Bristol City Council Clean Air Zone
Full Business Case

Environmental Appraisal

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Bristol City Council Clean Air Zone

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Contents

Acronyms and Abbreviations

AADT	Annual Average Daily Traffic
ANPR	Automatic Number Plate Recognition
AQMA	Air Quality Management Area
BCC	Bristol City Council
CAP	Clean Air Plan
CAZ	Clean Air Zone
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit (Defra and the Department for Transport)
LGV	Light Goods Vehicle
$\mu g/m^3$	Micrograms per cubic metre
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
OBC	Outline Business Case
OUV	Outstanding Universal Value
PCM	Pollution Climate Mapping
PM_{10}	Small airborne particles less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter
WHS	World Heritage Site

1. Introduction

1.1 Background

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2], to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

Jacobs has been commissioned to support BCC to produce a Full Business Case (FBC) for the delivery of the Clean Air Plan (CAP); a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in central Bristol.

The UK Government has an obligation to achieve EU Air Quality Limit Values (Directive 2008/50/EC, Annex III). The relevant 'Limit Value' relates to NO_2, which must not exceed 40 $\mu g/m^3$ as an annual mean (i.e. measured over a calendar year).

The primary drivers for this Limit Value are public health concerns associated with NO_2. Specific health impacts associated with NO_2 inhalation include (WHO, 2016):

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution

[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

- High concentrations can lead to inflammation of the airways; and
- Long-term exposure can increase symptoms of bronchitis in asthmatic children and reduce lung development and function.

A range of other public health issues are also linked to poor air quality, as detailed below. These issues are believed to disproportionately affect 'at-risk' groups, such as older people, children and people with pre-existing respiratory and cardiovascular conditions (World Health Organization, 2013).

- Long-term exposure to air pollution is linked to increases in premature death, associated with lung, heart and circulatory conditions;
- Short term exposure can contribute to adverse health effects, including exacerbation of asthma, effects on lung function and increases in hospital admissions;
- Other adverse health effects, including diabetes, cognitive decline and dementia, and effects on the unborn child (Royal College of Physicians, 2016) are also linked to air pollution exposure;
- Exposure can exacerbate lung and heart disease in older people (Simoni *et al.,* 2015); and
- Approximately 40,000 deaths can be attributed to NO_2 and fine particulate matter pollution in England every year (Royal College of Physicians, 2016).

In light of the public health issues outlined above, the UK government is legally responsible for ensuring that it complies with the provisions of the EU Air Quality Directive. The Government assesses air quality compliance with the EU Directive in 43 areas across the country at single locations, using both monitoring and modelling. It uses Defra's Pollution Climate Mapping (PCM) model to forecast exceedances, which is adjusted based on the monitored data. This is the approved means of reporting air quality information to assess legal compliance with the EU legislation.

In 2015, 37 of the 43 monitored areas across the country were in exceedance of the annual mean Limit Value for NO_2.

Baseline modelling (see Appendix D to the FBC) predicted that annual concentrations of NO_2 showed exceedances of the Limit Value for NO_2 in 2021 at various locations, predominantly in central Bristol (see Figure 1-1).

The UK Government has discretionary powers to pass on the responsibility of managing the exceedances (and associated legal outcomes) to local authorities. Hence, there are public health and regulatory imperatives for improving air quality in BCC's administrative area. This specifically applies to the City of Bristol.

To meet UK Government regulations, local authorities must demonstrate that they are working towards the National Air Quality Objectives (AQOs). The objective level for concentrations of NO_2 within the national legislation are the same as the European limits (annual mean of 40 $\mu g/m^3$) but are applied and assessed differently. AQOs only apply where people are exposed for the averaging period of the Objective (i.e. for a year) and therefore compliance with AQOs is assessed most commonly at building facades (where people are regularly present for long periods), including around busy major junctions.

The Government's Local Air Quality Management (LAQM) regime requires all local authorities to regularly review and assess whether AQOs have been achieved at relevant locations. Where the assessment shows exceedances at relevant locations, the authority must declare an Air Quality Management Area (AQMA) and prepare an action plan which identifies appropriate measures in pursuit of the national AQOs.

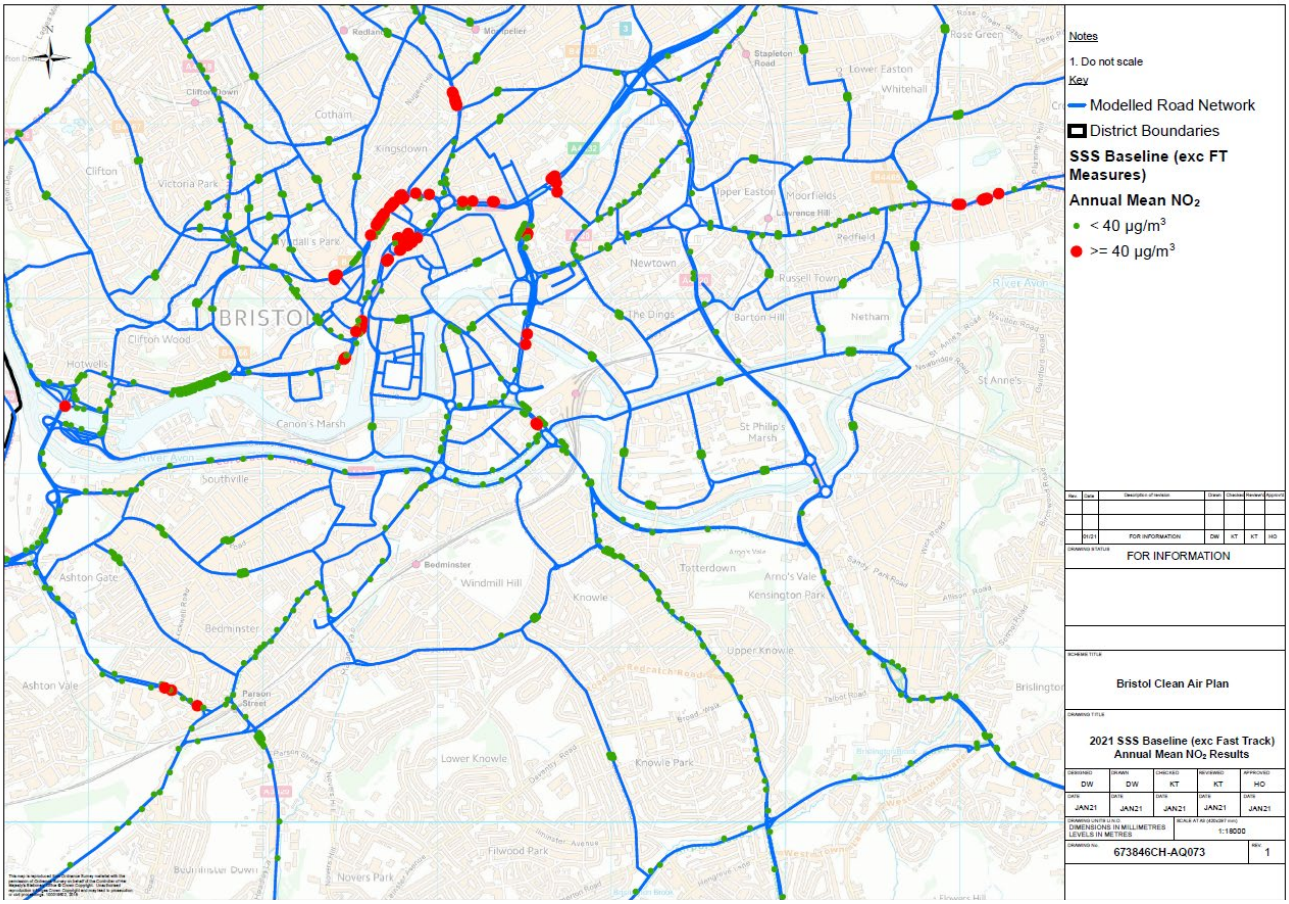
During the COVID-19 pandemic, a number of Street Space schemes have beeng implemented to open up road space usually reserved for parking and movement of general traffic to public transport, cyclists and pedestrians to:

- Enable better social distancing, especially in local shopping areas;
- Encourage people to travel by bike or walk; and
- Reduce air pollution.

These Street Space Schemes have been included within the Baseline modelling.

Further details of the Air Quality Modelling undertaken to support the FBC, are set out in Appendix D to the FBC.

Figure 1-1: Predicted NO_2 concentrations in 2021 (Baseline with Street Space Schemes scenario)



1.2 Clean Air Zones

In line with Government guidance, BCC has considered the implementation of a CAZ, including both charging and non-charging measures, in order to achieve a sufficient improvement in air quality and public health.

1) A CAZ is defined as a specific geographical area where targeted action is taken to improve air quality through charging a daily fee to vehicle owners to enter, or move within, the zone if they are driving a vehicle that does not meet the particular emission standard for their vehicle type in that zone.

2) A CAZ is different to a congestion charge. A CAZ aims to improve air quality through discouraging high emission vehicles. A congestion charge targets high traffic flow. The Government is providing funding for Local Authorities to implement charging CAZs within their area.

3) A CAZ would be supported by non-charging measures, which would prompt and help enable behaviour change and transport modal shift.

4) The CAZ classes are defined in the Defra/DfT's Clean Air Zone Framework (Defra, 2017). The framework sets out which vehicles are affected by each CAZ class and what the minimum Euro standards are for each vehicle type. The four CAZ classes include:

    - Class A charging: buses, coaches, taxis, private hire vehicles
    - Class B charging: buses, coaches, taxis, private hire vehicles and HGVs
    - Class C charging: buses, coaches, taxis, private hire vehicles, HGVs and LGVs

- Class D charging: buses, coaches, taxis, private hire vehicles, HGVs, LGVs and cars.

1.3 Business Case

This document is written to support the Full Business Case (FBC) and describes the environmental baseline data and potential environmental impacts of implementing the CAP scheme in Bristol. Due to the urban nature of the scheme, this assessment focuses on the environmental topics of most relevance to the inner city of Bristol, where the impacts can be estimated to a greater level of certainty than locations outside of this area. These impacts are attributed solely to vehicle traffic within and around the scheme, and they are predicted based on traffic modelling (Appendix E to the FBC). This document also considers the potential impacts on the adjacent South Gloucestershire Council (SGC) administrative area from the implementation of a Bristol CAP scheme and the potential displacement of traffic into South Gloucestershire.

A detailed assessment of the impacts of this scheme on air quality has been undertaken within the FBC, using traffic and air quality models. The option that has been fully modelled is the Small CAZ D Option. This scheme option together with the defined boundary are described in Sections 1.3.1 and 1.3.2 below.

The traffic modelling (Appendix E to the FBC) referred to in this report compares the 2021 and 2023 traffic model results (without scheme, but with the addition of the Street Space Schemes), with the results of the Small CAZ D scheme.

1.3.1 Preferred scheme option

The Small CAZ D Option consists of the following measures:

- A charging scheme for non-compliant buses, taxis, HGVs, LGVs and cars. This charge applies once a day regardless of how many times you go in or out of the small zone.
- Fast Track Measures including:
    - Cumberland Road closure inbound
    - Cycle scheme – Old Market Gap cycleway
    - Additional air quality monitors
    - Signal management

1.3.2 Traffic modelling

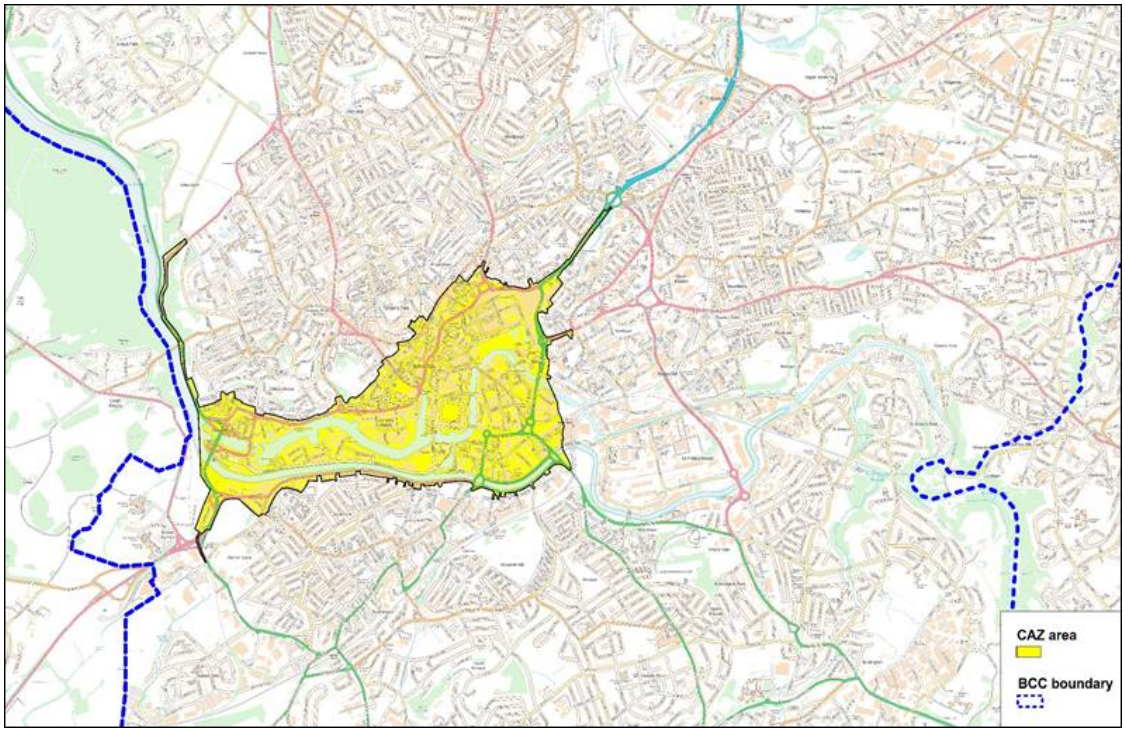
The traffic modelling results indicates that the Small CAZ D Option reduces vehicle traffic accessing the City Centre, as well as through traffic using roads in the CAZ, in 2021. However, it does result in some slight increases on roads mainly outside of the CAZ boundary, as non-compliant drivers attempt to avoid the charge by using routes around it. The scale of these potential impacts is considered to be modest, as almost all the changes on links showing increases can be considered as well within normal day-to-day variation in traffic volumes. With reduced traffic flows in the City Centre, traffic congestion in this central area could be reduced, leading to improvements not only for cars, but also quicker journey times and greater journey time reliability for public transport. This could allow greater punctuality of public transport and increase its attractiveness as an alternative to the car.

The work undertaken to inform the scope of the scheme is set out in the Option Assessment Report, Appendix C to the FBC.

1.3.3 Option Boundary

The boundary of the Small CAZ D Option is shown in Figure 1.2.

Figure 1.2: Small CAZ boundary



1.4 Scope of this Assessment

This high-level, non-statutory environmental assessment is focused on the potential environmental impacts of the Small CAZ D Option, as described in Section 1.3 of this document. The environmental topics (taken from DfT, 2015) of most relevance to the assessment, which are therefore 'scoped in' to this assessment are:

- Noise;
- Air quality;
- Cultural heritage
- Townscape; and
- Greenhouse Gases;

Topics scoped out due to the insignificance of any potential impacts, based on professional judgment, comprise:

- Biodiversity;
- Landscape; and
- Water Environment.

2. Greenhouse Gas Emissions

By changing travel behaviours (including number of trips, trip mode and vehicle type), the intervention option may influence the quantum of Greenhouse Gas (GHG) emissions generated by road transport. A change in GHG emissions, and CO_2 emissions in particular, could generate variable effects on climate change processes.

Based on air quality modelling outputs, the intervention option will marginally increase the quantum of GHG. This is linked to changes to vehicle speeds, vehicle redistribution, and fleet composition induced by the intervention (see Table 2-1). Further detail on Greenhouse Gas emissions can be found within the Economic Case (FBC-5).

Table 2-1: GHG impacts

Impact	Small CAZ D
Cumulative Difference in CO_2 Emissions, 2021-30 (tonnes)	-1,010

3. Noise

3.1 Baseline

The strategic-level noise mapping undertaken by Defra (http://www.extrium.co.uk/noiseviewer.html) of the road and rail network show the noise climate along the major roads and railways within the Study Area (refer to Figures 3.1 and 3.2).

Following a sift process undertaken by Defra, numerous locations have been identified as noise Important Areas (noise IA) within the BCC and SGC Authority Areas. Properties located within the identified noise IAs are be particularly sensitive to any increases in noise levels. Figure 3.3 illustrates the noise IAs for road and rail traffic within the Study Area.

In terms of sensitive receptors to noise and vibration, these are defined as those locations where members of the public might be regularly exposed to such factors, such as residential properties, schools, hospitals and care homes. The Study Area supports both commercial and residential land uses.

3.2 Potential Impacts

Although roads, rail and flights are known to be amongst the most significant noise sources in Bristol, there are no up-to-date noise data that have been produced for the Study Area specifically and no other detailed information is available relating to the noise baseline within or around the proposed CAZ scheme option. As a result, a detailed assessment of potential noise impacts that could arise from the proposed scheme option is not possible; however it is likely that the Small CAZ D option has the potential for both temporary (during construction) and permanent (during operation) adverse and beneficial impacts on noise sensitive receptors within the Study Area, depending on their locational relationship to the proposed measures.

Operational impacts have been screened out, as changes to traffic levels on most roads are expected be less than 25%.

In terms of construction impacts, Design Manual for Roads and Bridges; LA111 Noise and Vibration[3] states that 'construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding:

1) 10 or more days or nights in any 15 consecutive days or nights;

2) A total number of days exceeding 40 in any 6 consecutive months.'

The construction impacts of the proposed CAZ scheme is not expected to meet these thresholds.

[3] https://www.standardsforhighways.co.uk/prod/attachments/cc8cfcf7-c235-4052-8d32-d5398796b364?inline=true

Figure 3.1: Defra's strategic-level noise mapping – road traffic noise

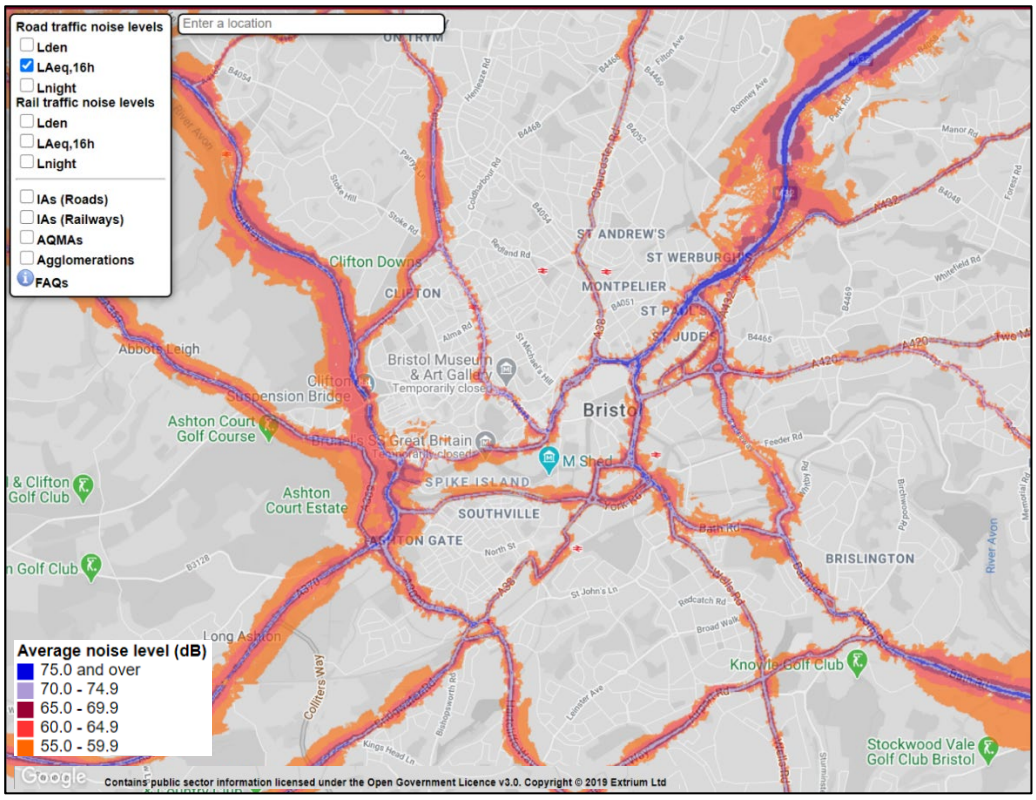


Figure 3.2: Defra's strategic-level noise mapping – rail traffic noise

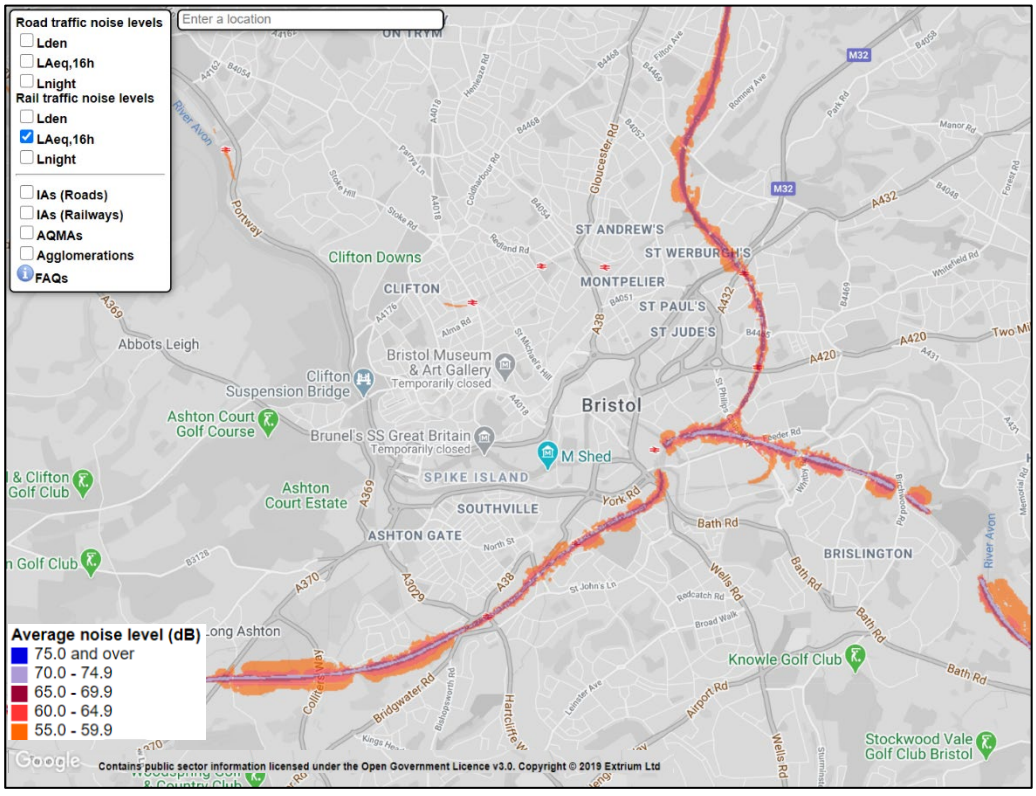
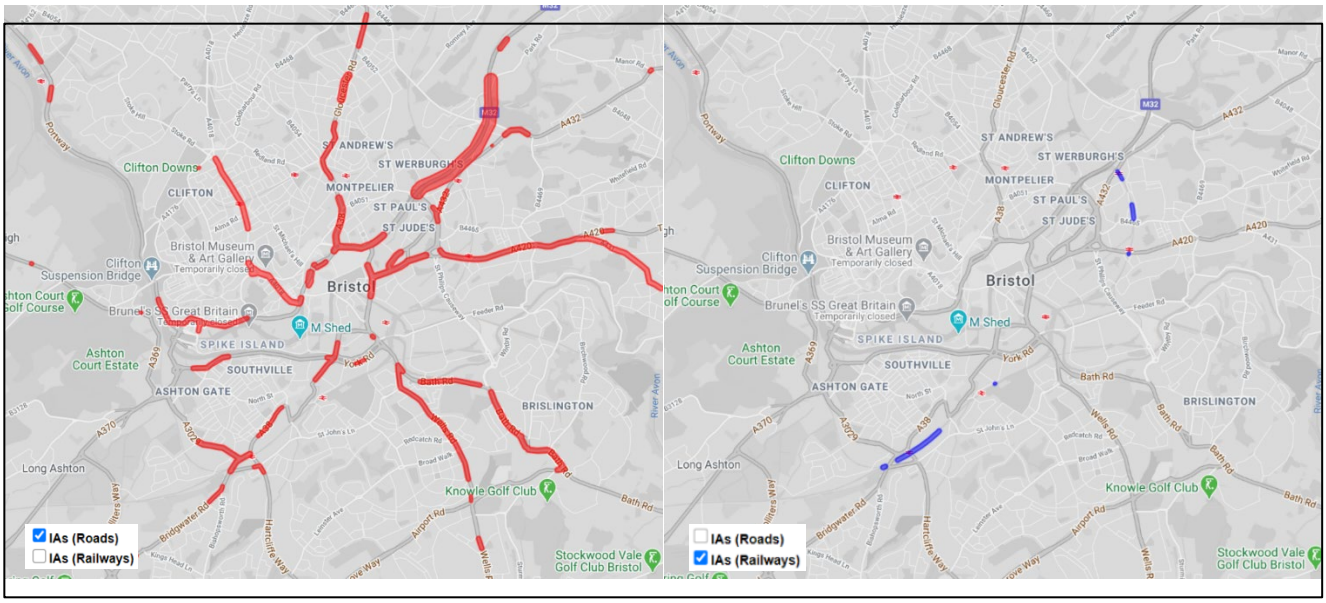


Figure 3.3: Defra's noise Important Areas



4. Air Quality and Human Health

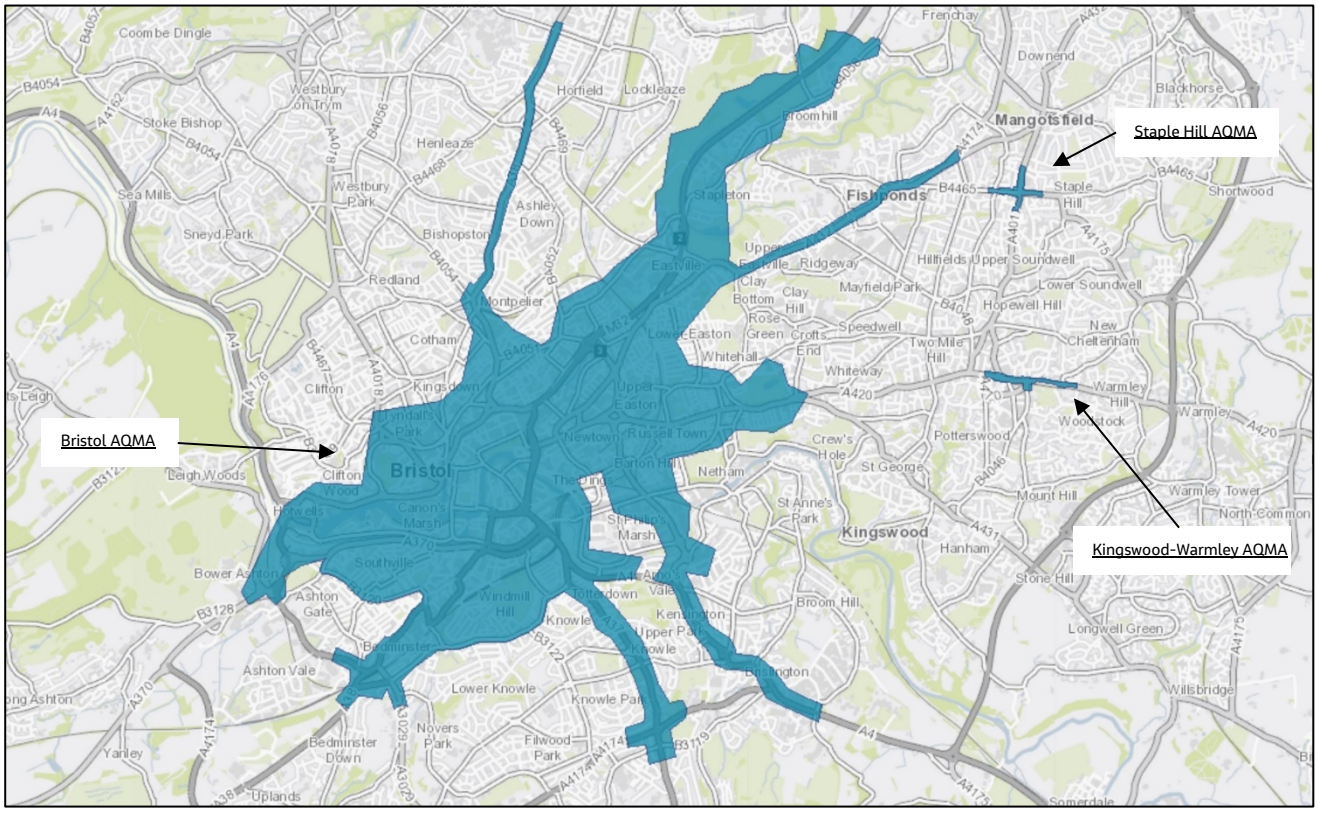
4.1 Baseline

The DMRB defines a sensitive air quality receptor as a location *where "people might experience a change in local air quality, near affected roads"*. This refers to locations of relevant exposure to the hourly and annual mean objective for NO_2, and the daily and annual mean objective for PM_{10}. Sensitive receptors in the context of the annual objectives are locations where people will be present for prolonged periods and include residential properties, schools, hospitals and care homes; this is important for young and elderly populations. The objectives do not apply to occupational uses such as shops and offices; or uses such as hotels or medical centres where the public would not be expected to be present over a full year. The land use within and surrounding the Study Area includes both commercial and residential land uses.

Air pollution has negative impacts on the health of people in Bristol, especially vulnerable members of the population. Evidence suggests that it can cause permanent lung damage in babies and young children and exacerbates lung and heart disease in older people. A 2017 report into the health effects of air pollution in Bristol concluded that around 300 premature deaths each year in the City of Bristol can be attributed to exposure to NO_2 and fine particulate matter ($PM_{2.5}$), with roughly an equal number attributable to both pollutants. This represents about 8.5% of deaths in the administrative area of Bristol being attributable to air pollution. This has an estimated cost to the NHS of £83m.

In 2001, an AQMA in Bristol was declared, covering the city centre and part of the main radial roads including the M32 for exceedances of the annual average NO_2 objectives of equal to or above 40µg/m^3. The AQMA has been reviewed several times, most recently in 2011. Figure 4.1 illustrates the extents of the Bristol AQMA.

Figure 4-1: AQMA Locations



In 2010, Staple Hill AQMA and Kingswood - Warmley AQMA were declared within the administrative boundary of SGC for the exceedances of the annual average NO_2 objective of equal to or above 40µg/m^3. Staple Hill AQMA, which was last amended in 2012, incorporates Broad Street A4175, High Street B4465, Victoria Street and

Soundwell Road A4017 crossroads. It extends along Broad Street to the junction with Seymour Road, along Soundwell Road to the road linking with Seymour Road and for distances of approximately 200m along High Street and approximately 170m along Victoria Street from the centre of the crossroads (refer to Figure 4.1).

Kingswood – Warmley AQMA (refer to Figure 3.1) incorporates the A420 road extending from the SGC / BCC boundary to the east along Two Mile Hill Road, Regent Street, High Street Kingswood, Hill Street, Deanery Road, High Street Warmley and London Road to the junction of Goldney Avenue; to the south along Hanham Road (up to and including The Folly); to the south-east along Tower Road North to the junction of Crown Gardens; and includes any properties that lie within the outlined boundary. Due to the extension of Kingswood AQMA along the A420 to Warmley following the 2014 Warmley Detailed Assessment, the AQMA was renamed from 'Kingswood AQMA' to the 'Kingswood-Warmley AQMA' in 2015.

In 2018, NO_2 concentrations were monitored at 131 sites in BCC. Forty six of these sites were in exceedance of the EU Limit Value. Air quality data for 2019 has now been released by BCC as part of their ongoing monitoring[4]. In 2019, NO_2 concentrations were monitored by diffusion tubes at 102 sites in BCC, 28 of these sites broke the 40 $\mu g/m^3$ annual compliance limit[5]. In addition, there are also 7 automatic monitoring sites within BCC, one of which was over the 40 $\mu g/m^3$ annual compliance limit in 2019 (located at Colston Avenue). Figure 4.2 shows the locations of the 2019 monitoring sites within BCC's administrative area and highlights the sites where monitored annual mean modelled NO_2 concentrations exceeded the EU Limit Value.

The monitoring indicates that exceedance locations were similar in 2018 and 2019, with several exceedences of the EU Limit Value measured, in particular in the City Centre as shown in Figure 4.2. The likely cause of the exceedances at these locations is a combination of the traffic mix (particularly diesel vehicles), road speed (i.e. slower speeds are generally accompanied by more frequent acceleration events) and presence of canyons (generally tall buildings on either side of the road which prevent pollutants from dispersing as effectively as they would in an open area).

Figure 4.3 shows the percentages of emissions attributed to each vehicle type in Bristol at all reportable roadside receptors. This shows that diesel cars are the most significant sources of vehicle derived NO_x emissions in Bristol. The vehicle type proportions are taken from the FBC Transport Modelling Reports (Appendix E to the FBC) and Euro standards and the fuel proportions are derived from Automatic Number Plate Recognition (ANPR) data collected around Bristol and described in the Air Quality Modelling Methodology Report (Appendix D to the FBC.

[4] https://www.bristol.gov.uk/documents/20182/32675/Bristol+City+Council+Air+Quality+Annual+Status+Report+2020.pdf/1cc35b4e-ca4f-412b-0b11-13afc31d9708

[5] https://opendata.bristol.gov.uk/pages/air-quality-dashboard-new/air-quality-now#statistics

Figure 4.2: NO_2 Monitoring within BCC– 2019 Annual NO_2 (Central area)

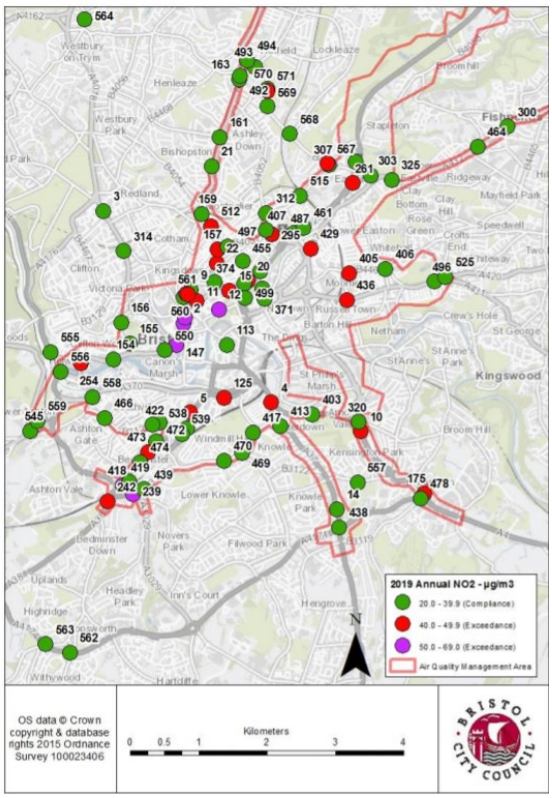
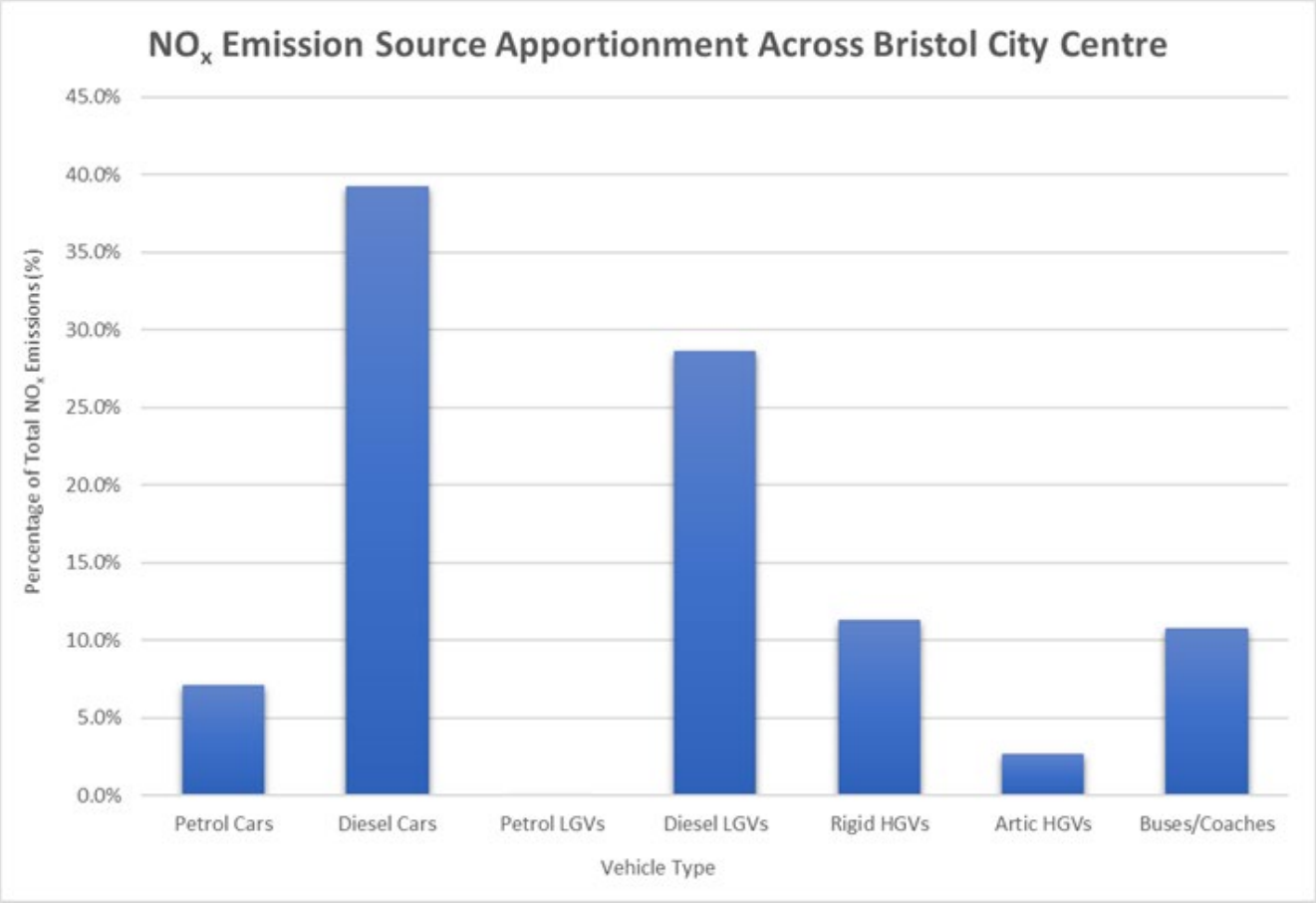


Figure 4.3: NO_x source apportionment by vehicle category across Bristol City Centre (%) – 2021 baseline. Source: Option Assessment Report, appended to the FBC.



4.2 Particulate Matter

There are Limit Values and Air Quality Objectives for particulate matter (PM), specifically PM_{10} (40 µg/m^3) and $PM_{2.5}$ (25 µg/m^3). Recent monitoring data within Bristol has demonstrated that PM emissions in Bristol have been under both Limit Values and Objectives for several years. Table 4-1 indicates that PM emissions are likely to reduce as a result of the Plan in 2021 and 2023 particularly.

Table 4-1: PM Annual Link Emissions

Scenario	Annual Link Emissions (tonnes / yr)	
	PM_{10}	**$PM_{2.5}$**
	2021	
SSS Baseline (exc fast track measures)	56.4	32.0
Small CAZ D RB4 (inc. fast track measures and SSS)	55.0	30.8
	2023	
SSS Baseline (exc fast track measures)	55.8	31.0

Scenario	Annual Link Emissions (tonnes / yr)	
	PM_{10}	**$PM_{2.5}$**
Small CAZ D RB4 (inc. fast track measures and SSS)	54.9	30.3
	2031	
SSS Baseline (exc fast track measures)	57.0	30.9
Small CAZ D RB4 (inc. fast track measures and SSS)	56.9	30.9

The impacts of PM are explored further in the Distributional and Equalities Impact Assessment, Appendix H.

4.3 Potential Impacts against Air Quality Objectives

Air Quality Modelling undertaken to inform the FBC indicated that implementation of the Small CAZ D RB4 (including SSS & fast track measures) scenario would have a large impact on air quality in 2021, when compared to the baseline scenario. With this scheme in place, there are 15 non-compliant receptors in 2021 and an overall predicted compliance year of 2023.

In 2023, the Small CAZ D leads to an improvement (change of <= -0.4 µg/m^3) in annual mean NO_2 concentrations at 1,059 reportable receptors within Bristol and no change (change of between -0.3 and 0.3 µg/m^3) at 333 receptors. The Small CAZ D is effective at improving NO_2 concentrations over much of the BCC local authority region, although the effects are smaller in some areas outside of the city centre because the CAZ itself covers only a small area. Annual mean NO_2 concentrations worsen (change of >= 0.4 µg/m^3) at 7 reportable receptors within BCC in 2023.

Table 4-2 identifies 76 locations that show an increase of 0.4 µg/m^3 of NO_2 in 2031. However, it should be noted that in the 2031 scenario, all of the modelled annual mean NO_2 concentrations are well below the EU limit values. Therefore, the increase in NO_2 levels would not create any locations of non-compliance with EU limit values. The CAZ is expected to have a very limited impact by 2031, due to the majority of vehicles being compliant irrespective of a CAZ being in place, and the increases in NO_2 levels are likely to be caused by redistribution of traffic across the network associated with the Fast Track Measures.

The 9 receptors predicted to have increased NO_2 levels in the 2021 scenario (see Table 4.2) are located on Lower Ashley Road, Easton Way and A4174 Callington Road. For the 2023 scenario, 7 receptors are predicted to have increased NO_2 levels, which are located at Lower Ashley Road and A37 Wells Road.

Table 4-2: Small CAZ D (inc. SSS and fast track measures) changes to annual mean NO_2 concentrations from equivalent baseline

	No. Reportable BCC Receptors		
	2021	**2023**	**2031**
Improvement (<= -0.4 µg/m^3)	1,153	1,059	63
No Change (-0.3 to 0.3 µg/m^3)	237	333	1,260

	No. Reportable BCC Receptors		
	2021	**2023**	**2031**
Disbenefits (>= 0.4 µg/m^3)	9	7	76

4.3.1 Impacts on human health

Based on the results of the modelling, the Small CAZ D option is predicted improve NO_2 concentrations at 1,153 locations in 2021 and 1,059 locations in 2023 (see Table 4.2). This would result in reduced impacts of NO_2 levels on health at these locations.

However, this option would also result in disbenefits to NO_2 levels at 9 locations in 2021, 7 locations in 2023 and 76 locations in 2031, resulting in associated health disbenefits at these locations.

4.4 Assessment of the potential Impacts against Air Quality Directive

The primary objective of the CAP is to bring about compliance across Bristol in the shortest possible timeframe, and the key success factor is therefore the earliest year where all modelled annual mean NO_2 concentrations are below 40 µg/m^3 (i.e. at PCM equivalent reportable receptors).

5. Cultural Heritage and Townscape

5.1 Baseline

Bristol contains the following heritage designations and assets, shown in Appendix A:

- 73 historic Registered Parks and Gardens
- 24 Scheduled Monuments,
- over 4,000 Listed Buildings;
- 33 Conservation Areas;
- 20 sites on the Heritage at Risk Register; and
- 516 locally valued buildings.

Vehicle emissions contain various pollutants that can damage buildings, including carbon dioxide (CO_2) and sulphur and nitrogen oxides, which all cause stone decay (van Grieken *et al*., 1998). The deposition of fine particles rich in carbon blackens buildings. Enhanced atmospheric CO_2 can lead to increased carbonic acid concentrations in rainfall, which can degrade limestone, which many properties in Bristol and the south west of England are constructed from.

Deposition of sulphur dioxide and its oxidation to sulphuric acid can damage carbonate stones (Brimblecombe and Grossi, 2007), including the oolitic limestone used for most buildings in Bristol and the south west of England. Allen *et al* (2000) have also shown that NO_2 and SO_2 have a synergistic damaging impact on Bristol's oolitic limestone, whereby the NO_2 acts as a catalyst for the oxidation of SO_2 on stone surfaces. The stone degradation that results is exacerbated in wet and humid conditions. Synergisms between air pollution, acid rain and biological weathering could all become an increasingly important problem for stone decay (Thornbush and Viles, 2006).

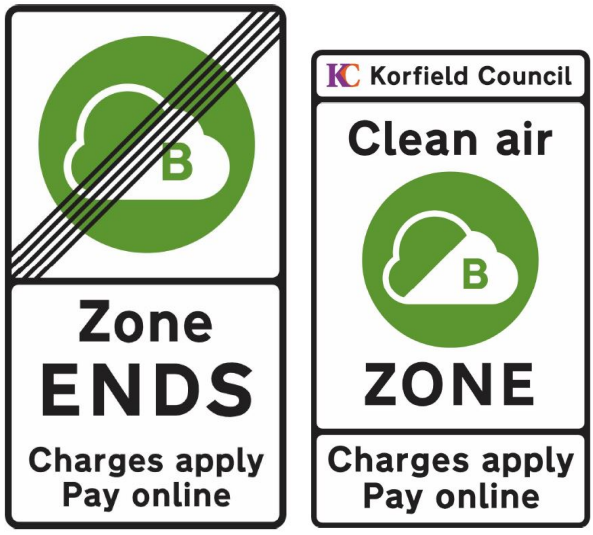
5.2 Potential Impacts

A reduction in the numbers of vehicles within the scheme boundary could reduce air pollution and therefore have a positive impact on the cultural heritage assets within the centre of Bristol (see Section 1.3.2). However, with the slight increase in traffic outside of the scheme boundary there is also potential for negative impacts on the cultural heritage (historic buildings) outside of Bristol City Centre via air pollution.

The magnitude of these impacts (positive and negative) can only be ascertained through the monitoring of historic buildings during implementation of the scheme. However, based on professional judgement, it is considered unlikely that any increase would result in notable impacts or significant negative effects on heritage assets, given almost all the changes on links showing increases are considered to be well within the normal day-to-day variation in traffic volumes.

Defra's CAZ Framework guidance, describes 'a minimum requirement for setting up a CAZ is to "*have signs in place along major access routes to clearly delineate the zone" (Defra 2017).* To ensure a national standard, the design of the CAZ symbol and traffic sign was produced centrally by Defra's Joint Air Quality Unit (JAQU), as shown in the Figure 5.1 examples.

Figure 5.1: CAZ signage examples provided by JAQU



For Bristol, it is proposed that most scheme boundary cordon points will have two entry and two exit signs, one of each on both sides of the carriageway. Posts would be required on both sides of the carriageway for the erection of one entry and one exit sign each way.

Unless placed sensitively, new signage could potentially affect important viewpoints in Bristol, including the visual setting of historic sites and buildings within the townscape. The historic feature that is the most sensitive to such visual impacts is the Clifton Suspension Bridge.

Clifton Suspension Bridge spans the Avon Gorge and River Avon, links Clifton in Bristol to Leigh Woods in North Somerset. The bridge is a Grade I listed structure based on an early design by Isambard Kingdom Brunel.

It is proposed that the bridge would have two entry signs, two exit signs and two enforcement signs (on either side of the road). It is also proposed that ANPR cameras are installed at both locations (also on either side of the road).

Signage should be designed and installed with viewpoints in mind, particularly near the Clifton Suspension Bridge. Where possible, the number of signs should be minimised to minimise impacts on the setting of these historic structures or any other heritage assets. The size of signs should also be minimised, whilst being fit for purpose.

6. Conclusions

The Small CAZ D Option is anticipated to reduce air pollution across Bristol city centre and the wider BCC / SGC administrative areas overall. Improvement in traffic congestion and associated anticipated reductions to existing air pollution have potential for positive impacts on a range of human receptors within the scheme area. Over the scheme as a whole, these benefits are anticipated to outweigh any disbenefits on air quality, noise and heritage receptors, based on the available data at this time. However, this Option also has potential to impact on the Bristol townscape through the introduction of new features as part of CAP implementation. It is recommended that any signage should be designed and installed with the historic townscape and important viewpoints in mind, particularly near Clifton Suspension Bridge, due to their historic importance and visual amenity value.

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Appendix A. Archaeological & Heritage Assets

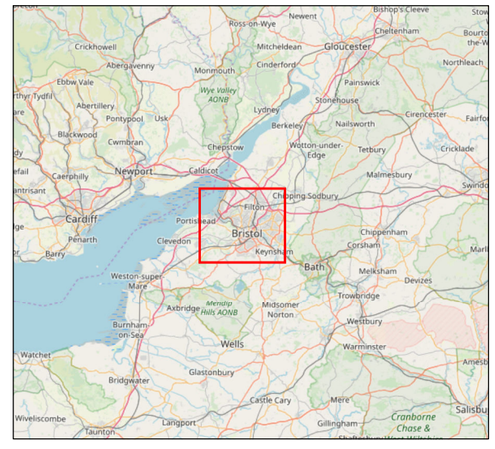
FIGURE A1

Legend

- Bristol City Council boundary
- Scheduled Monument
- Registered Park and Garden

Listed Building

- Grade I
- Grade II*



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