and industrial sources. For example, Airviro calculates primary pollutant emissions for each road by utilising a database of updated information on the type of vehicle journeys, average daily traffic flows, speeds and vehicle mix. (SMHI, 2004).

Meteorological data for all years from 1999 onwards is stored as a time series for all the key parameters and this is used for the dispersion calculations. Most of the meteorological data has been collected from a local met mast within Sheffield, this includes the wind direction, velocity and vertical temperature profiles. These were used to determine the boundary layer scaling parameters – surface friction velocity and the Monin-Obukhov length. The wind fields were simulated using the diagnostic wind model available in the tool, which considered the effects of topography, surface roughness and surface heating/cooling.

Sheffield CC and Rotherham MBC have used the Airviro system for air quality modelling, time series data collection and validation continuously for over 20 years, in partnership with Doncaster and Barnsley Councils.

The modelled domain included all the pollution climate mapping (PCM) road links as defined by Defra. It is possible to model the emissions from roads, industrial (point and area sources) domestic emissions (area sources) and background in the same calculation. However, for this feasibility study, most simulations were of road only sources from emissions databases (EDBs) provided by Systra. Each simulation was run over an area-wide domain including most of Sheffield and Rotherham. The Gaussian model was used for the simulations. The methodology was agreed with the Joint Air Quality Unit (JAQU) as per the Air Quality Tracking Table AQ1 in 2018 (appended and previously submitted and agreed with JAQU).

The 2017 Base Year and 2022 Baseline based on a projected vehicle fleet composition were modelled (Local Plan Transport Modelling Report T3). The 2017 vehicle fleet was based on the then current fleet derived from a full year of local Automatic Number Plate Recognition (ANPR)-based fleet profile data (collected between Dec 2016 to Nov 2017). Data for the local bus fleet was supplied by First Group and Stagecoach in Rotherham and Sheffield so represents a good data source for the majority of the fleet operating in South Yorkshire. This fleet composition was then forecast forward into for future years using EFT-based 'Business as Usual' year on year proportional growth with new fleet types introduced in the relevant years they are expected to come online. Baseline and 'Do Something' Fleet Assumptions for the potential CAZ scenarios were derived as per JAQU Guidance.

A similar methodology to that used by Leeds City Council for their CAZ Feasibility Study was used. The basic modelled grid size across the domain was a 250m x 250m grid (spatial resolution). This grid size was reduced to a 10m receptor grid when within 50m of a modelled road, point or line source emitting more than 0.000001g/s. This approach had the benefit of reducing what would have been extremely long run times had the whole domain been modelled with a resolution of a 50m or smaller grid.

The "Quad Grid" function within Airviro Dispersion module was enabled, with the threshold emissions value set to > 0.000001 or 1e-06g/(s*m) to ensure all road links with a noticeable significant emission rate are included in the simulation.

The Defra NOx to $NO_2$ calculator v6.1 was used for the conversion of road and background NOx to total $NO_2$. Primary $NO_2$ was calculated for each PCM link using EFT and supplied by Systra for the conversion.

## 3. Section 2 – Traffic Emissions Data

The annual average daily traffic (AADT) for each relevant year and scenario is derived from the Sheffield and Rotherham Transport Model, SCRTM1. This has a SATURN (Simulation and Assignment of Traffic to Urban Road Networks traffic model) based highway assignment module, which has been partially updated by SYSTRA for the CAZ Feasibility Study. The model outputs provide average weekday traffic volumes by vehicle class/purpose and speeds by road link for four periods covering the hours 0700-1900. For scenario modelling, Car, LGV and HGV user classes are split into compliant and non-compliant vehicles to allow any diversion impacts of a CAZ to be modelled. Buses, Black Cabs and PHV's are also modelled as fixed flows on each link, and also split into compliant and non-compliant segments.

ENEVAL, a Systra emissions model, outputs were used to create the Emissions Databases for each scenario. The transport modelling methodology is described in Local Plan Transport Modelling Reports T2 and T3.

### 3.1 NOx Emissions Databases

The annual emissions of NOx calculated for each road-type and time period were linked to a geo-referenced Shapefile representing the road centre lines of the network modelled within the Rotherham and Sheffield Transport Model. The shapefile was then converted into the correct format to be uploaded into an emissions database (EDB).

An emission database (EDB) is generated which proportions the emissions calculated for each time period by the number of hours within each time period to create hourly emission rates (in g/s). The emission rates are also proportioned between weekdays, Saturdays and Sundays based on the relationship of traffic flows on these day-types compared with the AADT flows used to calculate the emissions.

Model runs can be set up to apply meteorological data representing any calendar year to simulate the dispersion of the emissions and calculate the annual average concentration of NOx derived from the modelled road network. The meteorological data can be input as a time series covering every hour of any particular year. To run the number of scenarios simulations required for this study, a typical 'scenario' of representative annual weather for Sheffield and Rotherham was created from our existing meteorological data for the baseline and all future scenario simulations. This also has the advantage that a non-typical year is not used for future forecasting, therefore addresses the issue of uncertainty and sensitivity in meteorological data. However, whilst this gives a forecast representative of a typical year, natural variability may in practice impact dispersion, and this therefore is an uncertainty.

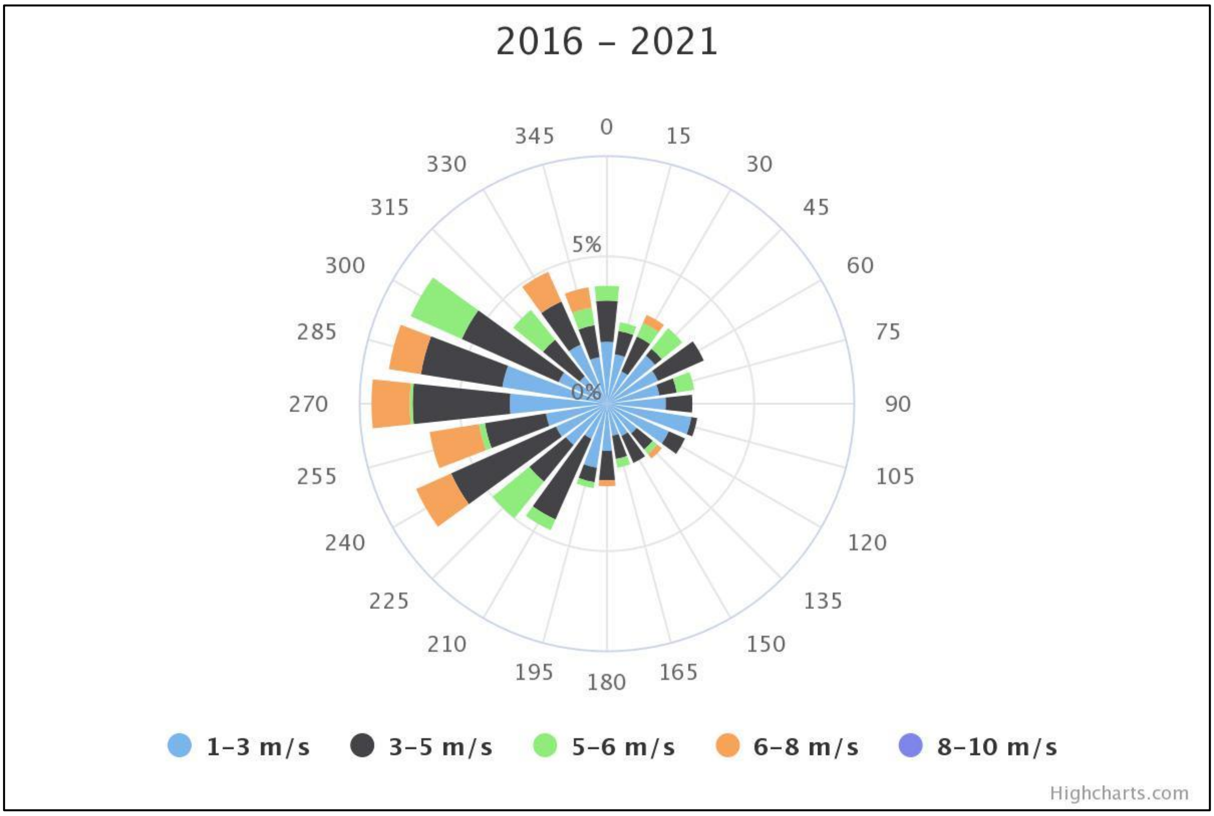
Met data for all years from 1999 is stored as time series for all the key parameters and this is used for the dispersion calculations. Most of the met data has been collected from a local weather mast within Sheffield. A meteorological pre-processor routine within the Airviro software tool analysed the local weather data obtained from the weather mast within Sheffield City, including the wind direction, velocity (see wind rose below) and vertical temperature profiles. These were used to determine the boundary layer scaling parameters – surface friction velocity and the Monin-Obukhov length. The wind fields were simulated using the diagnostic wind model available in the tool, which took into account the effects of topography, surface roughness and surface heating/cooling. Surface roughness describes the amount of near-ground turbulence that arises as a consequence of surface characteristics, such as land use (e.g., agriculture, lakes, urbanisation, woodland, open parkland, etc.). Farming areas may have a surface roughness of approximately 0.2m to 0.3m whereas built up cities, such as Sheffield and Rotherham, and woodlands may have a roughness of 1 to 1.5m. The wind field calculation is based on the concept first described by Danard (1976), "where mesoscale winds are generated by using:

- horizontal momentum equation
- pressure tendency equation
- first thermodynamic equation

This concept assumes that small-scale winds can be seen as a local adaptation of large-scale winds (free winds) due to local fluxes of heat and momentum from the sea or earth surface. Any non-linear interaction between the scales is neglected. Danard assumes that the adaptation process is very fast, 1.5 hours for model resolutions of 10*10 km. It is also assumed that horizontal processes can be described by non-linear equations while the vertical processes can be parametrised as linear functions."

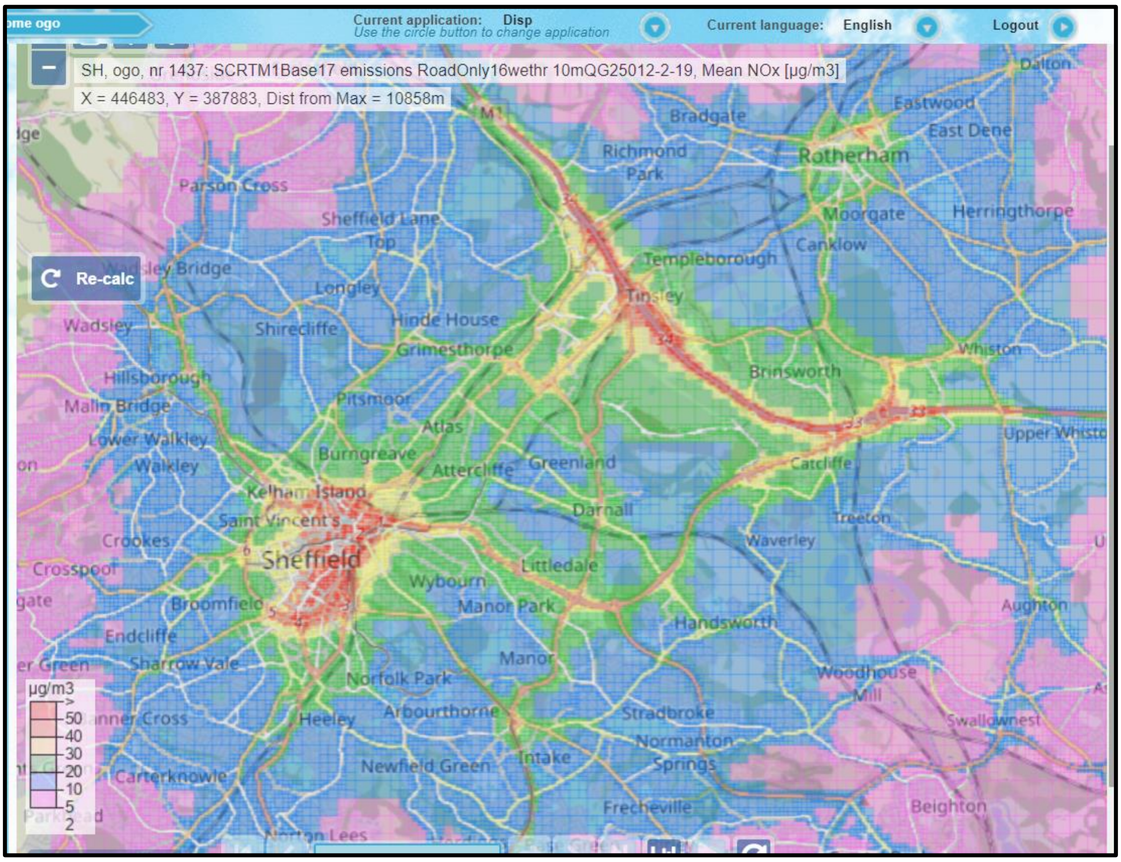
The Gauss model cannot resolve buildings and other large elements. These elements, for example, an urban area with buildings and street canyons of many different length scales, are parameterised as increased surface roughness. The wind field generated has one unique resolution regardless of the size or scale of the dispersion area, which depends upon the input of topographic and physiographic information. The physiographic information used in the modelling generates a local wind field with a 100m x 100m grid. The topography data allows the wind field generated within the dispersion calculation to better reflect the impact of funnelling effects of landforms and greater resolution of the land use, including building heights on the surface roughness effects.

**Figure 1 – Scenario Weather Frequency Distribution (Wind Rose) for year 2016 – 2021 Weather Data, with addition to sub-classes in each wind direction class**




The concentration of NOx at all locations within the modelled domain was calculated in each simulation. Predicted concentrations of NOx calculated at receptor points representing the locations of monitoring data collected in the baseline year of 2017 were used to validate the model and generate modelled NOx values for output to the Defra NOx to $NO_2$ calculator v6.1. Receptor points can be created for any location within the domain. Receptor points were set up for all PCM roads within the domain. As a large area (Sheffield and Rotherham) covering many square kilometres was modelled and as NOx emissions were generated from a strategic transport model, road NOx values required adjustment for different road links and zones within the domain.

**Figure 2 – An Illustration of the 2017 Road NOx Dispersion Model Output**



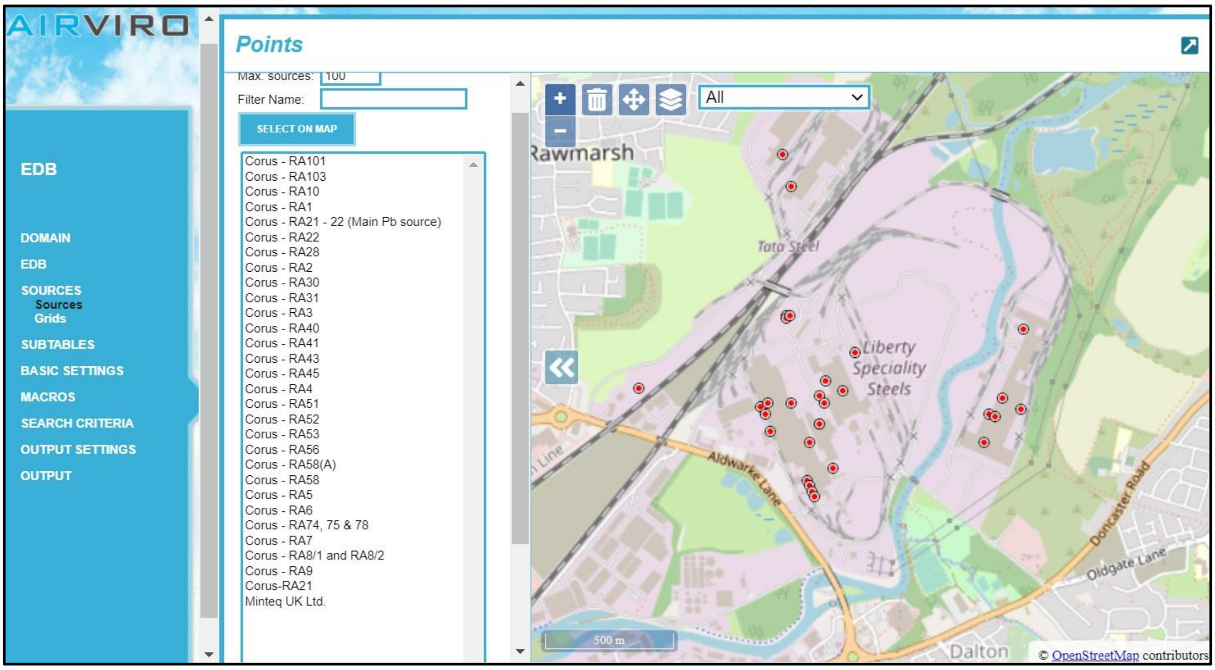

Road NOx for diffusion tube monitoring locations was calculated using v6.1 of Defra NOx:$NO_2$ calculator's Diffusion Tube Tab. The correct year is selected and then background values, nitrogen dioxide monitored values and f-$NO_2$ values calculated by Systra (see Technical Document T3 section 3.1 for details) for each road link were entered, and the assumed road NOx is calculated for each location.

The modelled road NOx values calculated for the 2017 base year were compared with 'monitored' road NOx data derived from the Defra calculator. The validation and model adjustment process confirmed the overall performance of the dispersion modelling and is described below. The factors for adjusting road NOx were determined on either a zonal or road link basis – see section 3.3.

### 3.1.1 Details of modelling for non-road transport sources.

Emission Databases (EDBs) containing industrial, commercial, and domestic sources for Rotherham and Sheffield have previously been developed in the South Yorkshire Airviro system independently of the CAZ programme. They include all known industrial emission sources such as biomass power plants, steel works, non-ferrous metal processes, and incinerators. The contributions from these sources were modelled to establish the non-road component (classed as 'background' in the NOx:$NO_2$ calculator). Alternatively, the one km grid square non-road NOx concentrations across the whole of the modelled domain were derived from the DEFRA Background Maps. In some kilometre grid squares, there are significant contributions of total NOx from industrial sources, e.g., steelworks, biomass power stations, glass works, energy from waste plant. For the east end of Sheffield and Rotherham town centre this is particularly relevant. To illustrate this, a screenshot from one of the Councils' EDBs below shows the location of the sources of NOx from Aldwarke steelworks:

**Figure 3 – An Illustration of a 2017 Non-Road Sources of NOx**




## 3.2 Assessment of PCM Road Links in the modelled domain

An assessment of all PCM road links was undertaken in the modelled domain. Context:

- Road locations situated within areas where members of the public do not have access and there is no fixed habitation or where there is no public access within 15 m (Annex III of AQD – 10 m), these roads have been excluded from the compliance assessment (JAQU guidance).
- Where there is access (houses, gardens, or footpaths) within 15 m at grade with the road, these road links are included (JAQU guidance).
- Where there is access via a footpath or similar that is not at grade with the road, because the road is elevated or in a cutting, these roads are included if the access is parallel to (runs alongside) the road (JAQU guidance) (Annex III of AQD – 10 m).
- If the only access (the footpath or another road with pavements) is not at grade with the main road but is perpendicular (goes under or over the main road with a bridge), then if there is no other access these roads may be excluded from the compliance assessment (JAQU guidance).
- Locations where the air sampled is representative of air quality for a street segment no less than 100 m length at traffic-orientated sites.
- Traffic-orientated sampling probes shall be at least 25 m from the edge of major junctions and within 10 m from the kerbside.

This assessment showed that the PCM links on the Sheffield section of the Parkway (A630 between Sheffield City Centre and the M1, Census IDs: 36588, 47855, 76045, 99303) are not considered to be a valid location for reporting compliance with the EU LV as they fall within the EU direction at **Annex IIIa** sub-section **2a** (locations where members of the public have no access and there is no fixed habitation) of AQD Annex III and JAQU guidance (see Appendix 3 (Technical Note) below – AQ2–SD03). The Census IDs specifically affected are: 36588, 47855, 76045, 99303. Pedestrians and cyclists are prohibited on these road links.

On the Rotherham stretch of the Parkway, there is one PCM road link, Census ID 73910, with four receptor point reporting locations referred to in this report. Three of these receptor point reporting locations grid references, (X-442410, Y-388731) (X-442398, Y-388723) and (X-442804, Y-388927) are not considered to be valid for reporting compliance with the EU LV, the fourth receptor point reporting location, (440725, Y-387859), may be considered to be a valid location. However, notwithstanding the above, we also note that the combined effect of the charging scheme in Sheffield, and the proposed 50mph speed limit, will bring all links on the Parkway in Rotherham within the limit value of $40\mu g\cdot m^{-3}$. It is therefore proposed to introduce the revised speed limit, with costs included in this full business case, to remove risk of challenge regarding public access, and to put compliance on this link beyond challenge or doubt. – see sections 1.1 above,

The non-valid PCM road link locations will therefore no longer be reported.

Furthermore, results for the M1 (which come under Highways England, now National Highways, jurisdiction), for example, for Census IDs 16007, 28052, 37913 and 73909 are also excluded, as reported in the Target Determination documents, our modelling suggests that the $40\mu g/m^3$ 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 National Highways.

Annual mean nitrogen dioxide is predicted for locations which meet the EU's and JAQU's requirements, i.e., >25m from a junction, be representative of air quality for a street segment no less than 100 m length and 4m from the kerb.

### 3.3 Road NOx Adjustment Factors and Verification

Verification is a way of establishing the extent to which a model and its' related data are a true representation of reality, for example, at particular real-world locations.

The transport emissions from the transport model do not account for all the monitored roadside NOx at 4m from the kerb (JAQU requirement), particularly if there are gradient or canyon effects. Therefore, the roadside NOx modelled was factored to verify it against monitored roadside NOx values across the domain. This approach therefore includes gradient and canyon effects in an inferred way. For roads where compliance is not currently achieved, it is particularly important to factor the roadside NOx by the correct road link specific factor. Below are illustrations of NOx adjustment factors for various locations across Sheffield in Table 1 and Rotherham in Table 2. Adjustment factors in Rotherham are also discussed further in Section 3.5.

**Table** 1 **– Sheffield Modelled Road NOx adjustment Factors**

| No. | Road Name | Road ID | Census_ID | Modelled Road NOx Adjustment Factor |
|---|---|---|---|---|
| 1 | Mansfield Road | A6135 | 7355 | 0.70 |
| 2 | Attercliffe Road | A6178 | 7380 | 1.84 |
| 3 | Upwell Street | A6102 | 7817 | 0.78 |
| 4 | Bochum Parkway | A6102 | 7818 | 0.79 |
| 5 | Whitham Road | A57 | 8144 | 1.25 |
| 6 | Abbeydale Road South | A621 | 8710 | 3.58 |
| 7 | St Mary's Road *Note 1* | A61 | 8744 | 0.63 |
| 8 | Suffolk Road | A61 | 8758 | 0.93 |
| 9 | Penistone Road | A61 | 16580 | 1.26 |
| 10 | Chesterfield Road | A61 | 16581 | 1.96 |
| 11 | Bawtry Road | A631 | 17332 | 0.96 |
| 12 | Brightside Lane | A6109 | 17718 | 1.61 |
| 13 | Burngreave Road | A6315 | 17728 | 1.78 |
| 14 | Hoyle Street | A61 | 17809 | 0.88 |
| 15 | Penistone Road | A61 | 18546 | 1.80 |
| 16 | Greenland Road | A6102 | 18721 | 0.76 |
| 17 | City Road | A6135 | 27373 | 0.89 |
| 18 | Abbeydale Road | A621 | 27381 | 1.68 |
| 19 | Attercliffe Road | A6178 | 27393 | 2.29 |
| 20 | Bradfield Road | A6101 | 27821 | 0.99 |
| 21 | Prince Of Wales Road | A6102 | 27822 | 0.58 |
| 22 | Queens Road | A61 | 27857 | 1.67 |
| 23 | Parkside Road | A6102 | 28172 | 1.32 |
| 24 | Shepcote Lane | A631 | 28868 | 1.22 |
| 25 | Sheffield Rd (M1 34S) | A6178 | 37441 | 1.15 |
| 26 | Queens Road | A61 | 37898 | 1.00 |
| 27 | Hawke Street | A6102 | 37902 | 1.21 |
| 28 | Attercliffe Common | A6178 | 38549 | 1.17 |
| 29 | Penistone Road | A61 | 46619 | 0.99 |
| 30 | Meadow Head | A61 | 46620 | 1.36 |
| 31 | Bramall Lane | A621 | 47393 | 1.27 |
| 32 | Ecclesall Road | A625 | 47396 | 1.26 |
| 33 | Burncross Road | A629 | 47405 | 1.69 |
| 34 | Meadowhall Road | A6109 | 47826 | 1.03 |
| 35 | Penistone Road North | A61 | 47856 | 1.44 |
| 36 | Upper Hanover Street | A61 | 47860 | 1.24 |
| 37 | Chesterfield Rd South | A61 | 48531 | 1.50 |
| 38 | Greenland Road | A6102 | 48804 | 1.50 |
| 39 | Shoreham Street | A61 | 48805 | 1.31 |
| 40 | Moorfields | A61 | 56608 | 0.94 |
| 41 | Cowley Lane | A629 | 56862 | 1.24 |
| 42 | Savile Street | A6109 | 56863 | 1.11 |
| 43 | Sheffield Road | A6178 | 57330 | 0.85 |
| 44 | St Mary's Gate | A61 | 57861 | 0.51 |
| 45 | Barnsley Road | A6135 | 57875 | 1.34 |
| 46 | Prince Of Wales Road | A6102 | 58427 | 1.13 |
| 47 | Sheaf Str station side | A61 | 60030 | 0.93 |

| | | | | |
|---|---|---|---|---|
| 48 | Shoreham Street | A61 | 75194 | 1.15 |
| 49 | Suffolk Road *Note 1* | A61 | 75195 | 0.85 |
| 50 | St Mary's Road *Note 1* | A61 | 75196 | 0.58 |
| 51 | St Mary's Road | A61 | 75197 | 0.61 |
| 52 | Fornham Street | A61 | 75198 | 1.08 |
| 53 | Matilda Street | A61 | 75199 | 0.82 |
| 54 | Wicker | A6135 | 76044 | 0.97 |
| 55 | Derek Dooley Way Nr Capita | A61 | 76046 | 0.83 |
| 56 | Manchester Rd(Crosspool) | A57 | 77544 | 0.73 |
| 57 | Holme Lane | A6101 | 77547 | 1.22 |
| 58 | Middlewood Road | A6102 | 77551 | 2.23 |
| 59 | Halifax Road | A61 | 77553 | 1.05 |
| 60 | Station Rd(Chapeltown) | A6135 | 77557 | 1.84 |
| 61 | Granville Road | A6135 | 81155 | 1.20 |
| 62 | Shalesmoor | A61 | 81162 | 0.68 |
| 63 | Herries Road | A6102 | 81227 | 1.15 |
| 64 | Herries Road South | A6102 | 81228 | 1.33 |
| 65 | Herries Road | A6102 | 81229 | 1.31 |
| 66 | Leppings Lane | A6102 | 81230 | 1.77 |
| 67 | Derek Dooley Way *Note 1* | A61 | 81236 | 0.83 |
| 68 | Derek Dooley Way LP93 *Note 1* | A61 | 81237 | 0.63 |
| 69 | Savile Street | A6109 | 81238 | 0.97 |
| 70 | Glossop Road B6547 | Glossop Rd B6547 | n/a | 1.44 |
| 71 | Barkers Pool Taxi Rank | Barkers Pool Taxi Rank | n/a | 1.01 |
| 72 | C710 Arundel Gate | C710 | n/a | 1.99 |
| 73 | Beeley Wood Road, S6 | Beeley Wood Rd | n/a | 1.00 |
| 74 | Arundel Gate, Gallery | C710 | n/a | 1.03 |
| 75 | Arundel Gate, Stoddart Bldg | C710 | n/a | 0.94 |
| 76 | Arundel Gate/Surrey Str | C710 | n/a | 0.74 |
| 77 | Orphanage Rd / Barnsley Rd | Barnsley Rd | n/a | 3.09 |

*Note 1 – Adjusted modelled road NOx (see Appendix 2 (Technical Note) below – AQ2-SD02): (This was note shared with JAQU in May 2021)*

**Table 2 – Rotherham Modelled Road NOx adjustment Factors**

| Zone | A630 Parkway AQMA1 | A629 AQMA2 | A630 Fitzwilliam Road AQMA3 | A633 Rawmarsh Hill AQMA4 | Average Town Centre/Inner road links | Average Outer road links |
|---|---|---|---|---|---|---|
| Modelled road NOx adjustment Factor | 1.407 | 2.789 | 1.691 | 3.417 | 1.846 | 2.822 |

Use of the whole domain average factor for adjusting road NOx concentrations for key exceedence locations such as these would result in under-predicted concentrations, showing compliance with limit values by a very large margin (which would not be the case in reality), resulting in communities continuing to being exposed to elevated levels of air pollution and attendant impacts on public health.

### 3.3.1 Further adjustment of modelled outputs

The appraisal that underpinned the 2018 OBC for the Sheffield and Rotherham Clean Air Plan, monitored roadside $NO_2$ data (2017) was not available at some locations on the Inner Ring Road, and these were adjusted using proxy sites – a standard approach. The Census ID locations affected are 8744, 75195, 75196, 81162, 81236, 81237. Therefore, an approach for the adjustment of modelled road NOx for these locations was developed.

*A more detailed technical note covering this adjustment is provided – Appendix 2 – AQ2–SD02, which has previously been shared with JAQU.*

### 3.3.2 Roads with high road NOx adjustment factor

In Table 1 above, some roads have high road NOx factor. Abbeydale Road South is one example, even though it is a flat road with no canyon but may experience congestion and low speeds. This may be a case where the transport emissions from the transport model, a strategic model, did not account for the monitored roadside NOx at 4m from the kerb.

Attercliffe Road, Census ID 27393, also has a high adjustment factor. The road is flat but there is congestion and low speeds. It is an arterial route into and out of the city, serving major entertainment and shopping centres such as the Arena, Centertainment, IKEA, Meadowhall Retail Park and Meadowhall.

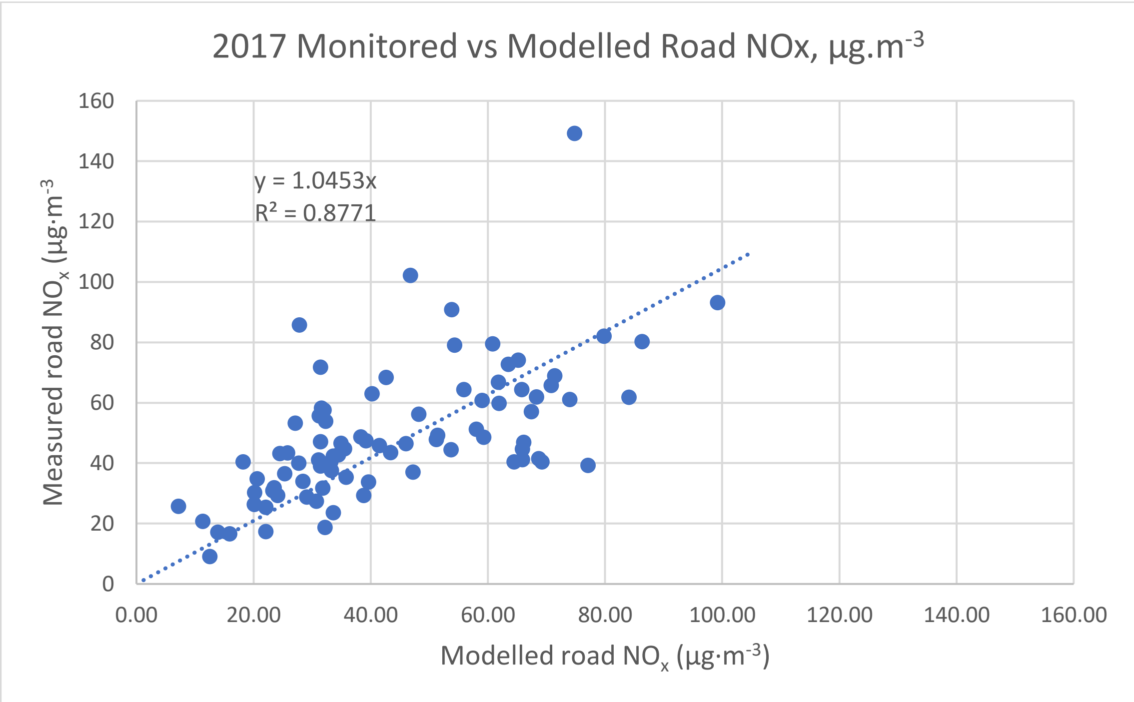
C710 Arundel Gate site also has a high road NOx adjustment factor. This location consistently has the highest levels of annual mean measured in Sheffield City Centre and is a key location for achieving compliance with the EU LV. It is a location where the majority of the emissions come from diesel buses using this street as one of the key bus interchange locations in the city centre.

## 3.4 **Incorporating background concentrations of NOx**

It is necessary to incorporate estimates of background concentrations of oxides of nitrogen (NOx) into the calculations of total annual mean nitrogen dioxide for a particular year and location. Background concentrations can be derived from Defra's national maps, with adjustments where necessary based on a comparison with local monitored data.

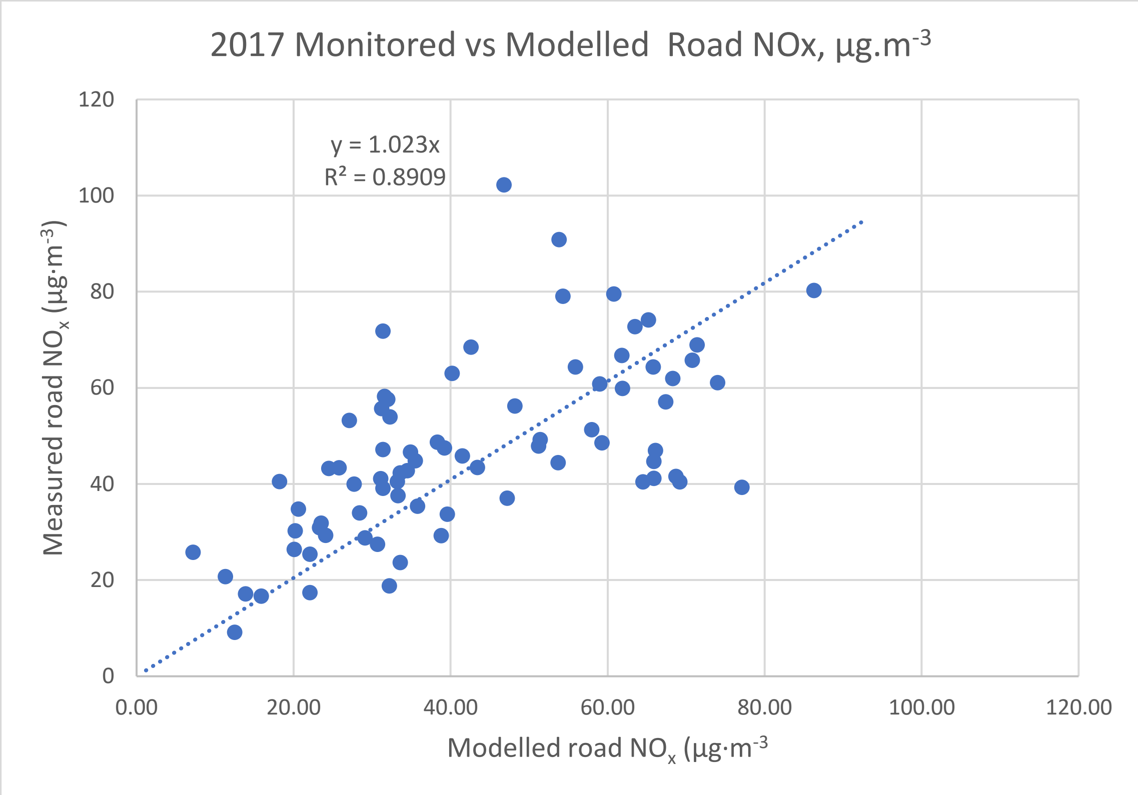
Most nitrogen dioxide ($NO_2$) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. The concentration of ozone therefore has an impact on concentrations of nitrogen dioxide, and next to major roads the levels of ozone are usually very low. This is one of the reasons why a reduction in NOx is not directly proportional to the reduction in $NO_2$ achieved from interventions at roadside. The other source of nitrogen dioxide is primary emission from vehicle combustion. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). It is also important to *only verify that part of the total concentration which is predicted by the dispersion model* (the background component has been verified and adjusted separately). This is because the alternative (i.e., verifying against the total concentrations only) risks hiding poor performance in the dispersion model. There will never be modelled run which does not differ from reality in some respect. As we are concentrating on predicting roadside concentrations of road-NOx, our verification and adjustment takes place at these roadside locations within the domain. Diffusion tube monitoring is a cost-effective way of establishing levels of annual mean nitrogen dioxide at a large number of roadside locations in any town or city. The monitored values represent reality at a particular location. Diffusion tube monitoring is more accurate than the results from any dispersion model; particularly where a local authority has a dataset which covers a number of years. In Rotherham and Sheffield, the QA/QC includes duplicate and triplicate co-location at some sites and co-location with some automatic stations. Bias adjustment of diffusion tube derived nitrogen dioxide concentrations is a crucial aspect of QA/QC. The Councils (along with Barnsley and Doncaster Councils) work collaboratively on this. We have used the same laboratory and adsorption technique for the past 20 years which provides consistency. In Sheffield, predictions of the annual mean road NOx concentrations during 2017 at 84 diffusion tube monitoring sites (77 on PCM link roads) was made for the verification of the dispersion model outputs. In Rotherham, predictions of the annual mean road NOx concentrations during 2017 at 40 diffusion tube monitoring sites and 2 automatic monitoring sites was also made for the verification of the dispersion model outputs.

The model output of road-NOx has been compared with the 'measured' road-NOx. In reality, it is impossible to measure the road-NOx component of a total concentration of nitrogen dioxide so the 'measured' road-NOx is calculated from the measured $NO_2$ concentrations and the predicted background $NO_2$ concentration using the NOx from $NO_2$ calculator Version 6.1 (JAQU Guidance 2017) available on the Defra LAQM Support website (Defra, 2018b). As this calculator is also used to produce the final predicted concentration of nitrogen dioxide, the errors within it hopefully cancel out. The following plots show unadjusted modelled road NOx v 'calculated measured' road NOx, using Defra's NOx:$NO_2$ calculator v6.1, for a number of sites in Sheffield – Plots A1 and A2, and in Rotherham – Plot B, which are not affected by significant gradient effects: Plot A1 – Sheffield.

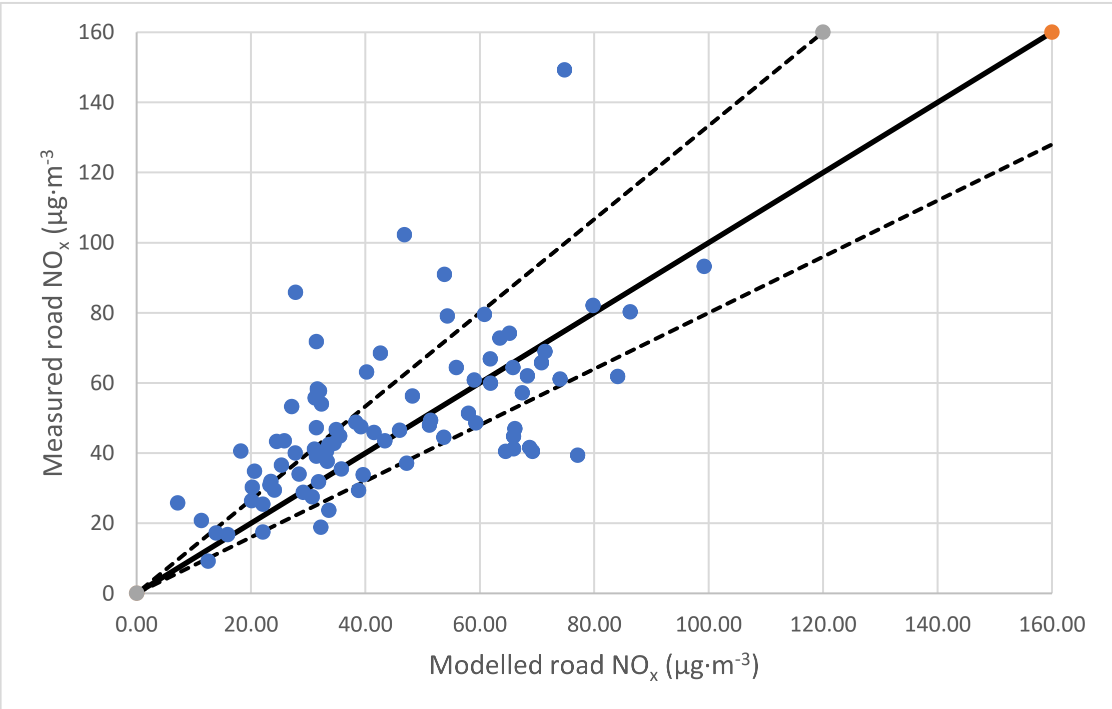



Plot A1 includes PCM and non-PCM identified link roads, for example, Arundel Gate, Beeley Wood Road.

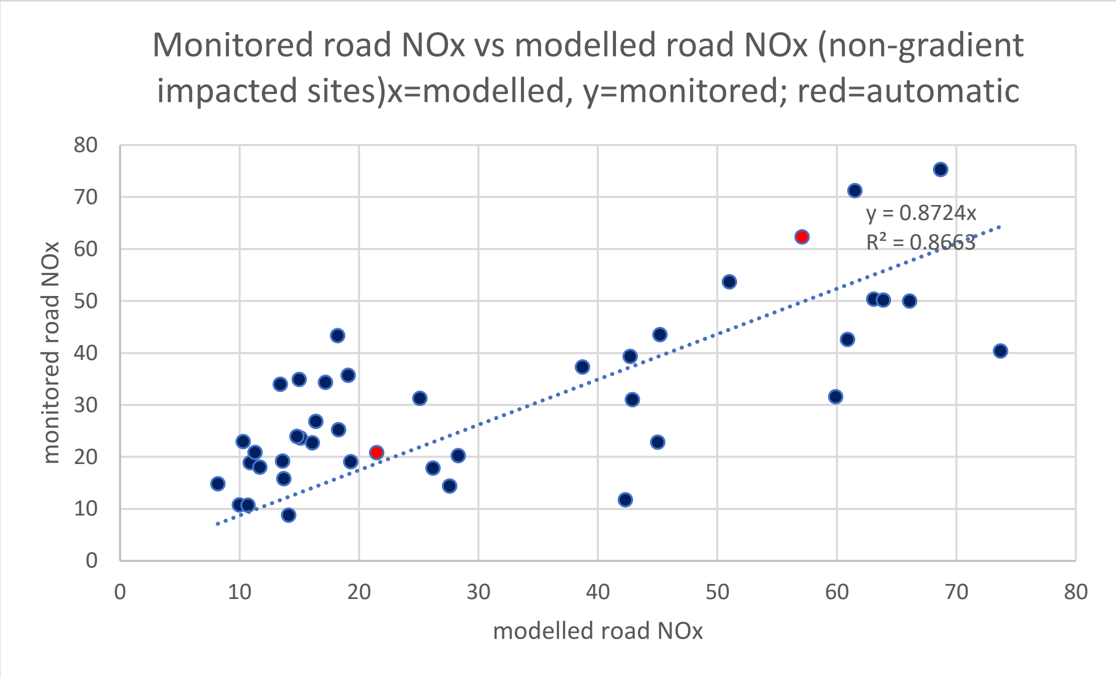
Plot A2 – Sheffield: PCM Link Roads Only




Plot A3 Monitored v unadjusted Modelled Road NOx with 25% confidence lines

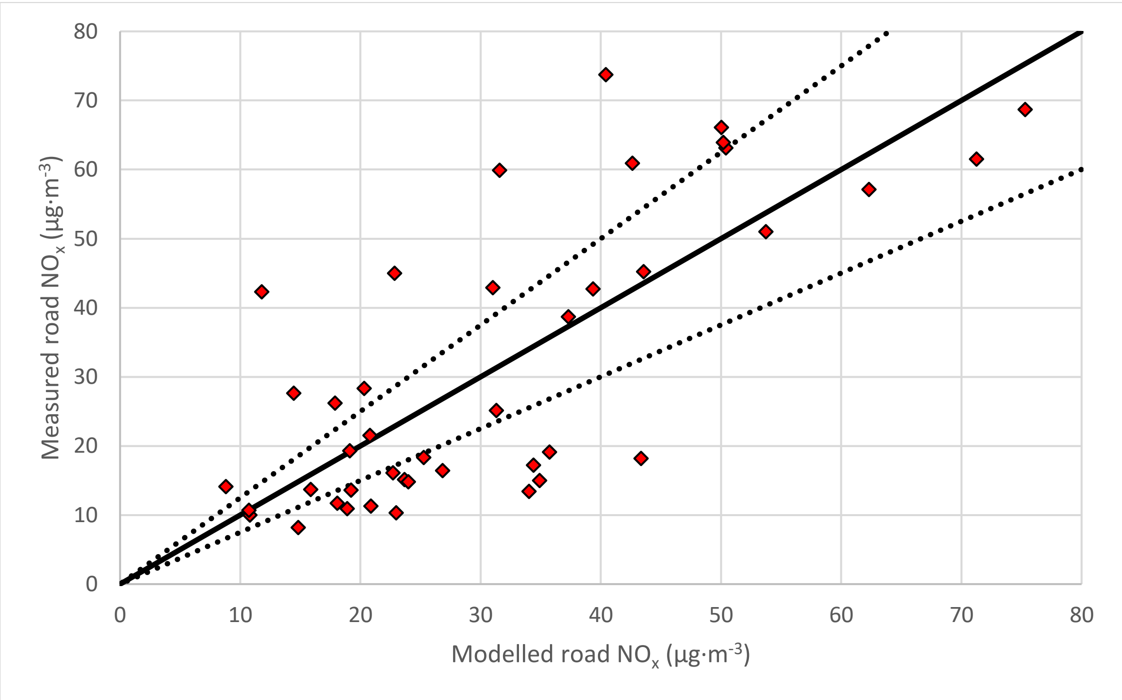


Plot B1 – Rotherham




The results of these comparisons showed the model performance for non-gradient impacted sites. As can be seen, it was necessary to adjust the raw road NOx values in order to obtain predictions of future NOx and $NO_2$ annual mean values.

Plot B2 monitored v unadjusted modelled road NOx with 25% confidence lines

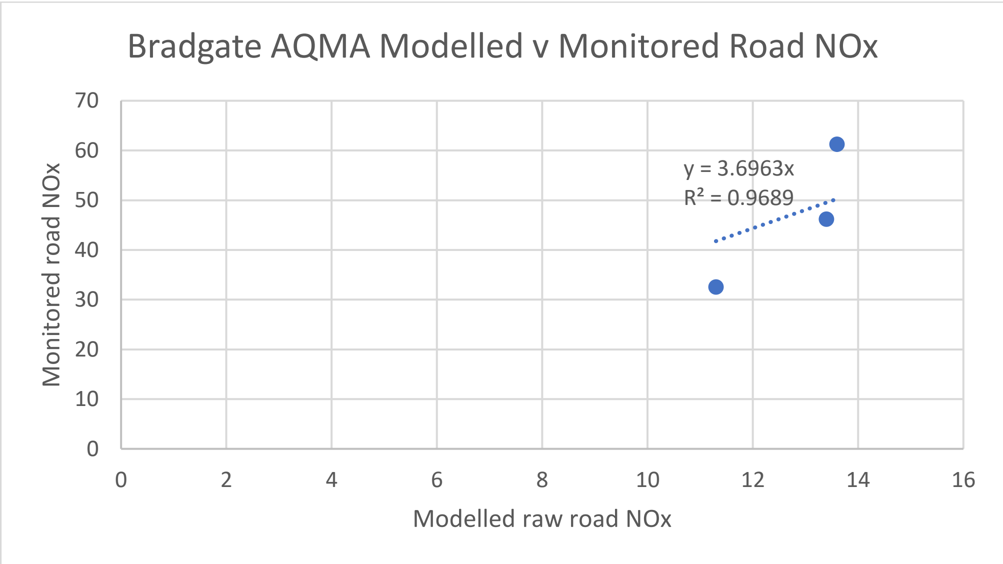


We found that there was consistent under-prediction of road-NOx concentrations at key monitoring sites in Air Quality Management Areas (where National Air Quality Objectives have been exceeded for many years) where gradient was a significant issue, particularly when this was combined with low speeds and acceleration away from a junction. This is understandable when predicting road NOx concentrations in urban environments using a dispersion model *with averaged NOx emissions over a road link calculated from emissions from Defra's EFT*. Averaged NOx emissions calculated over a road link calculated from emissions from Defra's EFT cannot provide accurate NOx emissions data for roads with significant gradient or for street canyons. It provides emissions data for a 'typical road'. The accepted approach to addressing this under-prediction, following both Defra and JAQU guidance, is to uplift (adjust) the model road NOx outputs to match the measurements by factoring them. The key road links identified and agreed with JAQU through the Target Determination process in Rotherham, other than the A630 Parkway are located close to the town centre and are impacted by a combination of gradient and industrial emissions to varying extents. They are Rawmarsh Hill A633, Wortley Road A629 and Fitzwilliam Road A630, all of which are in existing Air Quality Management Areas with sensitive receptors within 4m of the roadside.

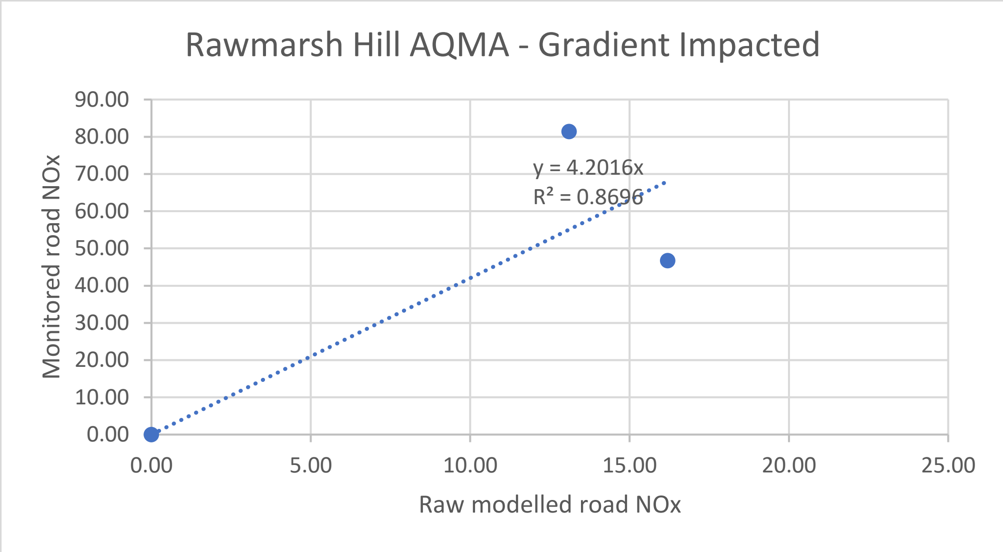
Examples of the plots of modelled v monitored (Defra NOx:$NO_2$ calculator derived) road NOx gradient–impacted sites follow:

Gradient Impacted sites situated within Rotherham AQMAs

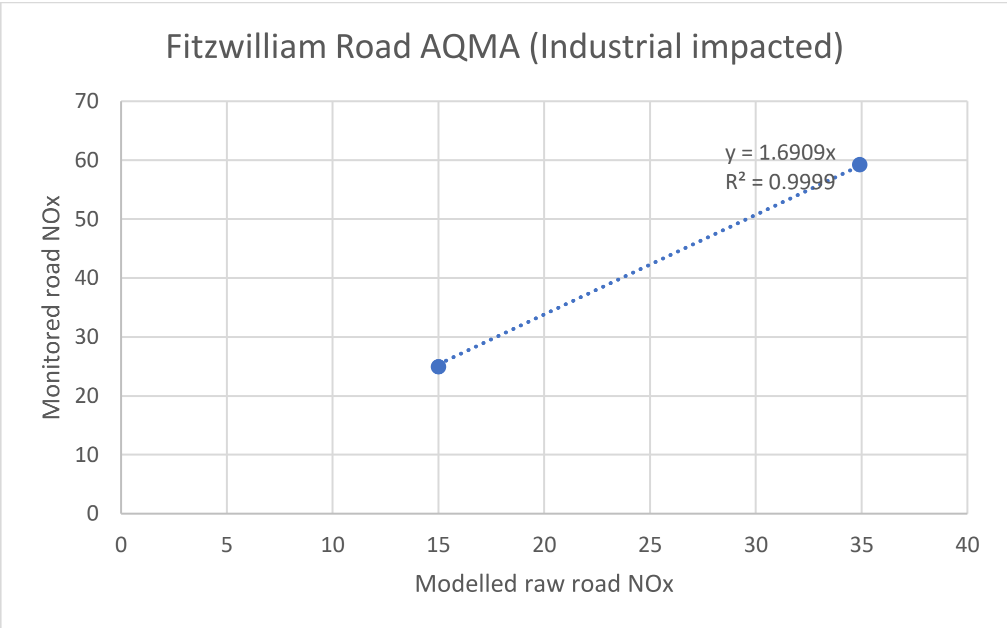
Plot C



Plot D – Rawmarsh Hill AQMA road NOx gradient impacted




Plot E – Fitzwilliam Road (road NOx), location influenced by industrial emissions:




There are currently no reporting locations in Sheffield for *CAP compliance* that are impacted by gradient, i.e., roads with gradients greater than 2.5%. Therefore, in accordance with LAQM-TG16, the effect of gradients on all vehicles in Sheffield can be justifiably neglected.

### 3.5 Road Link Specific adjustment of the model

Therefore, we have made use of Road Link Specific calibration for our modelling: an example is used here to illustrate why we used site specific factors. For a road which has minor gradient, i.e., gradient effect is less than 2.5%, or street canyon effects, e.g., the PCM link A61

St Mary's Road, there was little difference in modelled results obtained by either using a specific road link factor or the average domain factor. For the flat roads (no gradient, canyon):

- A61 St Mary's Road, Sheffield – nitrogen dioxide annual mean with one average factor = 99.1% of that calculated with site specific factor; and,
- A630 Fitzwilliam Road, Rotherham – nitrogen dioxide annual mean with one average factor = 99.5% of that calculated with site specific factor.

For flat roads, with no street canyon effects, one domain-wide average factor should result in valid modelled predictions.

However, for key road links with uphill gradient, low vehicle speeds and acceleration, congestion, canyon effects and in known Air Quality Management Areas we found the following:

- A633 Rawmarsh Hill annual mean nitrogen dioxide calculated using a whole domain average factor = 63.3% of that calculated with a road link specific factor.
- A629 Wortley Road annual mean nitrogen dioxide one average factor = 63.3% of that calculated with road link specific factor.

Use of the whole domain average factor for adjusting road NOx concentrations for locations such as these would result in under-predicted concentrations, showing compliance with limit values by a very large margin, resulting in communities continuing to being exposed to elevated levels of air pollution and attendant public health.

Rawmarsh Hill has a relatively high road NOx adjustment factor, this is explained by the steep gradient (which was not fully accounted for in the emissions data from the transport model), acceleration from standing at traffic lights uphill, and the presence of buildings close to the road (street canyon).

The A629 also has a steep gradient and vehicles accelerating between buildings (street canyon) from a roundabout. There are a significant number of HGVs using this route to access the M1.

The A630 Fitzwilliam Road is a relatively flat road and experiences peak time congestion. It also is in an area which is both close to the town centre and subject to a significant amount of industrial NOx emissions, e.g., major steel and glass works. Non-road sources were modelled in order to establish the non-road component (classed as 'background' in the NOx:$NO_2$ calculator) – see subsection 3.1.1 above.

Although gradients in Sheffield at reporting locations are less than 2.5%, a similar observation for non-canyon road links was also made. If an average factor had been used across the domain, a large majority of the receptor locations would have shown compliance, which would be far from reality.

Below are some results to illustrate this:

**Table 3 – Lower Sheffield City Centre PCM Link**

| PCM Link: Lower Sheffield City Centre | Census ID | X | Y | Monitored $NO_2$ µg.m$^{-3}$ | Lower SCC Zonal Total $NO_2$ µg.m$^{-3}$ | Site Specific Total $NO_2$ µg.m$^{-3}$ | 2017 $NO_2$ Zonal as a % of Site Specific |
|---|---|---|---|---|---|---|---|
| Sheaf Str station side | 60030 | 435769 | 386951 | **49.0** | **44.1** | **54.2** | 81.4% |
| A61 Shoreham Street | 75194 | 435549 | 386631 | **43.7** | 35.1 | **49.8** | 70.5% |
| A61 Suffolk Road | 75195 | 435810 | 386626 | **41.0** Note 1 | 39.1 | **46.8** | 83.5% |
| A61 Fornham Street | 75198 | 435737 | 386648 | 38.7 | 33.1 | **44.2** | 74.7% |
| A61 Matilda Street | 75199 | 435574 | 386556 | 38.0 | 37.0 | **43.9** | 84.2% |
| A61 St Mary's Gate | 57861 | 435005 | 386383 | 34.0 | **43.1** | 40.3 | 107.1% |
| A61 St Mary's Road | 75196 | 435753 | 386520 | 34.0 Note 1 | 39.8 | 40.1 | 99.1% |
| A61 St Mary's Road | 75197 | 435313 | 386367 | 34.0 | 38.9 | 40.1 | 97.1% |
| A61 St Mary's Road | 8744 | 435361 | 386381 | 34.0 Note 1 | 38.2 | 40.0 | 95.3% |

Notes

*Note 1 These are adjusted results (see Appendix 2 (Technical Note) – AQ2–SD02): Note on Adjustment of Modelled Road NOx for Assessment Locations)*

**Table 4 – Inner Ring Road North PCM Link**

| PCM Link: Inner Ring Road North | Census ID | X | Y | Monitored $NO_2$ µg.m$^{-3}$ | Inner SCC Zonal Total $NO_2$ µg.m$^{-3}$ | Site Specific Total $NO_2$ µg.m$^{-3}$ | 2017 $NO_2$ Zonal as a % of Site Specific |
|---|---|---|---|---|---|---|---|
| A61 Derek Dooley Way | 81236 | 435658 | 388179 | **43.3** Note 1 | **42.9** | **48.9** | 87.7% |
| A6109 Savile Street | 81238 | 435861 | 388168 | **42.0** | 38.3 | **47.8** | 80.0% |
| A6135 Wicker | 76044 | 435923 | 388023 | **41.0** | 37.5 | **46.0** | 81.7% |
| A61 Derek Dooley Way | 76046 | 436217 | 387889 | 36.0 | 35.8 | **44.5** | 80.4% |
| A61 Shalesmoor/ Bridgehouses | 81162 | 435402 | 388018 | 36.6 Note 1 | 40.0 | **42.1** | 95.1% |
| A61 Derek Dooley Way | 81237 | 435810 | 388040 | 34.0 Note 1 | 39.3 | 40.2 | 97.9% |

Notes

*Note 1 These are adjusted results (see Appendix 2 (Technical Note) – AQ2–SD02): Note on Adjustment of Modelled Road NOx for Assessment Locations)*

It is pertinent to provide an illustration of why applying one factor to a whole domain is not necessarily the best approach. Annual mean nitrogen dioxide monitored data (2017) for the same location but on opposite sides of the M1 motorway in South Yorkshire (source – National Highways automatic monitoring) (Northbound (NB) and Southbound (SB) at 4m) is as follows: NB (downhill gradient) 29.6ug/m$^3$. SB (uphill) 60.9ug/m$^3$.

Furthermore, each road link has its' specific calculated f-$NO_2$ value applied.

## 3.6 Canyon modelling

A canyon is a single road flanked by buildings on each side. A canyon model simulates the dispersion of pollutants generated by traffic on such a road. This section provides information on the simulation of modelled road NOx for those reporting locations in a canyon.

The appraisal and analysis that informed our OBC in 2018 did not include canyon modelling, the Street Canyon model in Airviro did not accept emissions data in the format provided from our transport model in grammes per second (g/s).

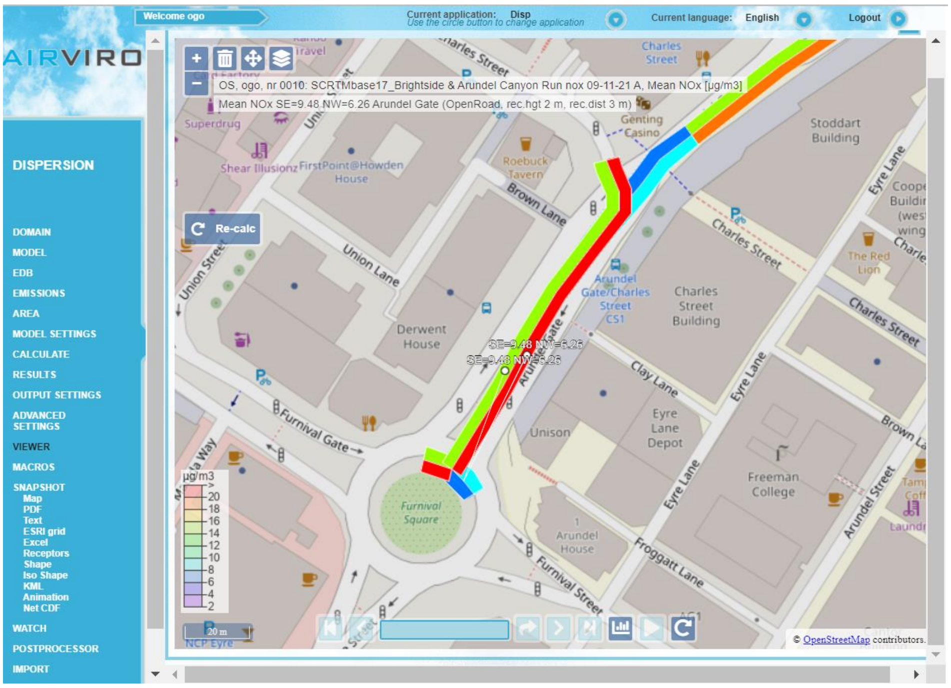
Airviro now includes OSPM, a state-of-the-art street pollution model, developed by the National Environmental Research Institute, Department of Atmospheric Environment in Denmark. Concentrations of exhaust gases are calculated using a combination of a plume model for the direct contribution and a box model for the recirculating part of the pollutants in the street. “It is assumed that both the traffic and emissions are uniformly distributed across the canyon. The emission field is treated as a number of infinitesimal line sources aligned perpendicularly to the wind direction at the street level. The cross wind diffusion is disregarded. The wind direction at the street level is assumed to be mirror reflected with respect to the roof level wind. The plume expression for a line source is integrated along the path defined by the street level wind. The length of the integration path depends on the extension of the recirculation zone.” (*See Appendix 2J: The OSPM Model, Airviro User’s reference, Working with the Dispersion Module)*.

Using local knowledge and information on building heights and road widths two locations, Brightside Lane and Stoddart Building Arundel Gate, valid for reporting compliance have been identified as candidates for canyon modelling.

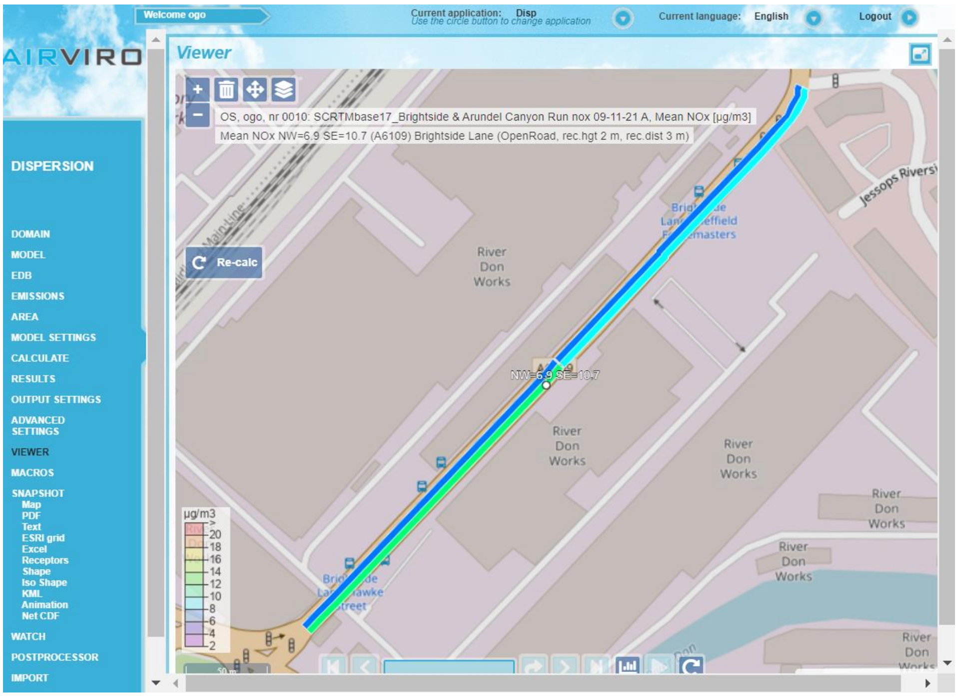
The modelled domain has all the relevant input parameters including calculation area, surface characteristics, topography Met input, i.e., time series of wind, temperature and vertical temperature difference, Emissions: Street/Road sources, traffic. The model output includes time series concentrations on both sides of the street canyon (road).

Figs 3 and 4 show example plots of the canyon modelling. The road NOx concentrations modelled in the baseline and PO steps respectively, without the streets canyon road NOx emissions, were added to the combined annual northwest (NW) and annual southeast (SE) results from the OSPM street canyon model, and post-processed using the Defra NOx:$NO_2$ calculator, to obtain their $NO_2$ concentrations. The results do not change the conclusion that a scheme is required and not a risk to the PO.

## Fig 3 Stoddart Building, Arundel Gate Canyon




## Fig 4 Brightside Lane Canyon



### 3.7 Additional Model Verification

Monitoring sites on the PCM road link have been used to further analyse and verify the model – see Table 5 below. Uncertainties have been considered by using statistics to calculate Root Mean Square Error (RMSE). In accordance with Defra's Local Air Quality Management Technical Guidance (LAQM TG(16) where a model's performance is within 25% of the objective being assessed, in this case 40µg/m$^3$ for annual mean $NO_2$, or if a Root Mean Square Error (RMSE) of 10µg/m$^3$ or less is estimated, it can be considered to perform well. Therefore, RMSE in this case should be within 10% of the air quality objective, i.e., 4µg/m$^3$.

The calculated RMSE was 0.09, which is within 10% of the annual mean limit value for $NO_2$. Fractional bias (FB) was also calculated and found to be 0.0. FB is used to find out if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.

**Table 5 – Verification Monitoring Sites (Post Verification Concentrations)**

| Site Location | Census _ID | X | Y | Monitored $NO_2$ (µg/m$^3$) | Total modelled $NO_2$ (site specific verification) | difference Modelled vs Monitored $NO_2$ | Square of difference |
|---|---|---|---|---|---|---|---|
| A6178 for TD | 7380 | 437928 | 388797 | 40.40 | 40.38 | -0.02 | 0.00 |
| A57 | 8144 | 433584 | 387108 | 33.00 | 32.99 | -0.01 | 0.00 |
| A61 | 16581 | 435140 | 384991 | 39.10 | 39.10 | 0.00 | 0.00 |
| A631 | 17332 | 440115 | 390799 | 37.90 | 37.90 | 0.00 | 0.00 |
| A6109 | 17718 | 438610 | 390617 | 45.60 | 45.60 | 0.00 | 0.00 |
| A6315 | 17728 | 435840 | 388817 | 38.70 | 38.66 | -0.04 | 0.00 |
| A61 | 17809 | 434808 | 388215 | 38.70 | 38.70 | 0.00 | 0.00 |
| A61 | 18546 | 433440 | 390517 | 41.30 | 41.30 | 0.00 | 0.00 |
| A61 | 27857 | 435695 | 385892 | 38.40 | 38.38 | -0.02 | 0.00 |
| A6178 | 37441 | 439717 | 390829 | 46.30 | 46.29 | -0.01 | 0.00 |
| A61 | 37898 | 435809 | 386349 | 35.10 | 35.10 | 0.00 | 0.00 |
| A6178 | 38549 | 438548 | 389660 | 39.10 | 39.07 | -0.03 | 0.00 |
| A625 | 47396 | 434317 | 386286 | 34.80 | 34.80 | 0.00 | 0.00 |
| A6109 | 47826 | 439171 | 391727 | 40.30 | 40.25 | -0.05 | 0.00 |
| A61 | 47856 | 433384 | 390693 | 33.90 | 33.90 | 0.00 | 0.00 |
| A61 | 47860 | 434401 | 386985 | 35.30 | 35.30 | 0.00 | 0.00 |
| A6109 | 56863 | 436322 | 388234 | 35.20 | 35.18 | -0.02 | 0.00 |
| A6135 | 57875 | 436492 | 390149 | 35.70 | 35.68 | -0.02 | 0.00 |
| A61 | 75194 | 435548 | 386632 | 43.70 | 43.70 | 0.00 | 0.00 |
| A6135 | 76044 | 435921 | 388024 | 41.10 | 40.95 | -0.15 | 0.02 |
| Glossop Road B6547 | n/a | 433413 | 386746 | 30.60 | 30.56 | -0.04 | 0.00 |
| Barkers Pool Taxi Rank | n/a | 435289 | 387227 | 33.60 | 33.50 | -0.10 | 0.01 |
| C710 Arundel Gate | n/a | 435600 | 387293 | 61.10 | 60.69 | -0.41 | 0.17 |
| Beeley Wood Road, S6 | n/a | 433248 | 391121 | 30.10 | 30.10 | 0.00 | 0.00 |

## 4.0 Uncertainty and Sensitivity Tests

Modelling work undertaken to date has indicated that the CAP schemes will be required to achieve compliance during 2022, including buses on key routes throughout the domain being upgraded to Euro VI. During 2020, we investigated potential COVID-impacts, and it was necessary to delay the predicted year of compliance to 2022.

SCC and RMBC recognise there are considerable uncertainty in modelling, especially given the shock of the COVID-19 pandemic. We have set out uncertainties and sensitivity tests in respect of the modelling that are of particular significance to the Clean Air Plan in sections 4 of a separate Sensitivity Test document and in AQ3 (See FBC Transport Model Sensitivity Tests Note).

Although the charging zone is not anticipated to be operational until late in 2022, many of the vehicle upgrades which are required to have been carried out for compliance will have taken place, with the prospect of the charging CAZ in Sheffield providing a strong incentive to operators. The anti-idling and Transforming Cities Scheme on Arundel Gate will also contribute to a significant reduction in NOx emissions at roadside. In Rotherham's case compliance is achieved through highways schemes, all of which will be in place by Spring 2022 and bus fleet upgrades which are scheduled for early 2022. There is therefore confidence that compliance will be reached in Rotherham and Sheffield during 2022.

**APPENDIX**

Appendix 1 – AQ2–SD01

**Briefing note re the validity of the Parkway as a location for reporting CAP compliance**

**Purpose:**

This DRAFT briefing note is to be read in conjunction with the accompanying slide pack (See AQ2 – SD01A). This note has been prepared to inform the discussion with JAQU on the 24th May 2021.

**Context:**

As part of our series of quality assurance checks, each current reporting location for CAP compliance has been assessed against the requirements within Annex III of the EU AQ Directive and JAQU's guidance The assessment criteria include:

- Road locations situated within areas where members of the public do not have access and there is no fixed habitation or where there is no public access within 15 m (Annex III of AQD – 10 m), these roads have been excluded from the compliance assessment (JAQU guidance).
- Where there is access (houses, gardens, or footpaths) within 15 m at grade with the road, these road links are included (JAQU guidance).
- Where there is access via a footpath or similar that is not at grade with the road, because the road is elevated or in a cutting, these roads are included if the access is parallel to (runs alongside) the road (JAQU guidance) (Annex III of AQD – 10 m).
- If the only access (the footpath or another road with pavements) is not at grade with the main road but is perpendicular (goes under or over the main road with a bridge), then if there is no other access these roads may be excluded from the compliance assessment (JAQU guidance).
- Locations where the air sampled is representative of air quality for a street segment no less than 100 m length at traffic-orientated sites.
- Traffic-orientated sampling probes shall be at least 25 m from the edge of major junctions and within 10 m from the kerbside.

*A more detailed technical note covering this will be shared with JAQU shortly, prior to finalising and submitting the note we feel it is important to discuss the specifics in relation to the Parkway with JAQU and seek their view.*

**Parkway review conclusions:**

**Sheffield section of the Parkway:**

**The review has concluded that the Sheffield section of the Parkway is not a location relevant for monitoring compliance as it falls within the EU direction at Annex 3a 2a (location where members of the public have no access and there is no fixed habitation) of AQD Annex III and JAQU guidance. Pedestrians and cyclists are prohibited on this road link - Census IDs 36588, 47855, 76045, 99303 are specifically affected.**

**Rotherham section of the Parkway**

The location previously reported on A.630 Sheffield Parkway related to the link between the B.6544 at Catcliffe Dumbbells, and M.1 Junction 33. This location reflects the highest concentration forecast on the link accommodating our monitoring equipment (before and after the major highway improvements currently under construction – the equipment is to be moved as part of that scheme as existing access arrangements will not be viable as consequence of the scheme).

Considering JAQU guidance on the matter, this location is not considered to be a location with public access. Excepting one footpath crossing considered later, pedestrians and cyclists are prohibited from the full length of Sheffield Parkway between Catcliffe and the motorway, through both Sheffield and Rotherham, stopping is prohibited, and the existing parking lay-bys are being removed as part of the highway improvement scheme. No adjacent developed land that is both at grade, and within 15m of the edge of carriageway, has been identified on this section of the Parkway. The monitoring location has been dictated by the need for safe vehicular access for servicing, given the high speed nature of the Parkway. This constraint is reflective of, and evidence for, the aforementioned lack of public access to the A.630 Sheffield Parkway.

There is a location with public access at the footpath crossing approximately 2km to the southeast of the previously reported location, and the link between Catcliffe Dumbbells and the Borough boundary. Whilst usage of this crossing is thought extremely low, and so low as not to meet the test in the Directive of public exposure being for a period significant in relation to the averaging period of the limit value, we are reporting as an additional modelled data point at the crossing out of an abundance of caution. This indicates concentrations within limit value by significant margin in 2022, with concentrations forecast to be 31.0 $\mu g \cdot m^{-3}$ in 2022 Business as Usual, reducing to 29.5 $\mu g \cdot m^{-3}$ in the scenario with the Class C charging CAZ in central Sheffield.

We have also considered forecast concentrations at Whitehill Lane. This is not felt to constitute a location with public access because footways and adjacent premises are below grade, and Whitehill Lane crosses rather than runs parallel to the A.630 – this is consistent with JAQU's note 'Advice on Public Access' issued in 2017. Out of an abundance of caution, we report a figure for this location, which is within limit value for all CAZ scenarios, with concentrations of 40.0 $\mu g \cdot m^{-3}$ forecast in a CAZ C scenario. Note the reported figure is likely a considerable overestimate of concentrations at street level i.e. where the public actually have access; this is somewhat lower (at least 5 metres) than the A.630 which crosses Whitehill Lane on an overbridge at this point. This level difference is not accounted for in the Airviro model.

*Appendix 2 – AQ2–SD02*

**Note on Adjustment of Modelled Road NOx for Assessment Locations**

***1. Summary***

***This note sets out our approach to the adjustment of modelled road NOx for those locations on the Inner Ring Road, where monitored roadside $NO_2$ data (2017) was not available in the appraisal that underpinned the 2018 OBC for the Sheffield and Rotherham Clean Air Plan.***

***The adjustment of modelled road NOx for 2017 baseline locations without monitored roadside $NO_2$ data, informed by city centre roadside monitoring results collected throughout 2019, indicates that for the modelled 2021 baseline that all of these locations achieve compliance without intervention.***

**2. Identifying the requirement for adjustment**

The appraisal and analysis that informed our OBC in 2018 included the adjustment of all baseline assessment locations. This adjustment process primarily used monitored roadside concentrations data but for certain locations, where there was an absence of monitored roadside concentration data, these were adjusted using proxy sites – a standard approach.

The results of the appraisal and analysis indicated that some of the locations with the highest predicted road $NO_2$ concentrations in Sheffield were at sites where we did not have actual data, and we therefore deployed monitoring at these sites. These included a number of locations on the Inner Ring Road (IRR), including St Marys Road; Shalesmoor (Bridgehouses); Suffolk Road; and Derek Dooley Way. The reason there was no pre-existing monitoring at these locations is because there is no relevant exposure in terms of LAQM and in terms of meeting NAQS objectives.

Monitoring for nitrogen dioxide was undertaken for a full calendar year throughout 2019 (and has continued since) using diffusion tubes and the full annual average data was available in Feb/March 2020 after it had been processed in the lab and bias adjusted by SCC in the usual way (standard practice). The laboratory used to analyse the tubes is South Yorkshire Air Quality Samplers which over the latest rolling five round AIR PT (Proficiency Test) window (to November 2019), achieved 95 % of laboratory results ≤ ± 2. For a summary of the performance, for SYAQS participating in the AIR PT scheme, see link[1].

Clearly in Feb/March 2020 there were a number of issues influencing the CAZ programme:

- We received our Direction to proceed with the CAZ C+
- We became aware of the outcome of the funding from the CAF, and
- The full picture in relation to Covid-19 was starting to become clear (SCC focus on Public Health, remote working introduced, impact on productivity and remote access, etc)

As such the focus of our resources was in considering all these issues and more. However, monitoring of AQ and Traffic levels continued through 2020 and, as part of the announced C-19 review of the current CAZ proposals, we also reviewed the most up to date data we hold to understand how this relates to the data and forecasts we produced for the 2018 OBC.

[1] https://laqm.defra.gov.uk/assets/laqmno2performancedatauptonovember2019v1.pdf

This part of our review highlighted that at many of the locations on the IRR monitoring during 2019 has shown that the modelling reported in the 2018 OBC was over-predicting $NO_2$ concentrations at these locations. The locations of note are shown in the following table:

| | Census ID | | X | Y | Modelled Bau 2017 | Modelled Bau Baseline 2021 | Monitored 2019 |
|---|---|---|---|---|---|---|---|
| St Mary's Road | 8744 | A61 | 435362 | 386383 | 62.4 | 51.6 | 34 |
| Suffolk Road | 75195 | A61 | 435810 | 386626 | 65.2 | 53.4 | 42 |
| St Mary's Road | 75196 | A61 | 435753 | 386520 | 64.6 | 53.1 | 34 |
| Bridgehouses | 81162 | A61 | 435402 | 388018 | 59.3 | 49.7 | 37 |
| Derek D Way | 81236 | A61 | 435658 | 388179 | 58.7 | 50.3 | 44 |
| Derek D Way | 81237 | A61 | 435810 | 388040 | 60.5 | 50.1 | 34 |

**3. Approach to adjustment**

Given the significance of this issue and the need to ensure that the review of the CAZ is undertaken using the most appropriate data, we have performed a readjustment of the predicted $NO_2$ for the locations based on the *actual* roadside monitoring data at those locations where proxy sites were previously used.

The monitored $NO_2$ at these sites has been factored to 2017 to take account of the improvement that roadside concentrations displayed across monitored city centre locations in 2019 compared to 2017 – see **Appendix A**. After converting to road NOx using the DEFRA NOx to $NO_2$ Calculator, it was then used to adjust the modelled road NOx for 2017 results for the locations and then used to determine a more accurate 2021 BaU baseline.

The $NO_2$ data from the adjustment of baseline modelled road NOx is shown in the table below:

**Table of $NO_2$ results for baseline 2017 and 2021 following adjustment of modelled road NOx**

| Adjusted / AQ3 $NO_2$ | Census ID | | X | Y | *Modelled BaU 2017 $NO_2$ | *Modelled BaU Baseline 2021 $NO_2$ | Diff Tube Monitored 2019 $NO_2$ |
|---|---|---|---|---|---|---|---|
| St Mary's Road | 8744 | A61 | 435362 | 386383 | 34 | 26.7 | 34 |
| Suffolk Road | 75195 | A61 | 435810 | 386626 | 41 | 34.4 | 42 |
| St Mary's Road | 75196 | A61 | 435753 | 386520 | 34 | 26.5 | 34 |
| Bridgehouses | 81162 | A61 | 435402 | 388018 | 36 | 30.9 | 37 |
| Derek D Way | 81236 | A61 | 435658 | 388179 | 43 | 39.0 | 44 |
| Derek D Way | 81237 | A61 | 435810 | 388040 | 34 | 27.8 | 34 |

* Readjusted $NO_2$

**4. Conclusions**

The results of the adjustment of modelled road NOx show that because of the lack of actual roadside monitoring to undertake the adjustment of the predicted baseline results for those locations at that time the initial $NO_2$ concentrations submitted for these locations in the AQ3 report are high and incorrect.

The results also show that compliance is predicted at each of these IRR locations in the 2021 baseline.

**Appendix A:** Steps in adjusting road NOx at IRR sites and factoring to 2017 using Defra's $NO_x$:$NO_2$ calculator

Step 1 – Shows collated roadside diffusion tubes monitored 2017 and 2019 $NO_2$ concentrations at 7 locations in the city centre, including Calculated Ratios.

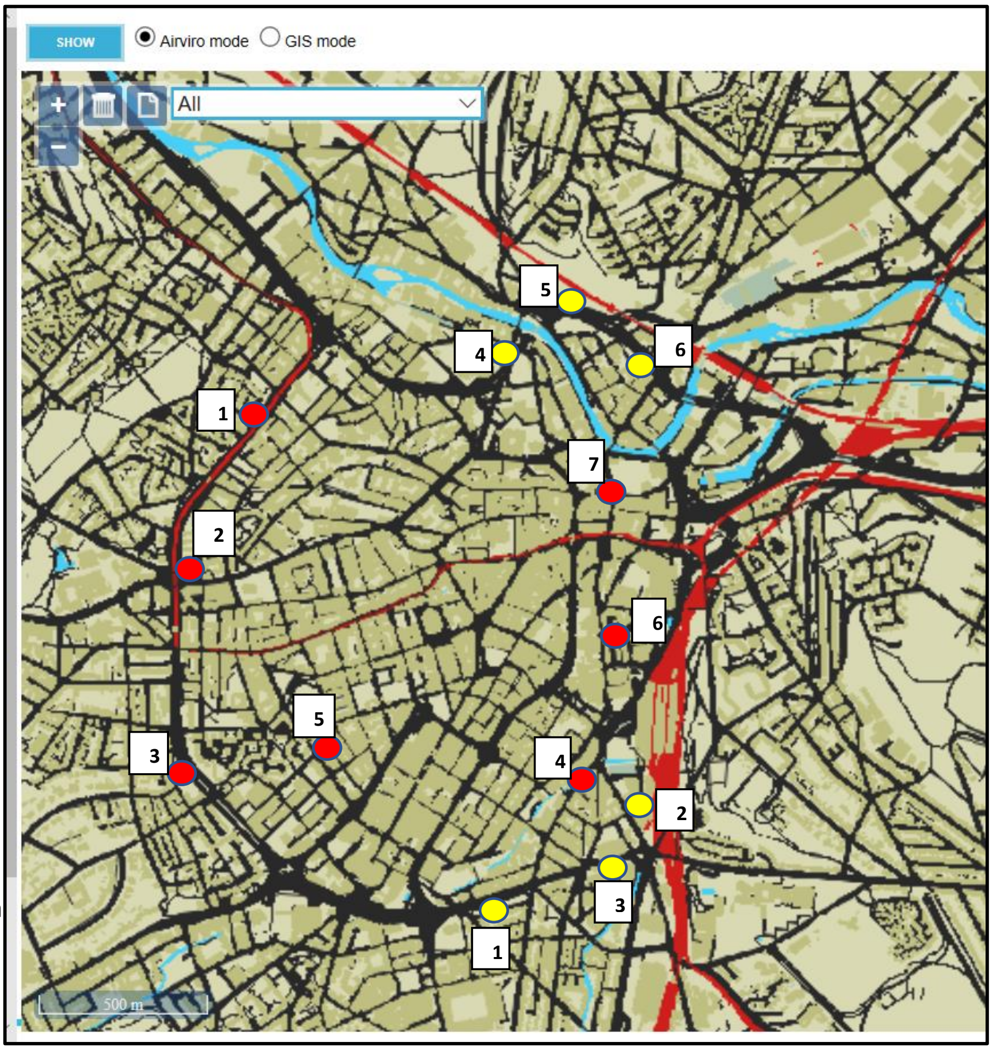
**Step 1 Monitored* $NO_2$ Concentrations at City Centre Locations and Calculated Ratios**

| | Locations** | X | Y | 2017 Annual Mean | 2019 Annual Mean | Ratio (2017/2019) |
|---|---|---|---|---|---|---|
| 1 | Netherthope School | 434638 | 387828 | 36 | 35 | 1.03 |
| 2 | Uni. Roundabout | 434434 | 387393 | 43 | 40 | 1.08 |
| 3 | Upper Hanover | 434405 | 386966 | 39 | 40 | 0.98 |
| 4 | Shoreham Street | 435554 | 386638 | 48 | 47 | 1.02 |
| 5 | Devonshire Green | 434799 | 386945 | 22 | 26 | 0.85 |
| 6 | Pond St Interchange | 435701 | 387258 | 49 | 50 | 0.98 |
| 7 | Waingate | 435739 | 387653 | 46 | 47 | 0.98 |
| | Average (Ra) | | | | | 0.99 |

* See link to Sheffield Diffusion Tubes Map: https://bit.ly/3qaAAjf

**Locations – see numbered red circles on map, Fig 1, below

**Fig 1 Monitored and adjusted sites Location map, Sheffield City Centre**




Step 2 – Sh

interest.

**Step 2** **Monitored 2019 and Adjusted 2017 $NO_2$ Concentrations at IRR Assessment Locations**

| | Locations** | Census ID | Road ID | X | Y | 2019 Annual Mean | Estimated 2017* (Ra x 2019 Annual Mean) |
|---|---|---|---|---|---|---|---|
| 1 | St Mary's Road | 8744 | A61 | 435362 | 386383 | 34 | 34 |
| 2 | Suffolk Road | 75195 | A61 | 435810 | 386626 | 42 | 41 |
| 3 | St Mary's Road | 75196 | A61 | 435753 | 386520 | 34 | 34 |
| 4 | Bridgehouses | 81162 | A61 | 435402 | 388018 | 37 | 36 |
| 5 | Derek D Way | 81236 | A61 | 435658 | 388179 | 44 | 43 |
| 6 | Derek D Way | 81237 | A61 | 435810 | 388040 | 34 | 34 |

* Calculated using above Average Annual Mean Diff Tubes Ratio (Ra = 0.99)

**Locations – see numbered yellow circles on map, Fig 1, above

**Appendix 3 – AQ2–SD03**

**Advice on Public Access – JAQU Guidance**

The AQD Annex III sets out the criteria for the assessment of locations, and explains that roads where there is no public access can be excluded for this purpose. The Department's approach, informed by our expert consultants Ricardo, has been to include roads on the following basis.

The PCM model provides modelled annual mean $NO_2$ concentrations at ~9000 urban traffic (roadside) locations at a nominal 4 m distance from the kerb representative of concentrations along a specific road link (typically the stretch of road between two junctions with other major roads). These locations have been identified by DfT as 'urban' using a definition of '*roads within an urban area with a population of 10,000 or more*'.

In most cases there is clear public access close to these urban roads such as pavements or houses. There are some instances where things are not as clear cut. The PCM uses the criteria specified in Annex III, C for traffic locations, that monitoring stations, or other forms of assessment, should assess concentrations at traffic locations within 10 m of the kerb. Given the uncertainties in assessing access using aerial photography (via Google maps, for example), PCM excludes roads if there is no clear access within 15 m. We have applied the following criteria:

- Where there is access (houses, gardens or footpaths) within 15 m at grade with the road, these road links are included.
- Where there is access via a footpath or similar that is not at grade with the road, because the road is elevated or in a cutting, these roads are included if the access is parallel to (runs alongside) the road.
- If the only access (the footpath or another road with pavements) is not at grade with the main road but is perpendicular (goes under or over the main road with a bridge), then if there is no other access these roads may be excluded from the compliance assessment.
- Where there is no public access within 15 m, these roads have been excluded from the compliance assessment.

A list of items typically reviewed as public access include pavements, buildings, gardens, car parks, cycle tracks or footpaths (running parallel to the road). So a larger trunk road that is classified as urban can be excluded from the compliance assessment if there is no public access within 15 m such as no pavements and large verges putting them some distance from buildings. While the presence of a footpath or cycle track running parallel within 15 m of the carriageway would mean the road is included in the modelling.

It should be noted that this represents the Department's view and approach, expressed to be helpful. However, it is not legal advice or a definitive interpretation of the law, as ultimately interpretation is a matter for the courts.