2021 Air Quality Annual Status Report (ASR)

In fulfilment of Part IV of the Environment Act 1995

Local Air Quality Management

Date: August 2021

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Executive Summary: Air Quality in Our Area

Air Quality in Carlisle City Council

Air pollution is associated with a number of adverse health impacts. It is recognised as a contributing factor in the onset of heart disease and cancer. Additionally, air pollution particularly affects the most vulnerable in society: children, the elderly, and those with existing heart and lung conditions. There is also often a strong correlation with equalities issues because areas with poor air quality are also often less affluent areas[1,2].

The mortality burden of air pollution within the UK is equivalent to 28,000 to 36,000 deaths at typical ages[3], with a total estimated healthcare cost to the NHS and social care of £157 million in 2017[4].

Air quality has been monitored in Carlisle and the surrounding district as part of the local authority review and assessment process since 1996. In addition to nitrogen dioxide, other pollutants measured include particulate matter (in two size ranges; $PM_{2.5}$ and PM_{10}) and benzene (measured as part of Defra's Non-Automatic Hydrocarbon Network). However, as local authorities are no longer required to report benzene concentrations we are not reporting these in this Annual Status Report.

Due to the impact of Covid-19, the average reduction of NO_2 concentrations in 2020 compared to previous years was about 20 % (the decreases ranged across the diffusion tube network from 10 % to 30 %). As a result, annual mean concentrations of NO_2 were below the 40 µg m^{-3} annual mean AQO within our AQMAs and all locations across the Council Area.

Nitrogen dioxide concentrations measured by the automatic analysers also remained below the annual objective concentration in 2020. The annual mean NO_2 concentrations

[1] Public Health England. Air Quality: A Briefing for Directors of Public Health, 2017

[2] Defra. Air quality and social deprivation in the UK: an environmental inequalities analysis, 2006

[3] Defra. Air quality appraisal: damage cost guidance, July 2020

[4] Public Health England. Estimation of costs to the NHS and social care due to the health impacts of air pollution: summary report, May 2018

were 19.0 µg m^{-3} at Paddy's Market. This represents a reduction of 23.4 %, compared to previous years. There were also no exceedances of the hourly mean objective. The highest annual mean NO_2 concentration (31.7 µg m^{-3}) measured anywhere in the diffusion tube network was at site E8 within the Bridge Street AQMA.

The PM_{10} annual mean concentration monitored by automatic analyser at Paddy's Market was 16.4 µg m^{-3} in 2020 and hence significantly below the annual mean air quality objective of 40 µg m^{-3}. There were also no exceedances of the short-term air quality objective.

Before 2020, the air quality measures introduced by Carlisle City Council, had tended to decrease NO_2 concentrations at all locations throughout the local authority. However, NO_2 concentrations before the pandemic suggested that the following AQMAs should remain:

- AQMA 1 (A7):
- AQMA 2 (Currock Street);
- AQMA 4 (Bridge Street);
- AQMA 5 (Dalston Road).

AQMA 1[5] was significantly reduced in size; it no longer includes the area along the A7 from Hardwicke Circus to Junction 44 of the M6 instead it includes just an area extending for approximately 100 m from the Stanwix Bank junction (A7) along Brampton Road including properties 1 to 17 on Brampton Road. The order came into force on 25th July 2019.

The orders for revocation of AQMA 3[6] and AQMA 6[7] came into force on 3rd July 2019. Copies of the orders can be obtained from www.carlisle.gov.uk (see footnotes below).

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5 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/Air%20Quality%20Management%20Order%20No%201%20.pdf

6 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/AL517%20-%20Order%20Revoking%20Air%20Quality%20Management%20Order%20Area%20No%203.pdf

7 https://www.carlisle.gov.uk/Portals/0/Documents/Residents/Environment/AL517%20-%20Order%20Revoking%20Air%20Quality%20Management%20Order%20.pdf

They can be viewed on the Department for Environment, Food and Rural Affairs (Defra) website: https://uk-air.defra.gov.uk/aqma/local-authorities?la_id=48

Carlisle City Council work alongside partners in Cumbria County Council, Highways Department and their consultants. We are in early-stage discussions on the potential to introduce new smart traffic signals, within the city centre. This could potentially be combined with continuous air quality monitoring, to reduce traffic derived emissions, in line with our Action Plan measures. This future project may involve an application to secure some grant funding from Defra.

Actions to Improve Air Quality

Whilst air quality has improved significantly in recent decades, and will continue to improve due to national policy decisions, there are some areas where local action is needed to improve air quality further.

The 2019 Clean Air Strategy[8] sets out the case for action, with goals even more ambitious than EU requirements to reduce exposure to harmful pollutants. The Road to Zero[9] sets out the approach to reduce exhaust emissions from road transport through a number of mechanisms; this is extremely important given that the majority of Air Quality Management Areas (AQMAs) are designated due to elevated concentrations heavily influenced by transport emissions.

Carlisle City Council has taken forward a number of measures during the current reporting year of 2020 in pursuit of improving local air quality. Key local measures continue to support improvements in local air quality and the City Council continues to work on:

- Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west. The route will include new junctions linking existing radial routes into Carlisle and the Garden Village. The 8km route will include bridges over two main railway lines and the Caldew and Petteril rivers, a network of footways and cycleway

[8] Defra. Clean Air Strategy, 2019

[9] DfT. The Road to Zero: Next steps towards cleaner road transport and delivering our Industrial Strategy, July 2018

- Bus infrastructure improvements: Ongoing improvements to bus services with new shelters and raised kerbs continues. In addition, plans for large new housing developments will include public transport provision.
- Potential opportunities to introduce new smart traffic signals, within the city centre. This could potentially be combined with continuous air quality monitoring, to reduce traffic derived emissions.
- Ongoing work to provide grant funding for home isolation and domestic renewable heating options.
- Ongoing schemes to introduce vehicle charging points on council owned land and as part of new private development, including charging provision in all new residential developments.

Conclusions and Priorities

2020 was an unusual year for air quality because nitrogen dioxide concentrations were significantly impacted by Covid-19 – there were no exceedances of the annual objective concentration for NO_2 at locations relevant for human exposure anywhere in Carlisle City Council. The average reduction of NO_2 concentrations at the automatic monitoring locations in 2020 compared to previous years was about 20 % (the decreases ranged across the diffusion tube network from 10 % to 30 %). Similar reductions were observed by the Air Quality Expert Group (AQEG)[10] which has estimated that during the initial lockdown period in 2020, within urbanised areas of the UK reductions in NO_2 annual mean concentrations were between 20 and 30% relative to pre-pandemic levels, which represents an absolute reduction of between 10 to 20 µg m^{-3} if expressed relative to annual mean averages.

Monitoring should continue to ensure the ongoing measures in the AQAP are achieving success.

Before 2020, monitoring of pollutants had shown a gradual but steady decline in nitrogen dioxide (NO_2) and particulate (PM_{10} and $PM_{2.5}$) concentrations. Although particulate measurements are well below the air quality objectives, some locations in 2019 across the

[10] Air Quality Expert Group, Estimation of changes in air pollution emissions, concentrations and exposure during the COVID-19 outbreak in the UK, June 2020

city still exceeded or are just below the air quality objectives for NO_2. It is expected that NO_2 will return to pre Covid-19 concentrations within 2021 or 2022. As a result, Carlisle City Council it is too early to consider changing the AQMAs within Carlisle City Council.

Carlisle City Council's priorities for the coming year are:

- Finalise the Air Quality Action Plan and drive forward on actions identified in the Action Plan.
- Promote travel plans and introduction of green spaces for all new housing developments – look to introduce zero and near zero emission vehicle uptake as part of new residential development.
- Continue to work with businesses to promote more widespread use of alternative transport.

Local Engagement and How to get Involved

There are a number of ways in which the public can get involved with improving air quality:

- Taking part in Green Travel Plan arrangements with their employer.
- Joining local cycle groups and walk to school/work groups.
- The use of sustainable transport options including cycling, walking and the bus.
- Investigate how to improve the energy efficiency at home, including sustainable heating and improved home insulation. Contact Carlisle City Council to find out what grants are currently available.
- Become involved other community groups such as the Waverly Viaduct Trust which is currently working to reopen the Waverly Viaduct Bridge. The Local Enterprise Partnership (LEP) also works to secure government grant funding for local projects.

The City council website can be used to view all previous air quality review and assessment reports as well as real time monitoring data and advice on how to reduce emissions to air.

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1 Local Air Quality Management

This report provides an overview of air quality in Carlisle City Council during 2020. It fulfils the requirements of Local Air Quality Management (LAQM) as set out in Part IV of the Environment Act (1995) and the relevant Policy and Technical Guidance documents.

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where an exceedance is considered likely the local authority must declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives. This Annual Status Report (ASR) is an annual requirement showing the strategies employed by Carlisle City Council to improve air quality and any progress that has been made.

The statutory air quality objectives applicable to LAQM in England are presented in Table E.1.

2 Actions to Improve Air Quality

Air Quality Management Areas

Air Quality Management Areas (AQMAs) are declared when there is an exceedance or likely exceedance of an air quality objective. After declaration, the authority should prepare an Air Quality Action Plan (AQAP) within 12 months setting out measures it intends to put in place in pursuit of compliance with the objectives.

A summary of AQMAs declared by Carlisle City Council can be found in Table 2-1. The table presents a description of the four designated AQMA(s) that are currently designated within Carlisle City Council. Appendix D: Map(s) of Monitoring Locations and AQMAs provides maps of AQMA(s) and also the air quality monitoring locations in relation to the AQMA(s). The air quality objectives pertinent to the current AQMA designation(s) are as follows:

- NO_2 annual mean.

Table 2-1 – Declared Air Quality Management Areas

AQMA Name	Date of Declaration	Pollutants and Air Quality Objectives	One Line Description	Is air quality in the AQMA influenced by roads controlled by Highways England?	Level of Exceedance: Declaration	Level of Exceedance: Current Year	Name and Date of AQAP Publication	Web Link to AQAP
AQMA 1	02/12/2005 Amended 25th July 2019	NO2 Annual Mean	AQMA 1 Amended 25th July 2019 to include just 100 m Section along B6264 Brampton Road.	YES	45.3	23.0	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Portals/0/AQAP_CCC_draft%202_for_consultation_stering.pdf
AQMA 2	26/01/2007	NO2 Annual Mean	AQMA 2 Currock Street and the properties immediately to the west of it, between the junction with James St/Water St and Crown St.	YES/NO	44.6	27.0	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Portals/0/AQAP_CCC_draft%202_for_consultation_stering.pdf
AQMA 3	01/08/2008 Revoked 3rd July 2019	NO2 Annual Mean	AQMA 3 Wigton Road between Crummock Street and Caldewgate roundabout as well as properties on Caldcotes.	N/A	40	N/A	N/A	N/A

AQMA Name	Date of Declaration	Pollutants and Air Quality Objectives	One Line Description	Is air quality in the AQMA influenced by roads controlled by Highways England?	Level of Exceedance: Declaration	Level of Exceedance: Current Year	Name and Date of AQAP Publication	Web Link to AQAP
AQMA 4	01/08/2008	NO2 Annual Mean	AQMA 4 North side of the A595 at Bridge Street, northbound from the junction with Shaddongate.	YES	43.9	31.7	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Portals/0/AQAP_CCC_draft%202_for_consultation_steering.pdf
AQMA 5	01/08/2008	NO2 Annual Mean	AQMA 5 Junction of Dalston Road and Junction Street	YES/NO	48	28.3	Carlisle City Council Air Quality Action Plan	https://www.carlisle.gov.uk/Portals/0/AQAP_CCC_draft%202_for_consultation_steering.pdf
AQMA 6	01/08/2008 Revoked 3rd July 2019	NO2 Annual Mean	AQMA 6 London Road and properties on either side near the junction with Blake Street	N/A	43.3	N/A	N/A	N/A

☒ **<Local Authority> confirm the information on UK-Air regarding their AQMA(s) is up to date (confirm by selecting in box).**

☒ **<Local Authority> confirm that all current AQAPs have been submitted to Defra (confirm by selecting in box).**

Progress and Impact of Measures to address Air Quality in Carlisle City Council

Defra's appraisal of last year's ASR concluded the report was well structured, detailed, and provides the information specified in the Guidance. With regards to the main comments made by the appraisal:

- *The Council have provided a thorough report which contains the required content.*

We will continue to ensure that the ASR meets the required reporting standard.

- *Comparison to the AQOs has been provided within the majority of the result tables, however this is absent in Table A.3 and has been done incorrectly in Table A.4. In Table A.3, concentrations exceeding the annual mean objective of 40 µg m^{-3} must be depicted in **bold**. Should concentrations exceed 60 µg m^{-3}, these must be shown in **bold underlined**. In Table A.4, values should only be depicted in bold where the site records 18 or more 1-hour means >200 µg m^{-3} during the reporting year. Whilst this is not considered sufficient to warrant rejection of the report, it must be amended prior to further publication of the ASR.*

We will also use the bold font to indicate the annual average is above the annual mean objective of 40 µg m^{-3}.

- *The Council have opted to apply the national factor to their results. The Council considered this more representative of the monitoring undertaken within the district, and offered a more conservative approach. This is appropriate. The Council are also commended on the inclusion of detailed discussion justifying their choice.*

As for previous years we will evaluate which bias adjustment factor is the most appropriate one to use.

- *Annual mean PM_{10} and $PM_{2.5}$ concentrations have increased by 2.4 µg m^{-3} and 2.2 µg m^{-3}, respectively, at Paddy's Market CMS compared to 2018. Although these concentrations do not exceed their respective annual mean air quality objectives, the Council are encouraged to discuss the possible reasons for these increases within the report, and continue to monitor particulate concentrations to ensure the upward trend does not persist.*

We have investigated reasons why the increase occurred. This is discussed in Appendix G.

- *Diffusion tube mapping is comprehensive and clearly demonstrates the monitoring network and the locations of the Council's AQMAs.*

Maps showing the location of the diffusion tubes and AQMA will again be presented.

- *The report draws links to the PHOF and fraction of mortality attributable to $PM_{2.5}$ emissions. This adheres with good practice and is encouraged in all future reports.*

The relationship of $PM_{2.5}$ concentrations with PHOF and fraction of mortality attributed to $PM_{2.5}$ emissions will also be updated this year.

- *The Council clearly outlines their priorities for the coming year, which is commended. The proprieties are considered appropriate, and progress made on these measures is expected to be discussed in next year's ASR.*

The progress on measures will be also be discussed.

Carlisle City Council has taken forward a number of direct measures during the current reporting year of 2020, in pursuit of improving local air quality. Details of all measures completed, in progress or planned are set out in Table 2-2. Thirteen measures are included within Table 2-2, with the type of measure and the progress Carlisle City Council have made during the reporting year of 2020 presented. Where there have been, or continue to be, barriers restricting the implementation of the measure, these are also presented within Table 2-2.

More detail on these measures can be found in the Action Plans.

Key completed measures are:

- Completion of the Carlisle Northern Development Route;
- Improvements in traffic management, including Smart Signalling at Hardwicke Circus;
- Improvements in bus service;
- Improved cycling and walking routes.

The updated Action Plan showed that the NOx emissions from Bridge Street needs to reduce by just 2.7 % to achieve compliance. Source apportionment showed that emissions from diesel vehicles dominated NOx emissions. A breakdown in NOx emissions, in terms of vehicle types, is as follows:

- Rigid HGVs 33.8 %;
- Diesel Cars 26.8 %;
- Buses/Coaches 13.7 %;
- Artic HGVs 12.4 %;
- Diesel LGVs 9.4 %;

- Petrol Cars 3.2 %;
- Motorcycles 0.30 %;
- Hybrids 0.29 %
- Petrol LGVs 0.02 %

Clearly reducing the proportion of diesel vehicles on Bridge Street would reduce NOx emissions. Increasing traffic flow through the traffic lights would also be beneficial.

The impact of increasing traffic speed on oxide of nitrogen emissions was investigated using the emission factor toolkit (EFT2019_v9.0)[11]. Traffic speeds were increased at 5 kph increments within the same model domain considered in the Air Quality Action Plan[12]. For the base case, NOx emissions were calculated to be 15.2 tonnes. Increasing the speed by 5 kph would cause a reduction of 17 % in NOx emissions easily exceeding the 2.7 % reduction required to achieve compliance of 40 µg m^{-3}. Emissions at the other speeds are given below:

	NOx emissions, tonnes / year	Percentage reduction, %
Base	15.2	
Base + 5 kph	12.7	17.0
Base + 10 kph	11.0	27.9
Base + 15 kph	9.9	35.1

Carlisle City Council will work with partners to implement actions to improve traffic flow along Bridge Street (AQMA 4). This future project may involve an application to secure some grant funding from Defra.

Carlisle City Council expects the following measures to be completed over the course of the next reporting year:

- Improve signalling to reduce standing and stop and start traffic at the pedestrian crossing on Bridge Street

[11] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[12] The Air Quality Action Plan has been updated as a draft and is currently under review by the Steering Body.

- Further progress on the Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west.

Carlisle City Council's priorities for the coming year are to:

- Continue to work with the planning department to ensure air quality implications are taken into account in the planning process.
- Improve cycle links
- Signal improvements to improve traffic flow at traffic lights on Bridge Street
- Further progress on the Carlisle Southern Link Road: This will connect Junction 42 of the M6 with the A595 to the west.

The principal challenges and barriers to implementation that Carlisle City Council anticipates facing is the bus fleet not being ungraded, as the decision to invest in the fleet would be made by commercial operators.

Progress on the following measures has been slower than expected due to budget and time constraints:

- Public promotion of air quality
- The implementation of a 'Transport Overview and Joint Parking Policy' has been abandoned.

Carlisle City Council anticipates that the measures stated above and in Table 2-2 will achieve compliance in AQMA 4.

Table 2-2 – Progress on Measures to Improve Air Quality

Measure No.	Measure	Category	Classification	Year Measure Introduced	Estimated / Actual Completion Year	Organisations Involved	Funding Source	Defra AQ Grant Funding	Funding Status	Estimated Cost of Measure	Measure Status	Reduction in Pollutant / Emission from Measure	Key Performance Indicator	Progress to Date	Comments / Barriers to Implementation
1	'Carlisle Northern Development Route,' to the west of the City will remove up to 25% of through traffic.	Traffic Management	Other	2010	2012	Cumbria County Council & Carlisle City Council	£158m of PFI funding	No	Complete	£158m of PFI funding	Complete	Anticipate approx. 25% reduction in NO2 in city centre.	Reduced NO2 levels at monitoring locations and within AQMA's.	CNDR operational. Monitoring at receptors on new road revealed consistently low NO2 levels, monitoring locations subsequently reduced in 2018. Further evidence of NO2 improvements and traffic reduction in the city centre. Several new cycle links from arterial routes to CNDR complete. Plans for future improvements	Plans to extend route via Carlisle Southern Link Road
2	Effective traffic management measures will be implemented to improve the existing road network and incorporate new developments.	Traffic Management	UTC, Congestion management, traffic reduction	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget. Defra grant	Possible future grant application	Possible future grant application	Unknown. Currently investigating options.	Ongoing	Not calculated. See above for modelling undertaken at Bridge Street AQMA.	Reduced NO2 levels and standing traffic within AQMA's.	Completed works on pedestrian crossing on Castle Way incorporating Smart Signalling from the main Hardwicke Circus roundabout. Ongoing work to improve traffic flow. Modelling working as part of AQAP has shown that emissions from diesel vehicles dominate emissions. Emissions factor toolkit has been used to show increased traffic speeds would reduce oxide of nitrogen emissions within Bridge Street. Work will continue to improve traffic management in this area.	Requires significant investment
3	Environmental Health will continue to work with the Planning Department with regard to new developments and ensure that air quality implications are taken into consideration in the planning process.	Policy Guidance and Development Control	Air Quality Planning and Policy Guidance	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Improved links between EH and Planning. AQIA's submitted as necessary. Early consultation with applicants.	Environmental Health is consulted on all proposed developments which may impact on air quality. Responses are aimed at minimising AQ impacts. This currently includes many large residential developments on fringe of city. Recommendations made for car charging points on all new residential properties with parking/garage provision.	Environmental Health comment on all potentially polluting developments
4	Upgrade of passenger transport infrastructure to make it more convenient and widely accessible across the County. Arrangements for sustainable transport systems will be integrated into major new and proposed developments	Transport Planning and Infrastructure	Bus route improvements	Ongoing	Ongoing	Cumbria County Council	Commercial investment from bus companies and County Council Highway projects.	No	ongoing	Unknown. Ongoing works	Ongoing	Not calculated	Improved bus service. Increased use of transport provided. Reduced NO2 along main routes	Ongoing improvements to bus services with new shelters and raised kerbs. Plans for large new housing developments include public transport provision and/or sustainable transport options.	Success is dependent on public uptake of sustainable transport options. No real control over the improvement of vehicle fleet.
5	Cycling and walking will be encouraged through reducing the impact of vehicle traffic in key areas of the city. New and improved pedestrian and cycle links including the Caldew and Lowry Hill Cycle ways and the River Petteril shared cycle/footway will be provided.	Transport Planning and Infrastructure	Cycle network	Ongoing	Ongoing	Cumbria County Council	Various grant schemes and S106 agreements	No	Ongoing	Unknown. Ongoing projects and funding applications from various sources	Ongoing	Not calculated	Completion of proposed works and ongoing improvement of the cycle and pedestrian route network.	The pedestrian crossing on Castle way incorporating Smart Signalling is complete. Pedestrian/cycle bridge connecting Currock and Denton Holme, over the railway line are complete. Ongoing applications for government funding for schemes that aim to improve the existing cycleways, creating new sections of cycle track and installing vehicle charging points. Extensive plans to increase the cycle path network are now in place.	Ongoing plans associated with improved pedestrian and cycle connections to the CNDR.
6	Travel plans will be required to be implemented and monitored through S106 agreements for all new developments that meet the criteria. Existing businesses will be encouraged to implement, monitor and review travel plans.	Promoting Travel Alternatives	Workplace Travel Planning	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased number of participant businesses and more widespread use of alternative transport.	All schools within the city now have travel plans. New developments likely to result in increased highway usage must submit a travel plan for approval when making an application.	Difficult to quantify the impact of Travel Plans
7	The City Council and the County Council will develop and implement a comprehensive 'Transport Overview	Policy Guidance and Development Control	Regional Groups Co-ordinating programmes to develop Area wide	N/A	N/A	Cumbria County Council & Carlisle City Council	N/A	No	N/A	N/A	Closed	Not calculated	Approval and adoption of Transport Overview and Joint Parking Policy.	No progress to date. No plans to progress the measure	To be taken out of revised action plan

Measure No.	Measure	Category	Classification	Year Measure Introduced	Estimated / Actual Completion Year	Organisations Involved	Funding Source	Defra AQ Grant Funding	Funding Status	Estimated Cost of Measure	Measure Status	Reduction in Pollutant / Emission from Measure	Key Performance Indicator	Progress to Date	Comments / Barriers to Implementation
	and Joint Parking Policy'.		Strategies to reduce emissions and improve air quality												
8	The City Council will continue to provide comprehensive control over emissions from all Part A2 and B Processes located within the local authority area.	Environmental Permits	Other measure through permit systems and economic instruments	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Risk based inspections showing that emission limits are being met and efforts are being made to improve on national objectives.	All processes which fall under part B & A2 processes are permitted by Carlisle CC. No recent enforcement action required in relation to emissions.	No new major polluting processes in previous year.
9	The City Council will continue to investigate complaints of black smoke and smoke nuisance as well as managing smokeless zones. Enforcement action will be taken as necessary.	Public Information	Other	Ongoing	Ongoing	Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Reduction in the number of complaints from members of the public. Reduction in repeat offenders.	There is information on website. Environmental Health provide advice and enforcement as required. Smoke complaints are responded to involving domestic fires, bonfires, trade waste, industrial and dark smoke. Advice leaflet sent out for all cases of domestic burning.	The Air Quality Strategy set out a goal to cut public exposure to particulate matter pollution. This measure will contribute to this target.
10	Energy savings advice and subsidised home insulation improvements will continue to be provided to the public. Uptake will be monitored.	Public Information	Other	Ongoing	Ongoing	Carlisle City Council	Through government grant schemes and energy providers	No	Funding secured for current schemes	Depends on uptake and grant schemes available	Ongoing	Cumbria Warm Homes Project (CWHP) delivered a reduction of 317296 lifetime carbon tonnes.	Number of properties taking up schemes, resulting in Improved energy efficiency of housing stock.	Carlisle CC Home Improvement Agency is currently delivering Health through Warmth Scheme, supported by the Energy Companies Obligation. This includes boiler upgrades and home insulation. Safe and warm grants are provided by the council to deliver up to £7,500 to enable low income homes to carry out minor repairs and energy efficiency measures to their homes. Work has begun on enforcing the Minimum Energy Efficiency Standards, specifically aimed at private rented sector properties. New energy efficiency grants are now available up to £3000 through council grant scheme.	Carlisle CC have revised Housing Renewal Assistance Policy under the Regulatory Reform Order 2002. This covers all grants involving housing and energy efficiency measures.
11	Environmental Health will work alongside the Neighbourhoods and Green Spaces team to investigate and implement the effective use of trees and green areas to offset traffic derived emissions in existing AQMA's and in new development areas.	Public Information	Other	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increase in trees and vegetation in visible locations. Increased public interest.	Carlisle City Council continues to manage and maintain trees in parks and green spaces, including some additional planting, of mainly mixed broadleaf species, where necessary. Planting of green areas is an essential part of many new developments, including residential.	Limitations to planting options in busy urban areas. Parks and open spaces do not have significant air quality issues. Green Spaces continue to have a positive public impact
12	Joint working will be extended in order to include air quality improvement in all relevant City Council and County Council policies and strategies.	Policy Guidance and Development Control	Air Quality Planning and Policy Guidance	Ongoing	Ongoing	Cumbria County Council & Carlisle City Council	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased awareness of air quality issues and consideration given by more council departments.	Included air quality links within most major relevant policies including Local Transport Plan (LTP 3) (2011-26) and The Carlisle District Local Plan (2015-30). New schemes being developed to deliver improved cycling routes and vehicle charging infrastructure. In line with the draft 'Carlisle Local Environment (Climate Change) Strategy'.	Air Quality considerations are put forward during discussion and consultation stages of policy development.
13	The City Council will promote air quality and sustainable transport issues. Up to date air quality information and monitoring data will be provided to the public.	Public Information	via the Internet	Ongoing	Ongoing	Carlisle City Council/ PH	Annual budget	No	Ongoing via annual budget	N/A	Ongoing	Not calculated	Increased public awareness and participation in improving air quality.	Air quality info and real time monitoring data is available on the website. Monitoring data shows continued improvement in most areas. Carlisle CC is actively supporting and promoting Clean Air Day, utilising social media and our website, as part of the Global Action Plan. Previous Clean Air Day included a competition, for all local primary schools. Prizes awarded including bikes and cycling equipment. Cumbria' County Council has ongoing projects to cut carbon emissions in the county. These aim to raise ambition to tackle climate change and sharing learning and resources. The public will be able to influence and drive climate action through citizens' juries and other projects, with community groups steering the programme.	Difficult to quantify any improvement as a direct result of promotional work or providing monitoring data.

$PM_{2.5}$ – Local Authority Approach to Reducing Emissions and/or Concentrations

As detailed in Policy Guidance LAQM.PG16 (Chapter 7), local authorities are expected to work towards reducing emissions and/or concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5µm or less). There is clear evidence that $PM_{2.5}$ has a significant impact on human health, including premature mortality, allergic reactions, and cardiovascular diseases.

Carlisle City Council is taking the following measures to address $PM_{2.5}$:

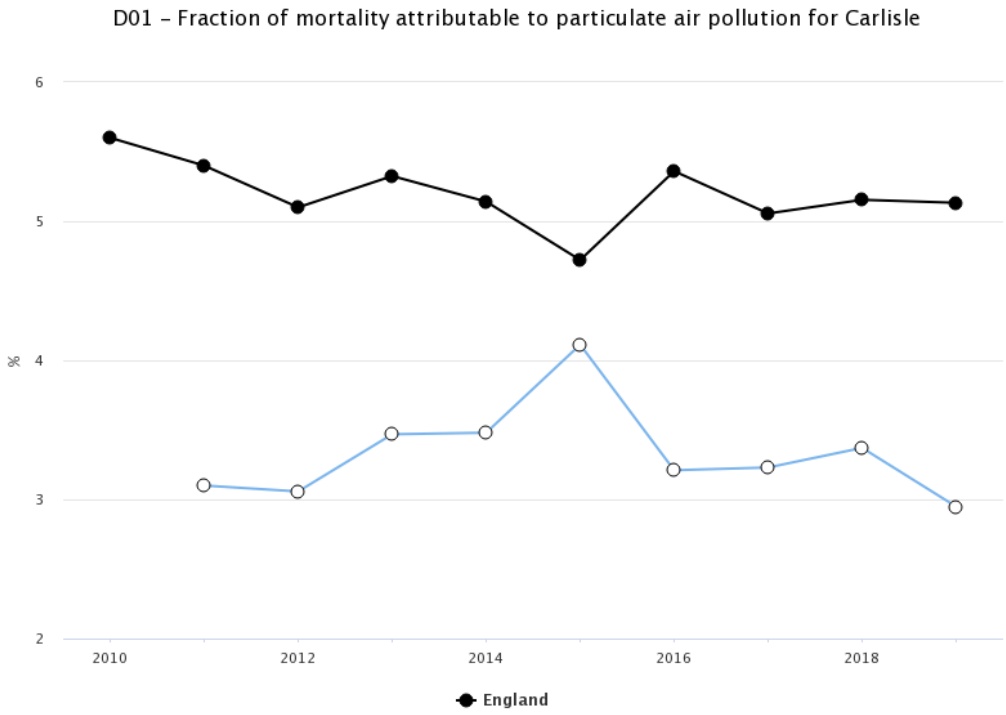
- Carlisle City Council has monitored $PM_{2.5}$ levels at Paddy's Market AQMS since 2009 as part of the AURN. This is a busy city centre junction between two AQMA's. The annual mean concentrations, since 2012, are consistently well below the objective at around 8-12 µg m^3 at this location (see Figure A.4), however ongoing efforts are being made to reduce these levels.
- Carlisle City Council will continue to work in partnership with Cumbria County Council as the highways authority and also in relation to any planning applications with significant air quality implications. The Environmental Health department will continue to work with the City Council Planning Department with regard to new local developments and ensure that air quality implications and mitigation measures are taken into consideration in the planning process.
- We will continue to work alongside the Neighbourhoods and Green Spaces team to investigate and implement the effective use of trees and green areas to offset traffic derived emissions in existing AQMA's and in new development areas.
- The City Council will also continue to provide comprehensive control over emissions from all Part A2 and B Processes located within the local authority area. We will work closely with the operators of these installations to continuously monitor and improve on their emissions to air as part of the permitting process. In line with measures 2, 3, 6, 8, 11 and 12 of the above Action Plan.

Carlisle City Council has four designated smoke control areas. The locations of the smoke control areas within Carlisle are highlighted on our online mapping tool (http://maps.carlisle.gov.uk/MyCarlisle.aspx) or can be downloaded as a map

(http://www.carlisle.gov.uk/LinkClick.aspx?fileticket=9E67HYHexDw%3d&tabid=729&portalid=0&mid=2838).

Work carried out by Public Health England as part of the Public Health Outcomes Framework (PHOF) shows that the mortality associated with particulate air pollution within Carlisle City Council was 2.9% in 2019. This information is available from the following web link: Public Health Outcomes Framework - Data - PHE and displayed in Figure 2-1 against the values calculated for England since 2010 (5.3% in 2019).

Figure 2-1 Fraction of mortality attributed to particulate air pollution in Carlisle City Council from 2010 to 2019



3 Air Quality Monitoring Data and Comparison with Air Quality Objectives and National Compliance

This section sets out the monitoring undertaken within 2020 by Carlisle City Council and how it compares with the relevant air quality objectives. In addition, monitoring results are presented for a five-year period between 2016 and 2020 to allow monitoring trends to be identified and discussed.

Summary of Monitoring Undertaken

3.1.1 Automatic Monitoring Sites

Carlisle City Council undertook automatic (continuous) monitoring at Paddy's Market[13] during 2020. Table A.1 in Appendix A shows the details of the automatic monitoring. NB. Local authorities do not have to report annually on the following pollutants: 1,3 butadiene, benzene, carbon monoxide and lead, unless local circumstances indicate there is a problem. Automatic monitoring results are available through the UK-Air website (https://uk-air.defra.gov.uk/data/data_selector).

Maps showing the location of the monitoring site are provided in Appendix D. Further details on how the monitors are calibrated and how the data has been adjusted are included in Appendix C.

[13] This site also formed part of Defra's compliance monitoring network in which it was known as Carlisle Roadside. The site was closed in June 2021 and relocated to a location approximately 1.6 km westwards along the A595. New site name is Carlisle Morton A595.

3.1.2 Non-Automatic Monitoring Sites

Carlisle City Council undertook non- automatic (i.e. passive) monitoring of NO_2 at twenty eight sites during 2020. Table A.2 in Appendix A presents the details of the non-automatic sites.

A Map showing the location of the monitoring site are provided in Appendix D. Further details on Quality Assurance/Quality Control (QA/QC) for the diffusion tubes, including bias adjustments and any other adjustments applied (e.g. annualisation and/or distance correction), are included in Appendix C.

Individual Pollutants

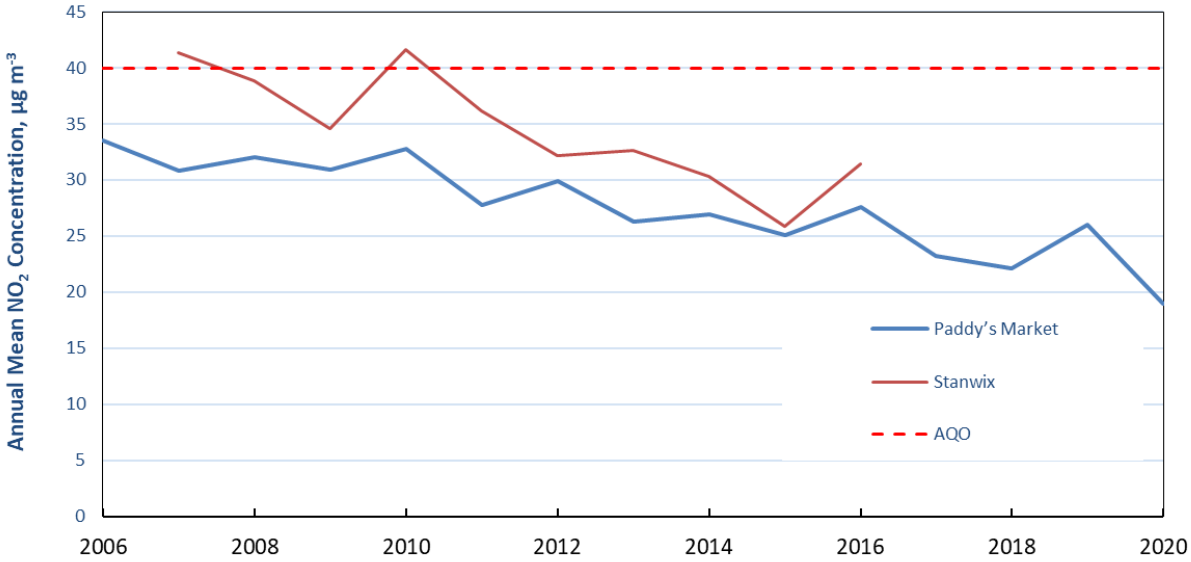
The air quality monitoring results presented in this section are, where relevant, adjusted for bias, annualisation (where the annual mean data capture is below 75% and greater than 25%), and distance correction. Further details on adjustments are provided in Appendix C.

3.1.1 Nitrogen Dioxide (NO_2)

Automatic monitoring of nitrogen dioxide concentrations began in 2006 at Paddy's Market (PM1). Automatic monitoring began at Stanwix Bank in 2007. Figure 3-1 compares the annual mean concentration at both sites with the annual mean objective concentration. Monitored NO_2 concentrations at Paddy's Market and Stanwix Bank automatic monitoring stations have been consistently below the objective concentrations since 2011. Monitoring at the Stanwix Bank site has now ceased.

Table A.3 (automatic monitoring) and Table A.4 (diffusion tubes) in Appendix A present the ratified and adjusted monitored NO_2 annual mean concentrations for the past five years. Note that the concentration data presented represents the concentration at the location of the monitoring site, following the application of bias adjustment and annualisation, as required (i.e. the values are exclusive of any consideration to fall-off with distance adjustment).

Figure 3-1: Automatic monitoring data (2006 – 2020)



The annual mean concentrations are compared with the air quality objective of 40 µg m^{-3} in Figures A.1 to A.5. In each case the NO_2 concentrations are clearly lower in 2020 due to the impact of Covid-19 on ambient concentrations.

Figure A.1 shows the NO_2 concentrations measured by the automatic monitor at Paddy's Market. As discussed previously concentrations at this site are significantly below the air quality objective.

For sites situated along the A7 (see Figure A.2) all sites showed the impact of Covid-19. In absolute terms the largest reduction was at Stanwix Bank (A10) for which there was a reduction of 13.5 µg m^{-3} in 2020 compared to the average of the previous four years.

For sites within AQMA 2 (Currock Street, B7) and AQMA 5 (Dalston Road, B4) NO_2 and in the city centre NO_2 concentrations also decreased significantly (see Figure A.3). Within both AQMA 2 and AQMA 5, the NO_2 concentrations decreased by about 10 µg m^{-3} compared to the previous four year average. The largest percentage decrease with the diffusion tube network (40 %) occurred at the Tourist Information Office. For sites situated along Wigton Road and Bridge Street NO_2 concentrations also decreased significantly (see Figure A.4). The highest concentrations continue to be measured at in AQMA 4 Bridge Street (E8).

The remaining sites situated along London Road (including revoked AQMA 6), along the Carlisle Northern Development Route and at a number of locations to the south of city centre and at the airport also showed significant decrease in concentration (see Figure A.5). However, the absolute decrease is relatively small as all these sites are located in non-urbanised locations. For example, at site G4 on the Carlisle Northern Development Route, the NO_2 concentration in 2020 was 8 µg m^{-3} a decrease of 4.4 µg m^{-3} compared to the average four years.

For diffusion tubes, the full 2020 dataset of monthly mean values is provided in Appendix B. Note that the concentration data presented in Table B.1 includes distance corrected values, only where relevant.

Table A.5 in Appendix A compares the ratified continuous monitored NO_2 hourly mean concentrations for the past five years with the air quality objective of 200µg m-3, not to be exceeded more than 18 times per year. There were no exceedances of the hourly mean concentration in 2020.

Table 3-1 presents the annual mean concentrations measured at monitoring stations within the current AQMAs. Recommendations for retaining, amending or revoking the AQMA's are also presented in Table 3-1. In each case given that 2020 was an abnormal year for air quality, monitoring should continue before decisions on amending or revocation can be made with confidence.

Table 3-1 – Nitrogen dioxide concentrations measured by diffusion tube within each air quality management area

Site ID	Site Name		NO_2 Annual Mean Concentration (µg/m^3)						Recommendation
		AQMA	2015	2016	2017	2018	2019	2020	
A9	AQMA 1 BRAMPTON RD	1	35.9	37.4	35.5	32.4	32.7	23.0	No exceedances of annual objective within AQMA 1 since 2013. Consider revocation if low concentrations remain.
B7	AQMA 2 CURROCK ST	2	36.5	37.7	37.0	35.2	38.1	27.0	While no exceedances measured in last six years, concentrations before 2020 concentrations were sufficiently high to suggest there may be a risk of exceedance in future years ***Keep AQMA***
B4	AQMA 5 DALSTON RD	5	41.0	40.0	39.9	35.8	38.7	28.3	While no exceedances measured in last five years, concentrations before 2020 concentrations were sufficiently high to suggest there may be a risk of exceedance in future years ***Keep AQMA***
E8	AQMA 4 BRIDGE ST	4	41.2	41.5	44.9	40.8	42.7	31.7	Likely to exceed in 2021. ***Keep AQMA***

3.1.2 Particulate Matter (PM_{10})

Table A.6 in Appendix A: Monitoring Results compares the ratified and adjusted monitored PM_{10} annual mean concentrations for the past five years with the air quality objective of 40 µg m^{-3}. Table A.7 in Appendix A compares the ratified continuous monitored PM_{10} daily mean concentrations for the past five years with the air quality objective of 50 µg m^{-3}, not to be exceeded more than 35 times per year.

The PM_{10} annual mean concentration monitored by the Paddy's market automatic analyser was 16.4 µg m^{-3} in 2020 and hence significantly below the annual mean AQO of 40 µg m^{-3}. There were also no exceedances of the short-term AQOs. The five year trend is for both air quality objectives are shown in Figure A.6 and Figure A.7, respectively.

3.1.3 Particulate Matter ($PM_{2.5}$)

Table A.8 in Appendix A presents the ratified and adjusted monitored $PM_{2.5}$ annual mean concentrations for the past five years.

$PM_{2.5}$ is the pollutant which has the biggest impact on public health and on which the Public Health Outcomes Framework (PHOF) indicator is based. Therefore, although not covered by the LAQM regulations local authorities are encouraged to understand the $PM_{2.5}$ concentration within their council area.

The annual mean was 8.4 µg m^{-3} which is lower than the World Health Organisation guideline of 10 µg m^{-3}. Elsewhere, the background $PM_{2.5}$ maps[14] for Carlisle City Council for 2020 showed no guideline concentration in 2020.

In Defra's appraisal of the 2020 ASR it was noted that there had been increases in the annual mean concentrations of PM_{10} and $PM_{2.5}$, by 2.4 µg m^{-3} and 2.2 µg m^{-3}, respectively, at Paddy's Market in 2019 compared to 2018. While the PM_{10} and $PM_{2.5}$ concentrations in 2020 have returned to concentrations similar to those measured in 2018, we have investigated reasons why the concentrations may have increased and attributed these to unique meteorological conditions that lead to particulate pollution events. More details are provided in Appendix G.

[14] https://uk-air.defra.gov.uk/data/laqm-background-home

Appendix A: Monitoring Results

Table A.1 – Details of Automatic Monitoring Sites

Site ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Monitoring Technique	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Inlet Height (m)
PM1	Paddy's Market	Roadside	339467	555974	NO_2	NO	Chemiluminescence	42	4	3
PM1	Paddy's Market	Roadside	339467	555974	PM_{10}	NO	BAM 1020 heated[15]	42	4	3
PM1	Paddy's Market	Roadside	339467	555974	$PM_{2.5}$	NO	BAM 1020 heated	42	4	3

Notes:

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on the façade of a residential property).

(2) N/A if not applicable

[15] Note the instrument to measure PM_{10} and $PM_{2.5}$ in the 2020 ASR was wrongly described as a FIDAS it should have been a BAM 1020 heated instrument. This instrument replaced the TEOM FDMS on 20th November 2018.

Table A.2 – Details of Non-Automatic Monitoring Sites

Diffusion Tube ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube Co-located with a Continuous Analyser?	Tube Height (m)
A1	45 SCOTLAND RD	Roadside	339995	557188	NO_2	NO	4.5	1.5	NO	3.05
A10	STANWIX BANK	Roadside	340008	556842	NO_2	NO	1.5	1.5	NO	2.95
A12	STANWIX BANK CAR PARK	Roadside	339935	557125	NO_2	NO	0.0	3.0	NO	2.8
A5	37 KINGSTOWN RD	Roadside	339758	558059	NO_2	NO	0.0	4.0	NO	2.8
A7	282 KINGSTOWN RD	Roadside	339526	559285	NO_2	NO	7.5	4.0	NO	2.7
A9	BRAMPTON RD	Roadside	340028	556833	NO_2	Yes, AQMA 1	0.0	1.5	NO	2.75
B4	DALSTON RD	Roadside	339434	555638	NO_2	Yes, AQMA 5	0.0	3.5	NO	2.8
B7	12 CURROCK ST	Roadside	340205	555198	NO_2	Yes, AQMA 2	0.0	3.0	NO	3.05
C1	LOWTHER ST	Roadside	340216	556131	NO_2	NO	0.0	3.0	NO	2.85
C2	TOURIST INFO	Urban Centre	340069	555955	NO_2	NO	N/A	N/A	NO	2.7
C3	DEVONSHIRE ST	Roadside	340218	555768	NO_2	NO	0.0	3.0	NO	2.85
D12	POST OFFICE	Kerbside	340307	555718	NO_2	NO	N/A	5.0	NO	2.95
D7	282 WARWICK RD	Roadside	341593	555893	NO_2	NO	0.0	7.0	NO	2.8
E22	FINKLE ST	Roadside	339834	556137	NO_2	NO	0.0	12.0	NO	2.8
E12	3 WIGTON RD	Roadside	339225	555821	NO_2	NO	2.0	2.5	NO	2.95
E15	22 WIGTON RD	Roadside	339091	555736	NO_2	NO	0.0	4.5	NO	3.9
E16	JOVIAL SAILOR	Roadside	339141	555900	NO_2	NO	0.0	2.5	NO	2.7
E19	49 WIGTON RD	Roadside	338953	555610	NO_2	NO	0.0	2.5	NO	3.1
E6A, E6B, E6C	PADDYS MARKET	Roadside	339467	555974	NO_2	NO	N/A	9.0	Yes	3
E8	BRIDGE ST	Roadside	339516	556024	NO_2	Yes, AQMA 4	0.0	4.0	NO	3.05

Diffusion Tube ID	Site Name	Site Type	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Pollutants Monitored	In AQMA? Which AQMA?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube Co-located with a Continuous Analyser?	Tube Height (m)
F10	155 BOTCHERGATE	Roadside	340600	555349	NO_2	NO	0.0	3.0	NO	2.7
F7	24 LONDON RD	Roadside	340708	555240	NO_2	NO	0.0	4.5	NO	2.7
F9	129 LONDON RD	Kerbside	341099	554931	NO_2	NO	0.0	0.5	NO	2.95
G4	THE HOBBIT	Rural	336905	554036	NO_2	NO	0.0	19.0	NO	2.85
H5	WIGTON RD	Roadside	337643	554100	NO_2	NO	0.0	1.5	NO	2.4
H6	PETER LANE	Roadside	337962	553220	NO_2	NO	0.0	4.0	NO	2.4
H7	DALSTON RD	Roadside	338282	553396	NO_2	NO	0.0	6.5	NO	2.4
H8	AIRPORT	Other	347874	561254	NO_2	NO	0.0	2.0	NO	2.4

Notes:

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on the façade of a residential property).

(2) N/A if not applicable.

Table A.3 – Annual Mean NO_2 Monitoring Results: Automatic Monitoring (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
PM1	339467	555974	Roadside	99	99	27.6	23.3	22.1	26.0	19.0

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

☒ **Reported concentrations are those at the location of the monitoring site (annualised, as required), i.e. prior to any fall-off with distance correction.**

Notes:

The annual mean concentrations are presented as µg m^{-3}.

Exceedances of the NO_2 annual mean objective of 40 µg m^{-3} are shown in **bold**.

All means have been "annualised" as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Concentrations are those at the location of monitoring and not those following any fall-off with distance adjustment.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Table A.4 – Annual Mean NO_2 Monitoring Results: Non-Automatic Monitoring (µg m^{-3})

Diffusion Tube ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
A1	339995	557188	Roadside	100	100	33.7	31.7	30.1	31.7	23.3
A10	340008	556842	Roadside	100	100	**42.6**	36.4	37.6	36.7	24.9
A12	339935	557125	Roadside	100	100	18.7	28.6	28.2	28.7	20.8
A5	339758	558059	Roadside	100	100	32.1	32.5	29.2	31.5	21.4
A7	339526	559285	Roadside	100	100	24.9	23.4	21.2	20.7	14.1
A9	340028	556833	Roadside	100	100	37.4	35.5	32.4	32.7	23.0
B4	339434	555638	Roadside	100	100	**40**	39.9	35.8	38.7	28.3
B7	340205	555198	Roadside	100	100	37.7	37	35.2	38.1	27.0
C1	340216	556131	Roadside	100	100	27.9	27.2	27.4	27.6	19.7
C2	340069	555955	Urban Centre	100	100	18.7	19.3	20.2	17.8	11.5
C3	340218	555768	Roadside	100	100	29.5	25.5	24.4	27.5	18.6
D12	340307	555718	Kerbside	100	100	36.8	34.4	30.4	32.7	20.4
D7	341593	555893	Roadside	100	100	30.8	32.1	28	28.3	20.8
E22	339834	556137	Roadside	100	100	31.5	30.5	29.1	31.4	22.0
E12	339225	555821	Roadside	100	100	35.7	33.5	31.9	33.9	24.6
E15	339091	555736	Roadside	100	100	32	30.2	28.4	29.2	21.4
E16	339141	555900	Roadside	100	100	32.7	31.4	31.7	32	22.6
E19	338953	555610	Roadside	100	100	34.8	31.5	30.6	31.2	22.2
E6A, E6B, E6C	339467	555974	Roadside	100	100	29.0	27.4	28.3	26.4	21.1
E8	339516	556024	Roadside	100	100	**41.5**	**44.9**	**40.8**	**42.7**	31.7
F10	340600	555349	Roadside	100	100	35.8	36.3	35.3	34.4	25.4
F7	340708	555240	Roadside	100	100	34.1	33.8	32.2	35.4	24.7
F9	341099	554931	Kerbside	92.3	92.3	32.4	30.4	30.3	31.4	23.6

Diffusion Tube ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
G4	336905	554036	Rural	100	100	13	12	12.6	12.1	8.0
H5	337643	554100	Roadside	100	100	16.1	16.6	15.7	14.1	10.4
H6	337962	553220	Roadside	100	100	12	9.4	11.4	10.1	8.4
H7	338282	553396	Roadside	100	100	17	15.1	18.7	15.1	11.6
H8	347874	561254	Other	100	100	8	7.5	8.2	6.9	4.8

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

☒ **Diffusion tube data has been bias adjusted.**

☒ **Reported concentrations are those at the location of the monitoring site (bias adjusted and annualised, as required), i.e. prior to any fall-off with distance correction.**

Notes:

The annual mean concentrations are presented as µg m^3.

Exceedances of the NO_2 annual mean objective of 40 µg m^{-3} are shown in **bold**.

NO_2 annual means exceeding 60 µg m^{-3}, indicating a potential exceedance of the NO_2 1-hour mean objective are shown in **bold and underlined**.

Means for diffusion tubes have been corrected for bias. All means have been "annualised" as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Concentrations are those at the location of monitoring and not those following any fall-off with distance adjustment.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.1 – Trends in Annual Mean NO_2 Concentrations: Automatic monitoring at Paddy's Market

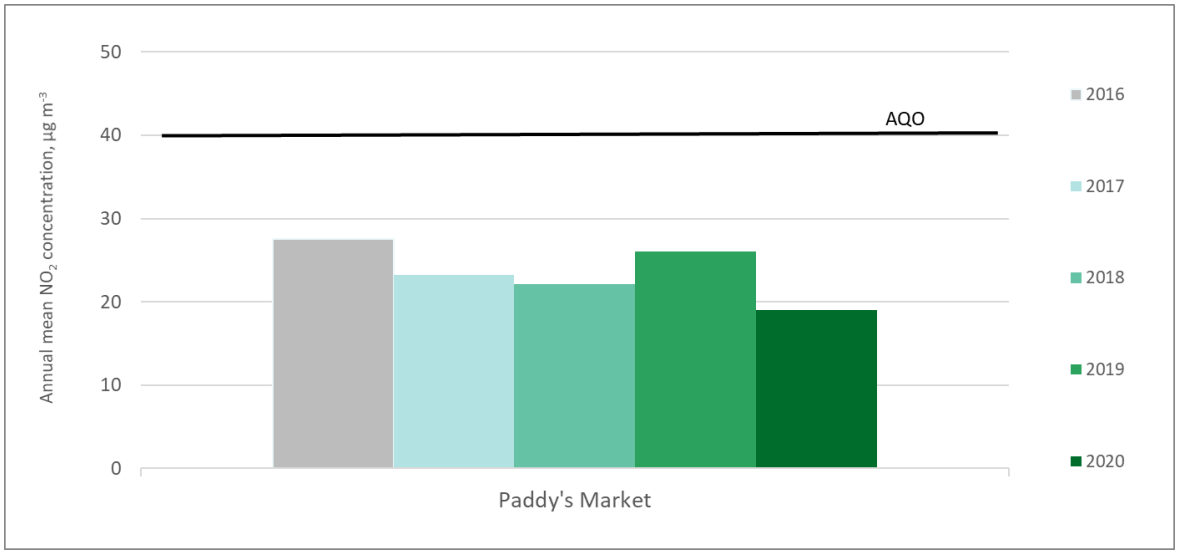


Figure A.2 – Trends in annual mean NO_2: along A7

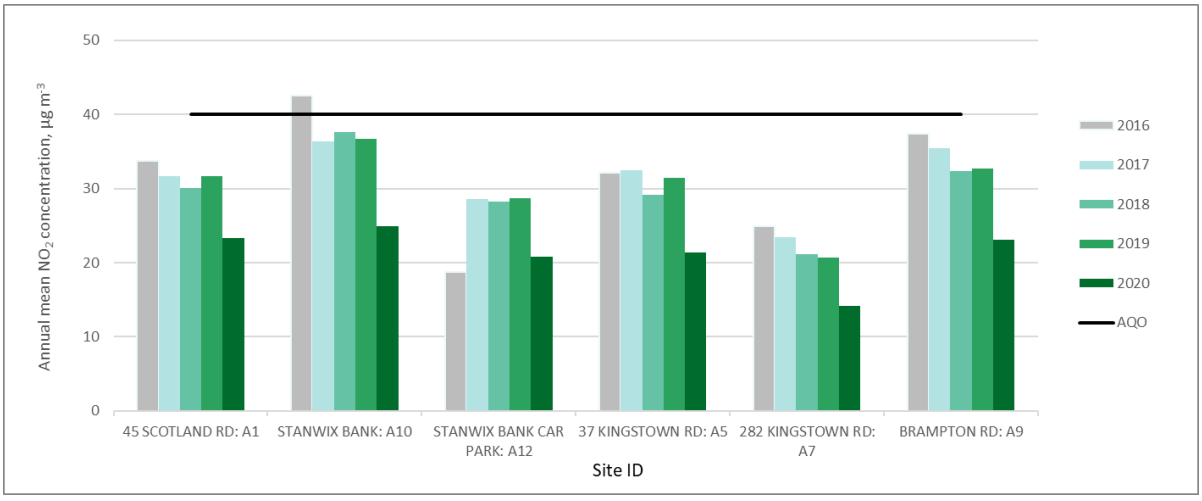


Figure A.3 – Trends in annual mean NO_2: for sites in city centre and within AQMA 2 and AQMA 5

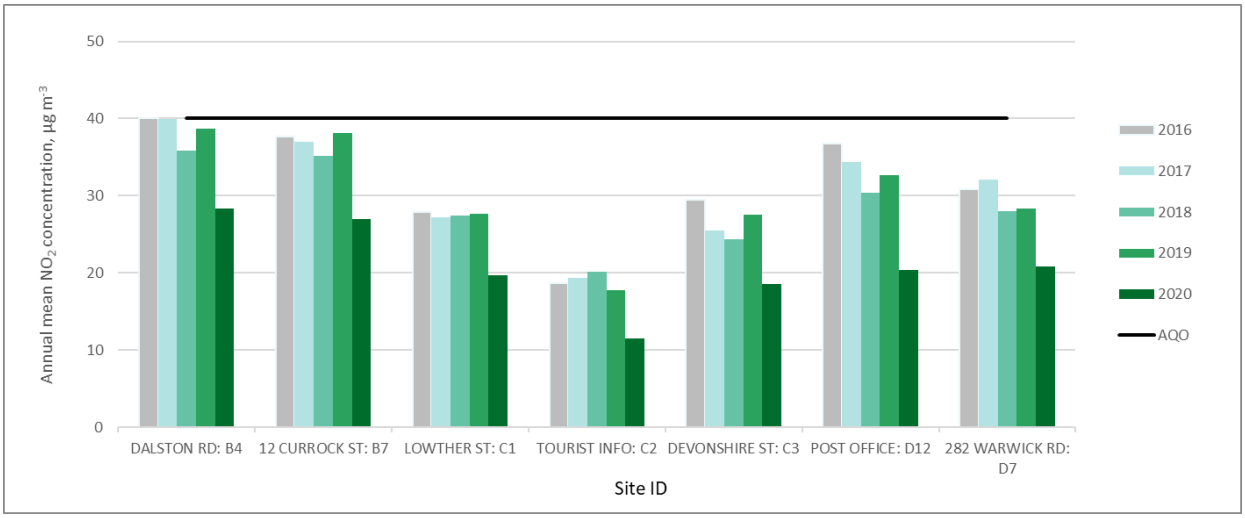


Figure A.4 – Trends in annual mean NO_2: along Wigton Road and Bridge Street

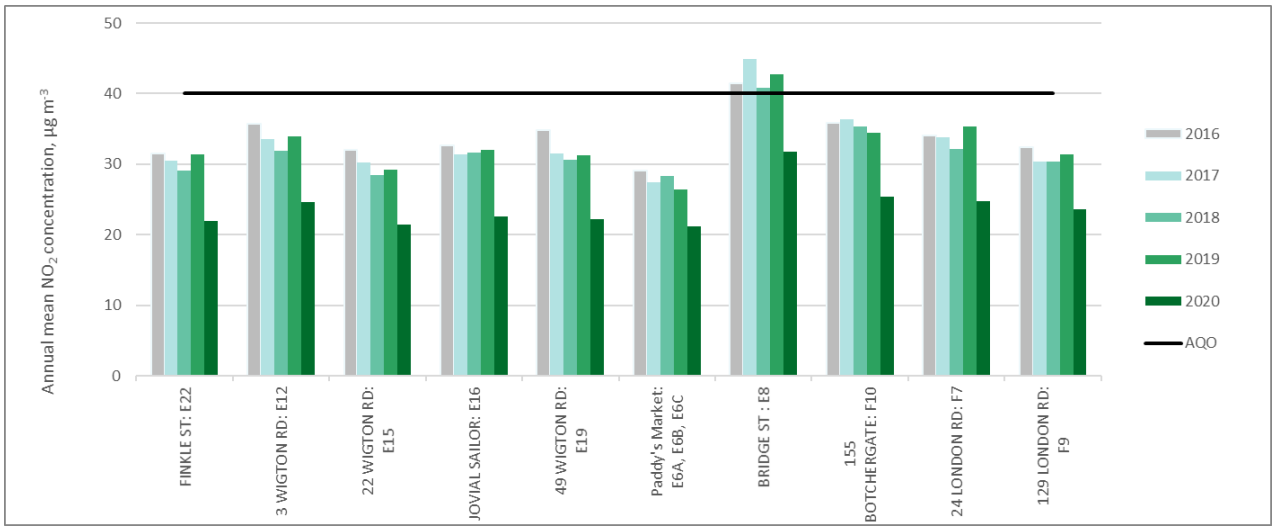


Figure A.5 – Trends in annual mean NO_2: at London Road, Carlisle Northern Development Route and various other locations

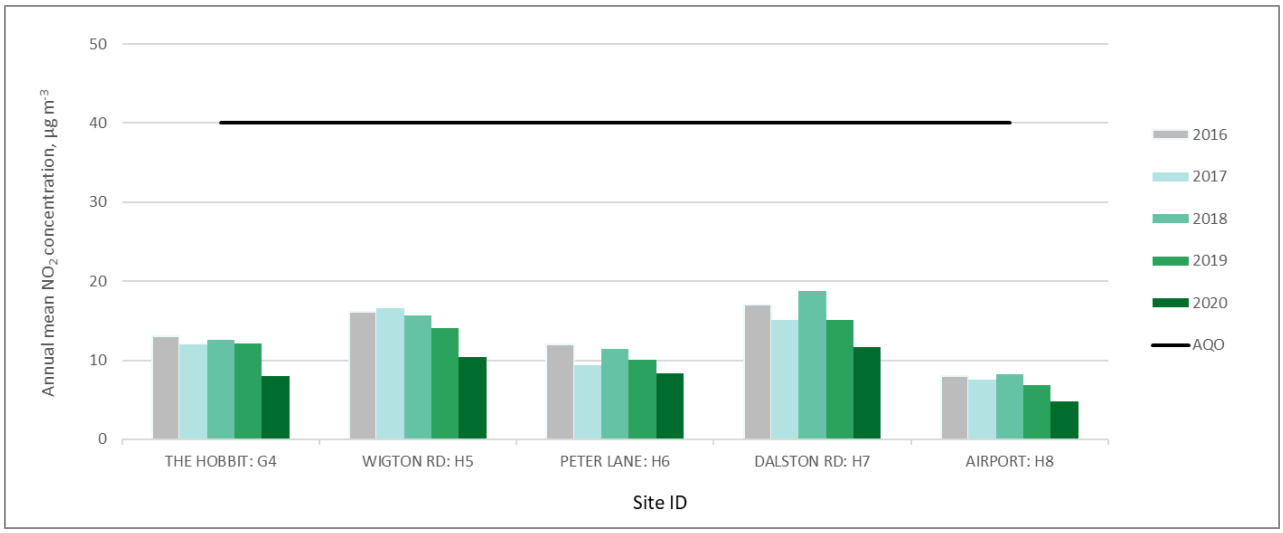


Table A.5 – 1-Hour Mean NO_2 Monitoring Results, Number of 1-Hour Means > 200 µg m^{-3}

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
PM1	339467	555974	Roadside	99	99	0	0	0	0	0

Notes:

Results are presented as the number of 1-hour periods where concentrations greater than 200 µg m^{-3} have been recorded.

Exceedances of the NO_2 1-hour mean objective (200 µg m^{-3} not to be exceeded more than 18 times/year) are shown in **bold**.

If the period of valid data is less than 85%, the 99.8th percentile of 1-hour means is provided in brackets.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Table A.6 – Annual Mean PM_{10} Monitoring Results (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
PM1	339467	555974	Roadside	93.3	93.3	13.6	14.6	16.2	18.6	16.4

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

Notes:

The annual mean concentrations are presented as µg m^{-3}.

Exceedances of the PM_{10} annual mean objective of 40 µg m^{-3} are shown in **bold**.

All means have been "annualised" as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.6 – Trends in Annual Mean PM_{10} Concentrations

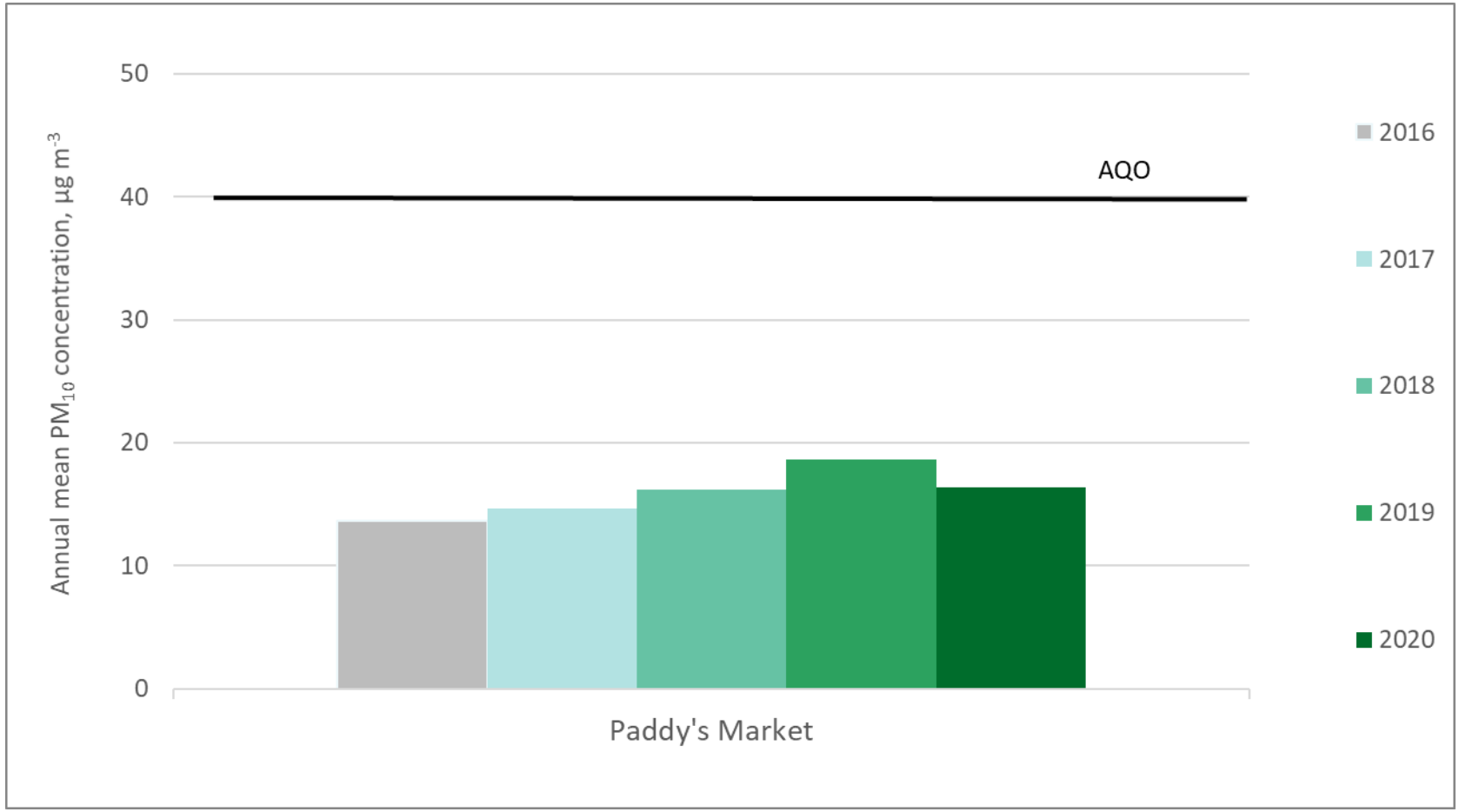


Table A.7 – 24-Hour Mean PM_{10} Monitoring Results, Number of PM_{10} 24-Hour Means > 50 µg m^{-3}

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
PM1	339467	555974	Roadside	92.9	92.9	0	1	0	5	0

Notes:

Results are presented as the number of 24-hour periods where daily mean concentrations greater than 50 µg m^{-3} have been recorded.

Exceedances of the PM_{10} 24-hour mean objective (50 µg m^{-3} not to be exceeded more than 35 times/year) are shown in **bold**.

If the period of valid data is less than 85%, the 90.4th percentile of 24-hour means is provided in brackets.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.7 – Trends in Number of 24-Hour Mean PM_{10} Results > 50 µg m^{-3}

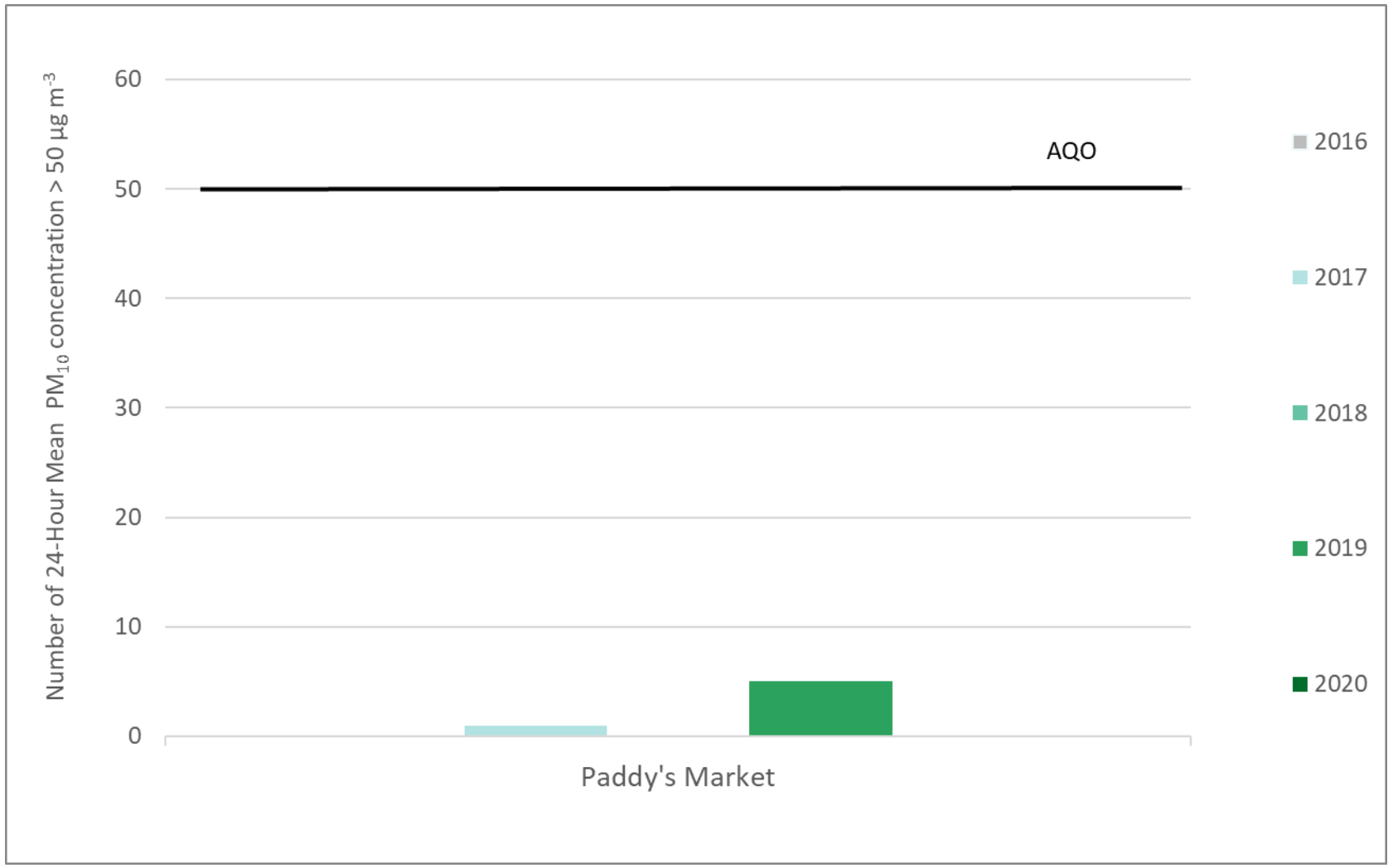


Table A.8 – Annual Mean $PM_{2.5}$ Monitoring Results (µg m^{-3})

Site ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Northing)	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2020 (%) (2)	2016	2017	2018	2019	2020
PM1	339467	555974	Roadside	96.8	96.8	9.9	8.58	8.6	10.8	8.4

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16**

Notes:

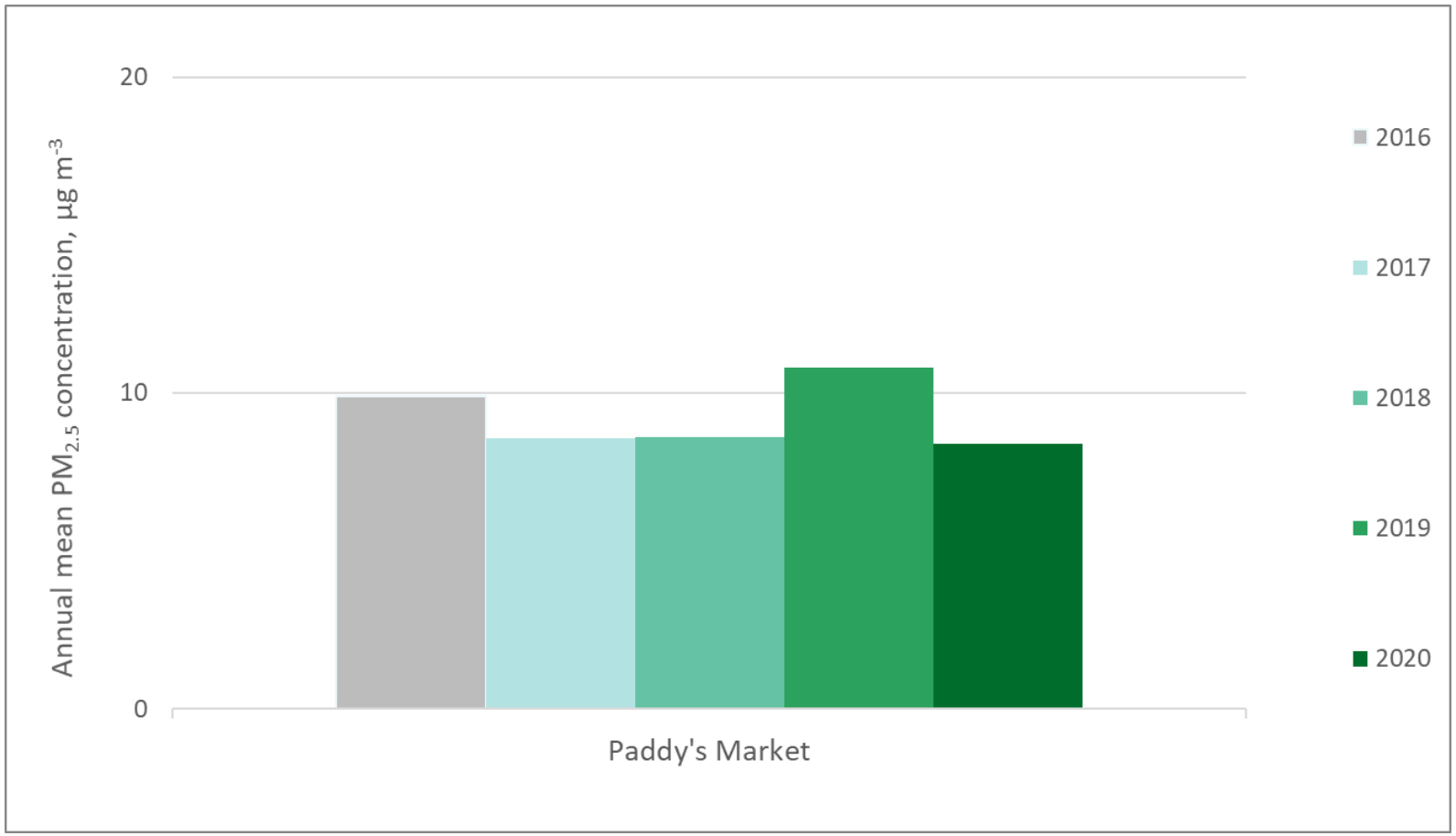
The annual mean concentrations are presented as µg m^{-3}.

All means have been “annualised” as per LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

Figure A.8 – Trends in Annual Mean $PM_{2.5}$ Concentrations



Appendix B: Full Monthly Diffusion Tube Results for 2020

Table B.1 – NO_2 2020 Diffusion Tube Results (µg m^{-3})

DT ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Easting)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean: Raw Data	Annual Mean: Annualised and Bias Adjusted 0.81	Annual Mean: Distance Corrected to Nearest Exposure	Comment
A1	339995	557188	44.2	37.8	27.2	14.1	20.9	19.2	23.9	20.6	28.3	32.8	36.8	39.0	28.7	23.3	-	
A10	340008	556842	35.0	27.7	25.9	21.1	23.2	30.2	21.3	36.9	36.4	33.0	37.7	40.9	30.7	24.9	-	
A12	339935	557125	29.5	26.1	24.7	13.7	18.0	22.5	19.3	26.9	28.7	29.6	31.5	37.1	25.6	20.8	-	
A5	339758	558059	37.6	32.8	25.5	13.3	18.8	18.8	22.5	21.3	28.2	30.9	32.1	35.1	26.4	21.4	-	
A7	339526	559285	26.1	21.3	17.4	7.7	10.5	12.3	14.8	13.1	17.9	20.8	21.9	25.6	17.5	14.1	-	
A9	340028	556833	32.0	34.5	26.0	14.7	24.5	24.5	26.1	27.6	34.7	35.1	28.0	33.9	28.5	23.0	-	
B4	339434	555638	48.1	39.0	33.7	20.5	29.2	25.6	34.4	30.0	36.6	37.7	41.7	43.3	35.0	28.3	-	
B7	340205	555198	44.8	42.4	33.5	18.5	25.3	25.1	25.8	21.7	36.0	38.2	41.8	46.4	33.3	27.0	-	
C1	340216	556131	30.4	31.3	23.2	14.6	14.7	19.8	19.0	23.8	26.2	26.2	29.2	32.8	24.3	19.7	-	
C2	340069	555955	17.9	17.9	14.1	9.0	7.6	8.3	8.4	12.2	15.0	13.5	20.5	25.3	14.1	11.5	-	
C3	340218	555768	26.1	24.5	21.2	14.7	16.7	19.3	18.4	25.6	27.2	23.5	27.5	30.2	22.9	18.6	-	
D12	340307	555718	39.9	36.1	25.9	13.1	14.6	1.6	22.6	20.8	29.8	29.7	31.5	36.5	25.2	20.4	-	
D7	341593	555893	31.4	33.3	24.7	13.7	21.9	20.9	22.0	21.6	27.4	28.2	31.7	31.9	25.7	20.8	-	
E22	339834	556137	35.3	33.0	24.1	15.9	18.9	20.5	23.4	23.6	29.4	30.9	34.1	36.1	27.1	22.0	-	
E12	339225	555821	32.2	34.1	29.2	20.7	24.3	27.2	26.5	29.4	34.0	31.9	36.9	37.8	30.3	24.6	-	
E15	339091	555736	32.8	30.7	25.6	17.5	22.0	21.1	21.7	21.8	29.9	28.2	32.1	34.2	26.5	21.4	-	
E16	339141	555900	28.4	29.2	24.8	24.1	25.0	26.8	20.8	35.5	27.3	28.2	34.5	29.8	27.9	22.6	-	
E19	338953	555610	26.6	29.9	29.1	20.0	22.5	25.7	21.0	28.6	28.4	26.4	37.3	33.7	27.4	22.2	-	
E6A	339467	555974	28.1	27.1	25.4	17.5	20.8	22.3	20.5	26.2	28.8	26.1	27.2	30.6	-	-	-	Triplicate Site with E6A, E6B and E6C - Annual data provided for E6C only
E6B	339467	555974	28.0	27.2	24.1	18.0	19.5	22.7	19.9	26.4	31.0	29.5	28.7	36.8	-	-	-	Triplicate Site with E6A, E6B and E6C - Annual data provided for E6C only
E6C	339467	555974	26.6	27.4	23.7	18.8	21.5	22.6	20.8	25.9	33.4	33.5	28.5	44.7	26.1	21.1	-	Triplicate Site with E6A, E6B and E6C - Annual data provided for E6C only
E8	339516	556024	44.8	41.7	38.7	29.2	39.3	36.1	30.8	40.9	42.7	39.2	43.0	43.4	39.1	31.7	-	
F10	340600	555349	33.5	38.2	29.4	20.3	24.3	29.9	24.4	34.1	34.7	32.8	36.9	38.4	31.4	25.4	-	
F7	340708	555240	33.8	32.0	29.5	19.6	26.1	24.4	27.8	27.7	31.7	36.4	37.7	39.2	30.5	24.7	-	
F9	341099	554931		28.4	29.3	21.7	23.6	28.2	22.5	30.4	32.4	31.8	35.2	37.5	29.2	23.6	-	

DT ID	X OS Grid Ref (Easting)	Y OS Grid Ref (Easting)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean: Raw Data	Annual Mean: Annualised and Bias Adjusted 0.81	Annual Mean: Distance Corrected to Nearest Exposure	Comment
G4	336905	554036	10.8	10.8	9.6	5.7	7.1	7.3	7.4	8.2	10.4	11.6	14.7	15.0	9.9	8.0	-	
H5	337643	554100	18.2	15.7	15.1	7.1	8.4	7.4	8.5	9.2	11.1	14.3	17.2	22.1	12.9	10.4	-	
H6	337962	553220	6.5	6.1	9.4	7.0	6.8	8.4	29.9	8.6	10.0	8.3	10.5	12.3	10.3	8.4	-	
H7	338282	553396	14.9	14.2	14.1	9.6	9.7	11.8	10.4	14.7	15.1	16.5	20.3	20.8	14.3	11.6	-	
H8	347874	561254	7.9	6.9	5.0	3.9	3.7	4.1	4.4	4.8	6.1	5.5	9.9	8.4	5.9	4.8	-	

☒ **All erroneous data has been removed from the NO_2 diffusion tube dataset presented in Table B.1**

☒ **Annualisation has been conducted where data capture is <75% and >25% in line with LAQM.TG16.**

☐ **Local bias adjustment factor used.**

☒ **National bias adjustment factor used.**

☒ **Where applicable, data has been distance corrected for relevant exposure in the final column.**

☒ **Carlisle confirm that all 2020 diffusion tube data has been uploaded to the Diffusion Tube Data Entry System (confirm by selecting in box).**

Notes:

Exceedances of the NO_2 annual mean objective of 40 µg m^{-3} are shown in **bold**.

NO_2 annual means exceeding 60 µg m^{-3}, indicating a potential exceedance of the NO_2 1-hour mean objective are shown in **bold and underlined**.

See Appendix C for details on bias adjustment and annualisation.

Appendix C: Supporting Technical Information / Air Quality Monitoring Data QA/QC

New or Changed Sources Identified Within Carlisle City Council During 2020

Carlisle City Council has not identified any new sources relating to air quality within the reporting year of 2020.

Additional Air Quality Works Undertaken by Carlisle City Council During 2020

Carlisle City Council has not completed any additional works within the reporting year of 2020. The revised Action Plan is in Draft form and is currently going through the councils approval process.

QA/QC of Diffusion Tube Monitoring

This section provides detail relating to the following aspects of non-automatic monitoring using diffusion tubes:

Diffusion Tube Supplier

Carlisle City Council diffusion tubes are supplied and analysed by Gradko International using 20% TEA in water.

Gradko participate in the AIR-PT analysis scheme[16]. This is an independent analytical proficiency-testing scheme, operated by LGC Standards and supported by the Health and Safety Laboratory (HSL). Defra and the Devolved Administrations advise that diffusion

16 https://laqm.defra.gov.uk/documents/LAQM%20NO2%20Performance%20data_Up%20to%20March%202021_v2.pdf

tubes used for LAQM should be obtained from laboratories that have demonstrated satisfactory performance in the AIR NO_2 PT scheme. For those reporting periods in 2020 for which Gradko reported results, 75 % of the results were considered satisfactory (based on z-scores less than or equal to 2). The laboratory performance for Gradko is summarised below:

AIR PT Round	AIR PT AR036	AIR PT AR037	AIR PT AR039	AIR PT AR040
Round conducted in the period	January – February 2020	May – June 2020	July - August 2020	September – October 2020
Gradko International	75 %	No results reported		75 %

Diffusion Tube Calendar

The diffusion tube calendar used by Carlisle City Council is provided below. This did not deviate significantly from the 2020 Diffusion Tube Monitoring Calendar

Month	Tube On	Tube Off
Jan	08/01/2020	05/02/2020
Feb	05/02/2020	04/03/2020
Mar	04/03/2020	01/04/2020
Apr	01/04/2020	05/05/2020
May	05/05/2020	03/06/2020
Jun	03/06/2020	02/07/2020
Jul	02/07/2020	05/08/2020
Aug	05/08/2020	02/09/2020
Sep	02/09/2020	30/09/2020
Oct	30/09/2020	05/11/2020
Nov	05/11/2020	03/12/2020
Dec	03/12/2020	06/01/2021

Diffusion Tube Annualisation

All diffusion tube monitoring locations within Carlisle City Council recorded data capture of 75% therefore it was not required to annualise any monitoring data. In addition, any sites with a data capture below 25% do not require annualisation.

Diffusion Tube Bias Adjustment Factors

The diffusion tube data presented within the 2020 ASR have been corrected for bias using an adjustment factor. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser. LAQM.TG16 provides guidance with regard to the application of a bias adjustment factor to correct diffusion tube

monitoring. Triplicate co-location studies can be used to determine a local bias factor based on the comparison of diffusion tube results with data taken from NO_x/NO_2 continuous analysers. Alternatively, the national database of diffusion tube co-location surveys provides bias factors for the relevant laboratory and preparation method.

Carlisle City Council have applied a national bias adjustment factor of 0.81 to the 2020 monitoring data. A summary of bias adjustment factors used by Carlisle City Council over the past five years is presented in Table C.1.

Table C.1 – Bias Adjustment Factor

Year	Local or National	If National, Version of National Spreadsheet	Adjustment Factor
2020	National	06/21	0.81
2019	National	03/20	0.93
2018	National	03/19	0.93
2017	National	03/18	0.89
2016	National	03/17	0.94

Local Bias Adjustment

A local bias adjustment factor of 0.74 was derived by the collocation of the triplicate tubes and the automatic analyser at Paddy's Market. The bias adjustment was carried out using the NO_2 data processing tool[17] and the summary statistics are provided in Table C.2.

Table C.2 – Local Bias Adjustment Summary

	Local Bias Adjustment
Periods used to calculate bias	12
Bias Factor A	0.74 (0.7 - 0.78)
Bias Factor B	35% (28% - 43%)
Diffusion Tube Mean (µg m^{-3})	26.1
Mean CV (Precision)	5.1%
Automatic Mean (µg m^{-3})	19.3
Data Capture	99%
Adjusted Tube Mean (µg m^{-3})	19 (18 - 20)
Overall Diffusion Tube Precision	Good Overall Precision

[17] Diffusion tube data processing tool laqm (defra.gov.uk)

	Local Bias Adjustment
Overall Continuous Monitor Data Capture	Good Overall Data Capture
Local Bias Adjustment Factor	0.74

National Bias Adjustment

The national database of diffusion tube co-location surveys provides bias factors for the relevant laboratory and preparation method. A bias adjustment of 0.81 for the year 2020 (based on 27 studies) has been derived from the national bias adjustment spreadsheet (v06_21). A screenshot of the spreadsheet for Gradko is shown in Figure C.1.

Figure C.1 – National bias adjustment spreadsheet

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/21

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadsheet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated at the end of Sept 2021
LAQM Helpdesk Website

The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.

Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.

Step 1:	Step 2:	Step 3:	Step 4:
Select the Laboratory that Analyses Your Tubes from the Drop-Down List	Select a Preparation Method from the Drop-Down List	Select a Year from the Drop-Down List	Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.
If a laboratory is not shown, we have no data for this laboratory.	If a preparation method is not shown, we have no data for this method at this laboratory.	If a year is not shown, we have no data[2]	If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@bureauveritas.com or 0800 0327953

Analysed By[1]	Method	Year[2]	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Monitor Mean Conc. (Cm) (µg/m³)	Bias (B)	Tube Precision[5]	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in water	2020	R	Gedling Borough Council	10	31	25	24.1%	G	**0.81**
Gradko	20% TEA in water	2020	R	SOUTHAMPTON CITY COUNCIL	12	37	27	37.1%	G	**0.73**
Gradko	20% TEA in water	2020	R	Fareham Borough Council	10	25	14	77.4%	G	**0.56**
Gradko	20% TEA in water	2020	R	Fareham Borough Council	12	30	22	35.1%	G	**0.74**
Gradko	20% TEA in water	2020	R	Fareham Borough Council	10	22	17	26.5%	G	**0.79**
Gradko	20% TEA in water	2020	R	SOUTHAMPTON CITY COUNCIL	11	32	31	4.9%	G	**0.95**
Gradko	20% TEA in water	2020	KS	Marylebone Road Intercomparison	12	57	43	33.3%	G	**0.75**
Gradko	20% TEA in water	2020	R	Bath & North East Somerset	11	32	29	13.0%	G	**0.89**
Gradko	20% TEA in water	2020	R	Gateshead Council	12	22	17	28.1%	G	**0.78**
Gradko	20% TEA in water	2020	R	Gateshead Council	12	23	21	11.6%	G	**0.90**
Gradko	20% TEA in water	2020	R	Gateshead Council	10	26	25	6.5%	G	**0.94**
Gradko	20% TEA in water	2020	R	Gateshead Council	12	28	21	30.5%	G	**0.77**
Gradko	20% TEA in water	2020	R	Gateshead Council	12	31	32	-3.4%	G	**1.03**
Gradko	20% TEA in water	2020	R	Luton Borough Council	9	38	28	33.8%	G	**0.75**
Gradko	20% TEA in water	2020	R	Nottingham City Council	12	31	34	-8.5%	G	**1.09**
Gradko	20% TEA in water	2020	R	Dudley MBC	13	33	28	19.9%	G	**0.83**
Gradko	20% TEA in water	2020	UB	Dudley MBC	13	23	14	61.2%	G	**0.62**
Gradko	20% TEA in water	2020	R	Dudley MBC	13	44	34	30.6%	G	**0.77**
Gradko	20% TEA in water	2020	R	Ards and North Down Borough Council	10	27	20	34.0%	G	**0.75**
Gradko	20% TEA in water	2020	R	Belfast City Council	10	26	21	22.8%	G	**0.81**
Gradko	20% TEA in water	2020	R	Belfast City Council	10	41	36	12.6%	G	**0.89**
Gradko	20% TEA in water	2020	R	Belfast City Council	10	36	25	43.9%	G	**0.69**
Gradko	20% TEA in water	2020	R	Lancaster City Council	11	27	23	19.9%	G	**0.83**
Gradko	20% TEA in water	2020	R	Lancaster City Council	10	32	28	13.0%	G	**0.89**
Gradko	20% TEA in water	2020	R	Eastleigh Borough Council	9	23	20	13.6%	G	**0.88**
Gradko	20% TEA in water	2020	UB	Eastleigh Borough Council	9	22	19	17.9%	G	**0.85**
Gradko	20% TEA in water	2020	R	Lisburn & Castlereagh City Council	10	23	18	32.5%	G	**0.75**
Gradko	20% TEA in water	2020		**Overall Factor[3] (27 studies)**				**Use**		**0.81**

Selection of Appropriate Bias Adjustment Factor

NO_2 diffusion tubes should be corrected for bias. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser.

For the purpose of adjusting the 2020 diffusion tubes results, both local and the national bias adjustment factors, 0.74 (Paddy's Market) and 0.81 (National), were compared. Data capture for both the automatic monitors was above 85 %, the recommended minimum value to derive a local bias adjustment factor (Box 7.10 of the LAQM.TG(16)). For consistency with previous ASRs we will use the national factor of 0.81 to bias adjust the diffusion tube data.

NO_2 Fall-off with Distance from the Road

Wherever possible, local authorities should ensure that monitoring locations are representative of exposure. However, where this is not possible, the NO_2 concentration at

the nearest location relevant for exposure should be estimated using the Diffusion Tube Data Processing Tool. As there were no sites where the annual mean concentration was greater than 36 µg m^{-3}, no diffusion tube NO_2 monitoring locations within Carlisle City Council required distance correction during 2020.

QA/QC of Automatic Monitoring

Ricardo provides data management and local site operator (LSO) duties for the automatic monitoring sites within Carlisle City Council. The instrumentation is calibrated every two weeks and a full site service is carried out every six months. The calibration certificates are provided in in the following six pages. The QA/QC is accredited to ISO 17025. All data are ratified to all LAQM reporting requirements. Measurement data are available through UKAIR.

PM_{10} and $PM_{2.5}$ Monitoring Adjustment

PM_{10} and $PM_{2.5}$ are measured using BAM 1020 heated instrument. For the PM_{10} instrument a slope correction factor of 0.9662 is applied. No slope correction is required for the $PM_{2.5}$.

Automatic Monitoring Annualisation

All automatic monitoring locations within Carlisle City Council recorded data capture of greater than 75% therefore it was not required to annualise any monitoring data. In addition, any sites with a data capture below 25% do not require annualisation.

NO_2 Fall-off with Distance from the Road

Wherever possible, local authorities should ensure that monitoring locations are representative of exposure. However, where this is not possible, the NO_2 concentration at the nearest location relevant for exposure should be estimated using the NO_2 fall-off with distance calculator available on the LAQM Support website. Where appropriate, non-automatic annual mean NO_2 concentrations corrected for distance are presented in Table B.1.

No automatic NO_2 monitoring locations within Carlisle City Council required distance correction during 2020.

Appendix D: Map(s) of Monitoring Locations and AQMAs

Figure D.1 – Location of diffusion tubes within Carlisle City Council area

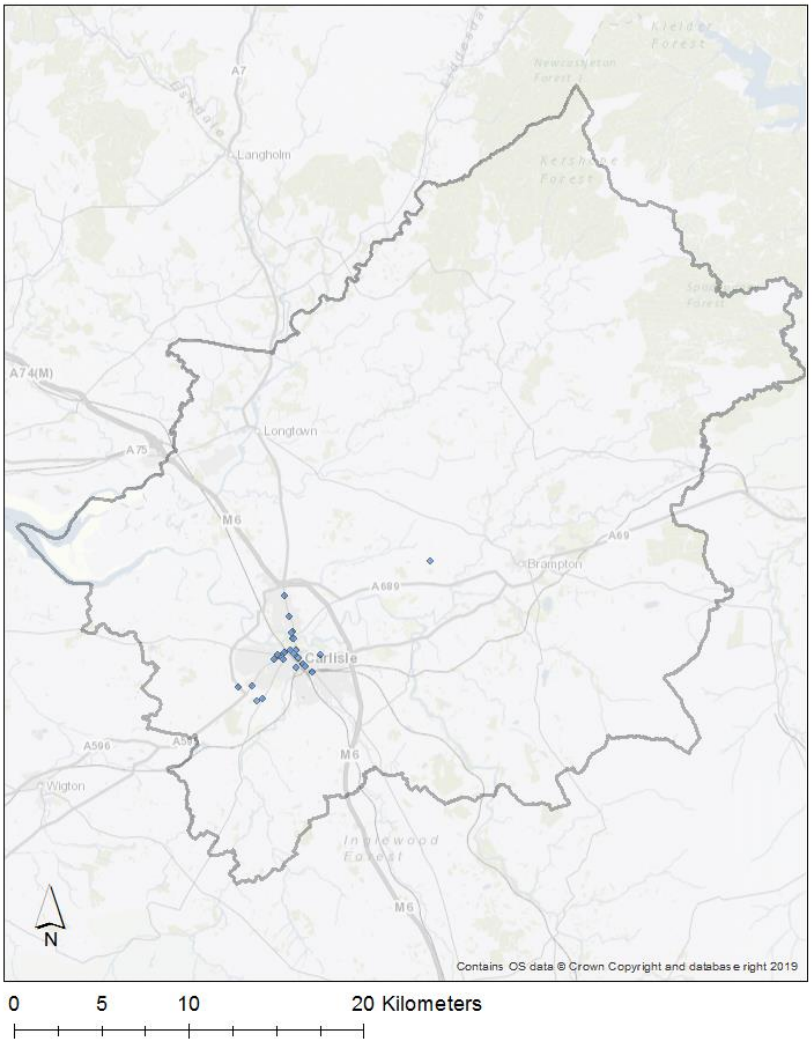


Figure D.2 – Location of diffusion tubes within Carlisle City Council area (with Site IDs)

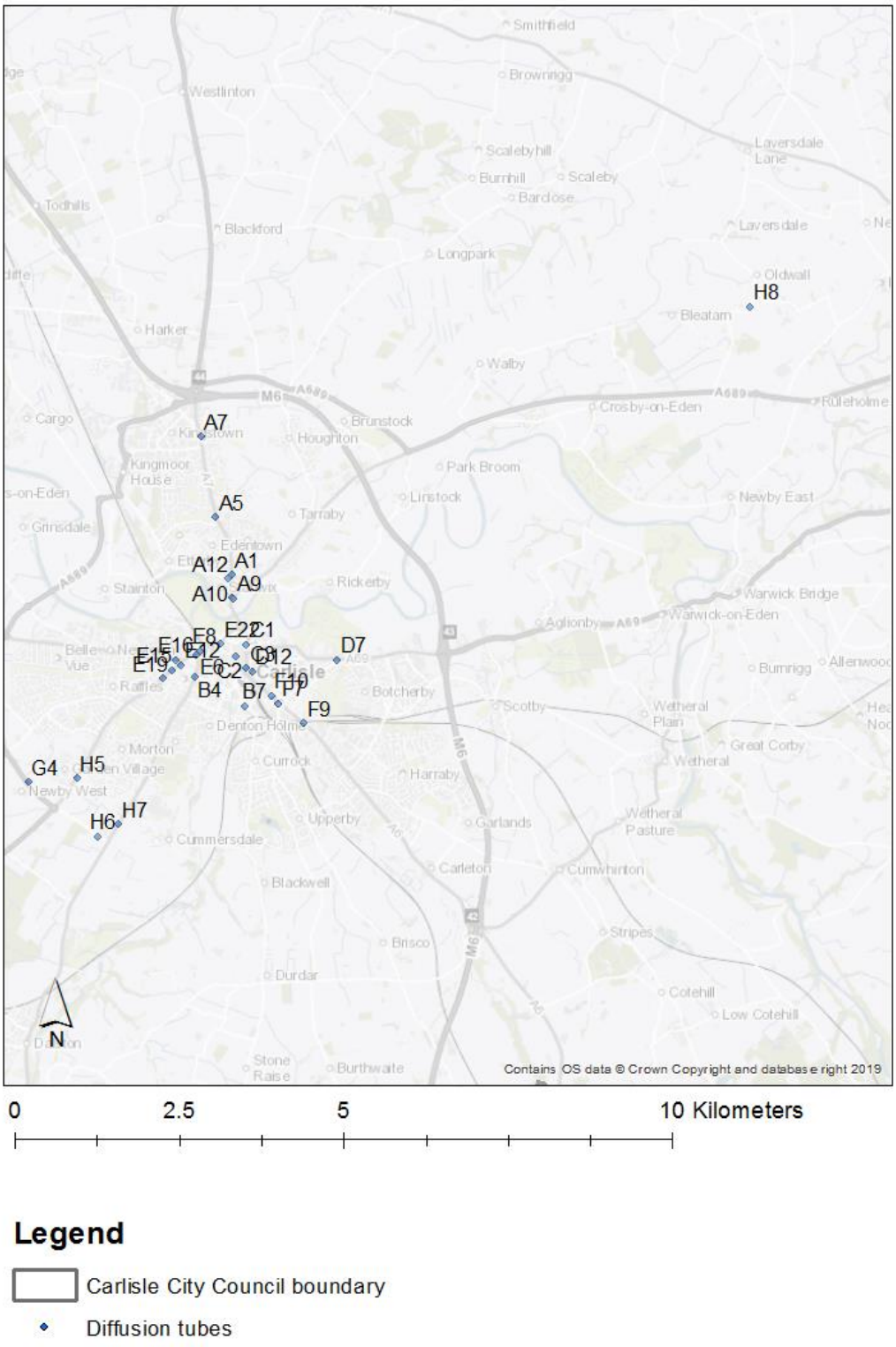


Figure D.3 – Location of air quality management areas and diffusion tubes (within city)

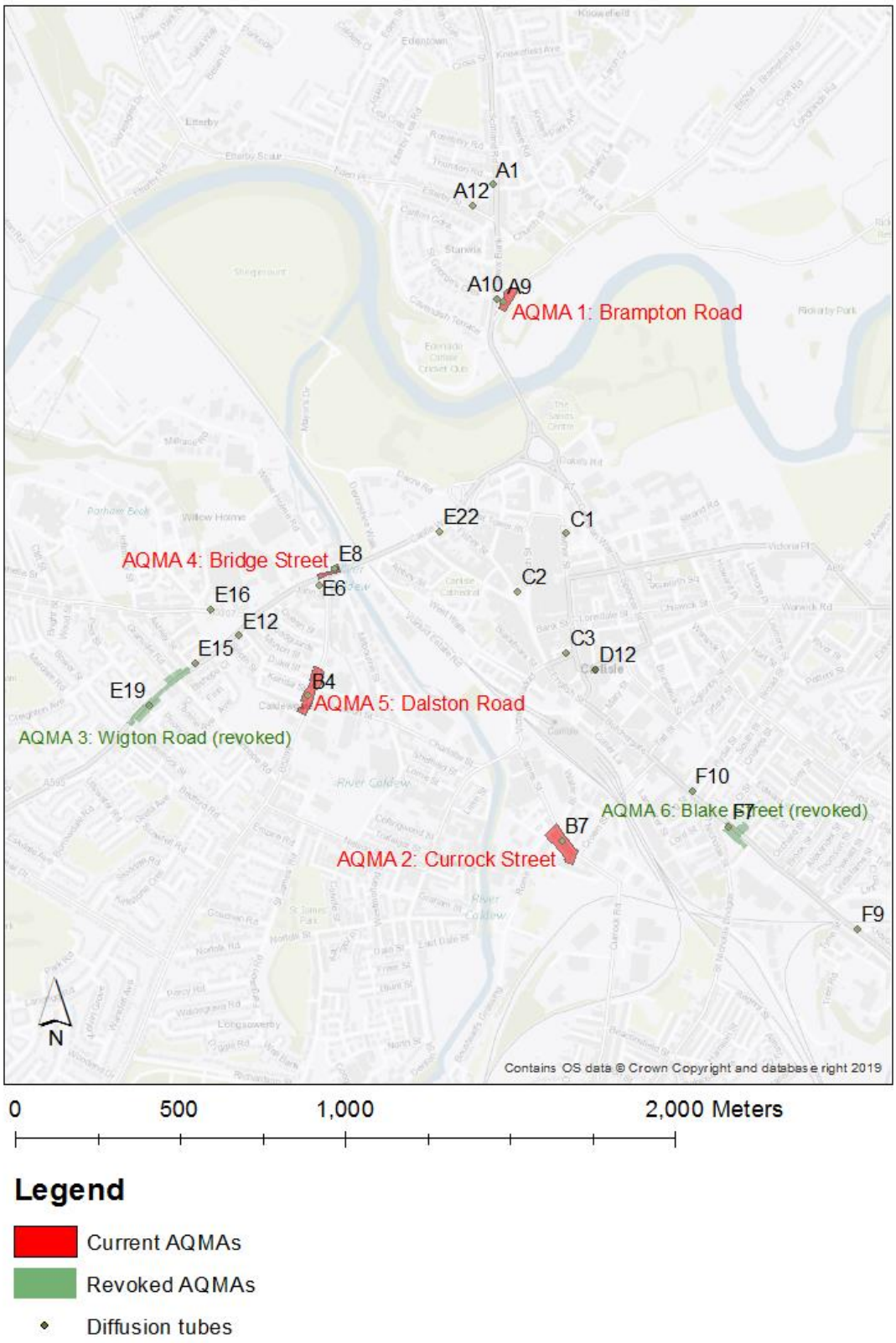
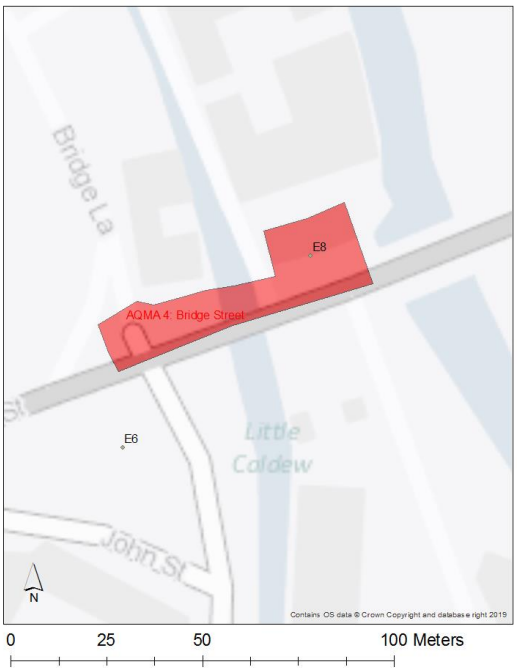


Figure D.4 – Location of air quality management areas (zoomed in)

AQMA 1: Brampton Road

AQMA 2: Currock Street

AQMA 4: Bridge Street



AQMA 5: Dalston Road

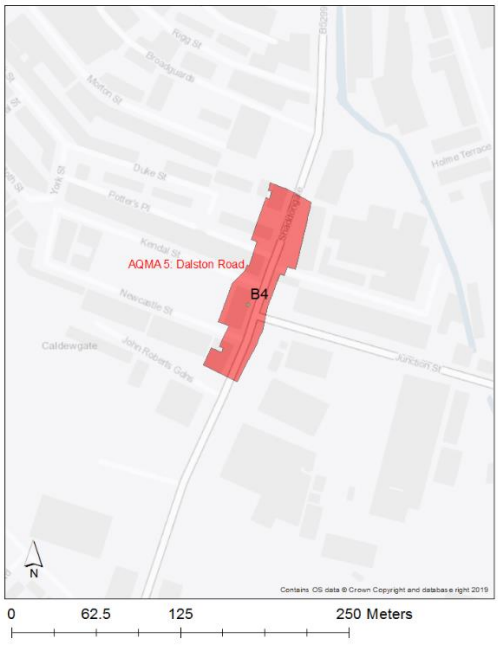
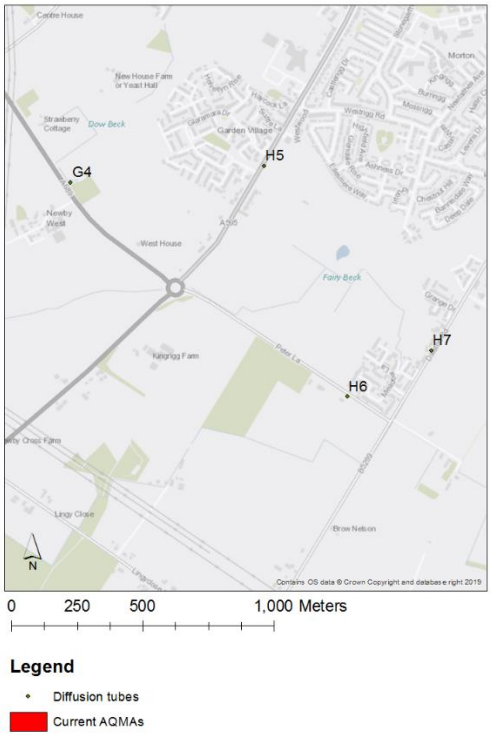
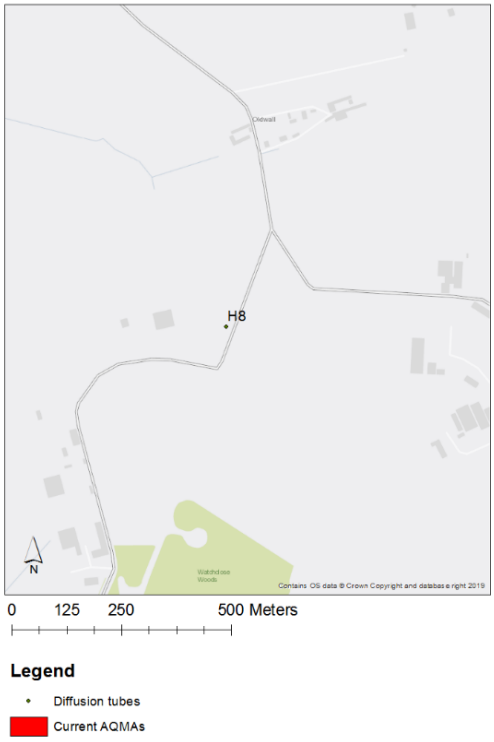


Figure D.5 – Location of diffusion tubes in outlying areas





Appendix E: Summary of Air Quality Objectives in England

Table E.1 – Air Quality Objectives in England[18]

Pollutant	Air Quality Objective: Concentration	Air Quality Objective: Measured as
Nitrogen Dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean
Nitrogen Dioxide (NO_2)	40µg m^{-3}	Annual mean
Particulate Matter (PM_{10})	50 µg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean
Particulate Matter (PM_{10})	40µg m^{-3}	Annual mean
Sulphur Dioxide (SO_2)	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean
Sulphur Dioxide (SO_2)	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean
Sulphur Dioxide (SO_2)	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean

[18] The units are in microgrammes of pollutant per cubic metre of air (µg m^{-3}).

Appendix F: Impact of COVID-19 upon LAQM

COVID-19 has had a significant impact on society. Inevitably, COVID-19 has also had an impact on the environment, with implications to air quality at local, regional and national scales.

COVID-19 has presented various challenges for Local Authorities with respect to undertaking their statutory LAQM duties in the 2021 reporting year. Recognising this, Defra provided various advice updates throughout 2020 to English authorities, particularly concerning the potential disruption to air quality monitoring programmes, implementation of Air Quality Action Plans (AQAPs) and LAQM statutory reporting requirements. Defra has also issued supplementary guidance for LAQM reporting in 2021 to assist local authorities in preparing their 2021 ASR. Where applicable, this advice has been followed.

Despite the challenges that the pandemic has given rise to, the events of 2020 have also provided Local Authorities with an opportunity to quantify the air quality impacts associated with wide-scale and extreme intervention, most notably in relation to emissions of air pollutants arising from road traffic. The vast majority (>95%) of AQMAs declared within the UK are related to road traffic emissions, where attainment of the annual mean objective for nitrogen dioxide (NO_2) is considered unlikely. On 23rd March 2020, the UK Government released official guidance advising all members of public to stay at home, with work-related travel only permitted when absolutely necessary. During this initial national lockdown (and to a lesser extent other national and regional lockdowns that followed), marked reductions in vehicle traffic were observed; Department for Transport (DfT) data[19] suggests reductions in vehicle traffic of up to 70% were experienced across the UK by mid-April, relative to pre COVID-19 levels.

This reduction in travel in turn gave rise to a change of air pollutant emissions associated with road traffic, i.e. nitrous oxides (NO_x), and exhaust and non-exhaust particulates (PM). The Air Quality Expert Group (AQEG)[20] has estimated that during the initial lockdown period in 2020, within urbanised areas of the UK reductions in NO_2 annual mean concentrations were between 20 and 30% relative to pre-pandemic levels, which

[19] Prime Minister's Office, COVID-19 briefing on the 31st of May 2020

[20] Air Quality Expert Group, Estimation of changes in air pollution emissions, concentrations and exposure during the COVID-19 outbreak in the UK, June 2020

represents an absolute reduction of between 10 to 20 µg m^{-3} if expressed relative to annual mean averages. During this period, changes in $PM_{2.5}$ concentrations were less marked than those of NO_2. $PM_{2.5}$ concentrations are affected by both local sources and the transport of pollution from wider regions, often from well beyond the UK. Through analysis of AURN monitoring data for 2018-2020, AQEG have detailed that $PM_{2.5}$ concentrations during the initial lockdown period are of the order 2 to 5 µg m^{-3} lower relative to those that would be expected under business-as-usual conditions.

As restrictions are gradually lifted, the challenge is to understand how these air quality improvements can benefit the long-term health of the population.

Impacts of COVID-19 on Air Quality within Carlisle City Council

An assessment of the impact on Covid-19 concentrations was carried for the diffusion tubes in each of the AQMAs. To do this the monthly NO_2 concentrations over the four year period were averaged and compared to 2020 concentrations. Figure F.1 compares the monthly mean NO_2 concentrations measured within AQMA 1. The largest change in concentration occurred for April when the month decrease was about 60 %. There was another large decrease of about 40 % in November.

Figure F.1 – Monthly mean diffusion tube concentrations in AQMA 1

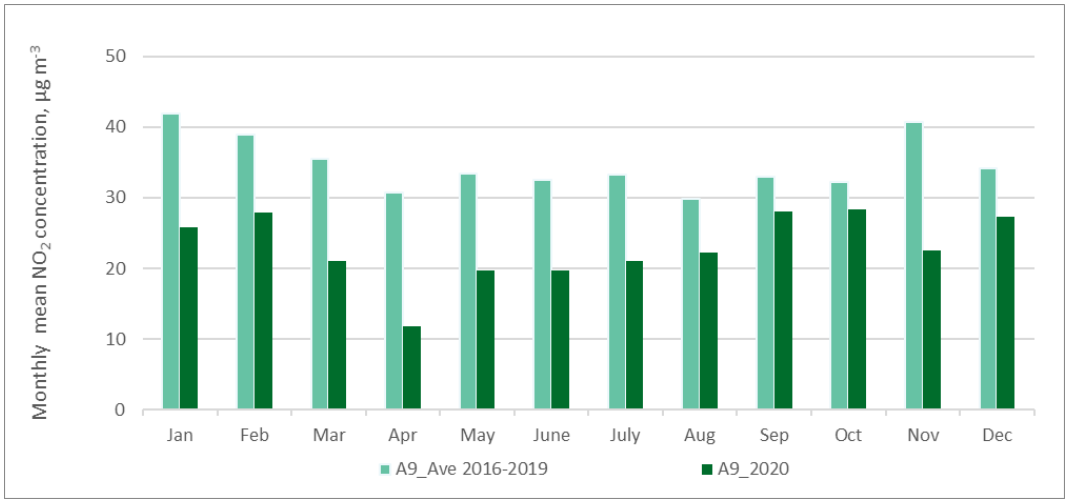


Figure F.2 compares the mean NO_2 concentrations measured in AQMA 2. The largest decrease was again in April (about 53 %) .

Figure F.2 – Monthly mean diffusion tube concentrations in AQMA 2

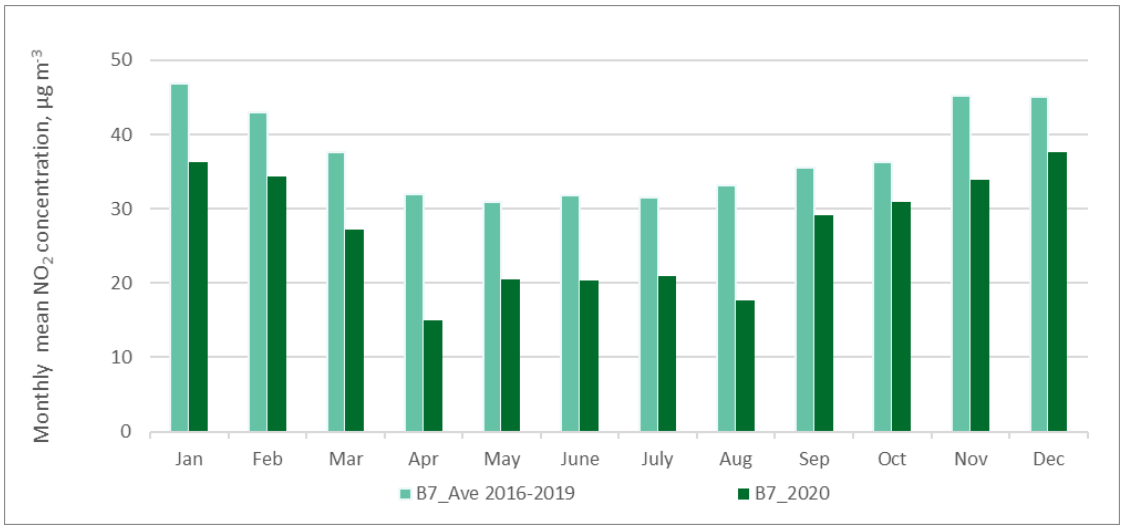


Figure F.3 compares the mean NO_2 concentrations measured in AQMA 4. The largest decrease was again in April (also about 53 %) .

Figure F.3 – Monthly mean diffusion tube concentrations in AQMA 4

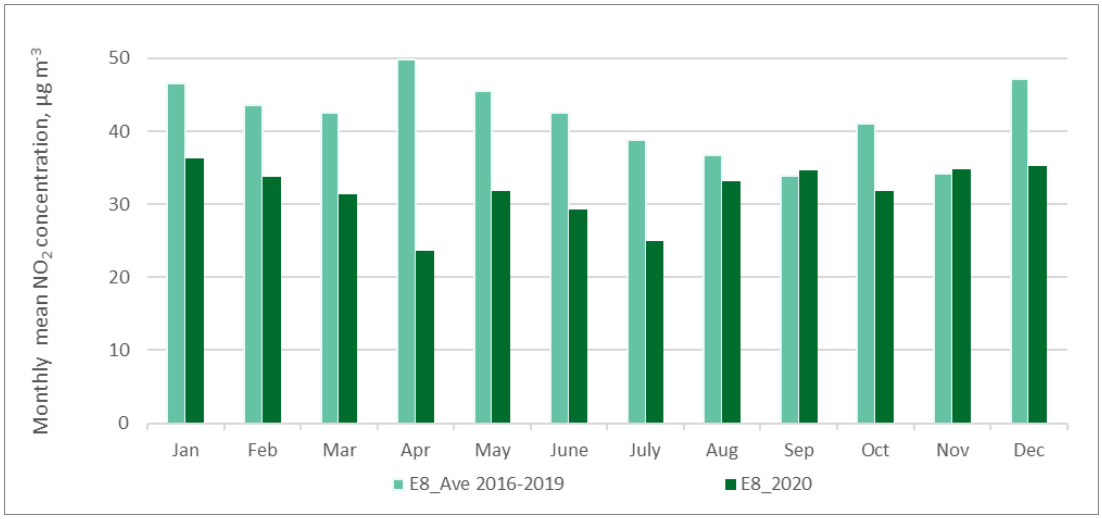
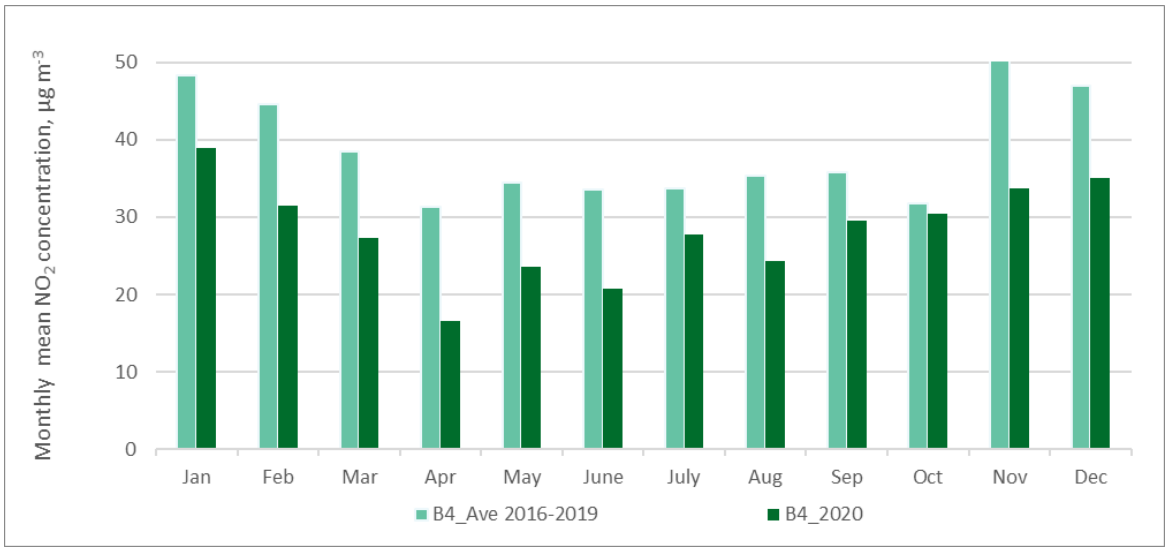


Figure F.4 compares the mean NO_2 concentrations measured in AQMA 5. The largest decrease was again in April (slightly less at about 47 %).

Figure F.4 – Monthly mean diffusion tube concentrations in AQMA 5



As discussed in the main body of the report the average decrease throughout the Council area was 30 %. The change in concentration at each site is shown in Table F.1. The largest decrease (40 %) occurred at the Tourist Information Office and the smallest (20 %) at Stanwix Bank Car Park.

Table F.1 – Percentage reduction in NO_2 concentration measured by diffusion tube with Carlisle City Council.

Diffusion Tube ID	Location	Annual mean concentration, µg m^{-3}					Average 2016 to 2019, µg m^{-3}	2020 compared to previous 4 years, %
		2016	2017	2018	2019	2020		
A1	45 SCOTLAND RD	33.7	31.7	30.1	31.7	23.3	31.8	-27
A10	STANWIX BANK	42.6	36.4	37.6	36.7	24.9	38.3	-35
A12	STANWIX BANK CAR PARK	18.7	28.6	28.2	28.7	20.8	26.1	-20
A5	37 KINGSTOWN RD	32.1	32.5	29.2	31.5	21.4	31.3	-32
A7	282 KINGSTOWN RD	24.9	23.4	21.2	20.7	14.1	22.6	-37
A9	BRAMPTON RD	37.4	35.5	32.4	32.7	23.0	34.5	-33
B4	DALSTON RD	40	39.9	35.8	38.7	28.3	38.6	-27
B7	12 CURROCK ST	37.7	37	35.2	38.1	27.0	37.0	-27
C1	LOWTHER ST	27.9	27.2	27.4	27.6	19.7	27.5	-29
C2	TOURIST INFO	18.7	19.3	20.2	17.8	11.5	19.0	-40
C3	DEVONSHIRE ST	29.5	25.5	24.4	27.5	18.6	26.7	-31
D12	POST OFFICE	36.8	34.4	30.4	32.7	20.4	33.6	-39
D7	282 WARWICK RD	30.8	32.1	28	28.3	20.8	29.8	-30
E22	FINKLE ST	31.5	30.5	29.1	31.4	22.0	30.6	-28
E12	3 WIGTON RD	35.7	33.5	31.9	33.9	24.6	33.8	-27
E15	22 WIGTON RD	32	30.2	28.4	29.2	21.4	30.0	-28
E16	JOVIAL SAILOR	32.7	31.4	31.7	32	22.6	32.0	-29

Diffusion Tube ID	Location	Annual mean concentration, µg m^{-3}					Average 2016 to 2019, µg m^{-3}	2020 compared to previous 4 years, %
		2016	2017	2018	2019	2020		
E19	49 WIGTON RD	34.8	31.5	30.6	31.2	22.2	32.0	-31
E6	Paddy's Market	29.0	27.4	28.3	26.4	21.1	27.8	-24
E8	BRIDGE ST	41.5	44.9	40.8	42.7	31.7	42.5	-25
F10	155 BOTCHERGATE	35.8	36.3	35.3	34.4	25.4	35.5	-28
F7	24 LONDON RD	34.1	33.8	32.2	35.4	24.7	33.9	-27
F9	129 LONDON RD	32.4	30.4	30.3	31.4	23.6	31.1	-24
G4	THE HOBBIT	13	12	12.6	12.1	8.0	12.4	-36
H5	WIGTON RD	16.1	16.6	15.7	14.1	10.4	15.6	-33
H6	PETER LANE	12	9.4	11.4	10.1	8.4	10.7	-22
H7	DALSTON RD	17	15.1	18.7	15.1	11.6	16.5	-29
H8	AIRPORT	8	7.5	8.2	6.9	4.8	7.7	-38

Opportunities Presented by COVID-19 upon LAQM within Carlisle City Centre

There has been a major increase in the number of staff home working or hybrid working within Carlisle City Council and other local commercial operations. This has led to reduced traffic, particularly during peak hours. It is hoped that new opportunities for homeworking will result in reduced emissions in the long term.

No new measures have been developed and implemented during 2020 as a consequence of COVID-19.

Challenges and Constraints Imposed by COVID-19 upon LAQM within Carlisle City Council

No challenges or constraints relating to LAQM have arisen during 2020 as a consequence of COVID-19 within Carlisle City Council.

Table F.2 – Impact Matrix

Category	Impact Rating: None	Impact Rating: Small	Impact Rating: Medium	Impact Rating: Large
Automatic Monitoring – Data Capture (%)	More than 75% data capture	50 to 75% data capture	25 to 50% data capture	Less than 25% data capture
Automatic Monitoring – QA/QC Regime	Adherence to requirements as defined in LAQM.TG16	Routine calibrations taken place frequently but not to normal regime. Audits undertaken alongside service and maintenance programmes	Routine calibrations taken place infrequently and service and maintenance regimes adhered to. No audit achieved	Routine calibrations not undertaken within extended period (e.g. 3 to 4 months). Interruption to service and maintenance regime and no audit achieved
Passive Monitoring – Data Capture (%)	More than 75% data capture	50 to 75% data capture	25 to 50% data capture	Less than 25% data capture
Passive Monitoring – Bias Adjustment Factor	Bias adjustment undertaken as normal	<25% impact on normal number of available bias adjustment colocation studies (2020 vs 2019)	25-50% impact on normal number of available bias adjustment studies (2020 vs 2019)	>50% impact on normal number of available bias adjustment studies (2020 vs 2019) and/or applied bias adjustment factor studies not considered representative of local regime
Passive Monitoring – Adherence to Changeover Dates	Defra diffusion tube exposure calendar adhered to	Tubes left out for two exposure periods	Tubes left out for three exposure periods	Tubes left out for more than three exposure periods
Passive Monitoring – Storage of Tubes	Tubes stored in accordance with laboratory guidance and analysed promptly.	Tubes stored for longer than normal but adhering to laboratory guidance	Tubes unable to be stored according to be laboratory guidance but analysed prior to expiry date	Tubes stored for so long that they were unable to be analysed prior to expiry date. Data unable to be used
AQAP – Measure Implementation	Unaffected	Short delay (<6 months) in development of a new AQAP, but is on-going	Long delay (>6 months) in development of a new AQAP, but is on-going	No progression in development of a new AQAP
AQAP – New AQAP Development	Unaffected	Short delay (<6 months) in development of a new AQAP, but is on-going	Long delay (>6 months) in development of a new AQAP, but is on-going	No progression in development of a new AQAP

Appendix G: Examination of PM_{10} and $PM_{2.5}$ concentrations in 2019

Defra's review of the 2020 ASR highlighted that the annual mean PM_{10} and $PM_{2.5}$ concentrations at Paddy's Market increased by 2.4 µg m^{-3} and 2.2 µg m^{-3} in 2019 compared to compared to 2018. While the 2020 annual means for both pollutants have returned to concentrations similar to those measured in 2018, here we review the PM_{10} concentrations using the OpenAir air quality analysis tool[21] to understand what may have produced relatively high PM concentrations in 2019.

The data were initially analysed using the time variation and calendar plots in OpenAir. The time variation plot shows variation by day of the week, hour of day, a combined hour of day – day of week plot and a monthly plot. The trends are plotted for 2016 to 2020.

Figure G.1 shows typical behaviour of PM_{10} in an urban environment, namely:

- Concentrations are higher during daytime hours with the highest concentrations measured around 18:00 each day;
- Concentrations are lowest during the summer months;
- Concentrations are lowest on Sundays;

However, there were peaks in the monthly concentrations for February and April 2019.

The calendar plot for 2019 shown in Figure G.2 shows daily concentrations above 50 µg m^{-3} for the five days: 25/2, 26/2, 27/2, 23/4 and 24/4. A cross check against the average wind speeds on the three days in February (Figure G.3) shows that the wind was from a southerly direction with relatively low wind speeds (the length of the arrow is proportional to the wind speed). For the two days in April with exceedance of 50 µg m^{-3} there was only sufficient meteorological data on the 23rd April to show that the wind came from an easterly direction.

[21] The openair book (bookdown.org). The ImportAURN package within OpenAir provides wind speed, wind direction and temperature that allows the wind direction and wind data to be presented in Figure G.3

Figure G.1 – Time variation plot for PM_{10} at Paddy's Market

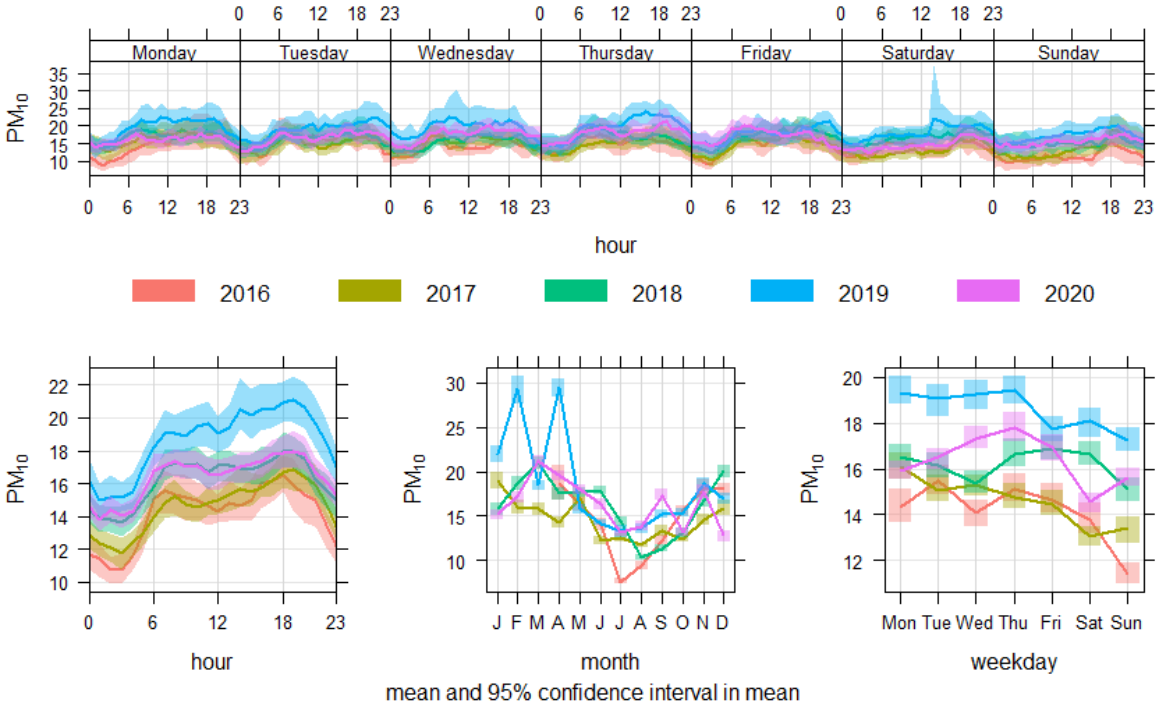


Figure G.2 – Calendar Plot showing the daily mean PM_{10} concentration for each day in 2019

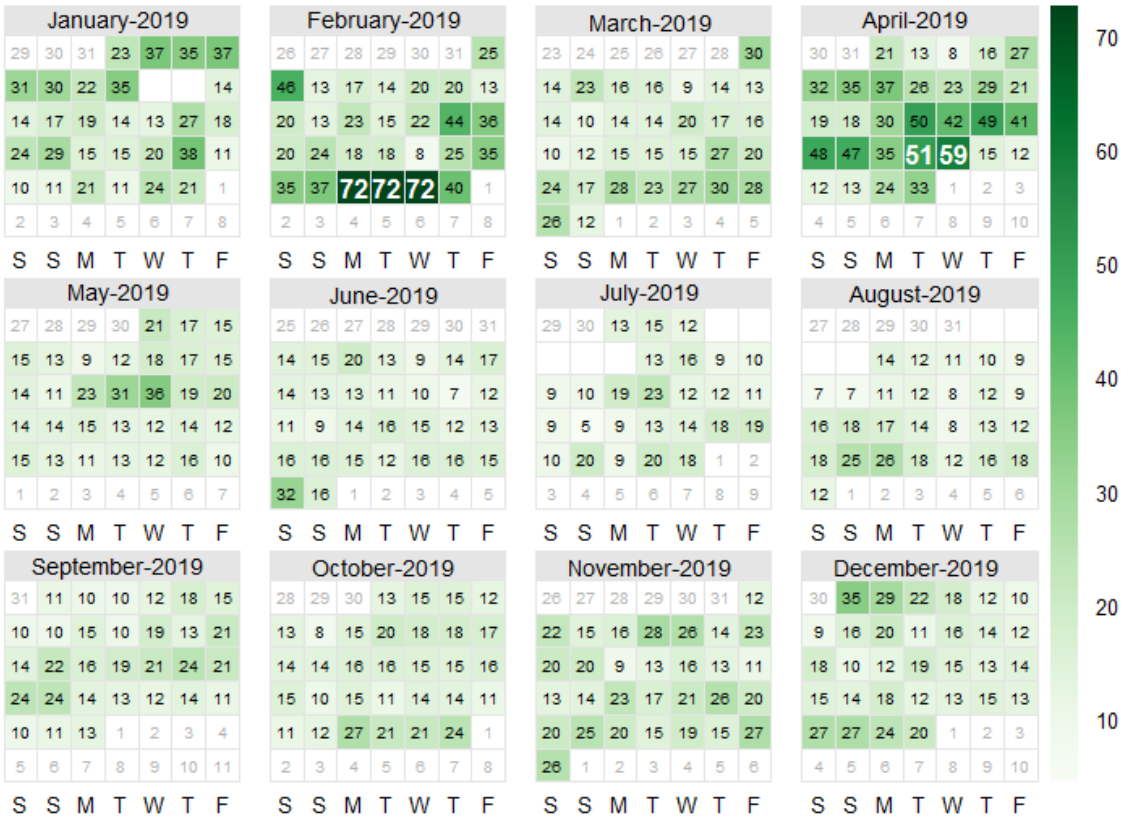
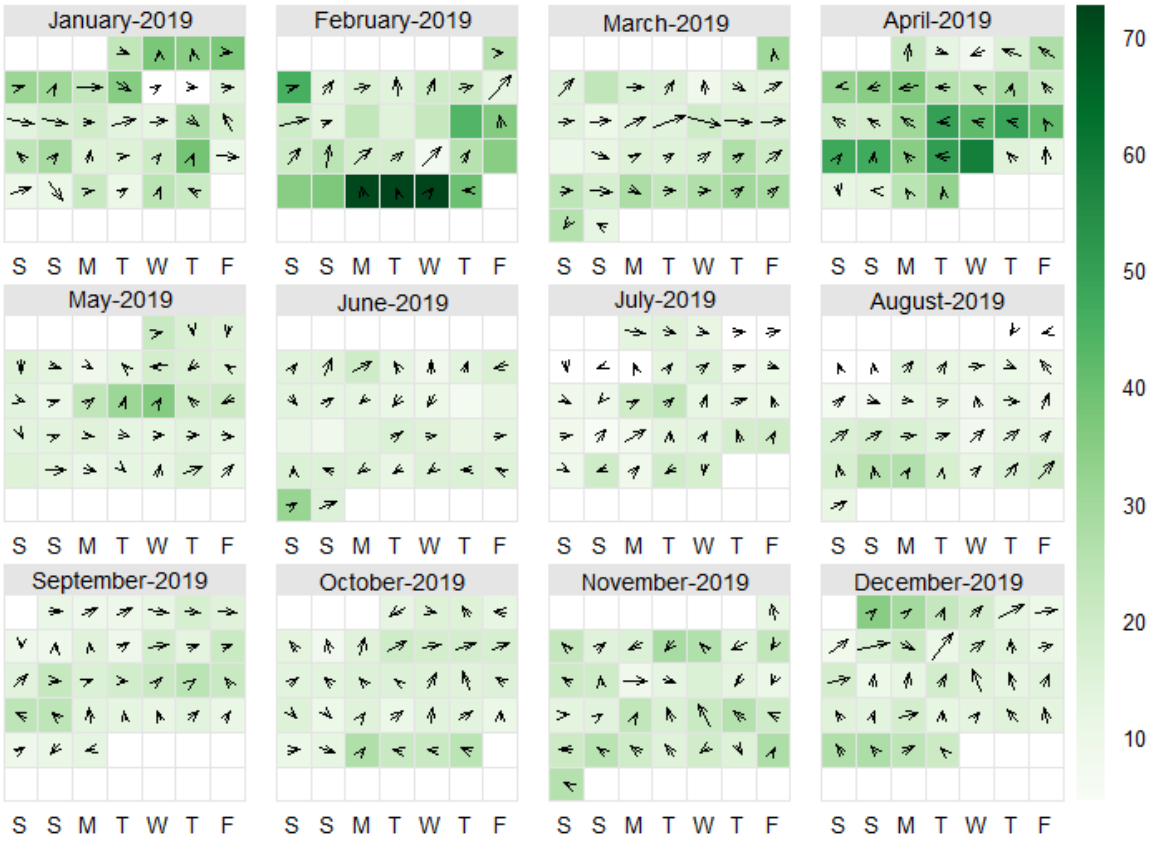


Figure G.3 – Calendar Plot showing the average daily average wind direction associated with daily mean PM_{10} concentration in 2019



In the Air Pollution in the UK publication[22] Defra have reviewed the meteorological conditions that had lead to these episodes and in the case of the February episode this was attributed to southerly winds and a high pressure system that lead to high levels of particulate matter both from local sources and from air masses that had originated from continental Europe.

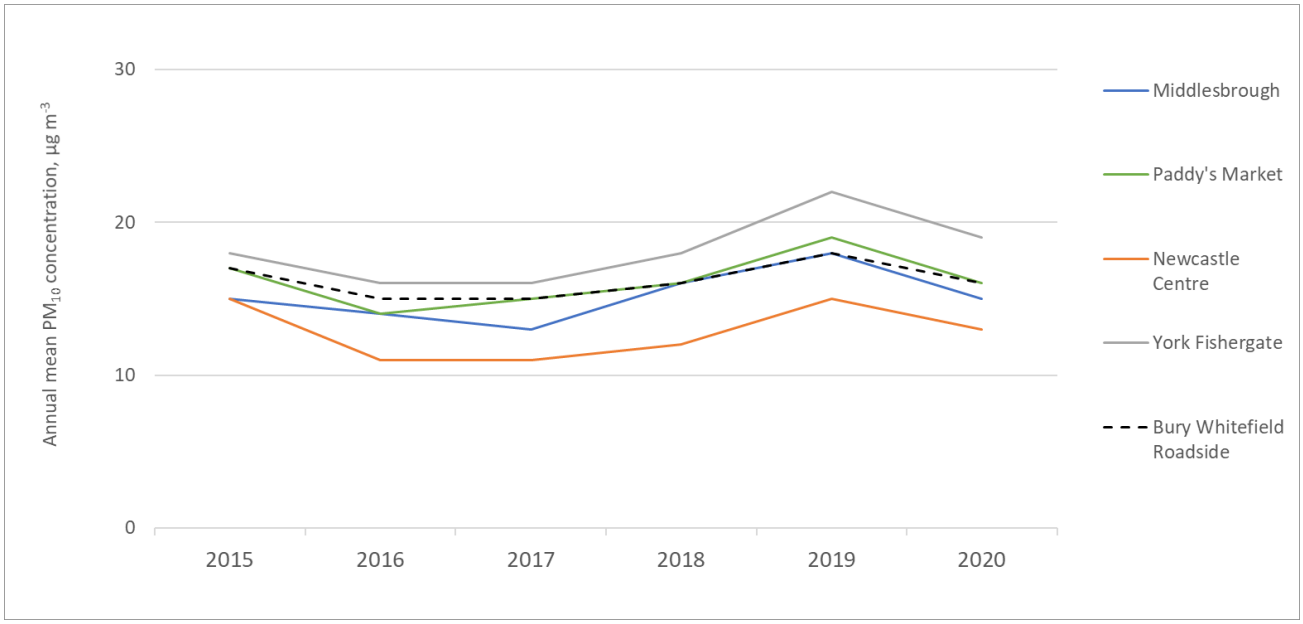
The April episode had occurred during a period that was hot and sunny with light winds from the east bringing polluted air masses to the UK which when mixed with local sources lead to elevated PM_{10} and $PM_{2.5}$ concentrations.

While pollution episodes will not necessarily lead to high annual mean concentrations, increases in annual mean concentrations from 2018 to 2019 was observed over a wide geographical area at a number of other locations in Northern England (Figure G.4). This increase suggests that meteorology, and in particular the meteorological conditions that

[22] https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2019_issue_1.pdf

lead accumulation of emissions from local sources and the transport of polluted air masses from continental Europe during the February and April pollution episodes, played an important role in causing the increase in PM_{10} and $PM_{2.5}$ annual mean concentrations.

Figure G.4 – Annual mean PM_{10} concentrations measured at a number of locations in northern England



Glossary of Terms

Abbreviation	Description
AQAP	Air Quality Action Plan - A detailed description of measures, outcomes, achievement dates and implementation methods, showing how the local authority intends to achieve air quality limit values'
AQMA	Air Quality Management Area – An area where air pollutant concentrations exceed / are likely to exceed the relevant air quality objectives. AQMAs are declared for specific pollutants and objectives
ASR	Annual Status Report
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges – Air quality screening tool produced by Highways England
EU	European Union
FDMS	Filter Dynamics Measurement System
LAQM	Local Air Quality Management
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PM_{10}	Airborne particulate matter with an aerodynamic diameter of 10µm or less
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of 2.5µm or less
QA/QC	Quality Assurance and Quality Control
SO_2	Sulphur Dioxide

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