Bristol City Council Clean Air Local Plan: Transport and Air Quality Compliance Timescales, Assumptions and Calculations

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1.0 Introduction

1.1 Overview

Due to forecast air quality exceedances of the European Union Limit Value for nitrogen dioxide Bristol City Council has been directed by Defra to produce a Local Plan to achieve air quality improvements in the shortest time possible. As part of the Local Plan, Bristol City Council is considering implementation of a Clean Air Zone (CAZ), possibly including both charging and non-charging measures. CH2M has been commissioned by Bristol City Council to assess the available CAZ options in order to establish which will deliver compliance in the shortest time possible.

This technical note outlines the Transport and Air Quality modelling assumptions and calculations undertaken to assess the timescales to achieve compliance of each charging option.

1.2 Options Assessed

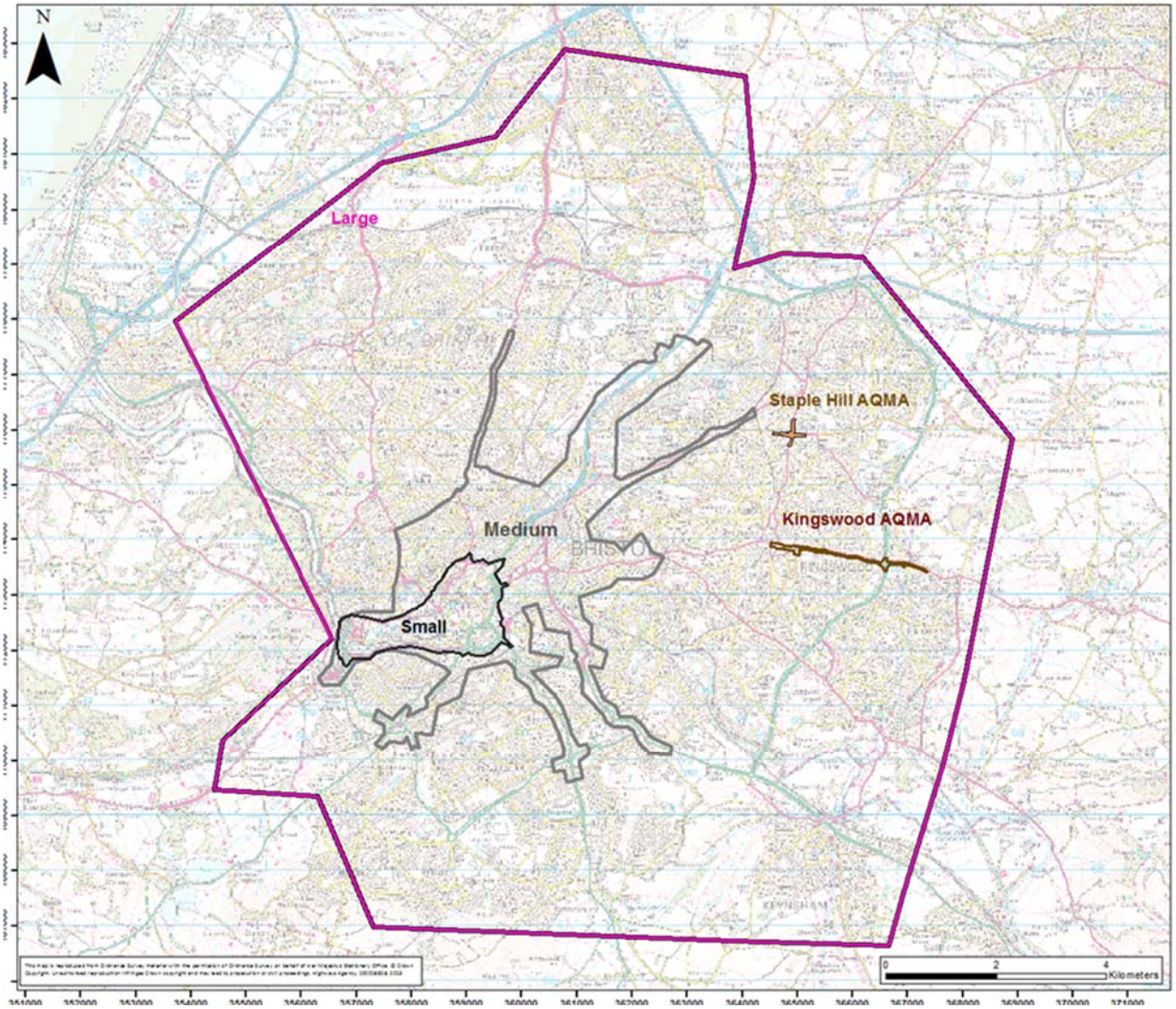
In total 20 charging options were identified, reflecting five different geographical areas and four CAZ classes. The following four CAZ charging classes, as set out in Defra / DfT's Clean Air Zone Framework have been assessed:

1. Class A charging – buses, coaches, taxis, private hire vehicles
2. Class B charging – buses, coaches, taxis, private hire vehicles and HGVs
3. Class C charging – buses, coaches, taxis, private hire vehicles, HGVs and LGVs
4. Class D charging – buses, coaches, taxis, private hire vehicles, HGVs, LGVs and cars

The geographical scopes assessed are listed below and shown in Figure 1;

1. Large - the Bristol urban area within the boundary of the M4 and M5 and excluding areas within B&NES and NSC.
2. Medium - BCC AQMA
3. Medium - BCC & SGC Kingswood-Warmley AQMA combined
4. Medium - BCC & SGC Kingswood-Warmley AQMA separate
5. Small - within the Inner Ring Road

Figure 1: Boundaries of CAZ geographical scopes assessed.



The large geography has been discounted from the list of options based on the timescales taken to implement the scheme (see Strategic Outline Case).

The three versions of the medium zone are all expected to achieve compliance with the EU Limit Values and national Air Quality Objectives in a similar timescale and so have been assessed simultaneously. Therefore, the assessment of timescales to achieve compliance has been undertaken for the following 8 options;

- Medium geography, CAZ Class A – charging
- Medium geography, CAZ Class B – charging
- Medium geography, CAZ Class C – charging
- Medium geography, CAZ Class D – charging
- Small geography, CAZ Class A – charging
- Small geography, CAZ Class B – charging
- Small geography, CAZ Class C – charging
- Small geography, CAZ Class D – charging.

2.0 Transport Modelling Assumptions

2.1 Overview

This section sets out the transport modelling methodology, and assumptions, used to assess the timescales in which compliance could be achieved for twenty CAZ charging options.

2.2 Base Model

In 2013, BCC commissioned CH2M to update the existing GBATS model, primarily to assess the MetroWest scheme. The updated model is called the GBATS4 Metro Model (GBATS4M). The GBATS4M model consists of:

- A Highway Assignment Model representing vehicle based movements across the Greater Bristol area for a 2013 autumn weekday morning peak hour (08:00-09:00), an average inter-peak hour (10:00-16:00) and an evening peak hour (17:00-18:00);
- A Public Transport (PT) Assignment Model representing bus and rail based movements across the same area and time periods; and
- A five-stage multi-modal incremental Variable Demand Model (VDM) that forecasts changes in trip frequency and choice of main mode, time period of travel, destination, and sub-mode choice, in response to changes in generalised costs across the 12-hour period (07:00 – 19:00).

2.3 Reference Case Model

The 2021 reference case model was developed from the Uncertainty Log collated in 2015, including any developments and infrastructure deemed 'near certain' and 'more than likely'.

A growth model has been developed within the Demand Model which creates highway and public transport future year demand matrices using the production and attraction trip end totals for the new development, a gravity model to distribute these new developments using base year travel costs and then converting to origin and destination format. These new trips are then added to the base year matrices. Three-dimensional matrix balancing to build full reference case matrices is undertaken, retaining the base year trip length distribution and control to the National Trip End model (NTEM, Tempro V7.2) OD growth for West of England and external zones.

These matrices are then run through the variable demand model until convergence is achieved within the limits specified by the DfT.

Light and heavy goods vehicle growth is based on forecasts produced by the National Transport Model (NTM) as advised by WebTAG. Goods vehicles are not subject to change via the demand model.

The model is considered to be the best local model for testing strategic schemes of this kind. The SATURN highway model was used for the CAZ tests in isolation, due to the complexity of the responses within a CAZ, the current structure of the variable demand model and level of detail required for the sifting exercise.

2.4 CAZ Option Modelling

The GBATS4M 2021 SATURN Highway reference case model was used to undertake initial approximate tests of vehicle trip responses to the implementation of a medium Class D CAZ and a small Class D CAZ.

The expected responses to the implementation of a CAZ have been taken from the 'Draft UK Air Quality Plan for tackling nitrogen dioxide' May 2017, Table 4.4, as shown overleaf. These responses were applied to the non-compliant vehicles only. As the highway matrices are not split into compliant/non-compliant trips, national non-compliant vehicle percentages were calculated from the Defra Emissions Factor Fleet Toolkit (EFT, version 8), as shown in Table 1 and 2, and applied to the matrices and traffic link data during post-processing respectively.

Figure 2: Table 4.4 from the Draft UK Air Quality Plan for tackling Nitrogen Dioxide – Technical Report

Table 4.4: Proportions of non-compliant trips by response to the presence of a CAZ

	Cars	LGVs	HGVs	Buses	Coaches
Pay charge	7%	20%	9%	0%	16%
Avoid zone	7%	8%	0%	0%	0%
Cancel journey / change mode	21%	8%	9%	6%	13%
Replace vehicle	64%	64%	83%	94%	72%

Table 1: 2021 National Non-Compliant Vehicle Percentages by Vehicle Type

Year	Cars	LGVs	HGVs
2021	20%	29%	14%

Table 2: 2021 National Non-Compliant Vehicle Percentages by Vehicle/Fuel Type

Year	Cars		LGVs		HGVs
	Petrol	Diesel	Petrol	Diesel	Diesel
2021	1.71%	34.19%	3.06%	29.39%	14.19%

The GBATS4M SATURN Highway model was used to replicate these responses in 2021 using the following methodology:

1. Pay Charge – no change to the model;
2. Avoid Zone – a charge was applied to each inbound CAZ link to replicate the above percentage change of non-compliant cars and LGV's avoiding the CAZ (HGV's not included since 'Avoid zone' response is 0%);
3. Cancel journey / change mode – this was modelled by reducing the number of trips made by non-compliant vehicles to/from the CAZ area and within it, to replicate the percentage change from the reference case, as shown above. This was undertaken by identifying the zones within each CAZ area and applying reduction factors (non-compliant % x response %) for all trips to/from/within the CAZ boundary;
4. Replace Vehicle – no change to the model, however calculations were carried out using model outputs to determine the links which would be affected by the percentage change from non-compliant to compliant vehicles from the reference case. This was achieved by undertaking two-way select cordon analysis and outputting these link flows into a spreadsheet for post-processing for links outside the CAZ boundary. The select cordon identifies trips not only on the cordon boundary, but the routes take by these trips, therefore accounting for changes in fleet as a result of a CAZ, throughout Greater Bristol and beyond. For links within the CAZ boundary, total link flow was used. Post-processing for calculating the replace vehicle response involved the following:
    - Factors applied to calculated AADT flows from AM, Inter and PM peak flows (total and select cordon)
    - Splitting the highway link flows by fuel type using the WebTAG Databook, Table A1.3.9

- Calculating the number of non-compliant vehicles that replace vehicle (non-compliant % x response %) by link and vehicle/fuel type.

5. Each of these responses were modelled individually, as the responses stated above are compared to the reference situation. A final SATURN Highway model assignment was undertaken, including the charge required for achieving the avoid the zone response and the adjusted matrices from the cancel journey / change mode response. Link flows were extracted from these models and post-processing was undertaken using the following methodology:

   - Factors applied to calculated AADT flows from AM, Inter and PM peak flows
   - Splitting the highway link flows by fuel type using the WebTAG Databook, Table A1.3.9
   - Calculating the impact of the Avoid Zone and Cancel Journey / Change Mode by link (Final CAZ assignment – reference case)
   - Calculating the number of non-compliant trips by link and vehicle/fuel type as a result of a CAZ (link value x non-compliant % - number of vehicles replaced + avoid zone /cancel journey / change model impact)
   - Calculating the number of compliant trips by link and vehicle/fuel type as a result of a CAZ (link value x compliant % + number of vehicles replaced - avoid zone /cancel journey / change model impact)

2.5 Other Years

Other years were also required for calculating the year of compliance. Each year has not been modelled explicitly. Instead the 2021 transport flow data was extrapolated to 2022-2025 using the following methodology:

Reference Case

1. Tempro (V7.2) growth factors, as shown in Table 3, were applied by vehicle type to each modelled link flow;
2. The proportions of fuel type were adjusted to reflect the year using the WebTAG Databook Table A1.3.9;
3. The non-compliant percentages were changed for each year, using the EFT (version 8) Euro Fleet proportions, as shown in Table 4.

CAZ Options

1. Tempro (V7.2) growth factors, as shown in Table 3, were applied by vehicle type to each modelled link flow;
2. The proportions of fuel type were adjusted to reflect the year using the WebTAG Databook Table A1.3.9;
3. The non-compliant percentages were changed for each year, using the EFT (version 8) Euro Fleet proportion, as shown in Table 4s;
4. The impact of avoid zone, change mode/cancel trip and replace vehicle was reduced over time as the non-compliant percentages decreased. This was achieved by calculating the impact on each link in 2021 (reference case - CAZ option), then factoring this impact by the change in non-compliant percentages from 2021 for each year.

Table 3: Tempro V7.2 Growth Rates from 2021

Vehicle Type	2022	2023	2024	2025
Car	1.0086	1.0173	1.0261	1.0349
LGV	1.0265	1.0531	1.0796	1.1061
HGV	1.0063	1.0125	1.0188	1.0251

Table 4: National Non-Compliant Vehicle Percentages by Vehicle/Fuel Type

Year	Cars		LGVs		HGVs
	Petrol	Diesel	Petrol	Diesel	Diesel
2022	0.95%	28.19%	1.75%	23.53%	10.31%
2023	0.50%	22.60%	0.91%	18.64%	7.38%
2024	0.24%	17.72%	0.37%	14.57%	5.11%
2025	0.09%	13.30%	0.12%	11.18%	3.46%

Table 5 shows the total compliant and non-compliant flows for the reference, small and medium CAZ for year each. The figures show that the impact of the CAZ reduces over time. This is due to the change in fleet composition, reducing the number of non-compliant vehicles which the CAZ can influence.

Table 5: Total compliant and non-compliant flows for the reference, small and medium CAZ for year each

Year	Option	Total Flows			Difference % from Reference			Difference % 2021		
		Comp	Non-Comp	Total	Comp	Non-Comp	Total	Comp	Non-Comp	Total
2021	Reference	31060966	8356833	39417798						
	Small	32534835	6323253	38858088	4.75%	-24.33%	-1.42%			
	Medium	33655695	4687758	38343453	8.35%	-43.91%	-2.73%			
2022	Reference	33018952	6843482	39862434				6.30%	-18.11%	1.13%
	Small	34287597	5167061	39454658	3.84%	-24.50%	-1.02%	5.39%	-18.28%	1.54%
	Medium	35237788	3845305	39083093	6.72%	-43.81%	-1.96%	4.70%	-17.97%	1.93%
2023	Reference	34811371	5498008	40309379				12.07%	-34.21%	2.26%
	Small	35879938	4131472	40011409	3.07%	-24.86%	-0.74%	10.28%	-34.66%	2.97%
	Medium	36658349	3084112	39742461	5.31%	-43.90%	-1.41%	8.92%	-34.21%	3.65%
2024	Reference	36419253	4339402	40758654				17.25%	-48.07%	3.40%
	Small	37301276	3239511	40540788	2.42%	-25.35%	-0.53%	14.65%	-48.77%	4.33%
	Medium	37922011	2424058	40346069	4.13%	-44.14%	-1.01%	12.68%	-48.29%	5.22%
2025	Reference	37892796	3317484	41210280				21.99%	-60.30%	4.55%
	Small	38590201	2463373	41053574	1.84%	-25.75%	-0.38%	18.61%	-61.04%	5.65%
	Medium	39068090	1846860	40914950	3.10%	-44.33%	-0.72%	16.08%	-60.60%	6.71%

3.0 Links to Air Quality Model

3.1 Reference Data Use

Link based flows from the reference transport models has been output for Cars, LGVs and HGVs. The transport model outputs also include buses and net speeds. The data was processed to fit the EFT (version 8) 'Advanced Options' headings, using WebTAG Databook Table A1.3.9 to split by fuel type and factors from ATC data to calculate AADT flows from AM, Inter and PM peak flows.

3.2 Option Data Use

Link based flows from the CAZ Option transport models has been output for Cars, LGVs and HGVs, as well as bus flows and net speeds. The data was processed using the methodology discussed above and the following was produced for the air quality assessment:

- Separate EFT's for compliant and non-compliant vehicles, populated from the transport model, with 'Advanced Options' headings;
- Within each EFT, Euro Standard splits were calculated for the assessment year for complaint and non-compliant vehicle types, using EFT version 8 national forecasts.

4.0 Air Quality methodology and assumptions

4.1 Overview

This section covers the air quality methodology, and assumptions, used to assess the timescales in which compliance could be achieved for twenty CAZ charging options.

The latest available Defra Emissions Factor Toolkit (EFT v8.0) was used to obtain vehicle fleet proportions for road links in the study area for the reference (without CAZ) scenarios. EFT v8.0 uses emission factors from the latest COPERT 5 model, which is the most up-to-date vehicle emissions database available. Changes in vehicle fleet over time have been adopted from EFT, which reflects changes in emissions compliance rates with respect to Euro standards for each vehicle type. Further detail is provided in the transport section above.

4.2 EU Compliance

Defra's latest Pollution Climate Mapping (PCM) model assessment outputs were reviewed for the Greater Bristol area. Their latest prediction of nitrogen dioxide (NO_2) concentrations with and measures to improve air quality (primarily a charging Clean Air Zone) are presented in Figure 2 and Figure 3 overleaf. These figures show the modelled NO_2 outputs in relation to the EU Limit Value of 40 $\mu g/m^3$. Only a small section of the M32 in central Bristol remains non-compliant past 2020 (red link), with compliance projected to be achieved in 2022 without measures in place. The PCM model CAZ scenario projections forecast compliance to be achieved in Bristol by 2020.

Figure 2: PCM Model Outputs – No Measures

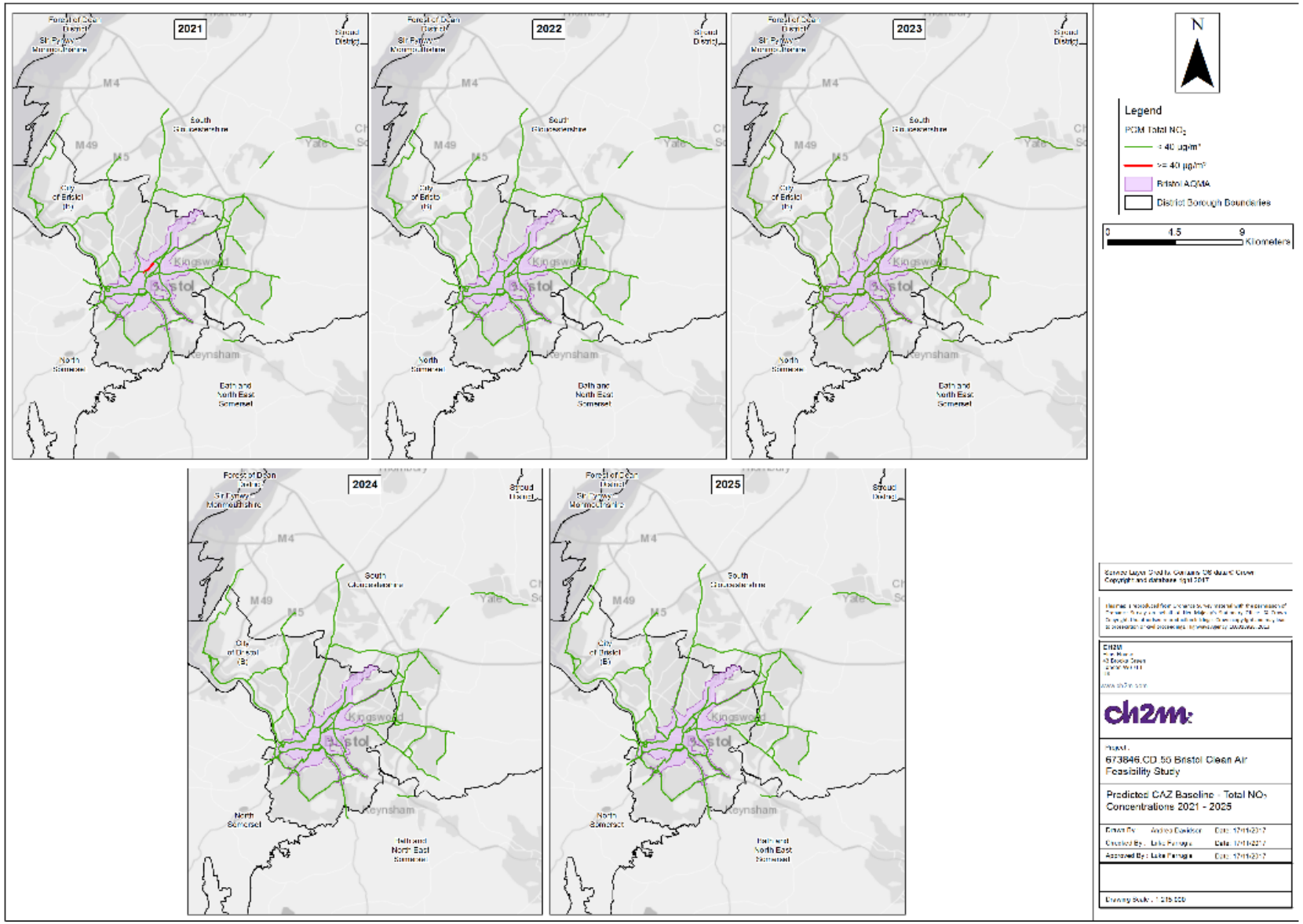


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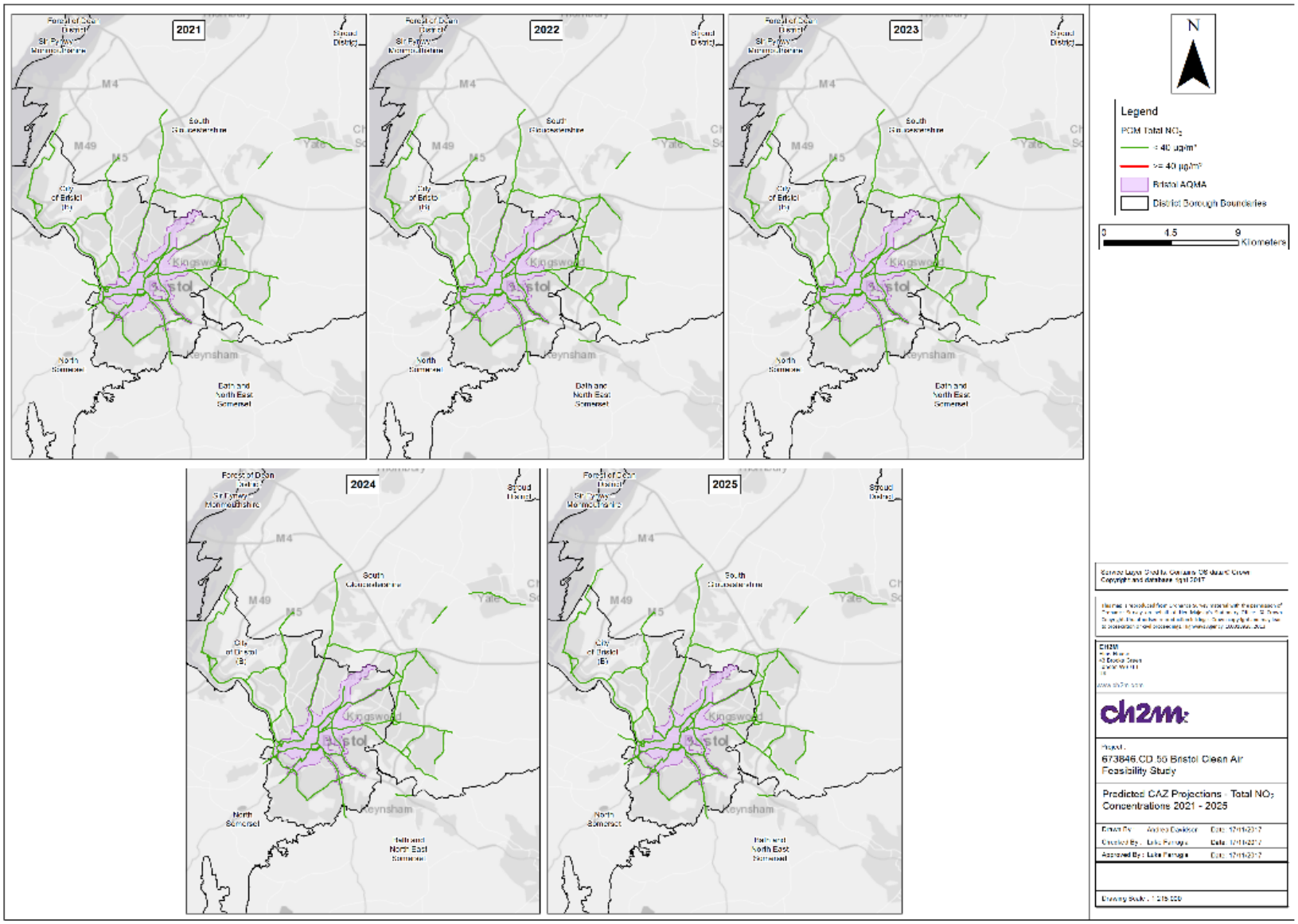
Figure 3 PCM Model Outputs –With Measures



4.3 Local Air Quality Management Compliance

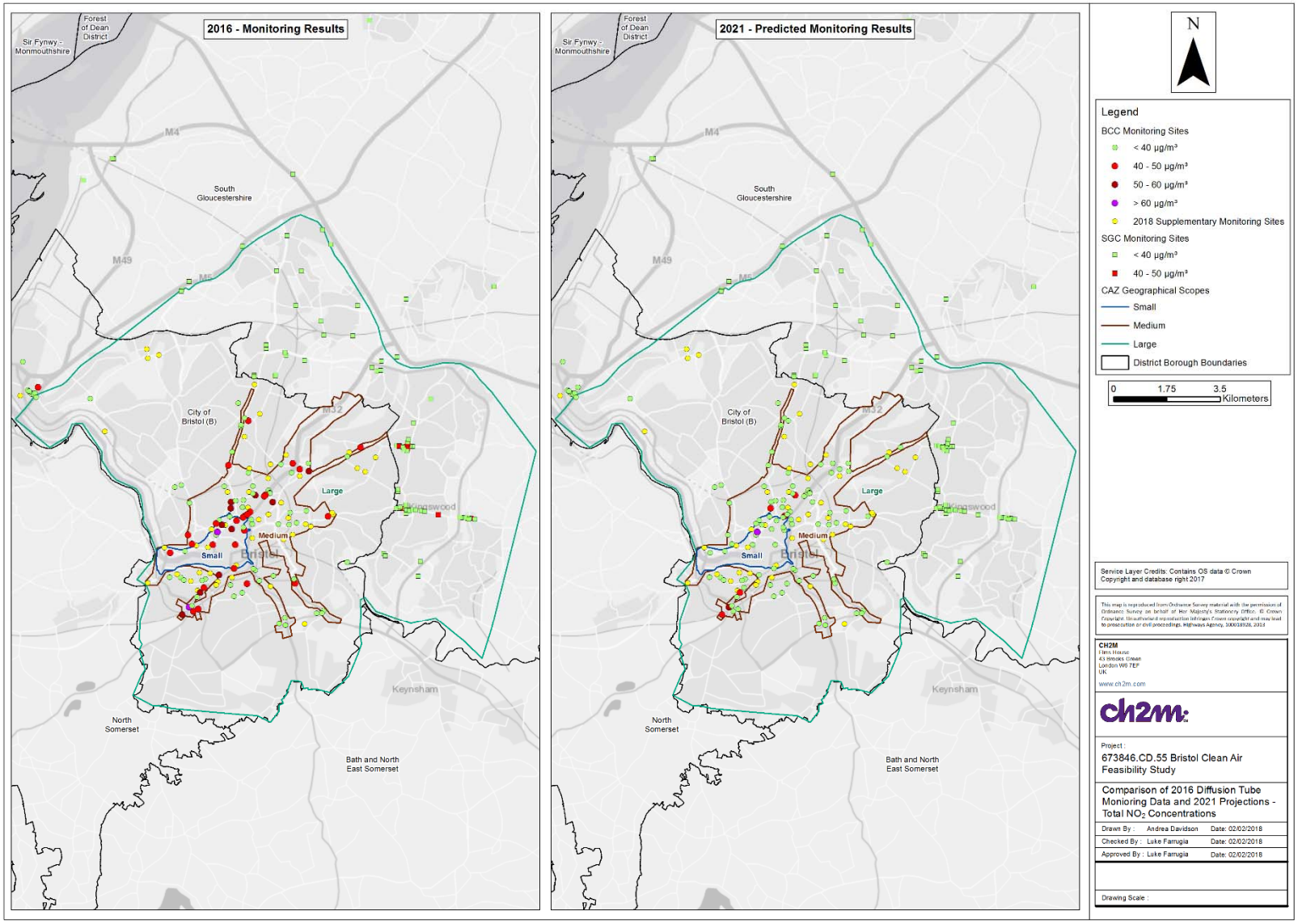
Data from a total of 107 diffusion tube monitors and 7 automatic monitoring stations were considered from Bristol City Council's latest draft Air Quality Annual Status Report (2017)[1]. 92 diffusion tubes from South Gloucestershire Council were also included in this assessment. Annual mean NO_2 concentrations were adjusted using Defra's Nitrogen Dioxide fall off with distance calculator to estimate the annual mean NO_2 at receptor considered as sites of relevant exposure based on Defra's Technical Guidance (TG16). The annual mean NO_2 concentrations were projected forward from the latest monitoring dataset available based on the EFT future projections used to represent improvements in ambient air quality in the future.

Figure 4 shows the 2016 monitored NO_2 concentrations (2015 used for some monitors affected by the MetroBus scheme improvements) and the predicted 2021 NO_2 concentrations.

The small, medium and large CAZ geographies areas are also shown in Figure 4. These boundaries have been used to define the emission reductions due to each CAZ option based on the CAZ's response within each zone. There is a diminishing effect in emissions reductions further away from the CAZ.

[1] Draft 2017 Air Quality Annual Status Report, September 2017, Accessed from: https://www.bristol.gov.uk/documents/20182/32675/Air+Quality+Annual+Status+Report+ASR+Report+2017+draft/9c167d10-1fef-bf3b-15eb-fa07d9e13f9d on 13/11/17.

Figure 4: Monitored (2016) and forecast (2021) NO_2 concentrations



Measured annual mean NO_2 concentrations were source apportioned making use of guidance set out in Defra's Technical Guidance (TG16, Box 7.5) and recently updated Defra background mapping[2] to split out the local (road) contribution from the total annual mean NO_2 concentrations. This enabled the number of compliant locations (within AQS Objective limit) to be identified with and without each class of CAZ for each year.

The receptors considered were all monitors within BCC and SGC, with the most recent reported data by the respective Local Authorities' Air Quality Annual Status Reports being used, where monitoring data were available. These annual mean values were also distance corrected to represent values relevant to the Air Quality Objective for annual mean NO_2.

4.4 Vehicle Emissions by Fleet

The EFT was used to obtain NOx emission outputs for all scenarios. The 'Advanced Options' function in EFT was used to include user defined Euro standards and fleet compositions. The EFT was run for 2021 and subsequent years to establish a reference scenario (assuming no CAZ) and to reflect the implementation of a CAZ for each year. 'Additional Outputs' functions were also selected to obtain emissions broken down by vehicle type and to allow outputs to be source apportioned. Emissions calculations were undertaken using EFT v8.0 using the "Alternative Technologies" option of the EFT for each road link. The year for calculation was set at 2021 to match the reference traffic year. The "User Euro" function was selected to allow the proportion of each vehicle type by Euro Standard to be defined according to data derived from the response of the non-compliant vehicles, described in the transport methodology. The option for "Output % Contributions from Euro Classes" was also selected to ascertain the percentage contribution of each Euro Standard to the emission rate of the corresponding vehicle type.

The EFT was run separately, according to the type of road to account for the varying proportions of vehicle type by Euro Standard and by road type. Two outputs are provided by the EFT. The first one is the emission rate (g/km) for each link entered by vehicle type. The second output is the percentage contribution of each Euro standard to the emission rate for each vehicle category. This information was used to determine the relative contribution of each vehicle type by Euro standard at selected receptors.

The EFT outputs were divided by sub area based on the CAZ geographies and the reduction in NOx emissions due to each CAZ was calculated within each sub area. These CAZ responses were used to estimate the corresponding change in local NO_2 contributions at each monitoring location. The % NOx emission reduction was assumed to produce the same % reduction in local road NO_2 concentration, as the receptors considered were all roadside measurements. This is only an approximation of what the likely reduction of each CAZ is expected to be, and is not as robust as detailed air quality dispersion modelling.

[2] Defra Background Maps, Accessed from: https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2015 on 13/11/17

5.0 Timescales to Achieve Compliance

5.1.1 Time Taken to Achieve Compliance Once Operational

In each year, the number of existing monitoring sites not expected to achieve compliance following implementation of each charging CAZ option has been calculated, and is summarised in Figure 5 and Figure 6 below alongside the reference case (no CAZ).

Figure 5: Number of Monitoring Sites Not Expected to Achieve Compliance with a Small CAZ

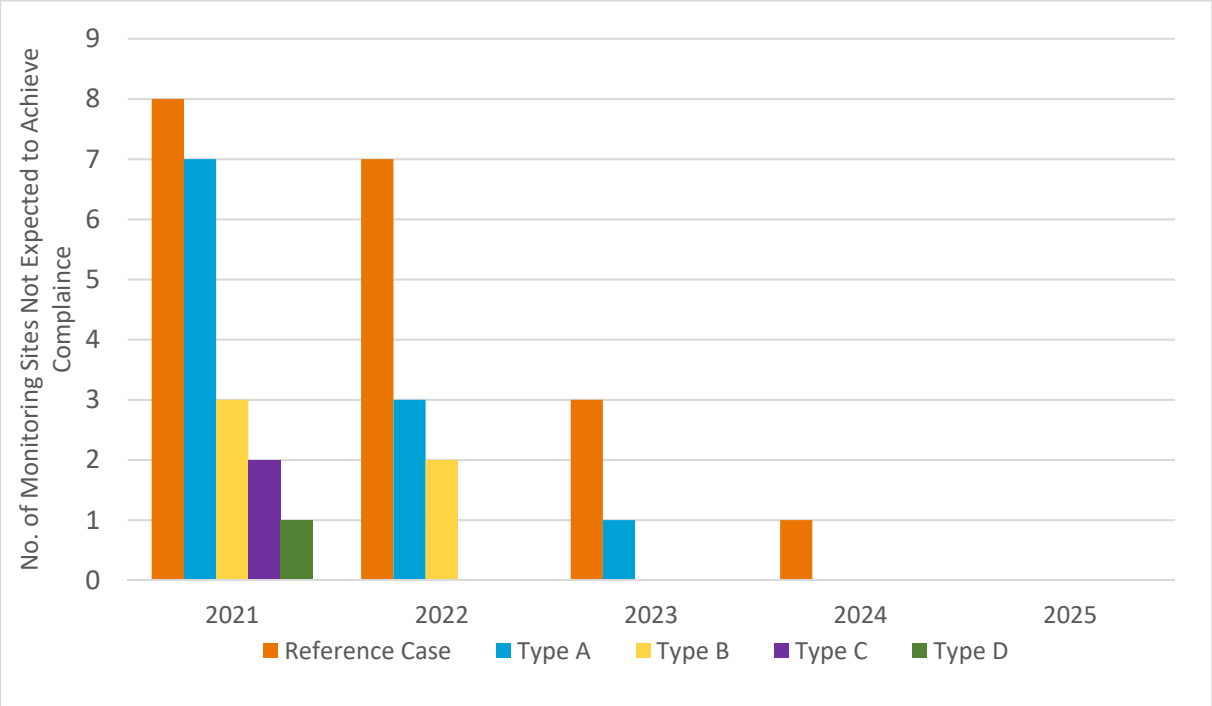
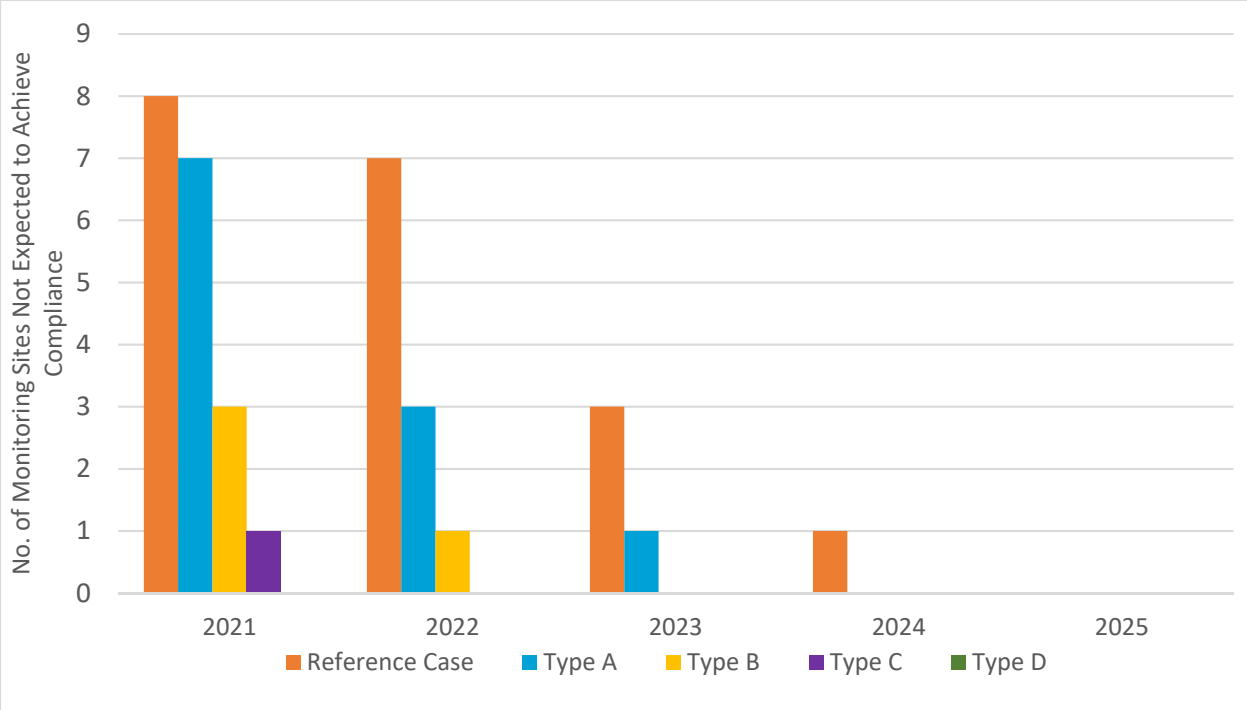


Figure 6: Number of Monitoring Sites Not Expected to Achieve Compliance with a Medium CAZ



The assessment demonstrates that compliance is expected to be achieved in all locations by 2025 without a CAZ. The most successful option in bringing forward this timescale is a Class D medium CAZ which is predicted to achieve compliance in 2021. However, it is anticipated that a medium CAZ could not be implemented until 2022, by which time both a type C and D would be sufficient to achieve compliance.

It should be noted that the analysis undertaken to determine the year of compliance is suitable to provide a relative comparison between options, but it relies on a number of assumptions which mean that the year of compliance calculated is indicative only. The assumptions will be revisited and revised as appropriate in the more detailed modelling of the OBC and the year of compliance may subsequently change.

The maximum annual mean NO2 concentrations following implementation of each charging CAZ option are presented in Figure 7 and Figure 8. These figures demonstrate the level of change that non-charging measures combined with a charging scheme would need to achieve to meet compliance sooner than a charging scheme in isolation.

Figure 7: Maximum Annual Mean NO_2 concentrations at air quality monitors with a Small CAZ

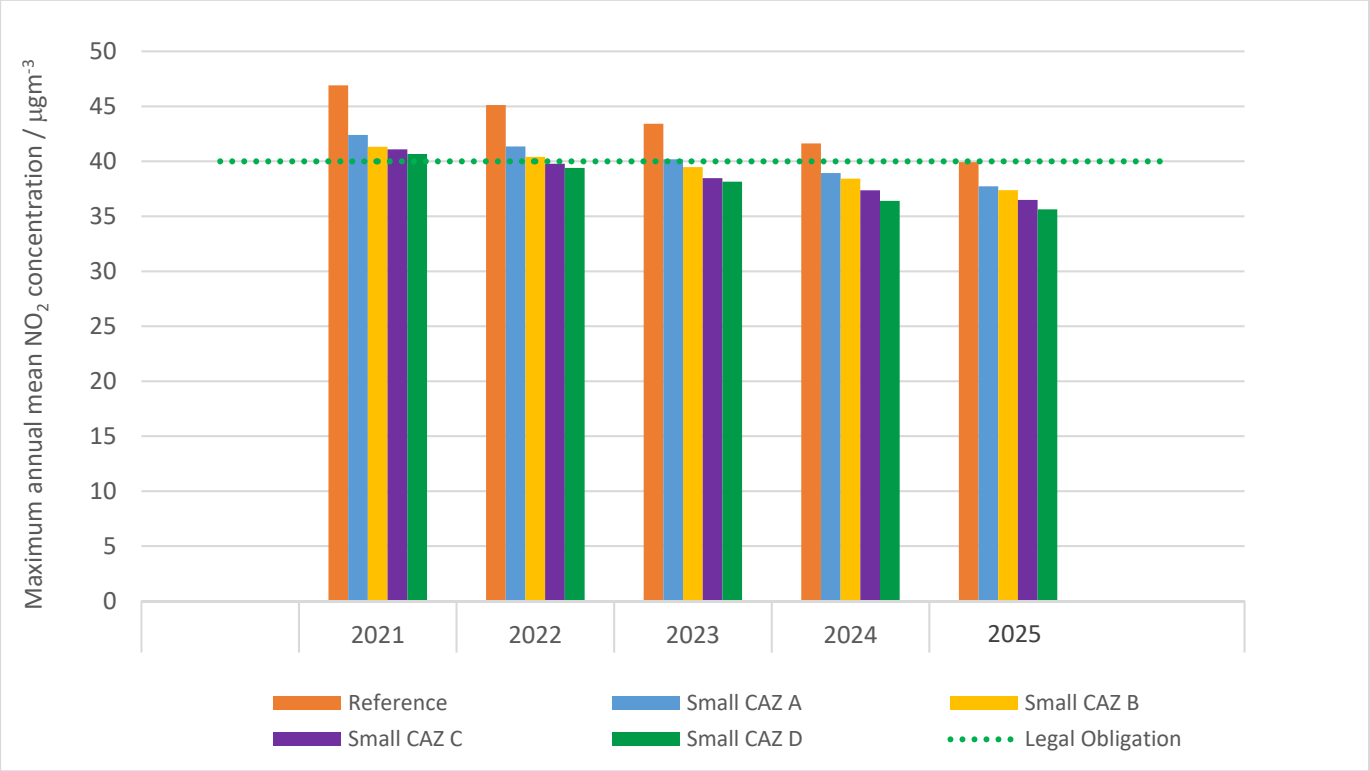
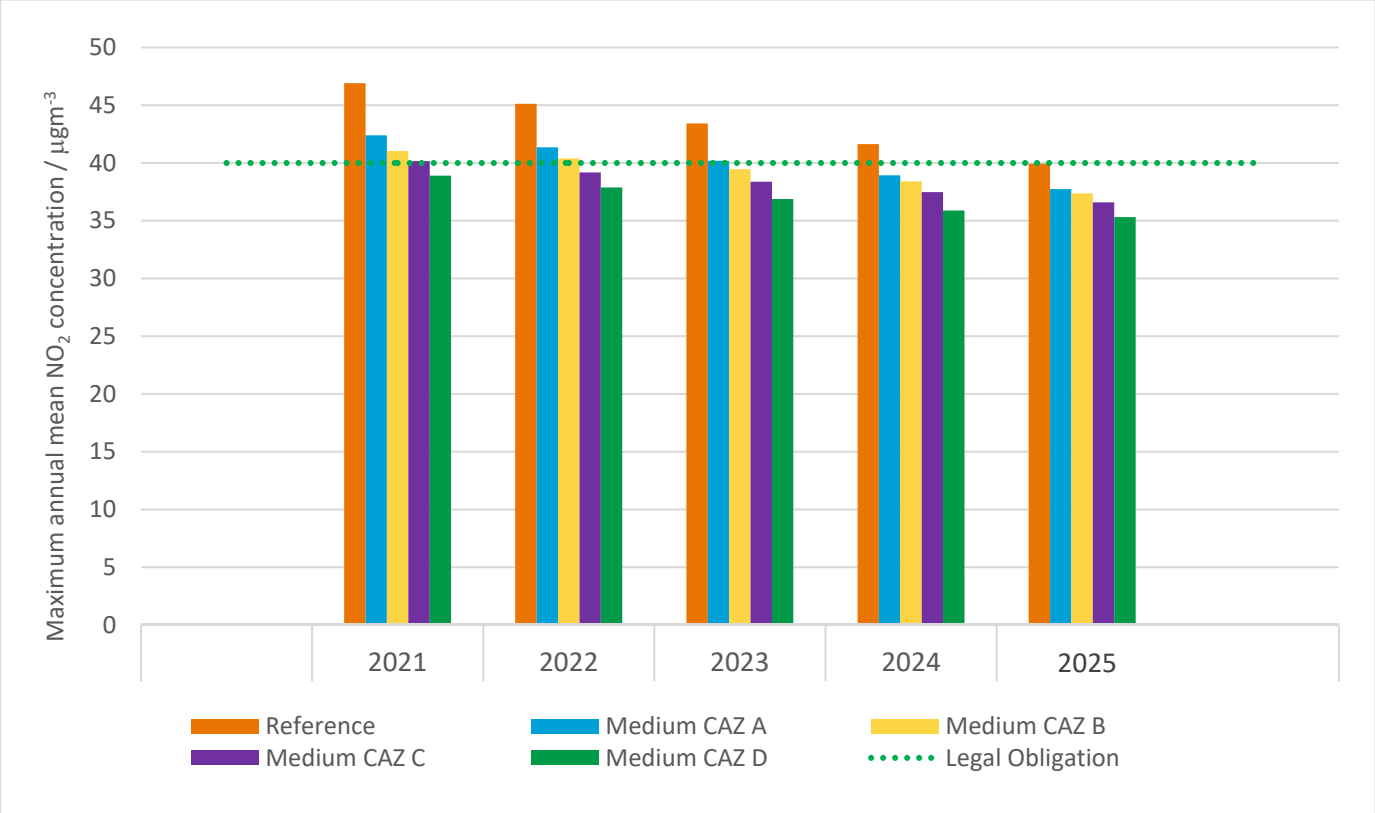


Figure 8: Maximum Annual Mean NO_2 concentrations at air quality monitors with a Medium CAZ



A Class D Medium CAZ is expected to achieve compliance at every monitoring location by 2021, bringing forward compliance by four years from compared to the reference case. A Class C (both Small and Medium) and Class D Small CAZ are expected to achieve compliance by 2022, however the remaining exceedances in these scenarios in 2021 are very small. It is possible that combining non-charging measures with each of these charging CAZs would elicit a greater change in behaviour which could achieve compliance in 2021.

Monitors on both Rupert Street and Bedminster Down Road currently record significant exceedances and these locations are predicted to remain uncompliant for several years into the future even with a charging CAZ. However, there are some uncertainties around the level of exceedance at these locations due to recent and ongoing changes to the highway network. The monitoring station on Rupert Street was not in place during 2016 due to road improvements to accommodate the MetroBus scheme, and the assessment undertaken here does account for the improvements due to the MetroBus scheme. Similarly, the data at Bedminster Down Road does not account for likely improvements resulting from the opening of the South Bristol Link Road in 2017. As a result, the prediction of these ongoing exceedances at Rupert Street and Bedminster Down Road may not be accurate. Should more detailed assessment predict that these locations will continue to exceed the Air Quality Objective it is anticipated that with some additional measures focused on these two locations, compliance may be achieved in 2021 with a Class C or D CAZ within either the small or medium sized boundary.

It is expected that the largest zone could not be implemented before 2024 at the earliest, by which time either the small or medium zones could have achieved compliance. Based on this test against the primary CSF, the large charging options have been discounted from this initial very long list of charging options since they cannot achieve compliance in the shortest time possible.

Class A and B charging zones are also discounted from this initial very long list of charging options since the analysis demonstrates that in both the small and medium zones these would take longer to achieve compliance than a Class C or D zone.

6.0 Recommendations

Based on the assessment of timescales required to achieve compliance set out in this report the following options are recommended to be taken forward for further assessment;

- Medium (BCC AQMA) geography, CAZ Class C – charging
- Medium (BCC AQMA) geography, CAZ Class D – charging
- Medium (BCC & SGC Kingswood-Warmley AQMA combined) geography, CAZ Class C – charging
- Medium (BCC & SGC Kingswood-Warmley AQMA combined) geography, CAZ Class D – charging
- Medium (BCC & SGC Kingswood-Warmley AQMA separate) geography, CAZ Class C – charging
- Medium (BCC & SGC Kingswood-Warmley AQMA separate) geography, CAZ Class D – charging
- Small geography, CAZ Class C – charging
- Small geography, CAZ Class D – charging