Air Pollution in Northern Ireland 2020

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1. Report Highlights

This is the nineteenth in a series of annual reports on air quality in Northern Ireland. It has been written and produced by Ricardo Energy & Environment, on behalf of the Department of Agriculture, Environment and Rural Affairs (DAERA).

The key purpose of this report is to summarise air quality monitoring results for Northern Ireland in 2020, in order to inform the public, government and wider air quality community in Northern Ireland. This report also contains useful information on air quality policy and legislation as well as on sources of pollution. Figure 1.1 shows the locations of all air quality monitoring sites in Northern Ireland that were in operation during part or all of 2020.

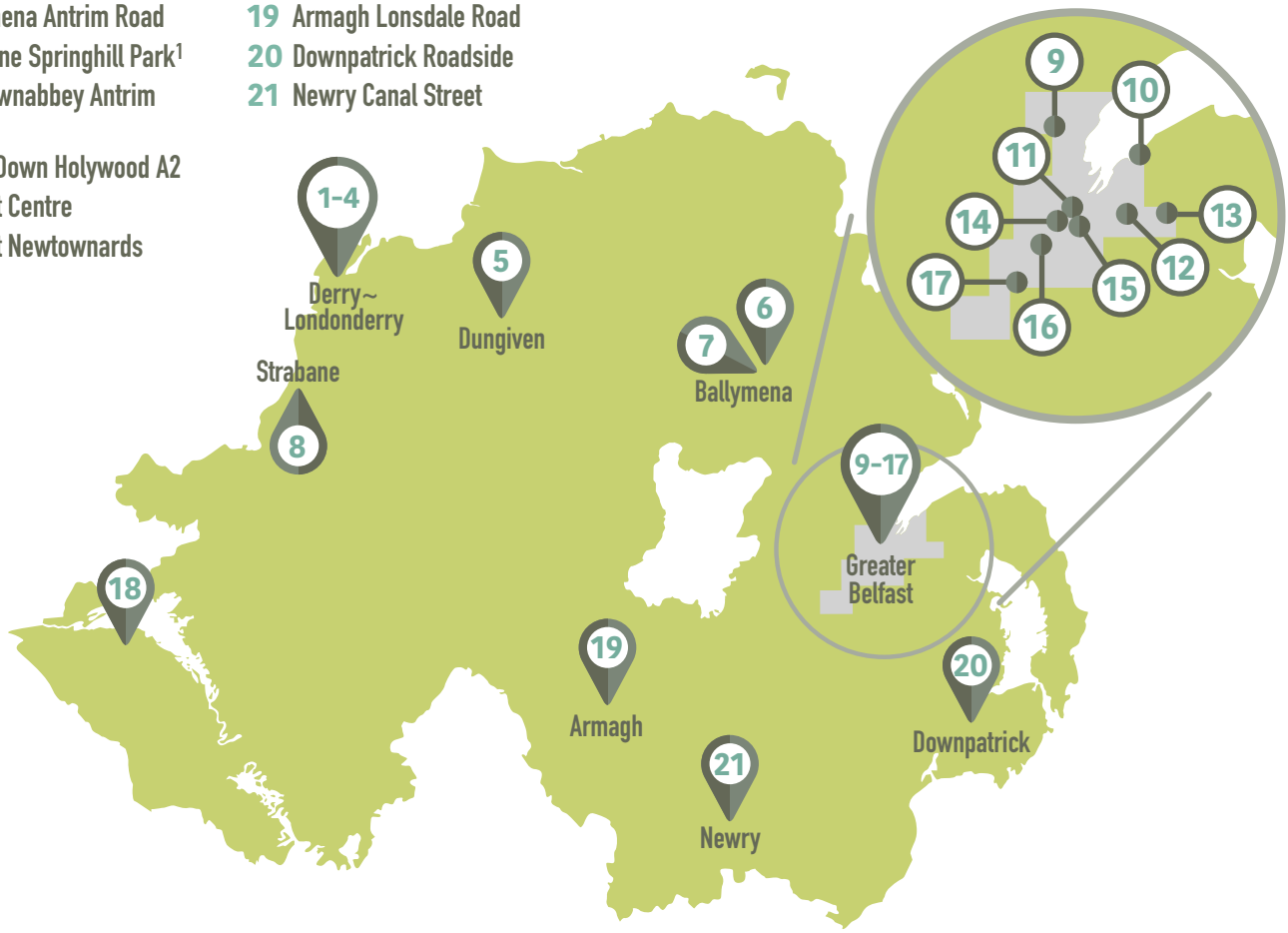
Fig. 1.1: Air Quality Monitoring Stations

1 Londonderry Rosemount
2 Londonderry Dale's Corner
3 Strathfoyle Bawnmore Place
4 Derry Brandywell
5 Limavady Dungiven
6 Ballymena Ballykeel
7 Ballymena Antrim Road
8 Strabane Springhill Park[1]
9 Newtownabbey Antrim Road
10 North Down Holywood A2
11 Belfast Centre
12 Belfast Newtownards Road
13 Castlereagh Dundonald
14 Belfast Westlink Roden Street
15 Belfast Ormeau Road
16 Belfast Stockman's Lane
17 Lisburn Dunmurry Seymour Hill[2]
18 Lough Navar
19 Armagh Lonsdale Road
20 Downpatrick Roadside
21 Newry Canal Street

21 sites operating in 2020. This map has been updated from the previous years to show the location of sites in the UK Black carbon and PAH Networks

[1] Black Carbon is measured at Strabane 2 which is at the same location as Strabane Springhill Park

[2] Black Carbon and PAHs are measured at Kilmakee Leisure Centre which is at the same location as Lisburn Dunmurry Seymour Hill



Derry City, Tourism NI

This report has been compiled from data supplied by Northern Ireland's network of air quality monitoring stations (Figure 1.1). Some of these are operated on behalf of DAERA, while others are managed by district councils, via the Local Air Quality Management framework, for which DAERA provides funding support. An interactive map of the automatic monitoring stations shown in Figure 1.1 can be found on the Northern Ireland Air Quality Website at www.airqualityni.co.uk.

This year's focus is on the effects of the first Covid-19 lockdown on Northern Ireland's air quality.

Information on the sites in Northern Ireland within the Black Carbon, PAH, Hydrocarbon, and Heavy Metals Networks, can be found on the UK-AIR website at https://uk-air.defra.gov.uk/interactive-map.

This report reviews the pollutants monitored, and highlights compliance as well as exceedances of air quality objectives. It also highlights emerging trends in air quality over time. Each edition of the report takes an issue to examine in-depth, and this year's focus is on the effects of the first Covid-19 lockdown on Northern Ireland's air quality.

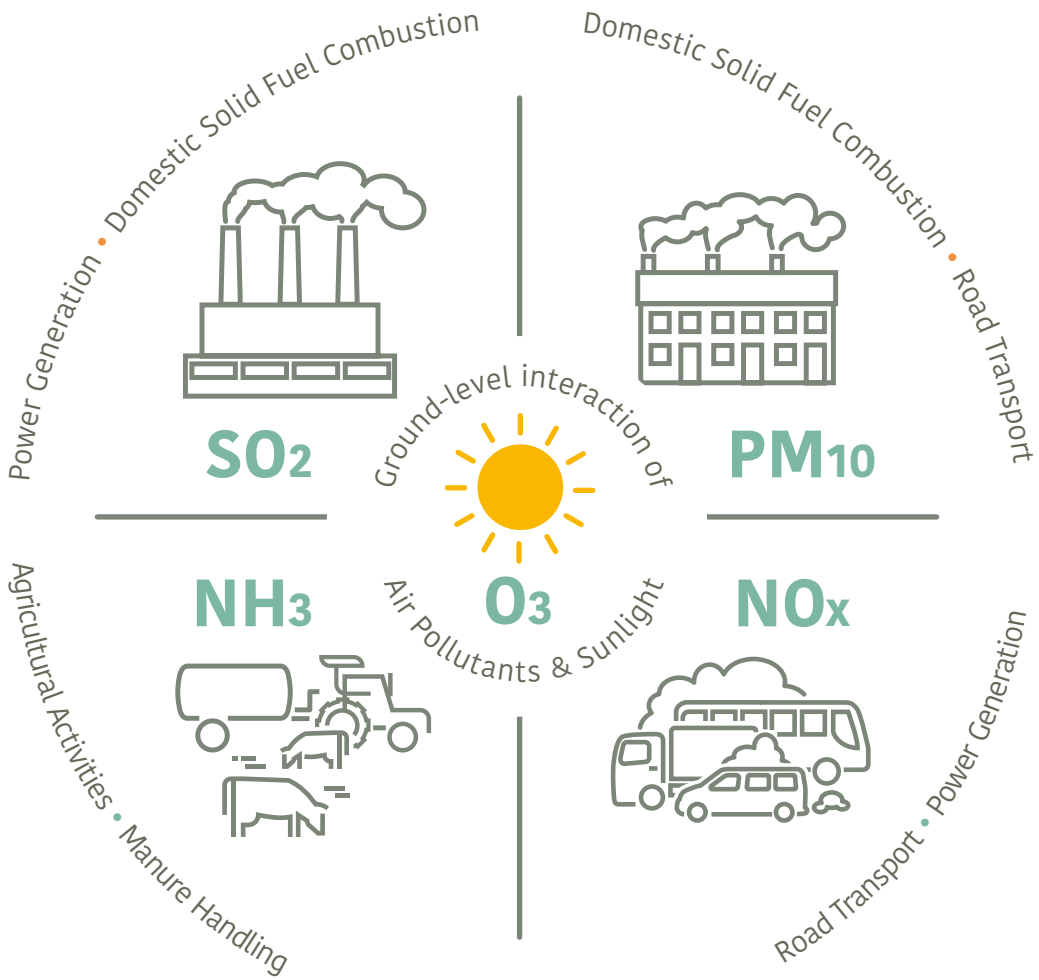
Air quality in Northern Ireland has improved substantially in recent decades. In particular, concentrations of sulphur dioxide, a pollutant associated with coal and oil combustion, have declined significantly over the past twenty years. However, some pollutants in some parts of Northern Ireland continue to exceed air quality objectives. A continued effort to reduce air pollution is therefore important, together with monitoring to assess progress and to provide sound, science-based input into policy development.

2. Sources of Air Pollution in NI

Figure 2.1 illustrates the most significant air pollutants for our region, and provides information on their sources:

- Nitrogen oxides (NO_x, which includes nitrogen monoxide NO and nitrogen dioxide NO_2): from combustion of fuels, most importantly in transport and energy generation. The NOx emitted by road transport, however, poses more of a problem because it leads to increased concentrations of NO_2 at ground level in busy streets where people are present. NO_2 is a respiratory irritant: it can irritate the airways and lungs. This can worsen the symptoms of people who have already have lung problems.
- Sulphur dioxide, SO_2: a pollutant produced during combustion of fuels containing sulphur (such as coal), particularly from power generation, industry, and household heating. SO_2 is a respiratory irritant that can cause the airways to constrict: people with asthma are likely to be particularly sensitive to it.

Figure 2.1: Main Sources of Air Pollution



Downhill Beach, Translink train (County Derry), Tourism NI

- Particulate matter, PM_{10} and $PM_{2.5}$: by-products of burning fuels, in particular use of solid fuels (e.g. domestic wood and coal burning), industrial combustion and road transport. Approximately half of the PM produced from road transport is from fuel combustion, while the other half is from tyre and brake wear and road dust. PM_{10} particles can travel into our airways where they can cause inflammation, and a worsening of the condition of people with heart and lung diseases. $PM_{2.5}$ particles are smaller still, and can be carried deep into the lungs: these ultrafine particles may carry surface-absorbed toxic, or carcinogenic, compounds into the body.
- Ground-level ozone, O_3: a secondary pollutant, formed by the interaction of other air pollutants in the presence of sunlight. Ozone irritates the eyes, airways and lungs, increasing the symptoms of those suffering from asthma and lung diseases.
- Ammonia, NH_3: a gas that is emitted from waste and agricultural activities – in particular, manure handling, storage and spreading. Ammonia contributes to air pollution because it can react with other pollutants (the oxides of nitrogen and sulphur) to produce fine particles of ammonium nitrate and ammonium sulphate.
- Polycyclic aromatic hydrocarbons, PAHs: typically formed by incomplete combustion or pyrolysis. Domestic combustion accounts for the majority of PAH emissions to the atmosphere. Several PAHs are toxic or can be carcinogenic, such as benzo[a]pyrene, which is used as a marker compound for PAHs in the UK.

3. Legislation and Policy: What Can Be Done

During 2020 the management of air quality in Northern Ireland was based on the requirements of the Air Quality Standards Regulations (Northern Ireland) 2010, the 2007 UK Air Quality Strategy and the Environment Order (NI) 2002.

The Air Quality Standards Regulations (Northern Ireland) 2010

Ambient air quality in Northern Ireland is regulated by the Air Quality Standards Regulations (Northern Ireland) 2010 and their subsequent 2016 amendment[1]. These Regulations transpose the following European Commission Directives:

- Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe (the Air Quality Directive), which relates to sulphur dioxide, oxides of nitrogen, particulate matter, lead, carbon monoxide, benzene and ozone in ambient air; and
- Directive 2004/107/EC (the Fourth Daughter Directive) relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons (PAH) in ambient air.

These Directives came into operation while the UK was a member state of the European Union (EU). The provisions of the Directives were required to be incorporated (or 'transposed') into Northern Ireland's own legislation, and the Regulations were the means by which this was done.

The full provisions of the above Directives therefore remain part of Northern Ireland's own legislation, even after the UK's departure from the EU in early 2020. As well as limit values and non-mandatory target values for ambient concentrations of pollutants, the Regulations set out requirements for ambient air quality monitoring, including the number of monitoring sites required, siting criteria and acceptable methodology. They also identify the duties of Northern Ireland's Government Departments in relation to achieving limit and target values. It is the responsibility of DAERA to inform the public about air quality in the region, particularly with regard to warning the public when air quality is poor.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, first published in 1997 and updated in 2007, provides a comprehensive framework for tackling air pollution. It was established on the basis of strong scientific evidence and a science-based understanding of the effects of air pollutants on health and the environment. The Strategy sets objectives to be met within the UK for a suite of pollutants. The scientific basis, the objectives set, and provisions contained within the Strategy are closely associated with the corresponding standards set within the European Air Quality Directives, as listed above. The Strategy's provisions for some pollutants differ from those in the Directives, with these differences relating to scientific evidence and expert opinion that is specific to the UK situation.

[1] Available at: https://www.legislation.gov.uk/nisr/2010/188/contents/made

As the Air Quality Standards Regulations have their origins in the EU Directives, this also means that there are some differences between the Strategy's provisions and those of the Regulations. However, all the Air Quality Strategy objectives are at least as stringent as the corresponding limit values in the Air Quality Directive or 4th Daughter Directive and the Regulations. The full Air Quality Strategy and its technical annexes are available online and can be downloaded from https://www.gov.uk/government/publications/the-air-quality-strategy-for-england-scotland-wales-and-northern-ireland-volume-1.

Local Air Quality Management

Local Air Quality Management (LAQM) provides the framework under the Environment Order (NI) 2002, within which air quality is managed by the 11 district councils in Northern Ireland. LAQM requires district councils to review and assess a range of air pollutants against the objectives set by the UK Air Quality Strategy, using a range of monitoring, modelling, observations and corresponding analyses. For locations where objectives are not expected to be met by the relevant target date, district councils are required to declare an Air Quality Management Area (AQMA), and (along with relevant authorities), to develop an Action Plan addressing the problem.

In 2020 there were 19 AQMAs in Northern Ireland, as shown in Table 3-1. Nine councils have AQMAs: of these, seven have AQMAs for NO_2 only, and two have AQMAs for PM_{10} and NO_2. There are no AQMAs in place for any other pollutants, in Northern Ireland.

Table 3.1: Air Quality Management Areas in Northern Ireland (as of September 2021)

District Council	Number of AQMAs	Pollutant that triggered designation	Sources
Antrim and Newtownabbey Borough Council	1	Nitrogen dioxide	Road traffic
Armagh City, Banbridge and Craigavon Borough Council	1	Nitrogen dioxide	Road traffic
Belfast City Council	4	Nitrogen dioxide	Road traffic
Causeway Coast and Glens Borough Council	1	Nitrogen dioxide	Road traffic
Derry City and Strabane District Council	4	Nitrogen dioxide	Road traffic
Fermanagh and Omagh District Council	0	-	-
Lisburn and Castlereagh City Council	1	Nitrogen dioxide	Road traffic
Mid and East Antrim Borough Council	2	Nitrogen Dioxide (1) and PM_{10} (1)	NO_2: Road traffic PM_{10}: Domestic Heating
Mid Ulster District Council	3	Nitrogen dioxide	Road traffic
Newry, Mourne and Down District Council	2	Nitrogen dioxide (1) and PM_{10} (1)	Road traffic
North Down and Ards District Council	0	-	-

4. Air Quality Monitoring Results for 2020

Monitoring in Northern Ireland

A wide range of air quality monitoring is carried out in Northern Ireland. Some monitoring sites are run as part of UK-wide monitoring networks; others are operated by district councils in order to meet local objectives.

The Air Quality Standards Regulations require Northern Ireland to be divided into 'zones' for reporting purposes. Northern Ireland comprises two reporting zones – the 'Belfast Metropolitan Urban Area' agglomeration (the conurbation of Greater Belfast), and the 'Northern Ireland' zone (the rest of the region). The Regulations then specify how many monitoring sites (or 'stations') are needed in each zone (based on its size and population). Only sites which meet the stringent siting criteria of the Regulations may be used for reporting compliance. The Regulations' siting criteria are different from those used for LAQM: for example, sites located close to major road junctions are used in LAQM but must not be used for compliance monitoring purposes. There are also different criteria regarding relevant public exposure.

The following pollutants were monitored in Northern Ireland during 2020:

- Carbon monoxide (CO);
- Oxides of nitrogen (NO_x), comprising nitric oxide (NO) and nitrogen dioxide (NO_2);
- Sulphur dioxide (SO_2);
- Particles (as PM_{10}, $PM_{2.5}$, and black carbon);
- Ozone (O_3);
- Benzene;
- Polluting elements – including lead, arsenic, cadmium, nickel and mercury; and
- Polycyclic Aromatic Hydrocarbons (PAH).

There were 21 air quality monitoring stations that operated for all or part of 2020 in Northern Ireland. Each was equipped with continuous monitoring equipment for one or more of the pollutants for which automatic methods are used: CO, NO_x, SO_2, PM_{10}, $PM_{2.5}$, O_3, and black carbon, and/or a non-automatic sampler for PAH. These sites (shown previously in Figure 1.1) provide information on a wide range of pollutants. Data from the continuous monitoring sites are communicated rapidly to the public via the website www.airqualityni.co.uk and the Northern Ireland Air app, which can be downloaded free of charge from https://www.airqualityni.co.uk/stay-informed. Public health warnings are issued when levels are forecast to, or reach 'high' levels as defined by the Daily Air Quality Index (see https://uk-air.defra.gov.uk/air-pollution/daqi for an explanation of this Index).

Seven of the automatic monitoring sites (Armagh Lonsdale Road, Ballymena Antrim Road, Ballymena Ballykeel, Belfast Centre, Belfast Stockman's Lane, Derry/Londonderry Rosemount and Lough Navar) were part of the UK's national monitoring network and were used to assess compliance with the Air Quality Standards Regulations. Non-automatic monitoring techniques are used for benzene, metallic pollutants, and PAHs. Some of these measurements are used to assess compliance with the Air Quality Standards Regulations and the Air Quality Strategy.

Upgrade of PM Monitoring Instruments in 2020

The Filter Dynamic Measurement System (FDMS) instrument has been used to measure PM_{10} and $PM_{2.5}$ at many of Northern Ireland's monitoring sites, including those which are part of the national monitoring network. However, many of these instruments were approaching the end of their functional lifetime, and the FDMS is no longer supported by the manufacturer. Therefore in 2018 the Environment Agency began a programme of upgrades, replacing old FDMS with new instruments of different types. Lough Navar, Belfast Centre and Derry Rosemount all had their FDMS replaced in 2018 and 2019. The FDMS at Armagh Lonsdale Road was replaced in February 2020.

The replacement of this last FDMS in Northern Ireland has had implications for sites using the unmodified Tapered Element Oscillating Microbalance (TEOM), which relied on the availability of nearby FDMS data in order to make use of the Volatile Correction Model (VCM). This issue is discussed below.

DAERA have funded the replacement of the TEOM at North Down Holywood A2 (in November 2020) and subsequently Lisburn Dunmurry Seymour Hill and Ballymena Ballykeel in 2021.

The Volatile Correction Model

Four of Northern Ireland's eleven PM_{10} monitoring sites used the Tapered Element Oscillating Microbalance (TEOM) to measure PM_{10} during 2020. The relatively high operating temperature of the TEOM (necessary to prevent condensation on the filter) can result in the loss of volatile components of the particulate matter sampled, causing under-estimation of the PM_{10} concentration. However, the data have historically been corrected for this using the Volatile Correction Model (VCM) developed by King's College, London and now administered by Imperial College, London. The VCM uses data from Filter Dynamic Measurement Systems (FDMS) PM_{10} analysers in the region, which measure both the volatile and non-volatile fractions, to calculate an appropriate correction based on the location of the instrument and the period of the measurements. The resulting corrected measurements have been demonstrated as equivalent to the European reference method. For more information, visit the Volatile Correction Model page[2]. This issue only arises for PM_{10}: there is at present no requirement to correct TEOM measurements of $PM_{2.5}$.

The ability of the VCM to calculate a reliable volatile correction depends on there being an FDMS within a specified distance. Historically this has been 130 km. However, as explained above, the FDMS instruments are reaching the end of their functional lifetime, and are no longer supported by the manufacturer. Since the last FDMS was replaced in Northern Ireland on 6th February 2020, there has no longer been data available for the VCM in Northern Ireland. Therefore, with the agreement of Imperial College London, to correct the TEOM PM_{10} data presented in this report to gravimetric equivalent using the VCM data, the radius has been extended to 200 km for all data as of 1st January 2020, to the end of 2020 and into 2021. No change has been made to earlier years' data.

The affected sites in 2020 are: North Down Holywood A2 (until November 2020), Lisburn Dunmurry Seymour Hill, Ballymena Ballykeel and Strathfoyle Bawnmore Place, but as explained above the VCM has been applied and we are confident that the data from these sites are reliable.

[2] http://www.volatile-correction-model.info/

Key Results for 2020

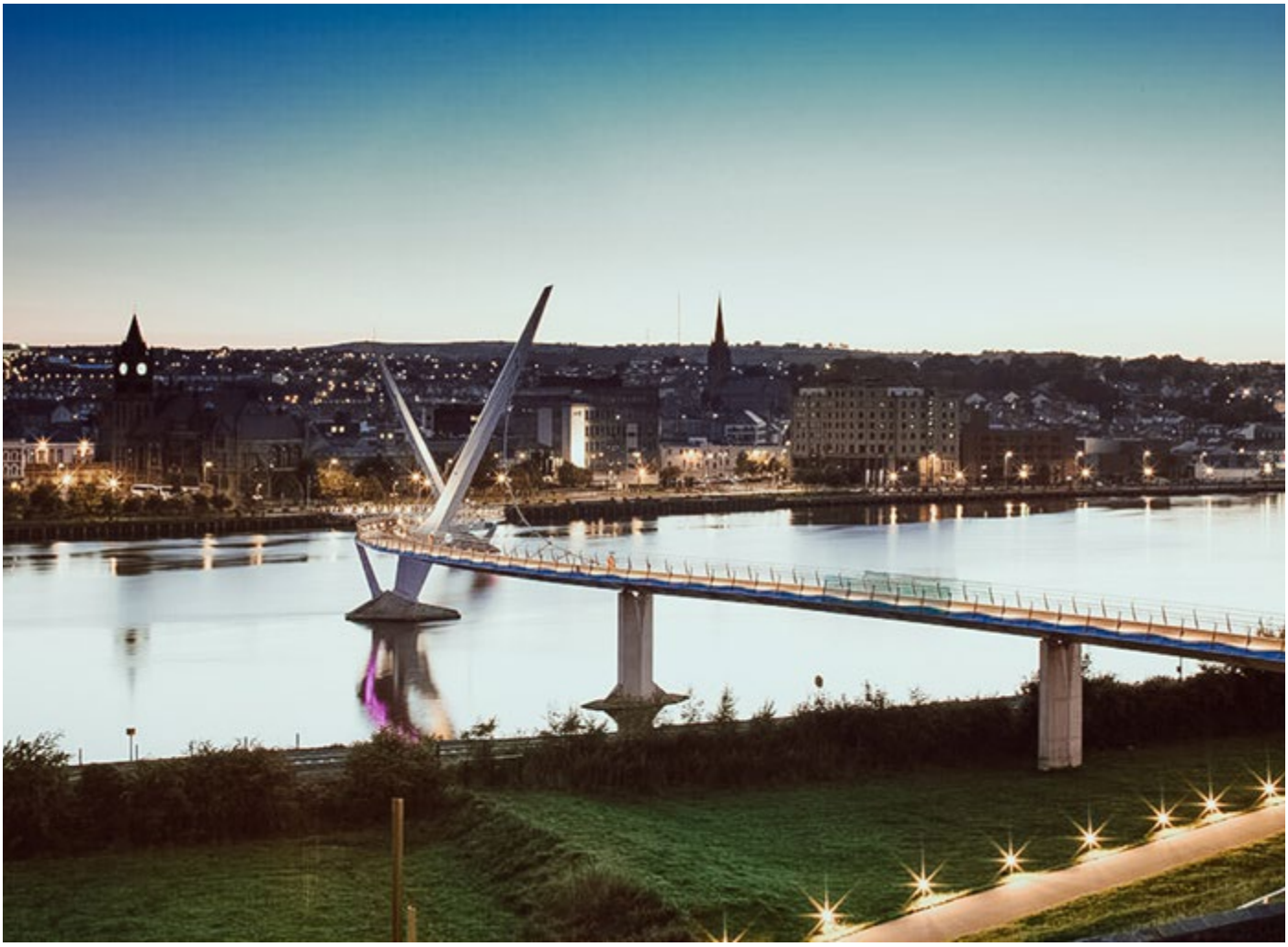
This section summarises key monitoring results from 2020, including compliance with Air Quality Standards Regulations limit values and the corresponding Air Quality Strategy (AQS) objectives. Further information is provided on the Northern Ireland Air website.

Carbon Monoxide was monitored using an automatic instrument at one site – Belfast Centre. The results were well within the Regulations limit value and AQS objective for this pollutant and have been for many years.

Benzene was monitored at one site, Belfast Centre, which met the annual mean limit value and AQS objective (for the running annual mean) in 2020, as it has for many years.

Metallic and Other Polluting Elements including lead, arsenic, cadmium and nickel – were monitored using non-automatic techniques at Belfast Centre, as part of the Heavy Metals Network. The results for 2020 were within the annual mean limit value and AQS objective for lead, and within the Regulations annual mean target values for arsenic, cadmium and nickel.

Sulphur Dioxide was monitored at five automatic sites during 2020. All sites met the limit values for SO_2 (1-hour and 24-hour mean), and the AQS objective for the 15-minute mean. (Note: one site, Ballymena Ballykeel, had limited data capture of 39% in 2020.)



Derry Peace Bridge, Tourism NI

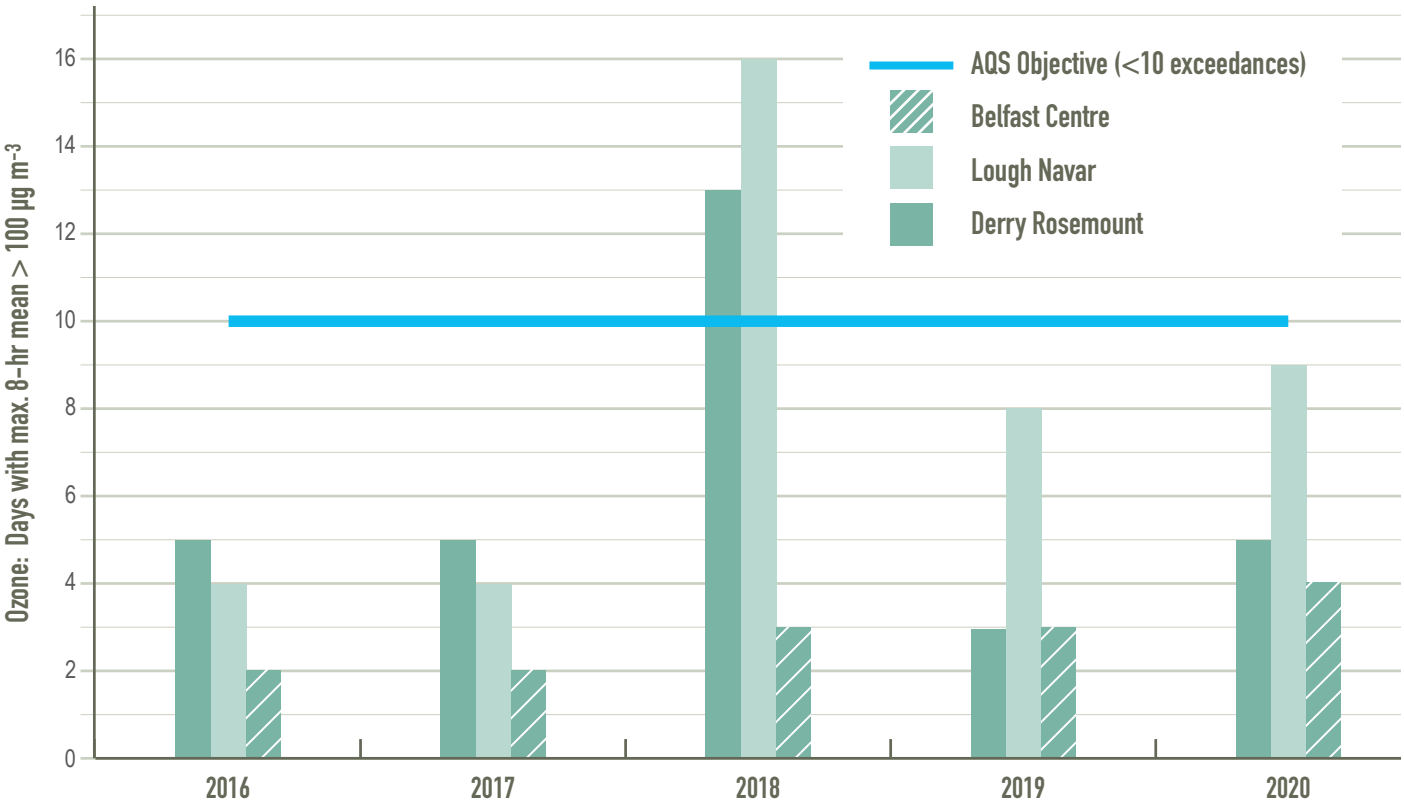
Ozone was monitored at Belfast Centre, Derry Rosemount, and the rural Lough Navar site. No sites exceeded the target value for human health of 120 µg m^{-3} (for the maximum daily 8-hour mean) on more than the permitted 25 days or exceeded the more stringent AQS objective of 100 µg m^{-3} on more than the permitted 10 days in 2020 (Figure 4-1).

Unlike some other pollutants, levels of ozone (O_3) in Northern Ireland do not appear to be decreasing but remain variable from year to year. Ozone exceedances happen in some years but not others. The reasons for this relate to how ozone is formed: it is a 'secondary' pollutant – that is, it is formed by reactions involving other pollutants, in the presence of sunlight, and over several hours. This means that the number of ozone exceedances in any given year depends substantially on weather conditions. There is also evidence that the 'hemispheric background' concentration of O_3 has increased since the 1950s due to the contribution from global human activities.

O_3 exceedances therefore remain possible in future. Ozone is also a 'transboundary' pollutant: once formed it may persist for several days and be transported over long distances. This means that much of the ozone measured in a particular area may have been generated elsewhere, and so it is more difficult to reduce concentrations by local action.

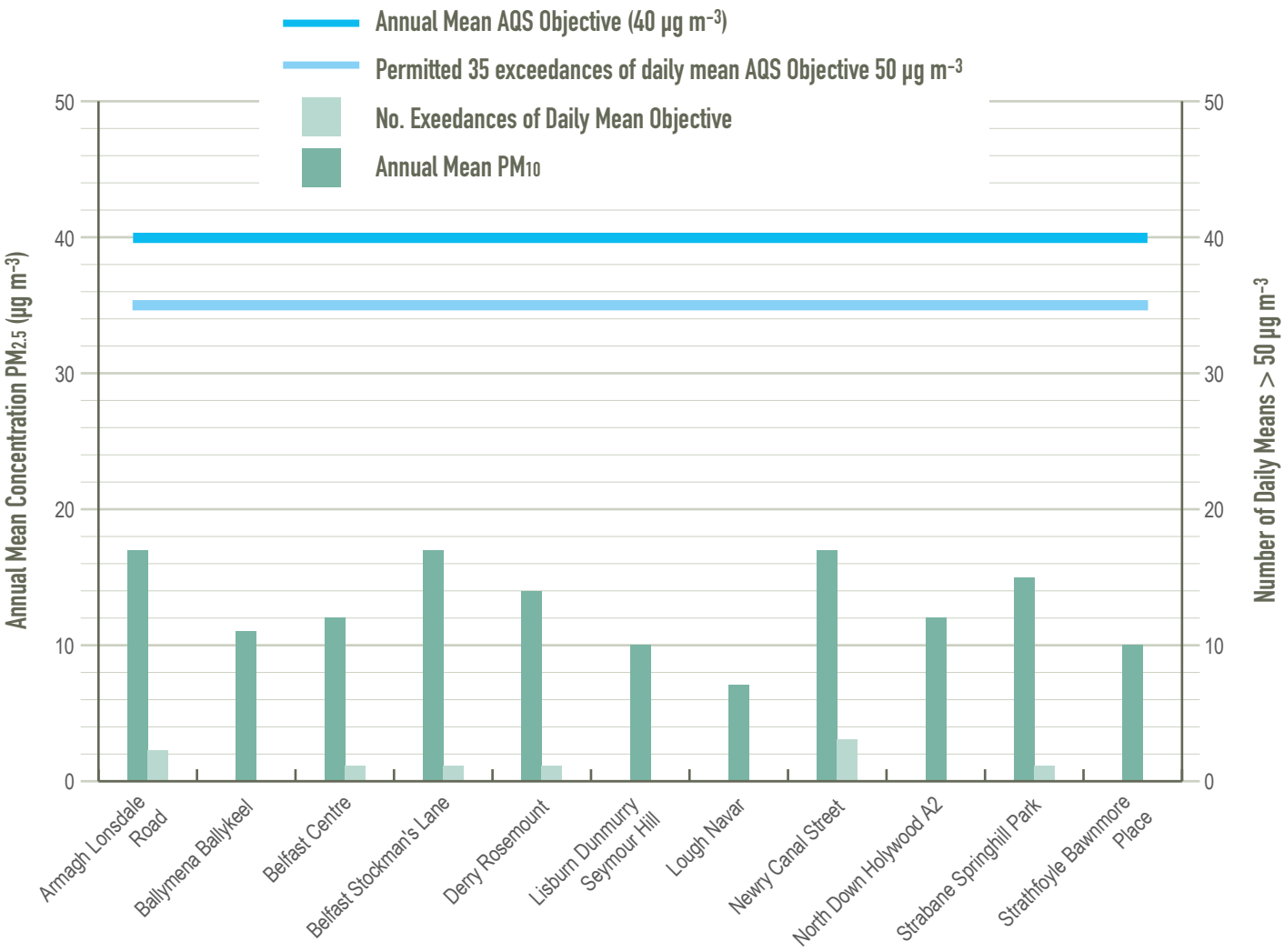
River Lagan, Northern Ireland

Figure 4.1: Days with Maximum 8-hour mean Ozone Concentrations > 100 µg m^{-3} for Five Years 2016-2020.



Particulate Matter PM_{10} Particulate matter as PM_{10} was monitored at eleven locations in 2020. Figure 4-2 shows the annual mean PM_{10} concentrations (shown by the darker coloured bars), and the number of exceedances of the daily mean limit value and objective (shown by the lighter coloured bars). As explained above, four of these sites (Ballymena Ballykeel, North Down Holywood A2, Lisburn Dunmurry Seymour Hill, and Strathfoyle Bawnmore Place) used the TEOM instrument during all or part of 2020, so data from these sites have been corrected to the gravimetric equivalent using the King's College Volatile Correction Model as explained earlier in this section – with an increased radius of 200 km. North Down Holywood A2 was replaced with a Fidas 200™ (a type of optical monitoring instrument which can measure both PM_{10} and $PM_{2.5}$ at the same time) in November 2020, therefore, data at this site were only VCM-corrected for the period while the TEOM was in use. All sites met the limit value and objective of 40 µg m^{-3} for annual mean PM_{10}, and no sites exceeded the daily mean limit value and objective of 50 µg m^{-3} on more than the maximum permitted 35 occasions during the year (after VCM correction if applicable). All sites had data capture rate of 85% or greater.

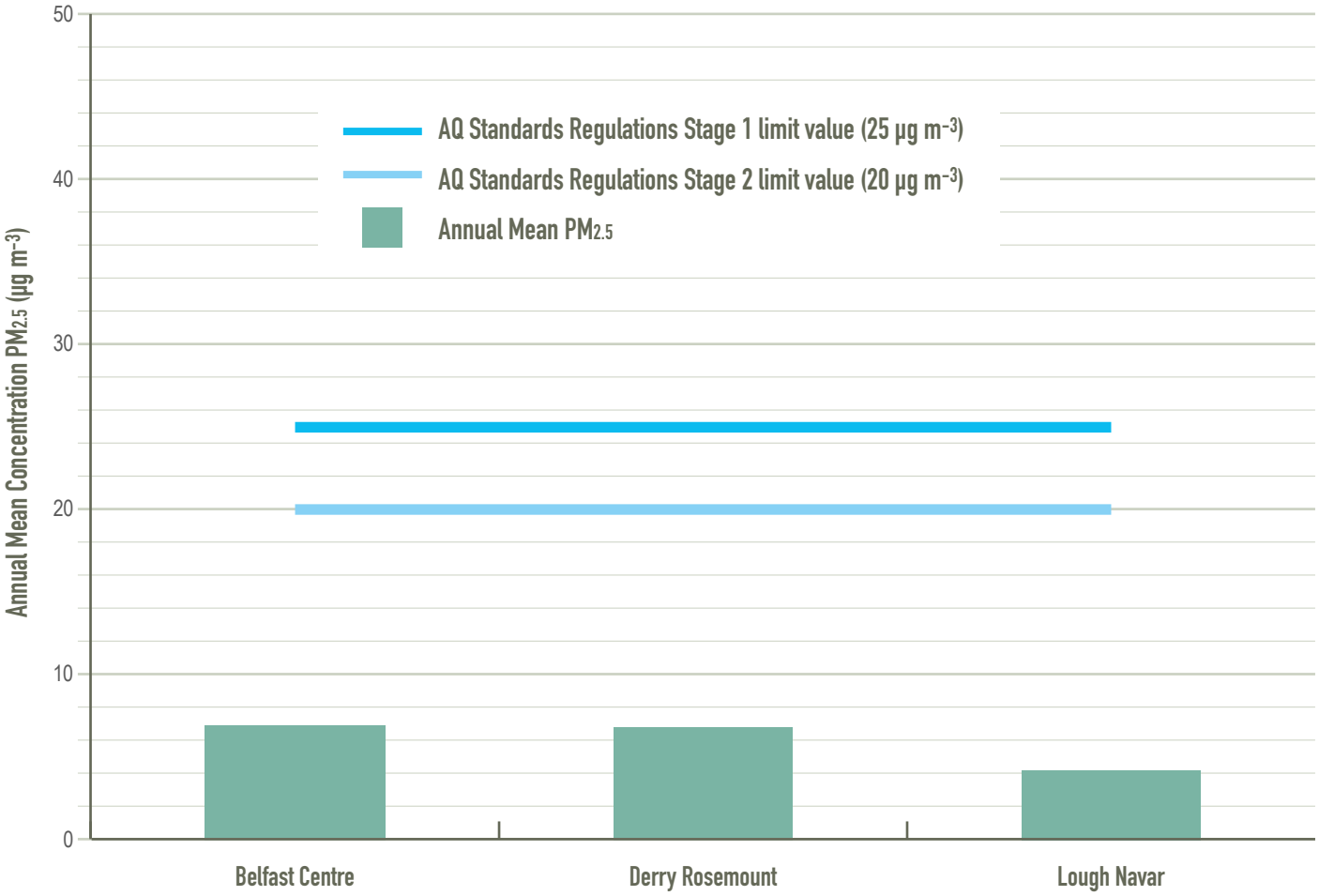
Figure 4.2: Annual Mean PM_{10} Concentrations and Exceedances of Daily Mean Objective, 2020.



Particulate matter $PM_{2.5}$ Fine particulate matter as $PM_{2.5}$ was continuously monitored at three sites in 2020; Belfast Centre, Derry Rosemount and Lough Navar. Figure 4-3 shows the annual mean $PM_{2.5}$ concentrations at these three sites for 2020. All three sites reported annual mean $PM_{2.5}$ concentrations well below the Regulations Stage 1 limit value of 25 µg m^{-3} (which had to be met by 1st Jan 2015). Levels were also below the Stage 2 limit value of 20 µg m^{-3} (which had to be achieved by 1st Jan 2020). North Down Holywood A2 began monitoring $PM_{2.5}$ in November 2020. Its first valid annual mean for $PM_{2.5}$ will therefore be reported in the 2021 report.

(Lisburn Dunmurry Seymour Hill and Ballymena Ballykeel's new monitoring instruments are also capable of measuring both PM_{10} and $PM_{2.5}$, so both these sites began measuring $PM_{2.5}$ in January 2021 and June 2021 respectively).

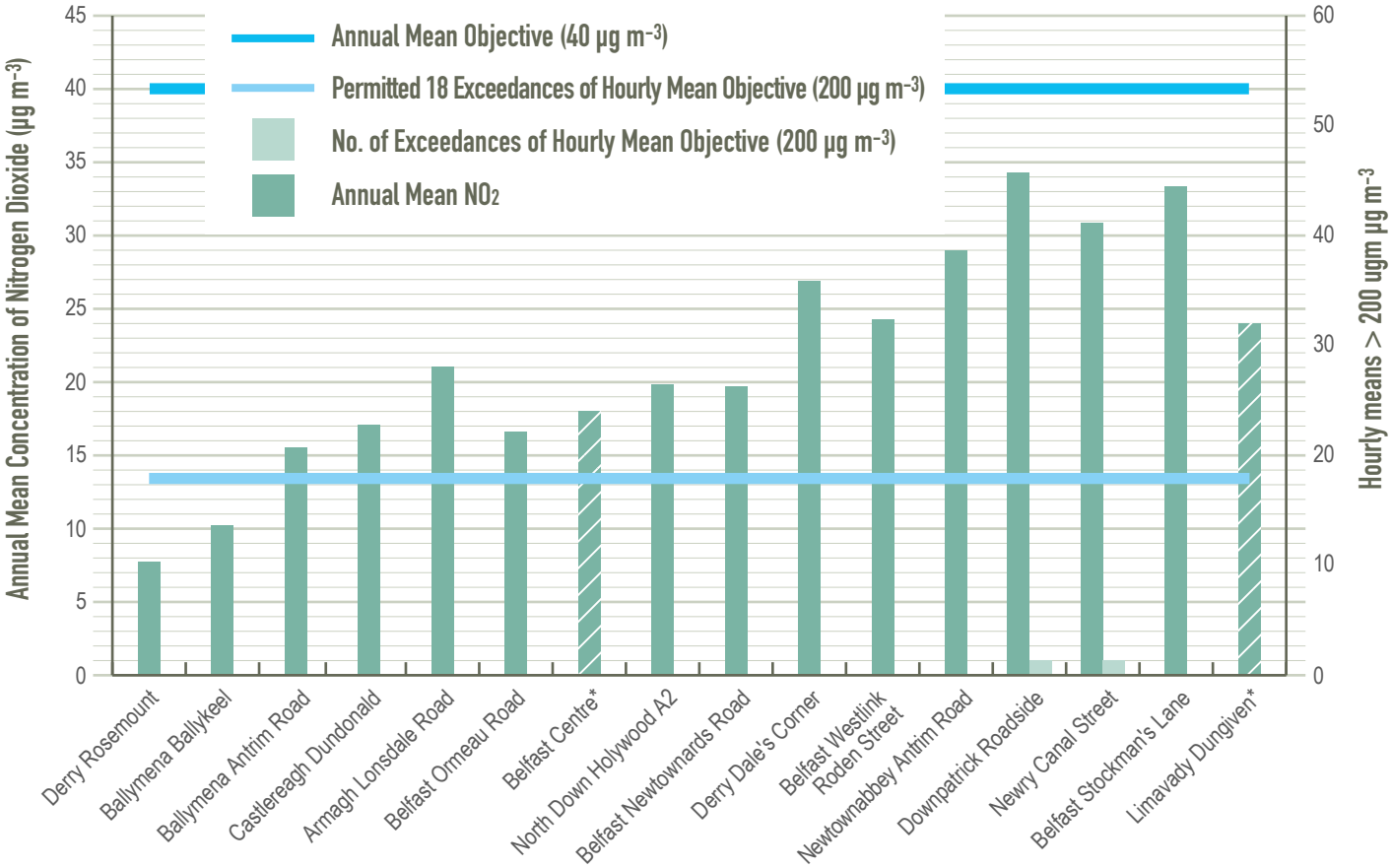
Figure 4.3: Annual Mean $PM_{2.5}$ Concentrations and Exceedances of Daily Mean Objective, 2020.



Nitrogen Dioxide was monitored using automatic analysers at 16 sites during 2020. Figure 4-4 shows the annual mean NO_2 concentrations (shown by the darker coloured bars), and the number of exceedances of the hourly mean objective (shown by the lighter coloured bars). For sites with less than 75% data capture, the data have been annualised to estimate the annual mean as per the procedure laid out in LAQM TG(16) (Box 7.9)[3]. This was the case for Limavady Dungiven and Belfast Centre, in 2020. To perform annualisation, data from two to four nearby continuous background monitors with capture rates greater than 85% should be used to calculate an annualisation factor. Data from Derry Rosemount and Ballymena Ballykeel were used to calculate an annualisation factor and estimate the annual mean for Limavady Dungiven. In the case of Belfast Centre, there was only one nearby background site with data available, therefore annualisation in this case was performed using data from four nearby roadside sites (Belfast Newtownards Road, Belfast Ormeau Road, North Down Holywood A2, and Belfast Westlink Roden Street).

No sites exceeded the AQS objective for annual mean NO_2 concentration (40 µg m^{-3}) or exceeded the hourly mean limit value of 200 µg m^{-3} on more than the permitted 18 occasions, in 2020. Where the data capture is less than 85%, exceedance of the hourly mean objective is judged on whether the 99.8th percentile of hourly values has exceeded 200 µg m^{-3} rather than the number of hourly means above the objective. In 2020, the two sites with data capture rates below 85%: Belfast Centre and Limavady Dungiven, the 99.8th percentile of hourly values were below 200 µg m^{-3}.

Figure 4.4: Annual Mean NO_2 Concentrations and Exceedances of Hourly Objective, 2020.



*** Asterisk indicates sites with < 85% data capture**
Where the valid data capture is less than 75%, the means have been "annualised" and shown as a striped bar

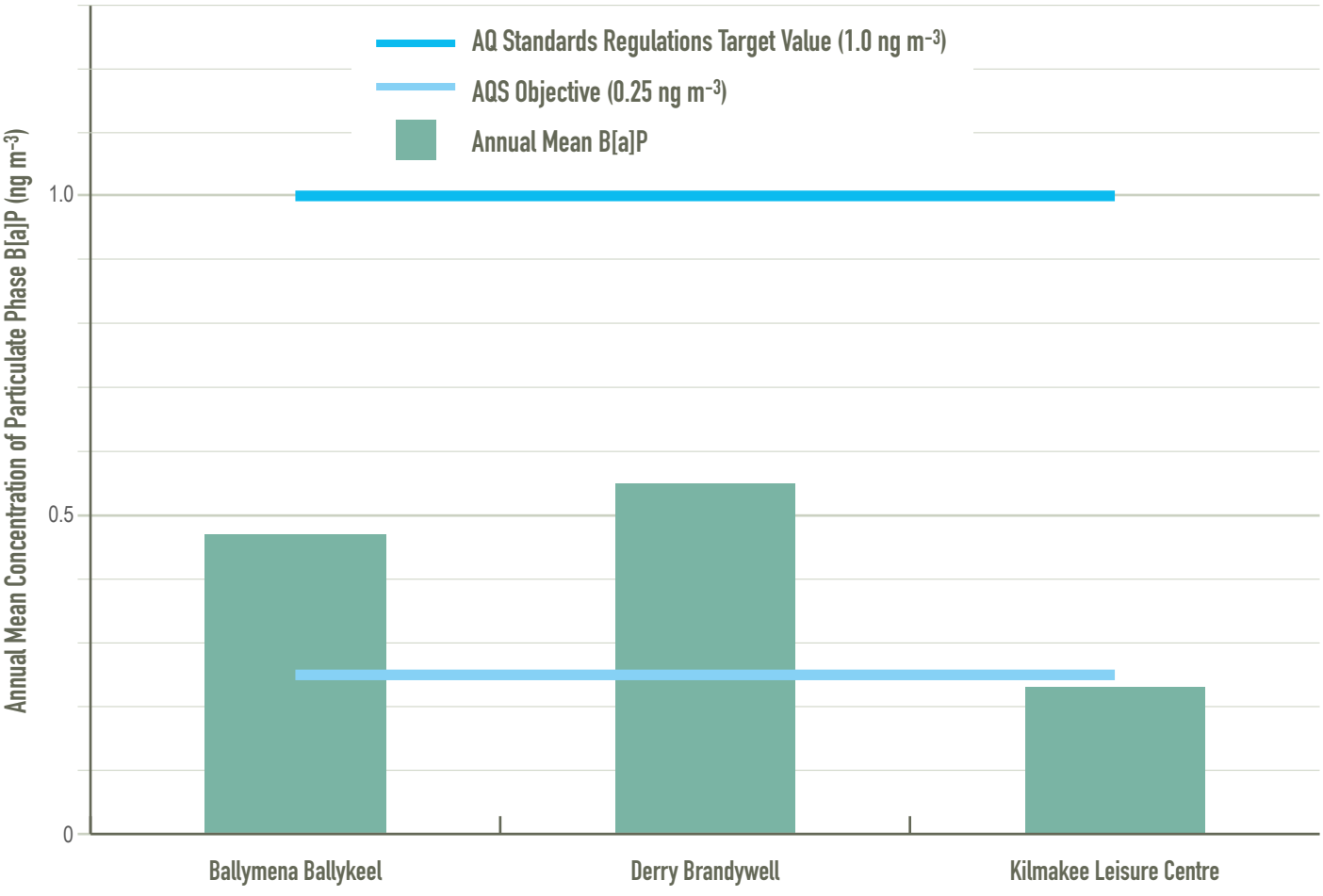
[3] Local Air Quality Management - New Technical Guidance TG(16): Available at https://laqm.defra.gov.uk/technical-guidance/

Annual mean NO_2 concentrations in 2020 were typically lower than in previous years, in part due to the Covid-19 pandemic and lockdown measures. Not since 2002 (when there were only four sites monitoring NO_2 with automatic analysers) has there been a year when no sites exceeded the annual mean NO_2 limit value within the Northern Ireland automatic monitoring network. Further information and analysis on the impact of Covid-19 on NO_2 in Northern Ireland is provided in Section 6.

Polycyclic Aromatic Hydrocarbons (PAHs) were monitored at three sites in 2020; Ballymena Ballykeel, Derry Brandywell and Kilmakee Leisure Centre in Dunmurry. All are part of the UK PAH Monitoring Network. The network measures a range of PAH compounds, but one species in particular, benzo[a]pyrene (B[a]P), is used as a 'marker' for PAH compounds and is the subject of an AQS objective and Air Quality Standards Regulations target value.

Figure 4-5 shows the annual mean concentrations at these three sites for 2020. No site exceeded the target value of 1 ng m^{-3} for annual mean B[a]P concentration during 2020 (which was to be met by 31st Dec 2012). Two of the sites (Ballymena Ballykeel and Derry Brandywell) exceeded the more stringent AQS annual mean objective of 0.25 ng m^{-3} for this PAH species, which was to have been achieved by 31st Dec 2010.

Figure 4.5: Annual Mean Concentrations of Benzo[a]pyrene for 2020.



Belfast City Hall, Tourism NI

Summary

Regulations limit values, target values and corresponding AQS objectives, have been met for the following pollutants in Northern Ireland –

- Particulate matter as PM_{10}
- Nitrogen Dioxide
- Ozone
- Carbon monoxide
- Benzene
- Sulphur dioxide
- The elements lead, arsenic, cadmium and nickel.

Of the three sites that measured $PM_{2.5}$, all met the Regulations Stage 1 (25 µg m^{-3}) and Stage 2 (20 µg m^{-3}) limit values for $PM_{2.5}$.

No site exceeded the target value for benzo[a] pyrene. However, two of the three sites where this pollutant is monitored continue to exceed the more stringent AQS objective.

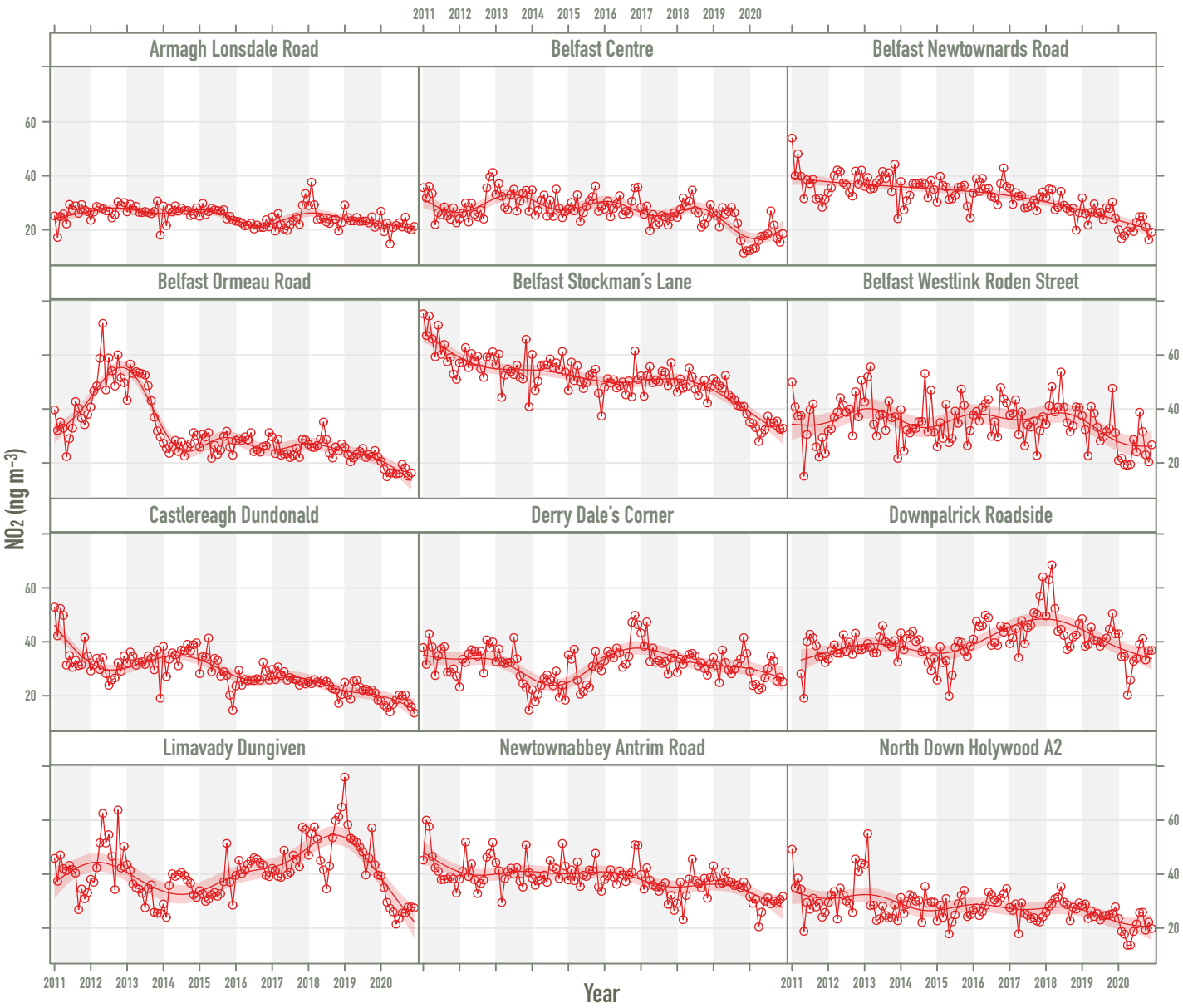
As a result of lockdown measures, no sites in the network exceeded the annual mean objective for NO_2, for the first time since 2002. Whether the NO_2 concentrations will return to pre-lockdown levels, and further exceedances occur, remains to be seen.

5. Air Quality Changes Over Time

This section looks at how NO_2 in Northern Ireland has changed over the past decade, as this pollutant is responsible for most of the exceedances of AQS objectives that occur in Northern Ireland.

Figure 5.1 shows the trend in NO_2 for twelve sites in Northern Ireland with long-term data available from 2011 to 2020. The trend line is determined using the "smoothTrend" function in Openair: a free, open-source software package of tools for analysis of air pollution data. Openair was developed by King's College London with the University of Leeds.

Figure 5.1: Smoothed trend plot for NO_2 at 12 sites in Northern Ireland from 2011 to 2020. The circles represent the monthly means calculated from the hourly data, the line is the smooth trend fit, and the shaded region the 95% confidence intervals in the trend.



For more information on this package please see http://www.openair-project.org/ The smoothed trend line is calculated using generalised additive modelling (GAM) and the shaded areas represent the 95% confidence intervals of the smoothed fit. The data has been "de-seasonalised" to statistically remove the influence of seasonal cycles. The de-season option also fills any gaps in the dataset by a linear interpolation method; therefore, the datasets shown in these plots appear uninterrupted, though this is not necessarily the case.

For most sites a general decrease in NO_2 concentrations over the 10 year period is observed. However, there are some sites where there is much more variability, with periods of higher NO_2 concentrations. One example is Belfast Ormeau Road, where NO_2 concentrations increased in 2012, then decreased again. This increase in NO_2 has been commented on in previous annual reports and has been attributed to changes in traffic management during this period. An increase in NO_2 concentrations is also observed at Downpatrick Roadside and Limavady Dungiven, peaking between 2018 and 2019 before decreasing again.

To determine the overall trend in NO_2 over the ten years, analysis has been performed using the Openair 'TheilSen' tool, based on the Theil-Sen statistical method. The trend analysis is based on monthly mean pollutant concentrations, calculated here from hourly mean data. The data has been 'de-seasonalised' to remove the influence of seasonal cycles, thus providing a clearer indication of the overall trend over the relevant time. Similar to the smoothTrend function, when the de-season option is used gaps in the dataset are filled by a linear interpolation method. The trend (in units of $\mu g\ m^{-3}$ per year) along with the 95% confidence intervals from the Theil-Sen trend analysis are presented in Table 5-1, for the twelve sites. The p-value is also shown and provides an indication of whether the trend is statistically significant, and at which level.

Table 5.1: Theil-Sen trend analysis results for NO_2 at 12 sites in Northern Ireland, from 2011 to 2020.

Site	slope ($\mu g\ m^{-3}$ /year)	95% CI ($\mu g\ m^{-3}$ /year)	p-value
Belfast Stockman's Lane	-2.33	[-2.72, -1.89]	< 0.001
Belfast Ormeau Road	-2.21	[-2.91,-1.83]	< 0.001
Castlereagh Dundonald	-1.88	[-2.25,-1.58]	< 0.001
Belfast Newtownards Road	-1.73	[-2.09,-1.41]	< 0.001
Newtownabbey Antrim Road	-1.05	[-1.39,-0.75]	< 0.001
Belfast Centre	-1.00	[-1.41,-0.55]	< 0.001
North Down Holywood	-0.83	[-1.19,-0.50]	< 0.001
Armagh Lonsdale Road	-0.62	[-0.78,-0.48]	< 0.001
Downpatrick Roadside	+0.57	[0.20,0.99]	< 0.01
Belfast Westlink Roden Street	-0.66	[-1.19,-0.06]	< 0.05
Derry Dale's Corner	-0.26	[-0.63,0.12]	No significant trend
Limavady Dungiven	+0.44	[-0.43,1.43]	No significant trend

Eight of the twelve sites presented here show a decreasing trend in NO_2 from 2011 to 2020, statistically significant at the 0.001 level. Belfast Stockman's Lane and Belfast Ormeau Road both show an average reduction in NO_2 greater than 2 µg m^{-3} per year over the period analysed.

Analysis for NO2 concentrations measured at Downpatrick Roadside indicates an increasing trend of 0.57 µg m^{-3} per year

Prior to 2020, the monitoring site at Belfast Stockman's Lane consistently measured NO_2 concentrations above the annual mean AQS objective.

In 2020, the NO_2 annual mean concentration at Belfast Stockman's Lane was 33 µg m^{-3}, likely reflecting changes in emissions as a result of the Covid-19 lockdown (see Section 6 for further information). The overall downward trend over the past decade, however, suggests that NO_2 concentrations at this site are decreasing and should meet the annual mean AQS objective in future years.

In contrast, the analysis for NO_2 concentrations measured at Downpatrick Roadside indicates an increasing trend of 0.57 µg m^{-3} per year, from 2011 to 2020, significant at the 0.01 level. The smoothed trend plot in Figure 5.1 does appear to indicate a peak in NO_2 levels around 2018, followed by a decrease. However, over the past five years NO_2 concentrations at Downpatrick Roadside have exceeded the AQS objective for annual mean NO_2 each year, except for 2020, so further reductions in NO_2 concentrations may still be required to meet the AQS objective in future years.

Cranfield beach, Northern Ireland

6. Effects of Covid-19 lockdown on NI's Air Quality in 2020

As a result of the Covid-19 pandemic, restrictions came into operation in Northern Ireland in 2020. Firstly, advice on social distancing was introduced on 16th March, which was then followed by a full lockdown on 23rd March. The lockdown continued until some gradual easing of restrictions began towards the end of May 2020.

Passenger Wearing a Face Mask on the Metro, Translink NI

A study was undertaken to investigate the impact of the first lockdown on air quality in Northern Ireland[4], covering the period 1st January to 30th June. During the first lockdown the public were asked to only travel if necessary, and work from home where possible. These measures had a large impact on transport, businesses, and industrial activities. The full report includes an investigation of changes in emissions for different sectors and subsequent impact on air quality across Northern Ireland. Here, a summary of the methodology and main findings relating to key air pollutants are given.

To assess the impact of the lockdown in early 2020 on air quality in Northern Ireland, statistical models were used to predict what the pollutant concentrations would be under normal 'Business As Usual' (BAU) conditions[5]. The models were built and tested with the deweather R package[6], using hourly pollution data from the monitoring stations in Northern Ireland, and meteorological data from the Weather Research and Forecasting (WRF) regional scale model.

BAU concentrations for each pollutant of interest were modelled for the period 1st January to 30th June 2020, and subsequently compared to the measured concentrations over the same period.

To investigate any differences between BAU and measured concentrations, cumulative sum (cusum) analysis was applied. Cusum analysis sums up the differences between BAU and measured concentrations each day. If measured concentrations do not deviate from BAU, the cusum value will, on average, be zero. However, if the measured concentrations increase or decrease with respect to BAU, the cusum value will also increase or decrease over time.

[4] https://www.airqualityni.co.uk/documents/technical-reports/NI_Covid_ShortSummaryReport_Issue1.pdf
[5] The technical term for this modelled scenario is the 'counterfactual': here we have used the less formal 'business as usual'.
[6] https://github.com/davidcarslaw/deweather

Nitrogen Dioxide: Figure 6-1 shows the cusum analysis results of measured minus BAU daily mean NO_2 concentrations, for the period 1st February to 30th June 2020, for the 16 sites monitoring NO_2 across Northern Ireland. The light shaded region represents the period when social distancing measures started on 16th March 2020, and the darker shaded region represents the period from 23rd March 2020 onwards, when the first lockdown was in place.

In February the NO_2 cusum values are around zero, indicating that the BAU and measured concentrations are similar. Downpatrick Roadside and Newry Canal Street show some indication of a decrease prior to social distancing measures being introduced. However, for all sites shown here, a decrease in the NO_2 cusum value can be observed during the lockdown period. Whilst traffic count data was not available, the reduction in NO_2 is likely a result of the reduced traffic volumes experience in 2020.

Figure 6.1: The cumulative sum of measured minus business as usual NO_2 at a range of air pollution monitoring sites across Northern Ireland. (Flat lines and gaps indicate missing data.)

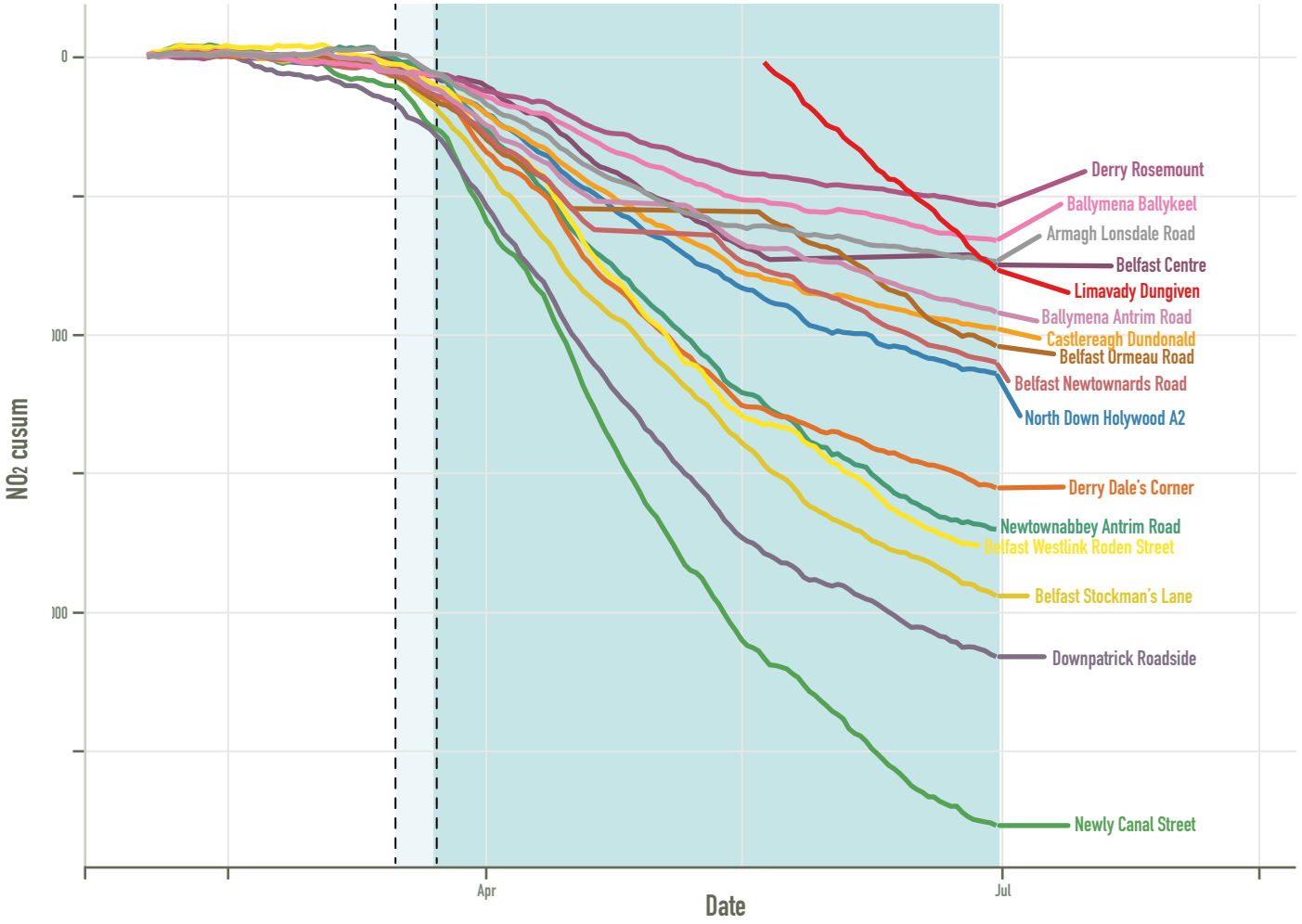
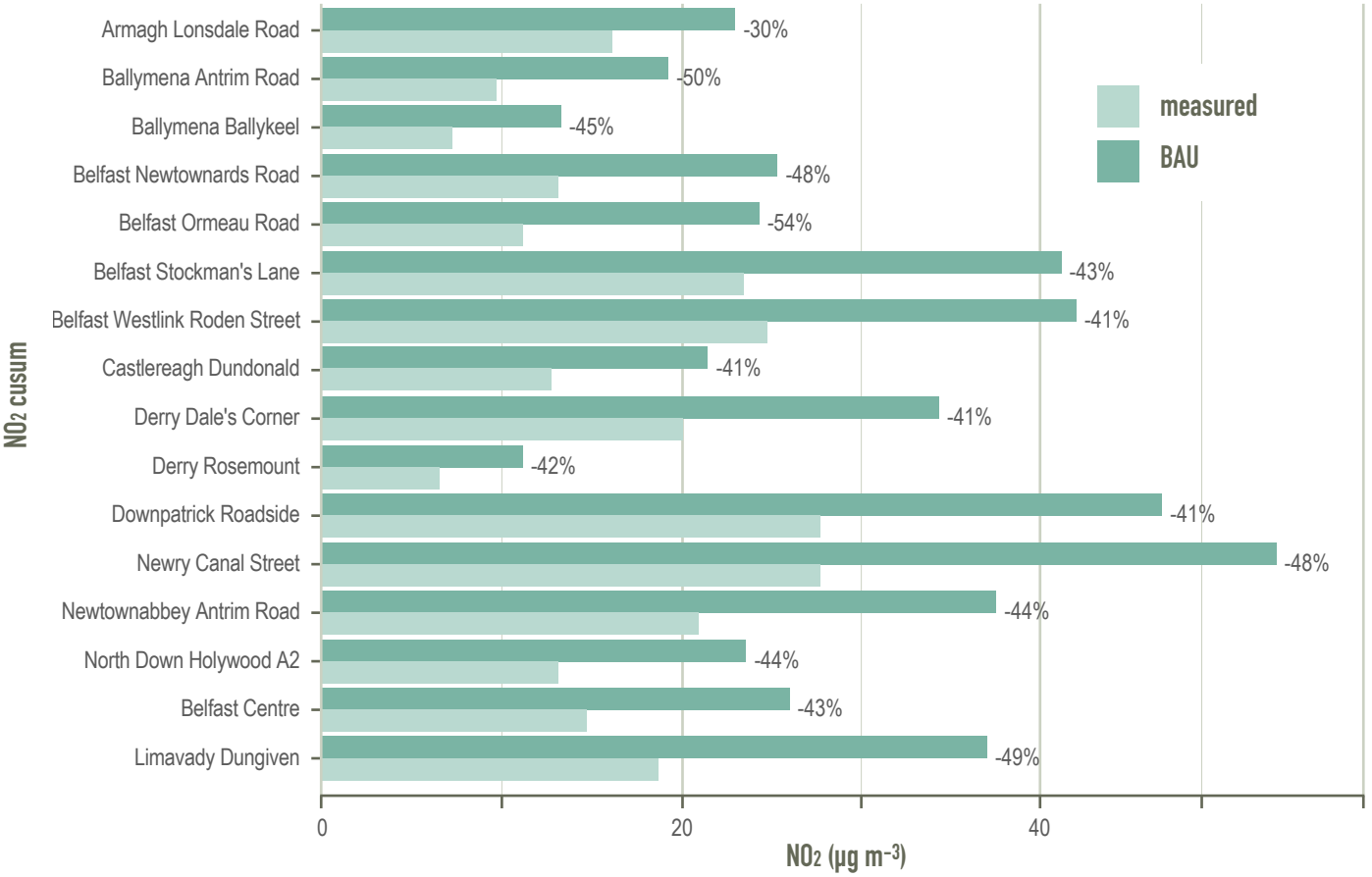


Figure 6.2: Measured and estimated 'business as usual' NO_2 concentrations by site. The numbers show the percentage change in concentration relative to business as usual.



Average measured and estimated 'business as usual' NO_2 concentrations over the period 23rd March to 30th June for each site are shown in Figure 6-2.

The percentage reduction in measured NO_2 from BAU, ranges from 30% to 54% over this period, with an average reduction over all sites of 44%.

Ozone: Results from the cusum analysis, applied to the three sites which measured ozone throughout 2020, are shown in Figure 6-3. At Belfast Centre (urban centre) and Derry Rosemount (urban background) an increase in measured O_3 concentrations during the lockdown period is clearly seen, whereas there is very little change at the rural Lough Navar site.

Figure 6.3: The cumulative sum of measured minus BAU O_3 at three monitoring sites across Northern Ireland.

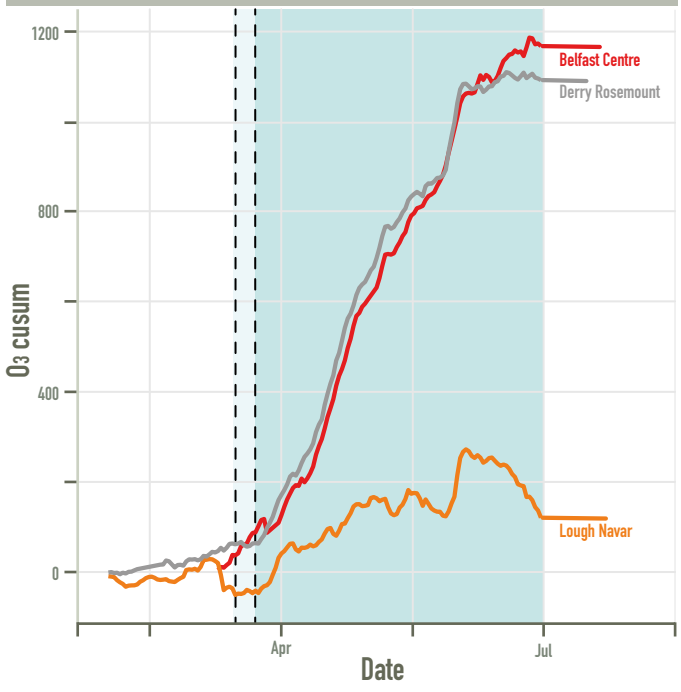


Figure 6.4: Measured and estimated BAU O_3 concentrations by site. The numbers show the percentage change in concentration relative to BAU.

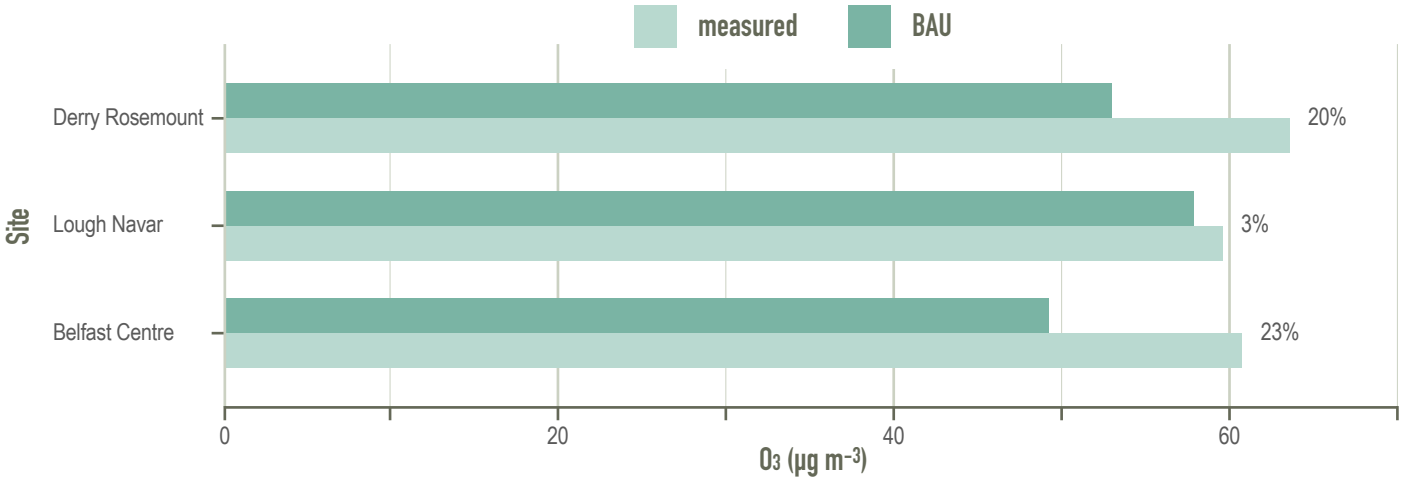


Figure 6-4 shows the average measured and estimated business as usual concentrations by site between 23rd March and 30th June. Increases in measured O_3 of 23% and 20% were observed for Belfast Centre and Derry Rosemount, respectively. At Lough Navar the observed increase in O_3 was much smaller, at 3%. The large increase observed at the two urban sites may be related to a decrease in NO_x in these areas. NO reacts readily with O_3, removing it from the atmosphere. With less NO available to scavenge O_3, an increase in O_3 concentrations may occur.

In addition, there was a noticeable change in weather conditions around the onset of lockdown, which is likely to have had an impact on the observed ozone levels. Prior to lockdown, the wind was predominantly strong and from a westerly direction, which typically brings clean air from the Atlantic Ocean to Northern Ireland. Between 23rd March and 30th June, the wind speeds dropped, and the wind direction was more variable. During April and May there were periods of warm and sunny weather with low wind speeds, conditions which are conducive to ozone formation.

Tollymore Forest Park, Northern Ireland

Particulate Matter: PM concentrations tend to be dominated by regional background levels rather than local primary emissions, which makes assessing changes in PM due to lockdown more challenging that other pollutants. One way to address this is to investigate changes in the urban increment in PM, i.e. concentrations above background levels. PM measurements at the rural Lough Navar site are used to represent the background concentrations. Note: as rural measurements of $PM_{2.5}$ at Lough Navar only started in July 2018, there was not enough data to perform a robust BAU model of the $PM_{2.5}$ increment, therefore the focus here is on PM_{10} only.

The cusum analysis of the urban increment in PM_{10} concentrations is shown in Figure 6-5. Some sites show an increase in the urban increment in PM_{10} concentrations during lockdown, and other sites show a decrease.

Average concentrations of measured and BAU PM_{10} increment for the period 23rd March to 30th June for each site are shown in Figure 6-6. Averaged across all sites the increment in PM_{10} was around 1 µg m^{-3} above BAU. As such, any conclusions on changes in PM_{10} should be considered as subject to greater uncertainty than the other pollutants investigated.

Figure 6.5: The cumulative sum of measured minus 'business as usual' for the increment in PM_{10} concentrations above regional background (Lough Navar) at air pollution monitoring sites across Northern Ireland.

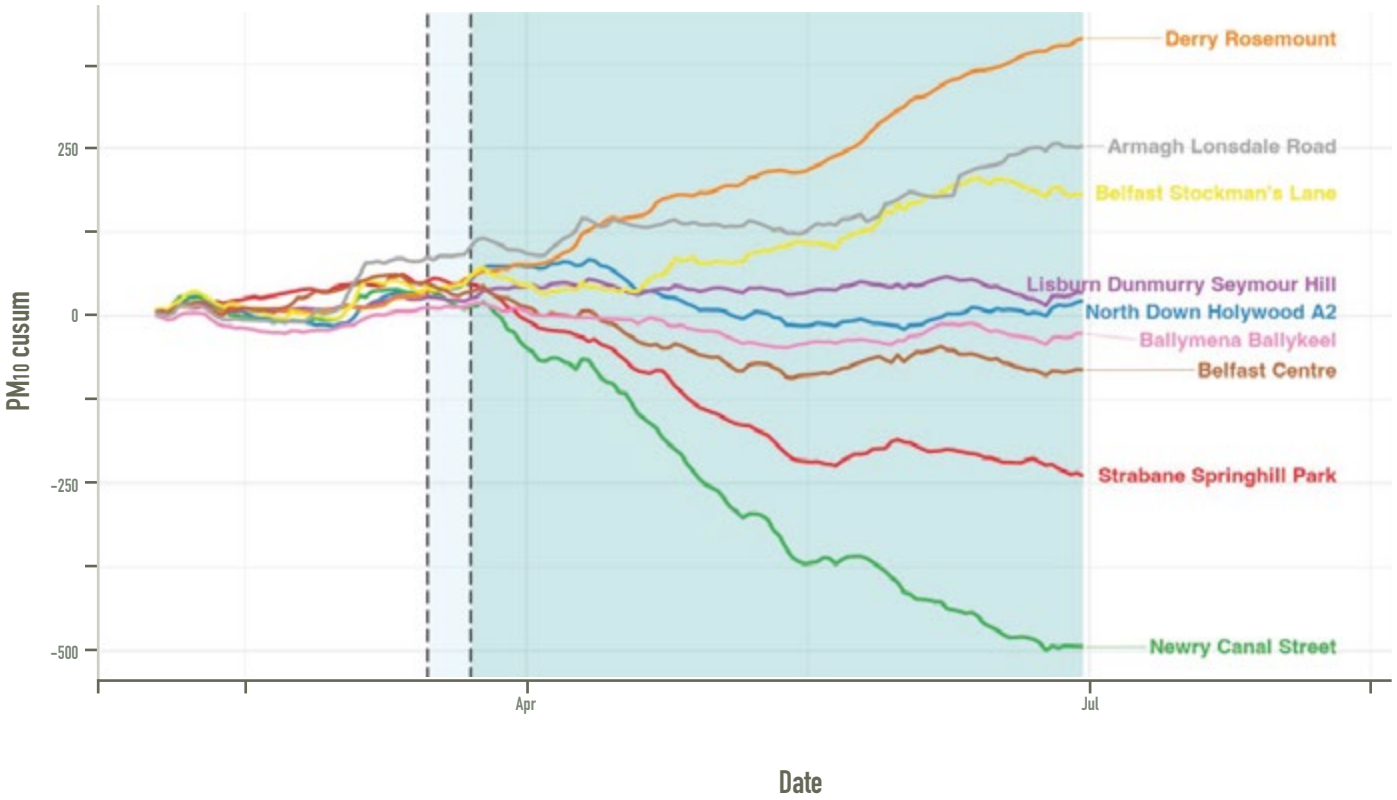
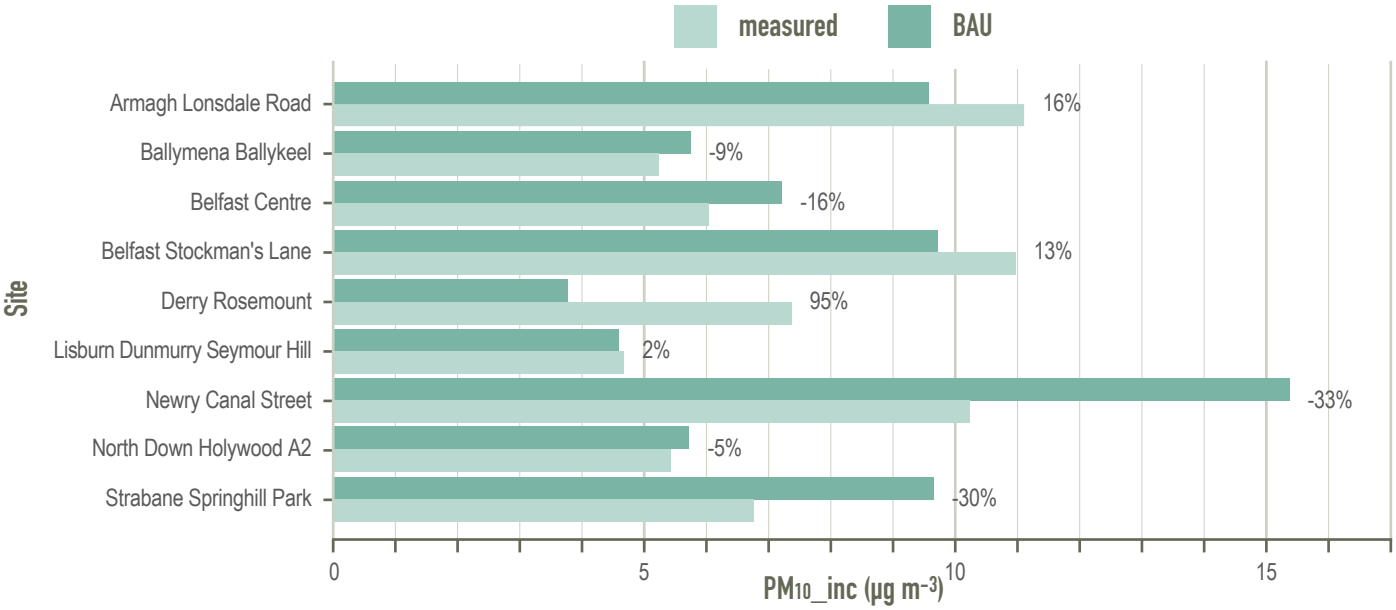


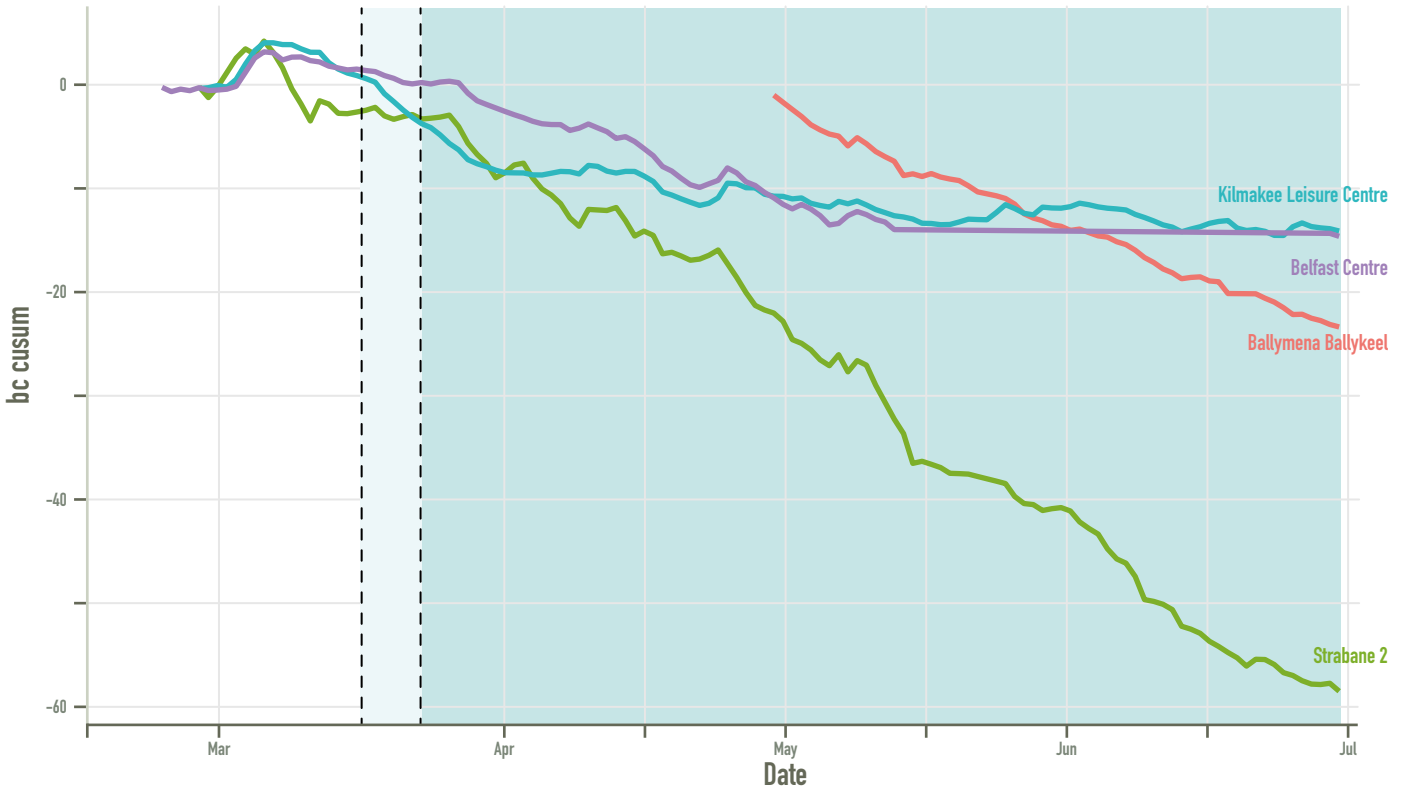
Figure 6.6: Measured and estimated 'business as usual' in the PM_{10} increment above regional background (Lough Navar) concentrations by site.



Black Carbon: Figure 6-7 shows the cusum analysis for black carbon at four sites in Northern Ireland. Two of these sites (Belfast Centre and Ballymena Ballykeel) have large periods of missing data but are shown for completeness.

There is clear evidence in a decrease in measured black carbon concentrations with respect to BAU at Strabane 2 (referred to as 'Strabane Springhill Park' in other networks). Kilmakee, on the other hand only shows weak evidence of a decrease in black carbon.

Figure 6.7: The cumulative sum of measured minus 'business as usual' BC at four monitoring sites in Northern Ireland.



Northern Ireland

Summary

The investigation into the effects of lockdown restrictions in early 2020 on air pollutants in Northern Ireland have shown:

- Measured NO_2 concentrations on average decreased by 44% between 23rd March and 30th June, when compared to the modelled BAU scenario over the same period.
- Ozone increased during lockdown at the two urban sites: Belfast Centre (23%) and Derry Rosemont (20%). The increase at the rural site at Lough Navar was much smaller, at 3%. The larger increase observed at the urban sites may be due to less NO available to scavenge O_3. Changes in meteorological conditions around the onset of lockdown, are likely to have also had an effect on the observed ozone levels.
- The cusum analysis of the urban increment in PM_{10} (i.e. PM_{10} concentrations above rural concentrations measured at Lough Navar) showed evidence of an increase in PM_{10} at some sites and a decrease at others. The overall change in PM_{10} was very small (1 µg m^{-3} above BAU) and subject to greater uncertainty than other pollutants.
- Strabane showed clear evidence of a decrease in measured black carbon concentrations during lockdown. Weaker evidence of a decrease in black carbon was observed at Kilmakee.

7. Measures, Initiatives and Reports

This section highlights some of the measures and initiatives taking place in Northern Ireland, which are expected to deliver improvements in air quality.

MyNI Campaign: MyNI is a government communications platform which uses social media to engage citizens and influence positive behavioural change through joined up digital communications. It aims to join up digital communications from Departments and other trusted bodies, to help drive calls-to-action that will motivate and enable citizens to change their behaviour. MyNI has delivered a series of mini campaigns on a range of environmental issues over the last couple of years that have demonstrated very high levels of engagement and tangible results.

MyNI ran a successful mini campaign in November and December 2019, promoting and encouraging users to respond to the NI Environment Strategy discussion document. That campaign also integrated messages and calls-to-action under air quality, cycling, public transport and health. Levels of reach and engagement with this content were high, demonstrating the high levels of interest among audiences in these cross-cutting issues.

From 27th March until 3rd June 2020, MyNI delivered a multi-streamed campaign called MyEco2020. It promoted 3 simultaneous, cross-cutting streams of campaign activity on Air Quality, Biodiversity and Food Waste Recycling. This 6-week campaign saw an increase in followers on MyNI Facebook (up 7%), Twitter (up 4%) and Instagram (up 9%).

Feedback from 161 MyNI users found that the number of people who were moderately interested in Air Quality increased by 3%, and 6% were influenced by MyNI to download the DAERA Air Quality app; and 25% said they felt better informed about Air Quality.

Activity on the MyNI communications platform will cease at the end of 2021.

The agriculture sector is responsible for the majority of ammonia emissions in Northern Ireland.

Ammonia Reduction: Northern Ireland is a relatively high contributor to ammonia emissions. In 2019, Northern Ireland accounted for 12% of the UK's total ammonia emissions despite having only 3% of the UK's population and 6% of the UK's land mass. The agriculture sector is responsible for the majority of ammonia emissions in Northern Ireland, in 2019 agriculture accounted for almost 97% of the ammonia emissions[7]. Ammonia emissions in Northern Ireland peaked in the late 1990s and by 2010, ammonia emissions were 17% less than they had been in 1998. From 2010 to 2017 ammonia emissions increased by 17% due primarily to a trend of increasing livestock numbers, greater use of indoor housing systems, and insufficient uptake of ammonia reduction measures.

[7] Air Pollutant Inventories for England, Scotland, Wales, and Northern Ireland: 2005-2019: https://naei.beis.gov.uk/reports/reports?report_id=1030

Since 2017, the trend has plateaued, however, with slight declines in dairy cattle numbers and in mineral fertiliser use being offset by an increase in poultry numbers. DAERA is developing an ammonia strategy to achieve the sustained and tangible reductions in ammonia emissions which will facilitate a flourishing environment and a sustainable and prosperous farming sector while facilitating the sustainable development of a prosperous agri-food sector. A consultation document is due to be published in late 2021.

Dairy Cows, DAERA NI

Environment Strategy for Northern Ireland: DAERA is currently finalising an Environment Strategy which will set out Northern Ireland's environmental priorities for the coming decades. DAERA has previously engaged with stakeholders to produce the Environment Strategy for Northern Ireland Public Discussion Document. There were approximately 2,500 stakeholder responses and a summary report was published in November 2020. DAERA launched a consultation exercise on the draft Environment Strategy on 11th November 2021 during the COP26 event in Glasgow, inviting the public to express their views on the Environment Strategy. Under Strategic Environmental Outcome 1: Excellent air, water, land & neighbourhood quality, the Environment Strategy covers Air Quality with a focus on providing cleaner air in NI and reducing pollutants with the aid of the forthcoming 'Clean Air Strategy' and 'Ammonia Strategy'. This consultation period runs until 18th January 2022 and a summary report will be published once the responses have been analysed. The final Environment Strategy should be published in early 2022.

Belfast Rapid Transport ('Glider'): To encourage people to use alternative travel methods, the Department for Infrastructure developed Belfast Rapid Transport (BRT) and launched the new Glider service, operated by Translink in September 2018. This first phase links East Belfast, West Belfast and the Titanic Quarter via the city centre and has proven very attractive with passenger growth exceeding its target by 26% within the first 52 weeks of operation. This equated to an additional 2m journeys above initial projections. This patronage demonstrates a significant modal shift from the private car to public transport with positive air quality benefits. Each 'Glider', having capacity for up to 105 people, is powered by hybrid diesel/electric engines achieving a 10% to 40% improvement in fuel efficiency when compared with other Metro buses (dependent on vehicle type) and a 90% improvement in emissions (reduction in NOx and particulate matter emissions). Phase 2 of the BRT network, to cover North and South Belfast and connect Queen's University and the City Hospital is at development stage. Funding to deliver this BRT expansion is subject to the project's inclusion within the Belfast Region City Deal with the Minister determined to ensure maximum environmental and air quality benefits are achieved when the project progresses.

Clean Air Strategy: The Clean Air Strategy, published in January 2019 by the UK Department for Environment, Food and Rural Affairs (Defra), sets out a number of objectives to improve air quality across the UK. Section 9.5 of the Clean Air Strategy covers air pollution in Northern Ireland. Additionally, DAERA issued a Clean Air Strategy for Northern Ireland Discussion Document for public consideration in November 2020. The period of public discussion closed in early 2021 and all responses have been reviewed. Officials will present findings to the Minister and to seek a view on preferred policy options and measures in advance of engagement with the other government departments.

Dark Hedges tree tunnel, Northern Ireland

Energy Strategy for Northern Ireland: The Department for Economy (DfE) is developing a new Energy Strategy to ensure Northern Ireland has a secure, affordable and clean energy system for current and future generations. The vision of Net Zero Carbon and Affordable Energy is part of the Executive's wider action to address climate change and deliver an economy that is ten times better than today through innovation. Some issues raised in the Clean Air Strategy discussion document are also being considered as part of this new Energy Strategy.

Development of the Energy Strategy began in December 2019 with a Call for Evidence. DfE has worked collaboratively with other departments since then to gather and assess further evidence alongside extensive stakeholder engagement. A draft Energy Strategy policy options consultation was issued on 31st March 2021 and closed on 2nd July 2021, with the new Energy Strategy to be published by the end of 2021.

Throughout the development of this strategy DfE has worked closely with a broad cross-section of consumers, business, government and the energy industry. An expert panel, bringing together expertise from across the UK and Republic of Ireland, has also supported this work. The Energy Strategy document sets out Northern Ireland's roadmap to 2030 as part of the longer-term pathway to 2050. This will provide the confidence to invest in infrastructure and the workforce and give clear signals for industry and consumers. Officials in DAERA and DfE will continue to work closely to ensure the Clean Air Strategy and Energy Strategy will be developed in tandem to allow for consistency of policies.

Where to find out more on air quality

The Northern Ireland Air Quality Website at www.airqualityni.co.uk provides information covering all aspects of air pollution in Northern Ireland.

DAERA's website at https://www.daera-ni.gov.uk/ provides links to information on a range of environmental issues including biodiversity, waste and pollution. DAERA's 'Protect the Environment' web page at https://www.daera-ni .gov. uk/topics/protect-environment covers air quality, climate change and local environmental issues including noise.

National and local air quality forecasts are available from:

- The Defra UK Air Information Resource (UK-AIR) at http://uk-air.defra.gov.uk/
- The Northern Ireland Air Quality website www.airqualityni.co.uk.

Download the Northern Ireland Air app for iPhone and Android, keeping you updated about air pollution in Northern Ireland. The app provides:

- Easy access to the latest pollution levels from the monitoring sites
- Colour coded map showing the pollution forecasts
- Approved health advice based on the pollution levels
- Subscribe to free alerts when moderate, high and very high pollution is forecast.

For information on air quality issues in your local area please contact the Environmental Health Department of your district council: https://www.nidirect.gov.uk/contacts/local-councils-in-northern-ireland

Department of Agriculture, Environment and Rural Affairs
www.daera-ni.gov.uk

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