The Scottish Government

Air Pollution in Scotland 2018

Ricardo Energy & Environment

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Introduction

This brochure has been produced as part of the Scottish Air Quality Database (SAQD) project on behalf of the Scottish Government. The 2018 brochure is the 12th in an annual series. It aims to provide a summary of the local air quality monitoring and associated work carried out by and on behalf of the Scottish Government and local authorities during 2018.

The SAQD project was developed as a comprehensive centralised resource that provided high-quality harmonised data and information. The quality assurance of the data generated by the Scottish network serves to improve research and analysis, and supports the evaluation of air quality policy in Scotland. Since the initial development of the SAQD in 2006, it has grown year on year. The total number of automatic air quality monitoring sites in the SAQD during 2018 was 97. The increase in the number of monitoring sites included in the SAQD since 2006 and locations of these sites are shown in Figure 1.1.

While air quality in most of Scotland is generally good, levels of some pollutants still exceed air quality objectives, particularly in urban areas. Therefore, continued efforts to reduce air pollution are vital, coupled with appropriate monitoring to assess progress. For more information on air quality in Scotland and, more specifically, your area, please visit the Air Quality in Scotland website (www.airqualityinscotland.co.uk).

A more detailed Annual Report on the SAQD project is available on the Air Quality in Scotland website.

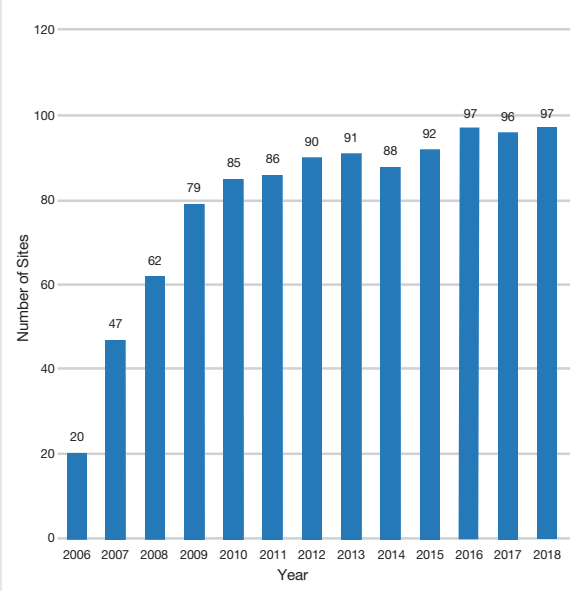

Figure 1.1

Growth in the number of monitoring sites included in the SAQD since 2006

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Legislation and Policy

Air quality management is shaped by statutory requirements transposed from EU and UK legislation and policies that have been adopted by Scotland. The foundations of Scotland's air quality management system are based on the following air quality directives adopted by all EU Member States:

- Directive 2008/50/EC – on ambient air quality and cleaner air for Europe (the Air Quality Directive)
- Directive 2010/75/EC – on industrial emissions (integrated pollution prevention and control) (the Industrial Emissions Directive)

The Scottish Government has duly transposed these Directives into national law through the Air Quality Strategy (AQS) and Air Quality Scotland Regulations 2000 (and subsequent amendments). A substantial review of the EU's air quality policy, including the Air Quality Directive, was undertaken in 2013 with the European Commission adopting a new Clean Air Policy Package, including a new Clean Air for Europe programme with measures to ensure that existing targets are met in the short term and new air quality objectives for the period up to 2030. The Package also includes support measures to help cut air pollution, with a focus on improving air quality in cities, supporting research and innovation, and promoting international cooperation.

2.1 Air Quality Standards and Objectives

A set of air quality standards and objectives has been developed for several pollutants of concern for human health. The objectives are derived from the standards and are a compromise between what is desirable purely on health grounds and what is practicable in terms of feasibility and costs. Each objective has a date by when it must be achieved. The objectives adopted in Scotland for the purpose of local air quality management (LAQM) are set out in the Air Quality (Scotland) Regulations 2000, the Air Quality (Scotland) Amendment Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016. Similar targets are set at EU level, where they are called limit and target values.

These limit and target values are set out in the Air Quality Directive and transposed into Scottish legislation. It is the responsibility of EU Member States to achieve these values. Scotland has adopted a more stringent objective for particulate matter up to 10µm and 2.5µm in diameter (PM_{10} and $PM_{2.5}$ respectively). A summary of the current Scottish air quality objectives is provided in Table 2.1.

Table 2.1 Summary of air quality in Scotland

Air Quality objective & pollutant	Concentration	Measured as	Date to be achieved by
Nitrogen dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg m^{-3}	Annual mean	31.12.2005
Particulate matter (PM_{10})	50 µg m^{-3}, not to be exceeded more than 7 times a year	24-hour mean	31.12.2010
	18 µg m^{-3}	Annual mean	31.12.2010
Particulate matter ($PM_{2.5}$)	10 µg m^{-3}	Annual mean	31.12.2020
Sulphur dioxide (SO_2)	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005
Benzene (C_6H_6)	3.25 µg m^{-3}	Running annual mean	31.12.2010
1,3 Butadiene (C_4H_6)	2.25 µg m^{-3}	Running annual mean	31.12.2003
Carbon monoxide (CO)	10.0 mg m^{-3}	Running 8-Hour mean	31.12.2003
Lead (Pb)	0.25 µg m^{-3}	Annual Mean	31.12.2008
Poly Aromatic Hydrocarbons*	0.25 ng m^{-3}	Annual Mean	31.12.2010
Ozone*	100 µg m^{-3} not to be exceeded more than 10 times a year	8 hourly running or hourly mean	31.12.2005

*Not required to be monitored or assessed by local authorities under LAQM, however is a UK requirement under EU directive (Directives 2004/107/EC and 2008/50/EC)

2.2 Cleaner Air for Scotland – The Road to a Healthier Future

The 'Cleaner Air for Scotland – The Road to a Healthier Future' (CAFS) strategy was published by the Scottish Government in November 2015. The purpose of CAFS is to provide a national framework that sets out how the Scottish Government and its partner organisations propose to achieve further reductions in air pollution and fulfil their legal responsibilities to achieve the air quality objectives. It is acknowledged in the CAFS strategy that, although progress has been made in Scotland, areas of poorer air quality still exist in towns and cities.

CAFS considers the impact of air quality on health, and looks at the estimated costs and predicted premature deaths associated with poor air quality. It has been estimated that 2,000 premature deaths and around 22,500 lost life-years across the Scottish population are linked to air pollution [1].

During the first half of 2019, the Scottish Government carried out an in-depth independent review of CAFS and the resulting documents were published in July 2019. The Scottish Government intend to use the information and recommendations made from this review to update CAFS in 2020.

2.2.1 Cleaner Air for Scotland Objectives

The CAFS strategy sets out six main objectives and the actions required to achieve improvements in air quality. A summary of these objectives and the 40 actions stated in CAFS are set out below.

1. Transport

A Scotland that reduces transport emissions by supporting the uptake of low and zero emission fuels and technologies, promoting a modal shift away from the car through active travel (walking and cycling) and reducing the need to travel.

This will be achieved by:

- Ensuring that all local authorities have a corporate travel plan that is consistent with any local air quality action plan
- Delivering the National Walking Strategy and Cycling Action Plan
- Working collaboratively with partners to deliver our shared vision in the Cycling Action Plan for Scotland
- Reviewing supporting green buses including the scope for supporting retrofitting existing vehicles, taking account of technology, market developments and climate change
- Evaluating the Bus Investment Fund
- Reviewing the Bus Service Operators' Grant to incentivise the use of low emission buses
- Reviewing guidance and legislation on the powers of local transport authorities regarding bus services
- Delivering 'Switched On Scotland: A roadmap to widespread adoption of plug-in vehicles'
- Reviewing the roadmap and developing a post 2015 plug-in vehicle action plan
- With key partners, investigating the use of hydrogen as a transport fuel and energy applications
- Reviewing the role less carbon-intensive fuels (such as liquefied petroleum gas (LPG), compressed natural gas (CNG) and biofuels) can play in achieving a near-zero-emission road transport sector by 2050
- Encouraging freight quality partnerships to consider their environmental impact
- Encouraging local authorities with Air Quality Management Areas (AQMAs) to establish a freight quality partnership to achieve improved air quality
- Reviewing ministerial guidance on regional and local transport strategies considering air quality management, and supporting a modal shift towards sustainable and active travel
- Reviewing the impacts of trunk roads on AQMAs and implementing mitigation measures where trunk roads are the primary contributor

2. Health

A Scotland that protects its citizens from the harmful effects of air pollution and reduces health inequalities.

This will be achieved by:

- NHS boards and their local authority partners including references to air quality and health in joint health protection plans

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PHE_CRCE_010.pdf

- Including World Health Organization (WHO) guideline values for PM_{10} and $PM_{2.5}$ in legislation as Scottish objectives

3. Legislation and policy

A Scotland where all European and Scottish legal requirements relating to air quality are, as a minimum, complied with.

This will be achieved by:

- Refocusing the LAQM system
- Establishing a PM2.5 monitoring network
- Producing revised and updated Scottish action plans to demonstrate how compliance with the Air Quality Directive will be achieved
- Designing, developing and implementing a two-level modelling system for regional and local scales to support potential transport and planning solutions to air quality issues
- Developing guidance and promoting a support network for all practitioners in reviewing and assessing air quality
- Undertaking detailed modelling of all four major cities in Scotland (National Modelling Framework (NMF))
- Identifying requirements and undertaking data collection for additional urban areas within 3 years
- Implementing the national databases for traffic data collection and local modelling outputs associated with CAFS
- Ensuring that the National Low Emission Factor (NLEF) criteria, tests and processes are developed, agreed and finalised
- Designing and implementing a standard appraisal process for assessing local air quality measures
- Developing software tools and guidance for the NLEF including funding options and technical reports

4. Placemaking

A Scotland where air quality is not compromised by new or existing development and where places are designed to minimise air pollution and its effects.

This will be achieved by:

- Ensuring Scottish Planning Policy and the National Planning Framework take account of CAFS
- Ensuring Local Development Plans and policies are consistent with the objectives of CAFS and any local authority Air Quality Action Plans
- Working with Environmental Protection Scotland (EPS) to produce updated guidance on air quality and planning
- Working with the Scottish Environment Protection Agency (SEPA) to introduce air quality training for local authority planners
- Supporting SEPA in revising its guidance on Strategic Environmental Assessment to bring it into line with CAFS

5. Communication

A Scotland where all are well informed, engaged and empowered to improve our air quality.

This will be achieved by:

- Developing a Scottish air quality indicator to assist in assessing compliance with air quality legislation and delivering the objectives of CAFS
- Developing a national air quality public awareness campaign
- Supporting the ongoing Greener Scotland communication campaigns and encouraging individuals to use their car less to improve their health and their local environment

6. Climate change

Reducing greenhouse gas (GHG) emissions and achieving renewable energy targets while delivering co-benefits for air quality.

This will be achieved by:

- Ensuring 'Low Carbon Scotland: Meeting Our Emissions Reduction Targets' publication takes into account air quality impacts
- Expecting Scottish local authorities to ensure a Sustainable Energy Action Plan includes air quality considerations
- Working with Forestry Commission Scotland to publish updated guidance on the impact of biomass on air quality to help local authorities fulfil their statutory responsibilities

2.2.2 National Low Emissions Framework (NLEF)

The NLEF has been developed to assist in the appraisal of air quality improvement options related to transport. Together with the National Modelling Framework, it provides guidance on the appraisal of such measures to help facilitate consistent assessment and implementation across Scotland.

The Scottish Government published the NLEF framework in January 2019 and is available at http://www.scottishairquality.scot/news/reports?view=technical. The framework provides a methodology for local authorities to undertake air quality assessment to inform decisions on transport related actions.

2.2.3 Low Emissions Zones

In Sept 2017, the Scottish Government committed to the introduction of Low Emission Zones (LEZs) into Scotland's four biggest cities (Glasgow, Edinburgh, Aberdeen and Dundee) by 2020 and into all other Air Quality Management Areas (AQMAs) by 2023 where the NLEF appraisal advocates such mitigation. In 2018 an LEZ was introduced in Glasgow city centre, the first of its kind in Scotland.

For the latest progress on CAFS, please visit www.scottishairquality.co.uk/air-quality/CAFS

2.3 Local Air Quality Management

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas to determine if the air quality objectives are likely to be achieved. Where an exceedance is considered likely, the local authority must:

- Declare an AQMA
- Assess and identify the reasons for the problem and develop an Air Quality Action Plan (AQAP) to help address the problem

In 2016, the Scottish Government produced and updated the technical guidance and policy guidance for the LAQM regime in the UK. The LAQM policy and technical guidance documents are available online (www.scottishairquality.co.uk/air-quality/legislation).

2.4 Air Quality Management Areas

In Scotland, there are 38 AQMA declared across 14 of the Scottish local authorities. The AQMAs in Scotland are declared for either nitrogen dioxide (NO_2) and/or PM_{10} concentrations, with the exception of the Grangemouth AQMA for sulphur dioxide (SO_2). The adoption of the $PM_{2.5}$ objective of 10 µg m^{-3} has not resulted in any additional AQMAs being declared. However, $PM_{2.5}$ monitoring continues to increase. The AQMAs declared in Scotland are presented in Table 2.2.

Table 2.2 Current AQMAs in Scotland

Local authority	Pollutant (no of AQMAs)	Main Source	AQMAs
Aberdeen	NO_2 and PM_{10}	Roads	3
City of Edinburgh	NO_2 (5) and PM_{10} (1)	Roads	6
Dundee City	NO_2 and PM_{10}	Roads	1
East Dunbartonshire	NO_2 and PM_{10}	Roads	2
East Lothian	NO_2	Roads	1
Falkirk	SO_2 (1), NO_2 (1), PM_{10} (1), NO_2 and PM_{10} (1)	Industry and roads	4
Fife	NO_2 and PM_{10}	Roads	2
Glasgow City	NO_2 and PM_{10} (1), NO_2 (2)	Roads	3
Highland	NO_2	Roads	1
North Lanarkshire	PM_{10}	Industry and roads	4
Perth and Kinross	NO_2 and PM_{10}	Roads	2
Renfrewshire	NO_2 (2), NO_2 and PM_{10} (1)	Roads	3
South Lanarkshire	NO_2 (1) and PM_{10} (2)	Roads	3
West Lothian	NO_2 (2) and PM_{10} (1)	Roads	3

3

Networks and Data

3.1 Monitoring in Scotland

Extensive air quality monitoring is carried out across Scotland. Some monitoring sites are run as part of UK-wide monitoring networks and others are operated by local authorities for LAQM purposes. The following AQS pollutants were monitored in Scotland during 2018:

- Benzene (C_6H_6)
- 1,3-butadiene (C_4H_6)
- Carbon monoxide (CO)
- Lead (Pb)
- Oxides of nitrogen (NOx), comprising nitric oxide (NO) and nitrogen dioxide (NO_2)
- Ozone (O_3)
- Particles (as PM_{10}, $PM_{2.5}$ and black carbon)
- Polycyclic aromatic hydrocarbons (PAH)
- Sulphur dioxide (SO_2)

The locations of automatic monitoring stations are shown in Figure 3.1. These stations provide high-resolution, hourly information on a wide range of pollutants. Data from national network monitoring sites are updated hourly in near real time on the SAQD. Data from local authority operated monitoring sites are updated hourly or daily depending on the station configuration. A typical automatic monitoring site is shown in Figure 3.2.

Scotland's automatic monitoring is supplemented by non-automatic monitoring techniques, for example the pumped-tube samplers used to monitor benzene, the high-volume samplers used to measure PAH and the non-automatic techniques used to monitor nitrogen dioxide and metals (such as lead).

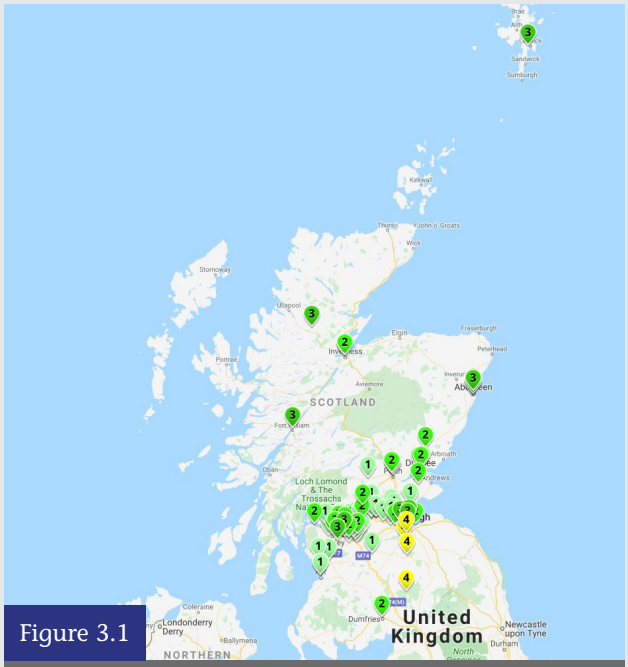


Figure 3.1

Location of automatic monitoring stations

Figure 3.2

Automatic monitoring stations (Edinburgh St Johns Road/Fife Dunfermline)

3.2 Key Results for 2018

This section provides a summary of results from automatic and non-automatic monitoring in Scotland in 2018 – including compliance with AQS objectives. Further information is provided on the Air Quality in Scotland website (www.scottishairquality.co.uk). This will be supplemented by further information and data to be published in the full Annual Report later this year. Data from individual local authorities' NO_2 diffusion tube networks are not included.

Benzene

This hydrocarbon is a constituent of vehicle exhaust emissions. Benzene was monitored using a non-automatic pumped-tube sampler at two sites (Glasgow Kerbside and Grangemouth) as part of the UK Non-Automatic Hydrocarbon Network. Benzene was also measure using automatic techniques at the rural supersite at Auchencorth Moss. All sites had annual mean concentrations well below the AQS objective for the running annual mean.

1, 3-Butadiene

1,3-butadiene is also a constituent of vehicle exhaust emissions. This pollutant was monitored at one rural site (Auchencorth Moss in Midlothian) as part of the UK Automatic Hydrocarbon Network. There were no exceedences of the 1,3 butadiene objective in 2018.

Carbon monoxide

This gas is a product of incomplete combustion, with vehicle exhaust emissions being an important source. It was monitored at two sites in Scotland in 2018 (Edinburgh St Leonards and North Lanarkshire Croy). Outdoor concentrations of CO were well within the AQS objective, as they have been for many years.

Lead

This toxic gas is emitted from most combustion processes, including power generation, domestic heating and vehicle engines. It was monitored at 82 automatic sites in Scotland during 2018 (shown in Figure 3.3). Of these, 8 achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean. This was because of instrument/sampling issues or the site starting up or closing down part way through the year.

Six sites had annual mean NO_2 concentrations greater than the AQS objective of 40µg m^{-3}. The highest annual mean concentrations were measured at Glasgow Kerbside, located close to a busy road, which had a measured concentration of 60.2µg m^{-3} (1.7 µg m^{-3} higher than in 2017). Figure 3.3 shows annual mean NO_2 concentrations at each site (with at least 75% data capture).

No site exceeded the hourly AQS objective of 200µg m^{-3} on more than the 18 permitted occasions.

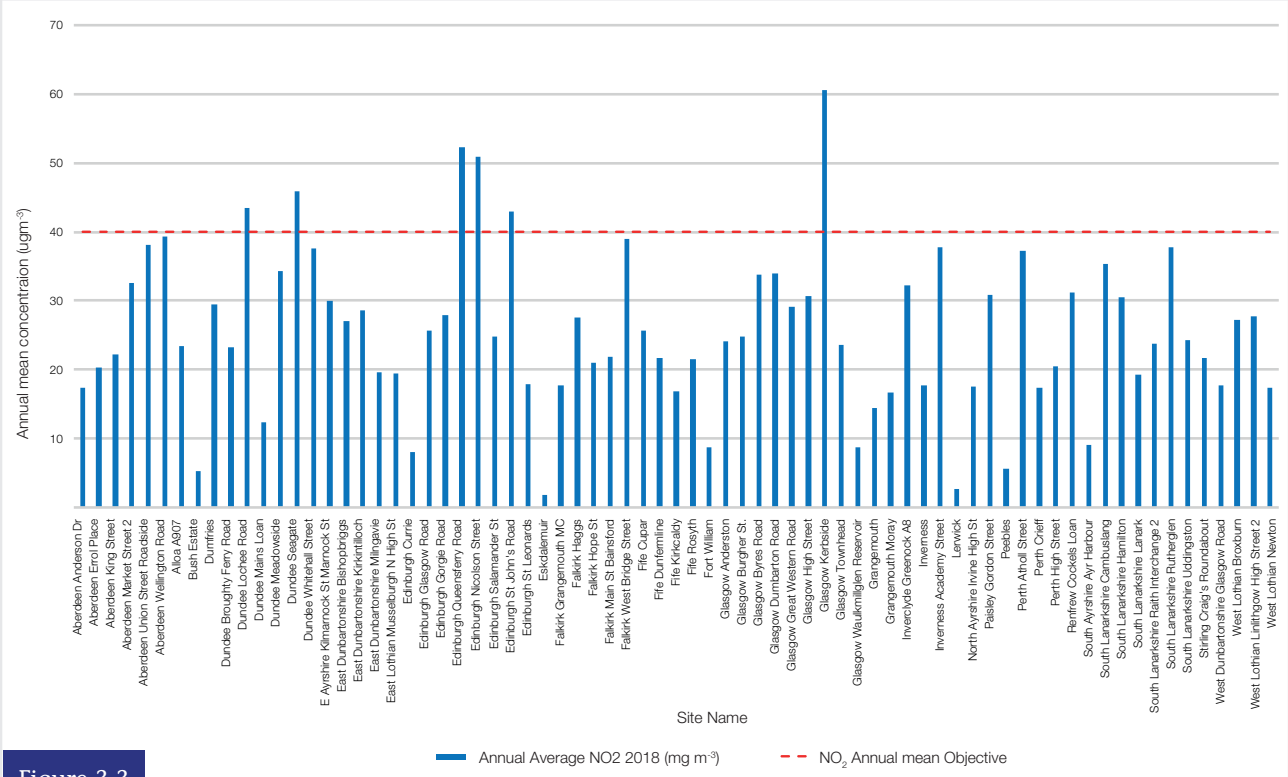


Figure 3.3

Annual mean NO_2 concentrations (2018)

Scottish Local Authorities also have a well established NO_2 diffusion tube network. This network of over 1100 sites across the 32 local authorities, measures indicative annual mean concentrations of NO_2 and is used;

- As a low cost alternative to automatic monitoring at a greater amount of locations of concern for use within Local Air Quality Management.
- To give an indication of longer term average NO_2 concentrations.
- For highlighting areas of high NO_2 concentrations where installation of an automatic analyser isn't feasible.

The Air Quality in Scotland Website now provides this data in an easy to use map. During 2018, 74 NO_2 diffusion tube monitoring sites exceeded the annual mean objective. The vast majority of these locations were located in the city centre areas of the four major cities in Scotland (Aberdeen, Dundee, Edinburgh and Glasgow) however other busy urban locations outside the centres also exceeded. To identify were these sites are, please got to http://www.scottishairquality.scot/latest/diffusion-sites.

Sulphur dioxide

This gas is emitted when fuels containing small amounts of sulfur (such as oil and coal) are burned. This pollutant was monitored at nine sites in 2018. All sites in Scotland met the requirements of the Air Quality Strategy for the 15-minute (no more than 35 times), 1-hour (no more than 24 times) and 24-hour (no more than 3 times) mean objectives SO_2 in 2018.

Particulate Matter as PM_{10}

Particulate matter arises from many sources. It can be directly emitted from combustion processes or formed from chemical reactions involving other pollutants. Natural sources (e.g. wind-blown dust and sea salt) also contribute. PM_{10} was monitored at 79 Scottish sites in 2018 sites using automatic monitoring and the Partisol™ daily sampler. Of these sites, 18 have less than 75% data capture. No site exceeded the UK AQS objective of 40µg m^{-3} for the annual mean. However, Scotland has adopted a more stringent annual mean objective of 18µg m^{-3}.

The Scottish annual mean objective of 18µg m^{-3} was exceeded at two sites in 2018 – Edinburgh Queensferry Road (25.0µg m^{-3}), and Edinburgh Salamander Street (18.7µg m^{-3}). Figure 3.5 provides annual mean PM_{10} concentrations for all sites in Scotland with 75% or more data capture.

The daily mean objective of 50 µg m^{-3} not to be exceeded more than 7 times in a year was not exceeded at any site.

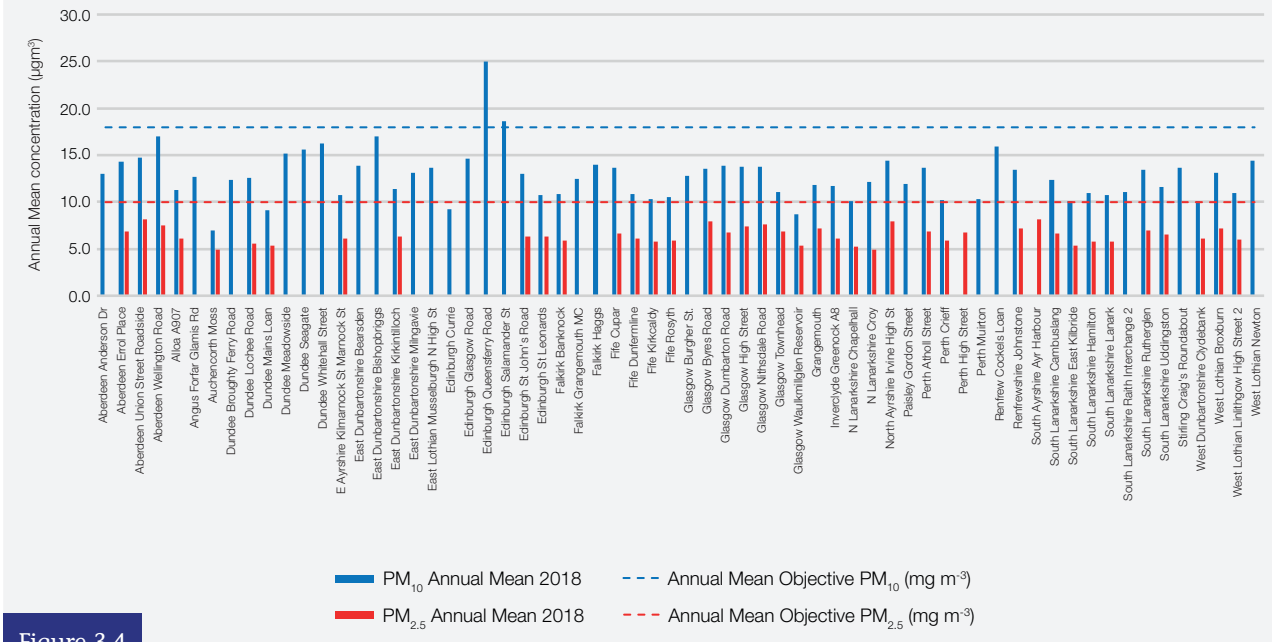


Figure 3.4

Annual average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites (2018)

Particulate Matter as $PM_{2.5}$

During 2018, the number of sites measuring the finer particle fraction, $PM_{2.5}$, increased from 41 to 55. Of these, 15 achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean. This was because of instrument faults or instrument installations during the year.

The Scottish AQS annual mean objective of 10 µg m^{-3} was not exceeded at any sites in Scotland. See Figure 3.4 for annual means at sites with a data capture of 75% or more.

Polycyclic Aromatic Hydrocarbons

This group of pollutants is monitored at four sites in Scotland. The AQS objective of 0.25ng m^{-3} for benzo[a]pyrene was not exceeded at any of the four sites during 2018.

Ozone

This is a secondary pollutant that is formed by reactions involving other pollutant gases in the presence of sunlight and over several hours. Once formed, it may persist for several days and be transported over long distances. This makes it difficult to control by local action. It was monitored at 11 sites in Scotland during 2018. Of these, the AQS objective of 100µg m^{-3} as an 8-hour running mean not to be exceeded more than 10 days was exceeded at nine sites (see Figure 3.5). During 2017 one site exceeded the objective.

The AQS objective is not included in regulations. This is in recognition of the fact that it is transboundary in nature and that local authorities have very little control over concentrations in their areas.

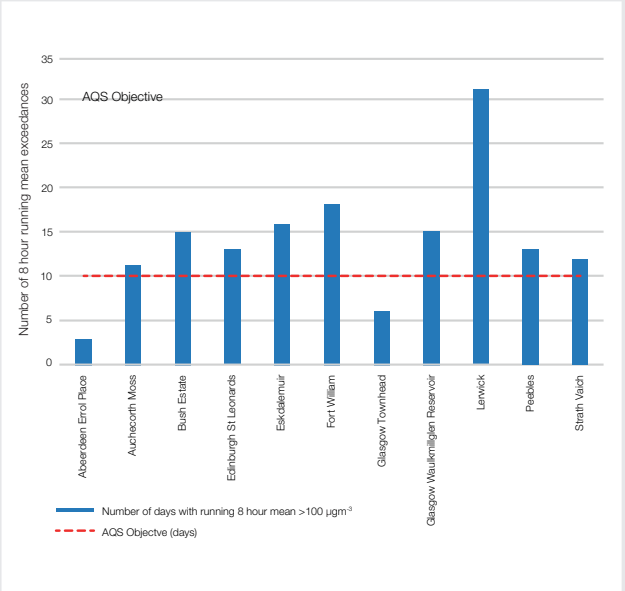


Figure 3.5

Exceedances of the 8-hour running AQS objective for ozone (2018)

4

Air Quality Trends

This section summarises how air quality in Scotland has changed over recent years. In previous years, the focus was on particulate matter. This year, the pollutants of interest are NO_2, PM_{10} and Ozone.

Automatic monitoring of NOx has been routinely carried out in Scotland since 1987. However, until 2000, there were relatively few automatic monitoring sites. Subsequent years have seen the number of monitoring sites in the SAQD increase from 20 (in 2000) to the current total of 97. The data produced by these monitoring sites has improved our understanding of Scotland's pollution climate. However, the increase in site numbers potentially complicates the investigation of trends in air quality. If trend investigation is based on all available data, the apparent trends seen may not reflect real changes in Scotland's air quality. Instead, they may be due to the changes in the number of sites (and their distribution). Therefore, for this report, investigation of trends has been based on subsets of long-running sites.

All the sites featured in this section have been in operation for a minimum of 5 consecutive years, as this is usually considered to be the minimum required to assess long-term trends at a monitoring site. In most cases, it is now possible to do trend analysis for longer periods (e.g. 10 years).

The trend analysis presented in this section has been carried out using the air pollution analytical tools available via the Air Quality in Scotland website. The main tool used was openair – a free, open-source software package of tools for analysing air pollution data[2].

The trend analyses were done using the openair 'TheilSen' tool. This uses the Theil-Sen statistical method to determine trends in pollutant concentrations over several years. The trend analysis is based on monthly mean pollutant concentrations. Openair includes an option to 'de-seasonalise' the data (i.e. statistically modify the plotted data to remove the influence of seasonal cycles, thus providing a clearer indication of the overall trend over the relevant time). The de-seasonalise option has been used in all the Theil-Sen trend graphs presented in this section. When the de-seasonalise option is used, openair fills in any gaps in the data using a linear interpolation method.

In these plots, the trend line is shown by a solid red line,

with 95% confidence intervals for the trend shown by dotted red lines. The trend is given at the top of the plot in green, with confidence intervals shown in square brackets. The trend is given as units (i.e. µg m^{-3}) per year, over the period shown. This may be followed by a number of stars:

* indicating that the trend is statistically significant at the 0.05 level

** indicating significance at the 0.01 level

*** indicating significance at the 0.001 level

The + symbol indicates that the trend is significant at the 0.1 level.

4.1 Nitrogen Dioxide

In Scotland (as elsewhere in the UK), the largest number of AQMAs have been declared in response to exceedances of the NO_2 objectives. This is also reflected in the number of monitoring stations reporting exceedances for this pollutant (see Section 3.2 of this report). In particular, the objective of 40µg m^{-3} for annual mean NO_2 concentration is the most widely exceeded (excluding ozone). Therefore, it is important to understand how concentrations of this pollutant vary with time.

[2] Visit http://analysistools.scottishairquality.co.uk/ for more information on the openair tools that are available and how to use them.

4.1.1 NO_2 at Urban Background Sites

There are relatively few long-running urban background monitoring stations in Scotland. Five urban non-roadside sites have been in operation for the past 10 years (2008-2017). These are Aberdeen Errol Place, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth. Fort William is classified as a 'suburban' site, Grangemouth is an 'urban industrial' site and the other three are 'urban background'.

The openair Theil-Sen function has been used to quantify trends in NO_2 at these monitoring stations over the period 2009-2018 – the trend plots are shown in Figure 4.1. It should be noted that Edinburgh St Leonards and Glasgow Anderston have large gaps in their 2014 and 2015 datasets. Edinburgh St Leonards and Glasgow Anderston showed highly significant negative trends (at the 0.001 level). This is the same as previous reports. For Aberdeen Errol Place, Fort William and Grangemouth, they all have significant negative trends (at the 0.05 level). For Fort William, this has change from last years analysis were trends indicated that concentrations have stayed, on average, static for the last 10 years. This analysis suggests that NO_2 concentrations are not decreasing at all urban non-roadside locations at the same rate. It also indicates that NO_2 concentrations are decreasing at a greater rate in the larger urban areas where concentrations were higher.

4.1.2 NO_2 at Traffic-related Urban Sites

Recent years have seen a substantial increase in the number of monitoring stations at urban traffic-related sites in Scotland. There are now 30 roadside or kerbside monitoring stations that have been in operation for 10 years or more and are still in operation.

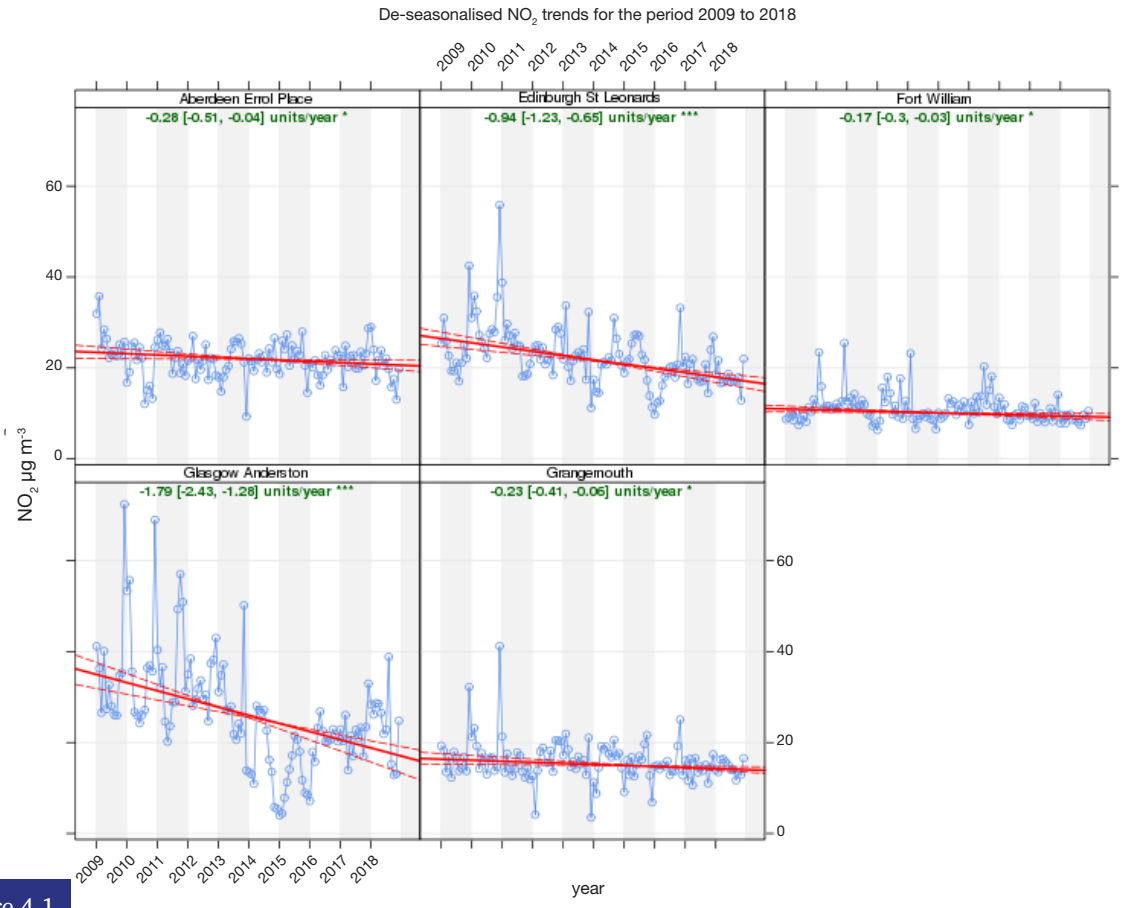


Figure 4.1

Trends in NO_2 concentrations non-roadside sites (2009-2018)

This is a large number of sites, so for the purposes of this brochure we have selected eight of the above long-running sites which have measured exceedances of the Air Quality Strategy Objective for annual mean NO_2 (40 µg m^{-3}) in recent years (though not necessarily 2018). Glasgow Kerbside, N Lanarkshire Chapelhall, Perth Atholl.

These are:

- Aberdeen Union Street
- Aberdeen Wellington Road
- Dundee Lochee Road
- Dundee Seagate
- Edinburgh St John's Road
- Glasgow Kerbside
- North Lanarkshire Chapelhall
- Perth Atholl Street

Figure 4.2 shows the trend plot. All nine sites showed significant downward trends in NO_2 concentration, eight of which were highly significant (at the 0.001 level). At East Dunbartonshire the trend was significant at the 0.01 level.

Trends over the most recent 5 complete years, 2014-2018, have also been examined for these sites. These are shown in Figure 4.3. Comparing the ten-year and five-year trends, the patterns are similar in that they all have downward trends but of varying significance. The exception to this is North Lanarkshire Chapelhall, where over the past 5 years there has been a slight upward trend (however not statistically significant) contrasting to the 10-year downward trend. At both Aberdeen sites, Dundee Seagate, & Perth Atholl St, the downward trend has become greater in magnitude over past 5 years compared to past 10. The other site to note is Edinburgh St Johns. The downward trend at this site has become greater during the past five years. This decrease is not consistent across all sites so though analysis suggests that concentration is continuing to fall in most cases it cannot be said that NO_2 concentrations during 2018 were generally lower than in recent years.

Further information on air quality trends for a range of pollutants is reported in more detail within the SAQD Annual Report.

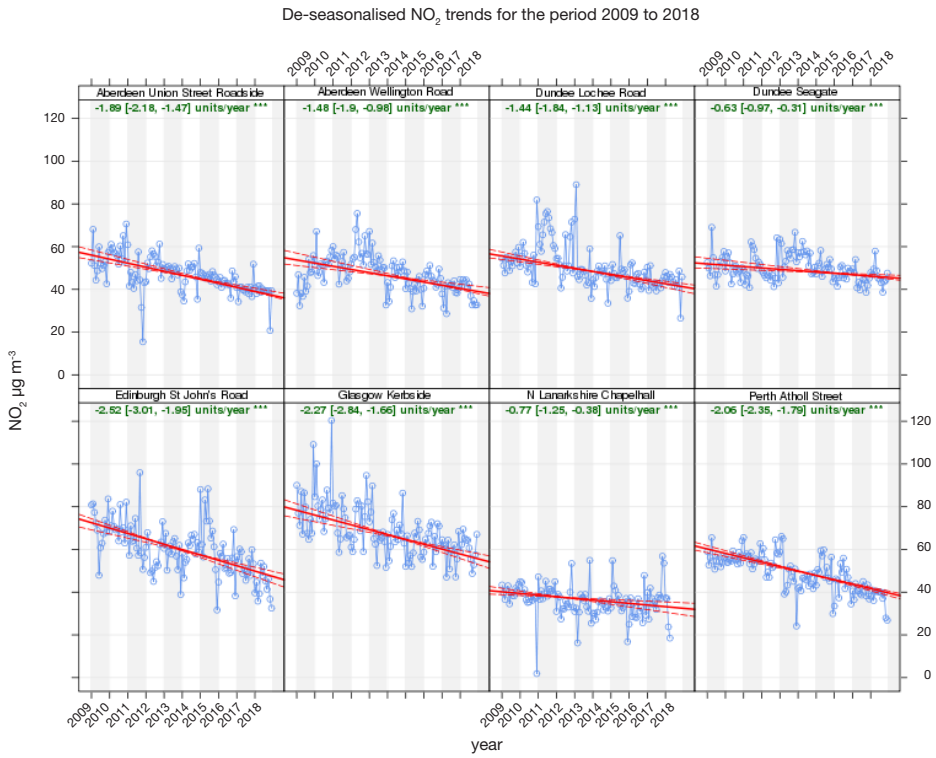


Figure 4.2

Trends in NO_2 concentrations at eight long-running urban traffic sites with exceedances (2009-2018)

4.2 Particulate Matter ($PM_{2.5}$)

This pollutant is of particular interest because:

- current evidence suggests that there is no safe level of particulate matter in terms of human health effects.

1. Scotland's current annual mean PM_{10} objective is 18 µg m-3, which is more stringent than the objective of 40 µg m-3 adopted in the rest of the UK.

4.2.1 PM_{10} at Urban Background Sites

There are now eight urban non-roadside sites in Scotland that have been monitoring PM_{10} for ten years or longer.

Figure 4.4 shows trends in de-seasonalised monthly mean PM_{10} at this subset of long-running sites. All eight sites showed a negative trend, significant at the 0.001 level at all sites except Aberdeen Errol Place where it was significant at the 0.01 level.

Trends in mean PM_{10} concentrations for the same eight sites (plus Edinburgh Queensferry Road), for the most recent five complete years 2014 – 2018, are shown in Figure 4.5. At four of the nine sites (the two located in Aberdeen, plus Fife Cupar and Perth Atholl Street) the downward trend is similar to the 10-year trend. However, for East Dunbartonshire Bishopbriggs, Edinburgh Salamander Street and Glasgow Abercromby Street, the downward trend has weakened or become less or insignificant. For Glasgow Byres Road the trend switches from a downward trend to an upward trend significant at 0.001. The reason for including Edinburgh Queensferry in the trend analysis is because it is one of two sites in Scotland (the other being Edinburgh Salamander) to exceed the annual mean objective in 2018. As can be seen, Edinburgh Queensferry Road has a statistically significant upward trend over the past five years. This may however be skewed by the 2018 data: during 2018 the PM_{10} concentrations at the site were heavily influence be ongoing construction work. This shorter-term trend analysis highlights that the long-term downward trend has not continued everywhere over more recent years and concentrations may either be stable or even increase in areas

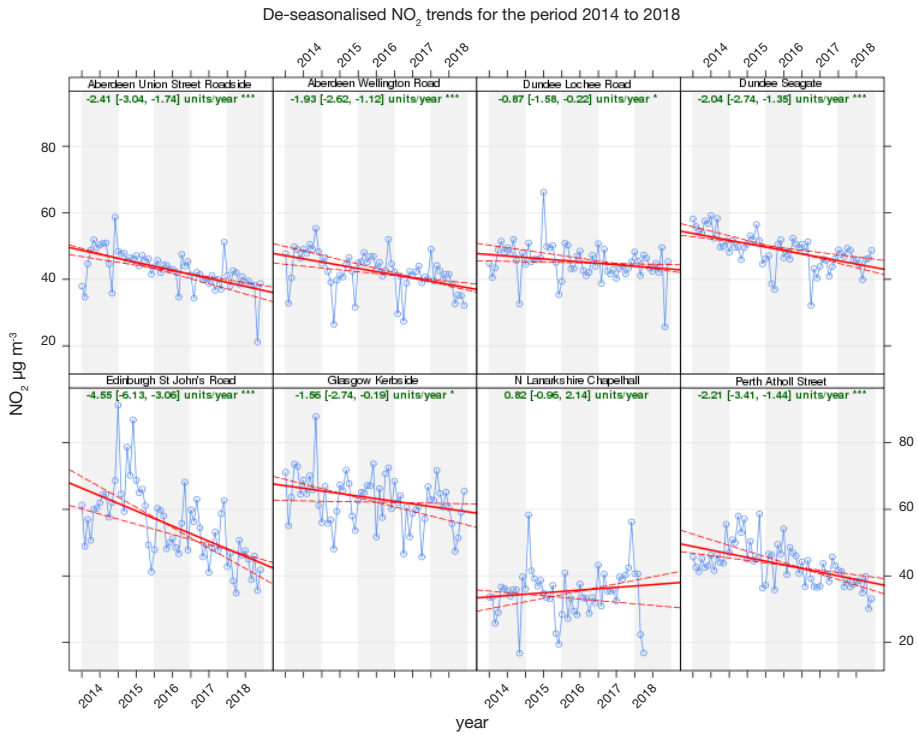


Figure 4.3

Recent trends in NO_2 concentration at nine long-running urban traffic sites (2014-2018)

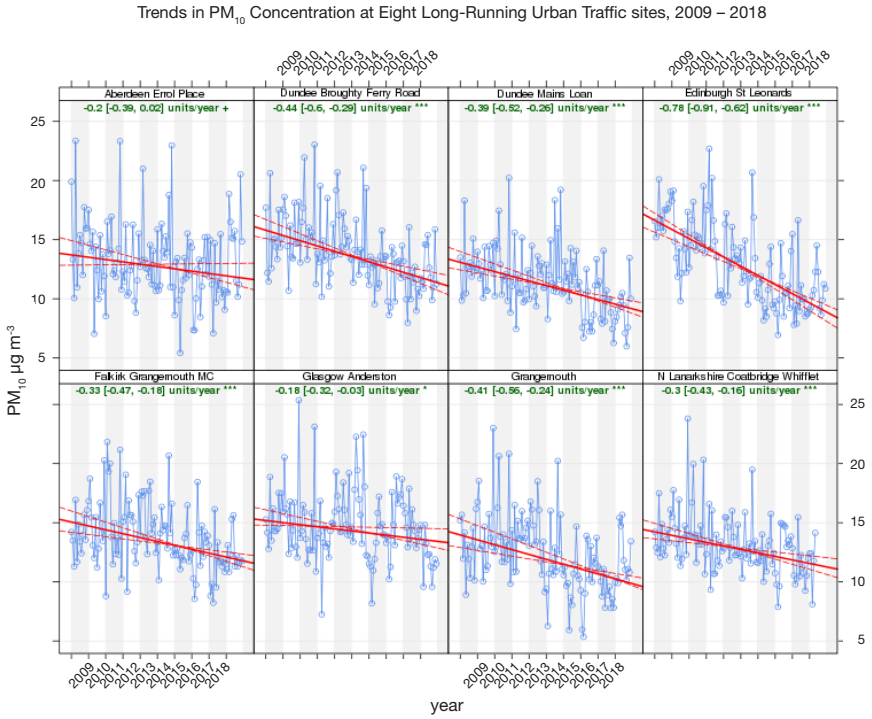


Figure 4.4

Trends in PM_{10} Concentration at Eight Long-Running Urban Traffic sites, 2009 – 2018

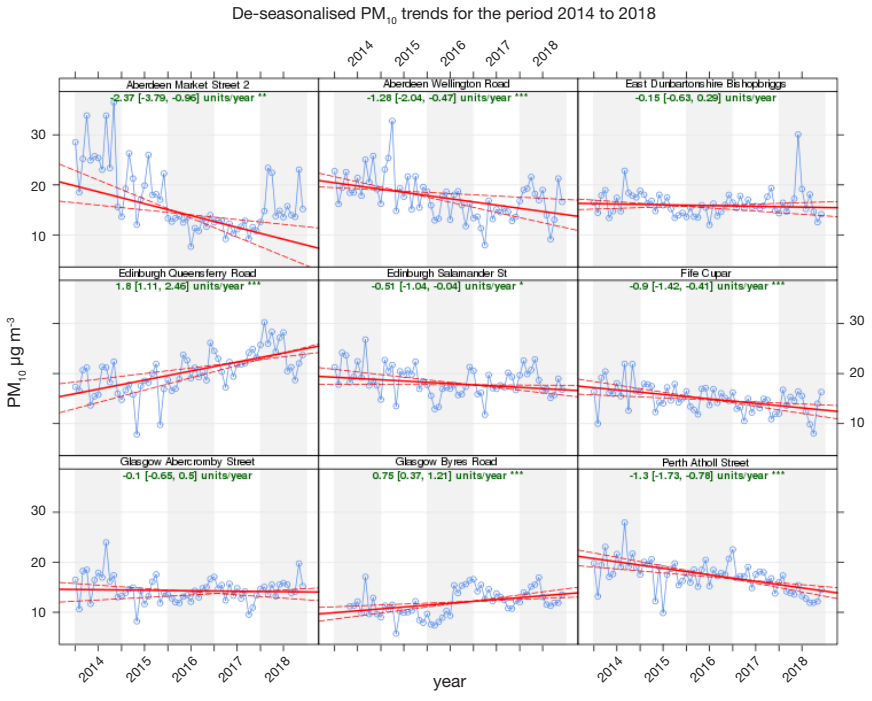


Figure 4.5

Recent Trends in PM_{10} Concentrations at Nine Urban Traffic Sites 2014 - 2018

4.3 Ozone (O_3)

Ozone has been include within this years trend analysis due to the fact that during 2018 nine out of 11 sites in Scotland exceeded the running eight hour mean objective not to be exceed 10 times per year. Trend analysis will identify whether this is unusual or part of a long term trend.

4.3.1 Rural Ozone

Three of Scotland's rural air quality monitoring stations have been monitoring ozone for 31 years, 1986 – 2018. These are Bush Estate, Eskdalemuir and Strath Vaich. Figure 4.6 shows long-term trends in ozone concentrations at these three rural monitoring sites. All three sites showed a small upward trend in rural ozone concentrations over this period. For Bush Estate and Eskdalemuir this trend was statistically significant at the 0.001 level. For Strath Vaich the trend was smaller and was not statistically significant.

Six sites have been in operation for over 10 years. These are the above three sites, plus Auchencorth Moss, Glasgow Waukmillglen Reservoir and Lerwick. Trends in ozone concentration at these six sites are shown Figure 4.7. In contrast to the thirty-year trends, the ten-year trends were less consistent. Five of the sites showed increasing trends, with only Lerwick being highly statistically significant (at 0.001 level), Auchencorth Moss (at 0.05 level) and Eskdalemuir (at 0.1 level) statistically significant. Bush Estate and Eskdalemuir showed increasing trends that were not statistically significant. The remaining site, Glasgow Waulkmillglen showed a not statistically significant decreasing trend.

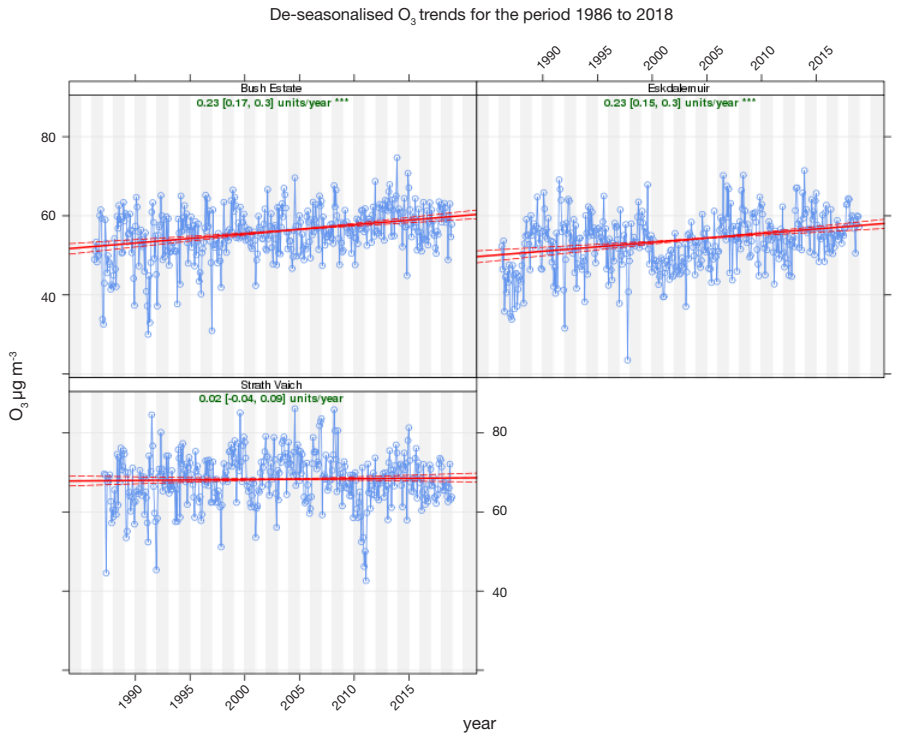


Figure 4.6

Recent trends in NO_2 concentration at nine long-running urban traffic sites (2014-2018)

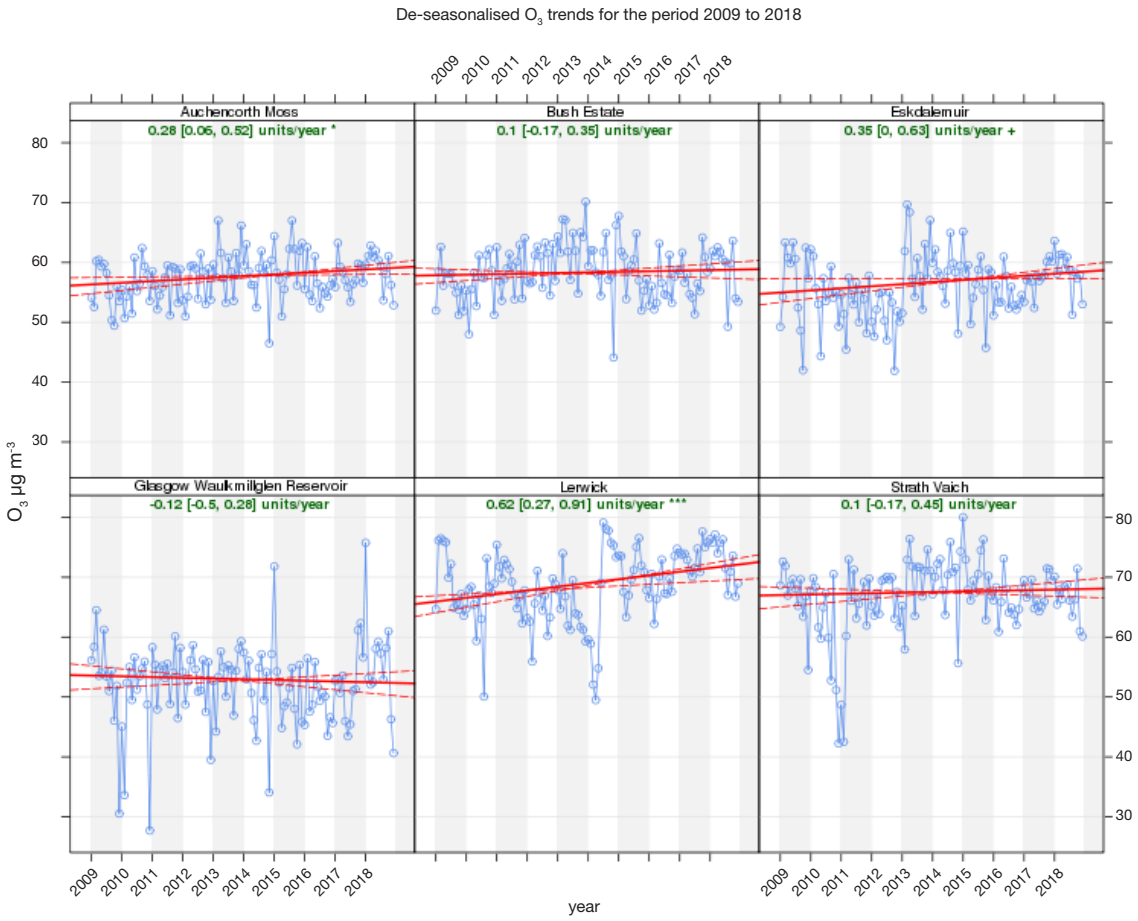


Figure 4.7

Trends in Ozone Concentrations at Six Long Running Rural Sites 2009 - 2018

4.3.2 Urban Background Ozone

Figure 4.8 shows trends in de-seasonalised monthly mean ozone concentrations at the two Scottish urban background monitoring sites which have been monitoring ozone for the past 10 years, 2009-2018: Edinburgh St Leonards and Aberdeen Errol Place. There is again a slight upward trend at both sites, however only Aberdeen Errol Place was highly significant at the 0.001 level.

Contrary to other pollutants analysed in this section there appears to be a slight (though not always statistically significant) upwards trend in ozone concentrations

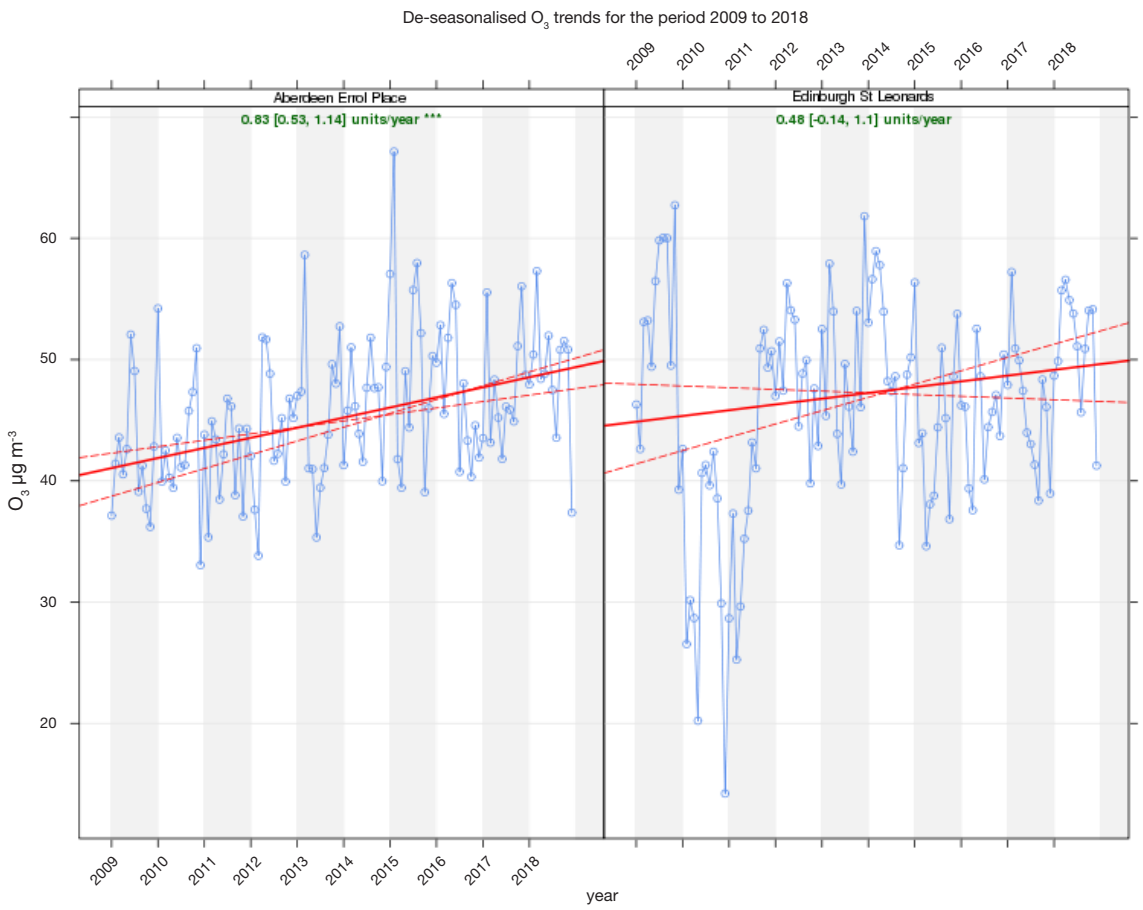


Figure 4.8

Trends in Ozone concentrations at Two Long Running Urban Background Sites 2009 - 2018

4.4 Regional Pollution Episodes 2018

During 2018, there were five moderate regional pollution events relating to the pollutant ozone. There were no other pollution events with regards any other pollutants.

The five moderate regional ozone episodes occurred on the following dates

- 17th April 2018
- 7th May 2018
- 19th – 21 May 2018
- 25th – 30th May 2018
- 27th – 29th June 2018

Figures 4.9 and 4.10 illustrates the elevated concentrations as seen on the Air Quality in Scotland website for the 25th – 30th May and 27th – 29th June 2018 episodes (www.scottishairquality.co.uk).

As illustrated in Figures 4.9 and 4.10, only a select amount of sites are flagged up as moderate on the maps. This is because Scotland only has 11 sites that measure Ozone. These sites are stated in figure 3.6 of this brochure.

These episodes were attributed mainly to a period of hot sunny weather initiating an atmospheric chemical reaction with pollutants VOCs (Volatile Organic Compounds) in the presence of Nitrogen Oxides (NOx). The sources of VOCs are similar to those described for NOx, but also include other activities such as solvent use, and petrol distribution and handling.

The chemical reactions do not take place instantaneously, but can take hours or days, therefore ozone measured at a particular location may have arisen from VOC and NOx emissions many hundreds or even thousands of miles away. Maximum concentrations, therefore, generally occur downwind of the source areas of the precursor pollutant emissions and often in rural areas.

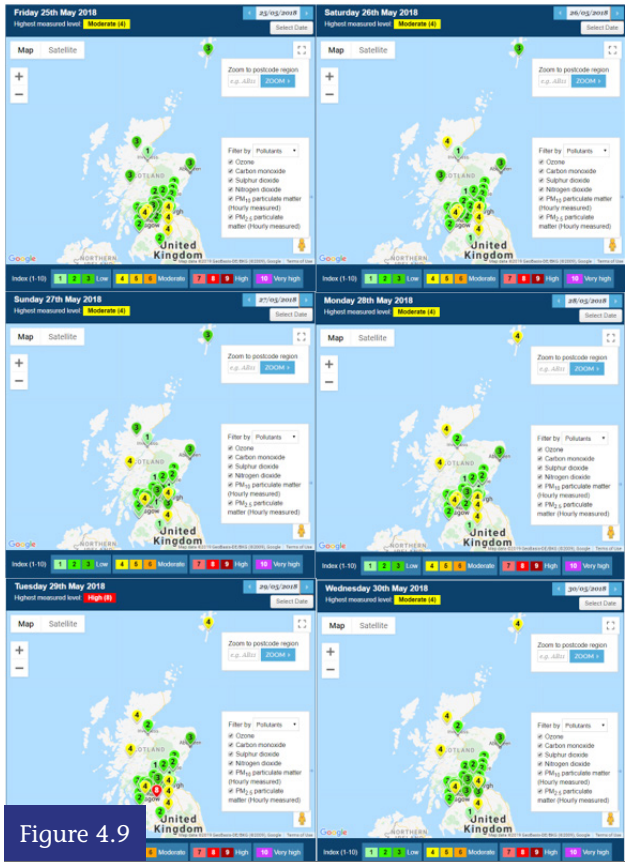


Figure 4.9

Air Quality in Scotland between website 25th – 30th May 2018

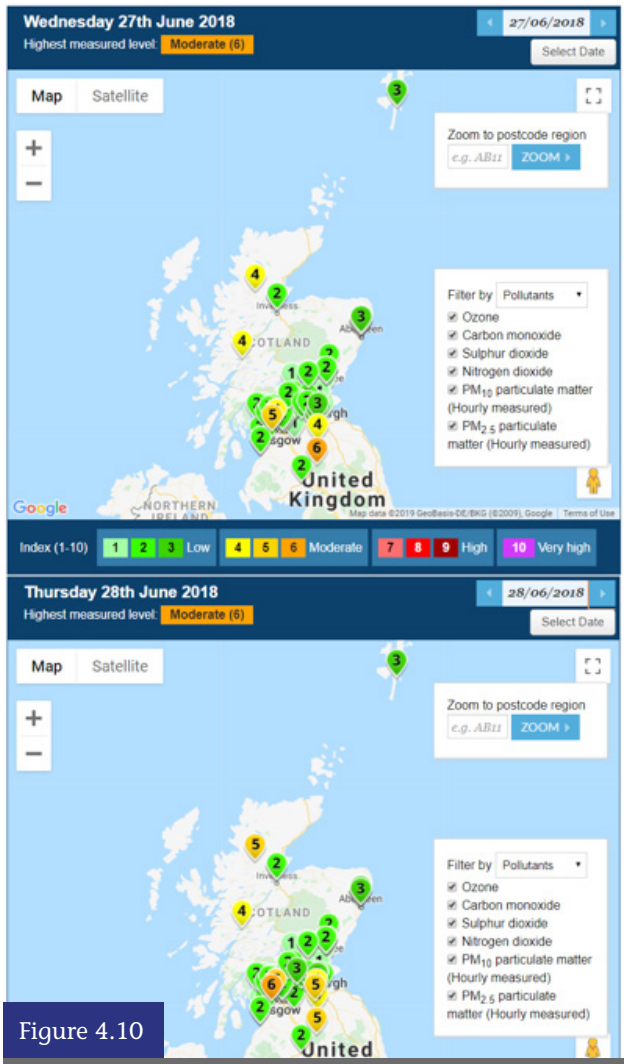


Figure 4.10

Air Quality in Scotland website 27th – 28th June 2018

5

Air Quality mapping for Scotland

As part of the SAQD project, Ricardo Energy & Environment provides mapped concentrations of modelled background air pollutant concentrations on a 1km x 1km basis for the whole of Scotland. Modelled roadside air pollutant concentrations are provided for road links in Scotland. The air pollution maps are derived from a combination of:

1. Measurements from Scotland's network of air quality monitoring stations
2. Spatially disaggregated emissions information from the UK National Atmospheric Emissions Inventory (NAEI)

The maps provide estimated pollutant concentrations for the whole of Scotland. The methodology for producing the Scottish maps is based on the UK Pollution Climate Mapping (PCM) approach. This is used for producing air pollution maps for the whole UK for the purposes of annual compliance reporting to the European Commission.

The PCM methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2017 (the most recent year available) using measurements exclusively from Scottish air quality monitoring sites and Scottish meteorology. The maps provide spatial representation of the annual mean concentrations of:

- PM_{10} (gravimetric equivalent)
- NOx and NO_2

The air pollution measurements used to prepare the maps consists of appropriately scaled PM_{10} monitoring data and automatic monitoring measurements for NOX and NO_2 in 2016. The model also uses Scottish meteorology observations (from Royal Air Force Station Leuchars) to create the Scotland-specific maps as shown in Figure 5.1.

This section discusses the maps of pollutant concentrations produced for the Scottish Government. The full range of maps, together with the most up-to-date interactive technical report, can be found here www.scottishairquality.co.uk/maps.php?n_action=data

This online, interactive reporting format makes reading the report a more dynamic experience. It does so by enabling the reader to interact with the maps and tables within the report itself allowing them to obtain usable data.

5.1 Air Quality Maps for Scotland

The 2017 annual mean NO_2 concentrations for Scotland were modelled for background and roadside locations. Figure 5.1 and Figure 5.2 show modelled annual mean NO_2 concentrations in Scotland for background and roadside locations respectively.

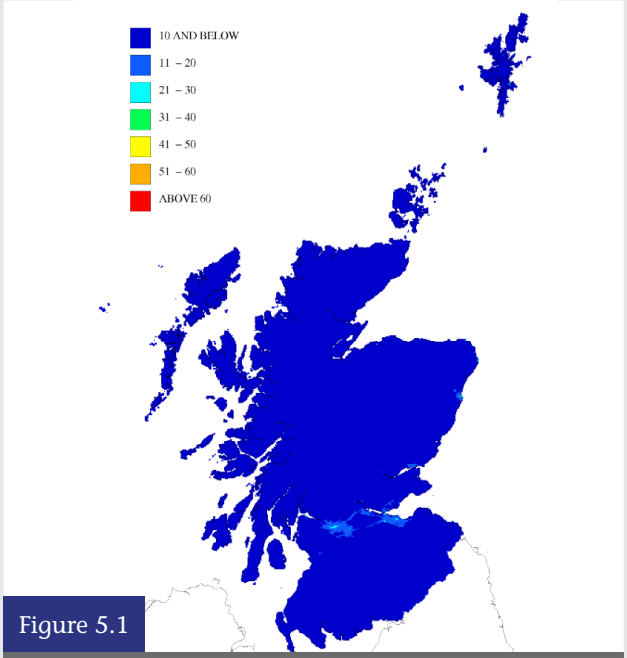


Figure 5.1

Background NO_2 map for 2017 (µg m^{-3}) (Scotland specific)

There were no modelled exceedances of the Scottish annual mean NO_2 objective of 40 µg m^{-3} at background locations. Overall exceedances of the Scottish annual mean NO_2 air quality objective were modelled at roadside locations in four of the six zones and agglomerations in Scotland. Exceedances of the annual mean NO_2 objective at roadside locations were modelled at 38 road links (57.5 km of road) in the Glasgow Urban Area and at 11 road links (21.7 km of road) in Central Scotland. In the Edinburgh Urban Area and the North East Scotland zone there were fewer than five road links where exceedances of the Scottish annual mean NO_2 air quality objective were modelled, affecting 4-6 km of roads. No roadside exceedances of the Scottish annual mean NO_2 air quality objective were modelled in the more rural zones and agglomerations of Scotland, i.e. the Highlands and Scottish Borders. More detailed maps showing the roadside annual mean NO_2 concentrations can be found in the Scottish Air Quality Mapping report 2017.

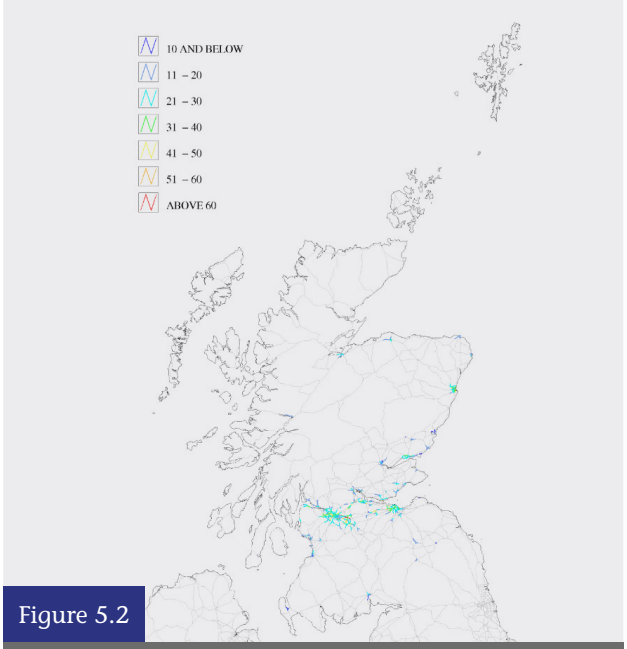


Figure 5.2

Roadside NO_2 map for 2017 (µg m^{-3}) (Scotland specific)

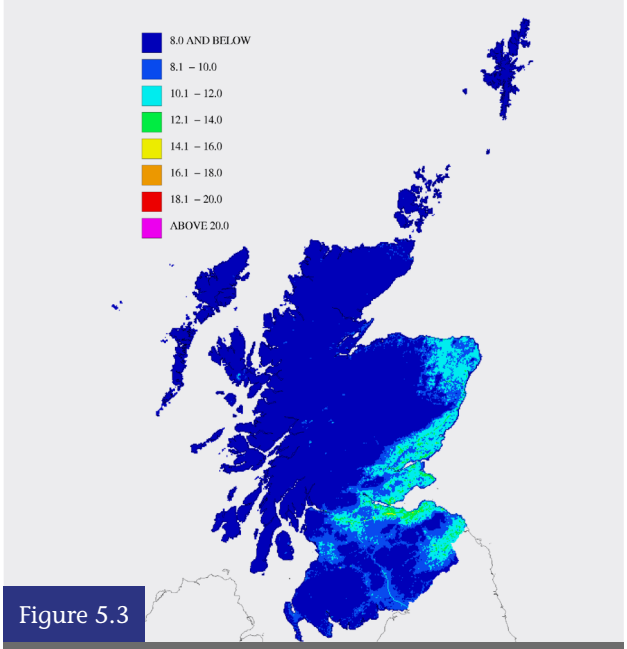


Figure 5.3

Background PM_{10} map for 2017 (µg m^{-3}) (Scotland specific)

5.2 PM_{10} Maps for 2017

Maps of the modelled 2017 annual mean PM_{10} concentrations for Scotland's background and roadside locations are shown in Figures 5.3 and 5.4, respectively.

The modelling methodology used to calculate the annual mean PM_{10} concentration was similar to that used in previous years and used a mixture of appropriately scaled PM_{10} monitoring data. Many of the chemical components of the PM_{10} model are not affected by the Scotland-specific changes to the UK PCM model. This includes the contribution to the total PM_{10} mass from the following components:

- Secondary inorganic aerosols (SIA) (e.g. sulfate, nitrate and ammonium-based particles)
- Secondary organic aerosols (SOA)
- Primary particles from long-range transport (e.g. soot particles from biomass burning)
- Sea-salt aerosol
- Iron- and calcium-based dusts

There were no modelled exceedances of the Scottish annual mean PM_{10} objective of 18 µg m^{-3} at background locations. Two road links (3.9 km of road) were identified as exceeding the Scottish annual mean PM_{10} air quality objective, these were located in the Glasgow Urban Area.

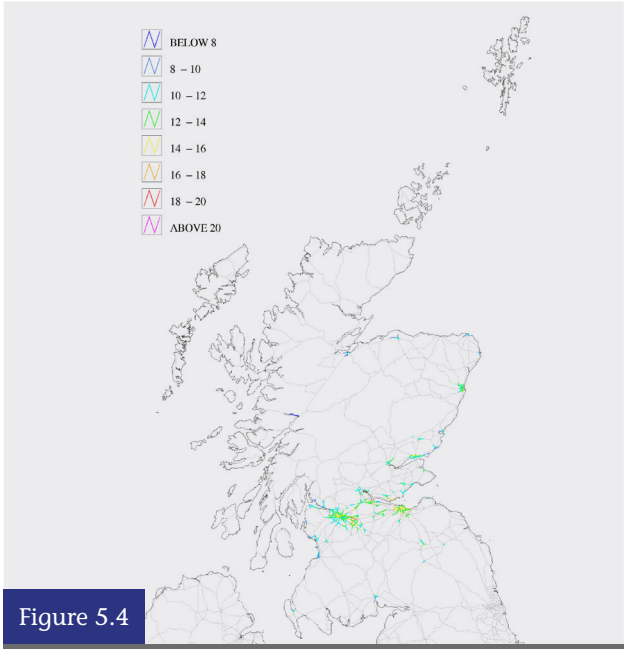


Figure 5.4

Roadside PM_{10} map for 2017 (µg m^{-3}) (Scotland specific)

6

Education

Education has been an ongoing development for air quality in Scotland. Interactive education packages have been developed through the creation of two sections that form part of the Air Quality in Scotland website. The first education website, 'Air Pollution Detectives', was created for schoolchildren in P5 to P7 (8-11 years old). The second website, 'Clear the Air', was developed in partnership with a number of secondary schools for pupils in S1 to S3 (12-15 years old). The education packages can be accessed from the Air Quality in Scotland website (www.scottishairquality.co.uk/education).

Figure 6.1

Air Pollution Detectives and Clear the Air

6.1 Air Pollution Detectives

Initially launched in 2011, the Air Pollution Detectives website has been continuously revised and updated. It was designed to introduce air quality issues to primary school pupils between the ages of 8 and 11. The animated, interactive webpages provide an introduction to air pollution sources and how pupils' actions can impact the air quality around them. Pupils can select individual pollutants to learn more and can take the quiz after each section to see what they have learned. The website is accompanied by a set of teachers' notes to enhance the learning experience and worksheets for pupils are provided. Figure 6.2 shows the worksheets that were updated during 2016.

Figure 6.3 shows the additional educational information that accompanies the Air Pollution Detectives website.

Figure 6.2

Updated worksheets are available on the Air Pollution Detectives webpage

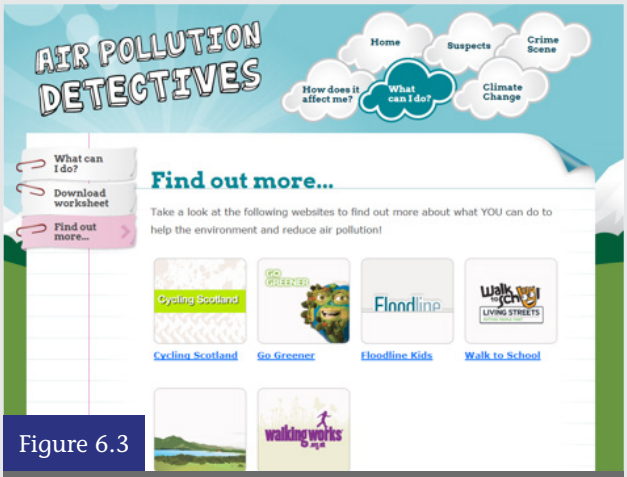


Figure 6.3

Additional information available on the Air Pollution Detectives webpages

Visit the Air Pollution Detectives website at www.scottishairquality.co.uk/education/

'The online education resources were extremely useful for teaching about sustainability and the environment. The activities were interesting, easy to use and the children loved being Air Pollution Detectives!'

Chloé McCallion, Primary School teacher at West Dunbartonshire Council

Figure 6.4

Clear the Air webpage

6.2 Clear the Air

The Clear the Air website was developed following the success of Pollution Detectives. The webpage, as presented in Figure 6.4, provides an interactive learning experience for air quality and citizen science aimed at secondary school age and above.

The Clear the Air package includes a series of interactive webinars and exercises designed to be undertaken by pupils. These interactive exercises include 'What air pollution is like near me', 'Calculating your emissions to school' and a citizen science project that enables classes to monitor air quality around the school by using NO_2 diffusion tubes. Pupils are given an NO_2 diffusion tube to take home so they can monitor outside their house.

6.2.1 The Clear the Air - Air Quality Monitoring Pack

The Clear the Air monitoring pack has been designed to give pupils hands-on experience with air quality monitoring equipment and a better understanding of the underlying science. As a class or group, pupils can undertake air quality monitoring around their school grounds, or at, or near, their homes. Once the results have been analysed, the monitoring data (location and measured concentration) can be uploaded via the school's private user portal so that the results can be displayed on a map (see Figure 6.5). The package encourages pupils to discuss the results and the factors influencing the air quality measured within the area. The Clear the Air package is supported by a teachers' pack including notes to supplement the monitoring equipment, and webinars to help introduce the concept of local air quality and how to conduct the monitoring.

Further information can be obtained at:
http://cleartheair.scottishairquality.co.uk

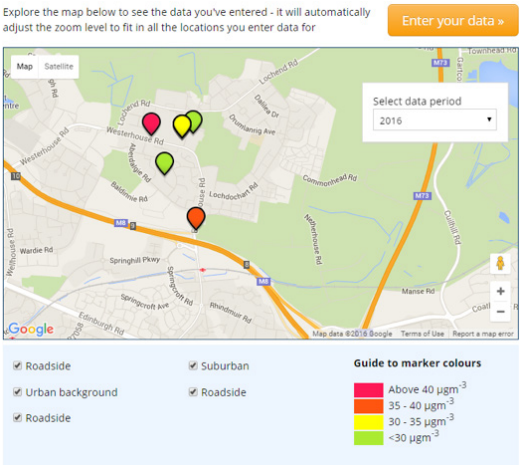


Figure 6.5

Data entry available for each school profile

7

Developments in 2018

7.1 Continued Expansion of the $PM_{2.5}$ Network

During 2018, the $PM_{2.5}$ monitoring network continued to grow to 55 sites from 41 in 2017. The growth in $PM_{2.5}$ monitoring sites (as illustrated in Figure 7.1) is a result on the introduction of the statutory $PM_{2.5}$ objective of 10µg m^{-3} in April 2016.

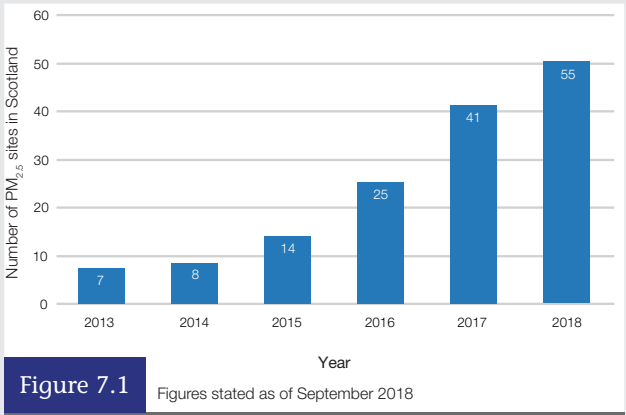


Figure 7.1 Figures stated as of September 2018

Number of $PM_{2.5}$ sites in Scotland since 2013

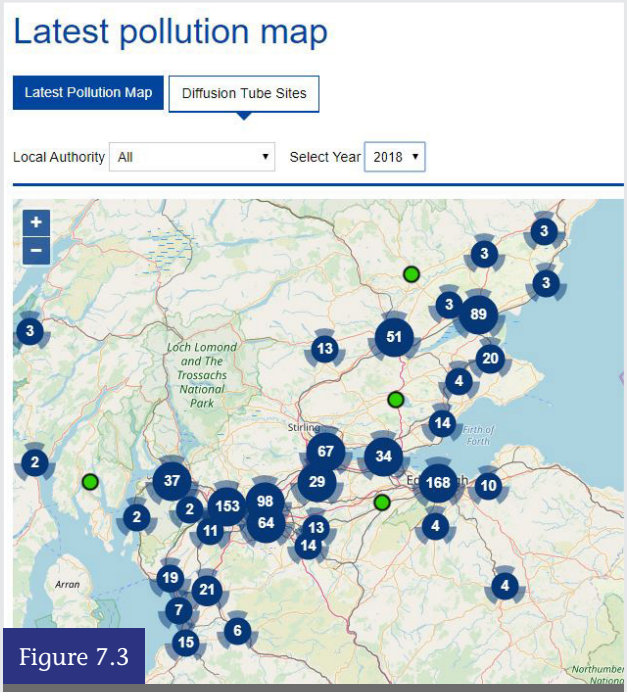


Figure 7.3

SAQD Diffusion Tube Map Cluster format

7.2 Development of NO_2 Diffusion Tube Map

Since 2006 the Scottish Air Quality Database and Website (SAQDW) project via the Air Quality Scotland website has successfully disseminated air pollution data from local authority automatic sites to the public. Local authority diffusion tube data has previously only been publicly available via the submission of Annual Progress Reports. In recent years there have been increasing interest in providing better access to local authority diffusion tube data via the SAQDW so that the public can obtain all the information easily and in a format that is straightforward to understand. The inclusion of this data would in turn increase the capabilities of the website and enhance its credentials as being the one stop shop for Scottish air quality data.

In October 2018 Scottish Government commissioned Ricardo to develop a NO_2 diffusion tube database and Map. The Map would provide bias corrected annual mean data previously published in the local authorities annual progress report.

The Map would also have the following features;

- Due to the large number of diffusion tube sites compared to automatic sites, a cluster format will be applied enabling the user to easily select specific sites whilst at the same time having a map easy to use, isn't overly busy and is visually aesthetic.
- The colour of each site markers will be related to the NO_2 annual mean concentration (i.e. displayed red when the annual mean exceeds 40 µg m^{-3}).
- A Year Selector will enable the user to view historical data from current and closed sites.
- A Local Authority drop down list will provide the user an alternative way to specify which local authority and site they wish to obtain data from rather than using the map.
- When the user selects a site, specific site details will appear giving information such as, site type, location coordinates, historical data, graphing capabilities.

Figures 7.3 and 7.4 provide images of how the diffusion tube map looks on the website. The Map has been in development throughout the last 3 months of 2018 and into 2019 and was released in June 2019.

Buchanan St

Local Authority Ref: CC05
Site Type: ROADSIDE
Region: City of Glasgow
Location Coordinates: [55.861725, -4.253586]
Data Available From: 2013
» View this site on the interactive map

Statistics | Graphing

Pollutant : Nitrogen Dioxide (NO_2)

Year	Annual Mean (µg m-3)	Data Capture (%)
2013	48	92
2014	41	83
2015	39	83
2016	39	100
2017	42	92
2018	41	100

All site data stated within this map has been provided by the relevant local authority and original published within the Local authorities LAQM Annual Progress Reports (APRs). For further information regarding any adjustments made to the published annual mean concentration, please refer to the appropriate APR. Adjustments are made to diffusion tube data in line with the
Local Air Quality Management Technical Guidance (TG16).

Local authority APRs can be located here or via the local authority website.

Figure 7.4

SAQD Diffusion Tube Map site Summary Page

7.3 Air Quality in Scotland App Update

In October 2018 Scottish Government commissioned Ricardo to update the Air Quality in Scotland App. As well as update the app, Scottish Government took this opportunity to increase the capabilities of the App by adding new functionality. These functionalities include:

- App Notification Alert Function for elevated site data
- App Notification Alert Function for Local Authority areas with forecast elevated pollution levels
- App Notification Alert Function when entering an AQMA
- Interactive AQMA map and Summary page which provides the location, area covered by the AQMA and supporting information.

In June 2019 the newest version of the Air Quality in Scotland App was released.

Figures 7.5 illustrates how the notification will look when the App user enters an AQMA. Figure 7.6 illustrates how the new AQMA map looks on the App.

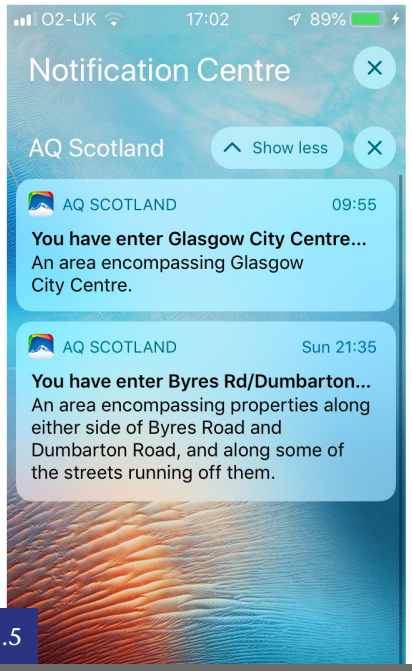


Figure 7.5

Air Quality in Scotland App AQMA notification alert

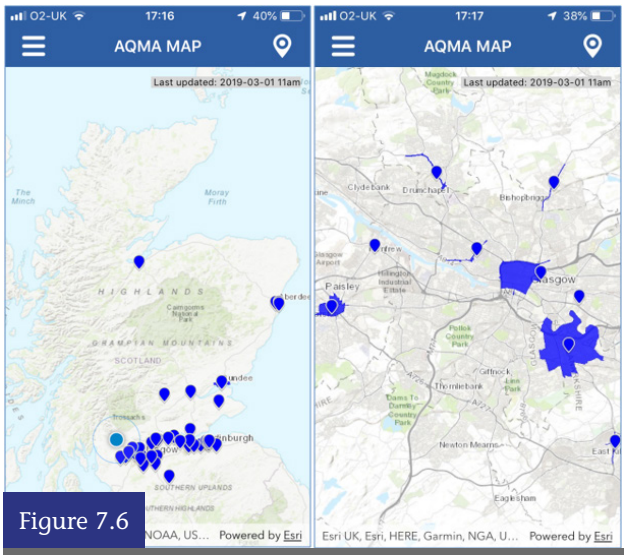


Figure 7.6

Air Quality in Scotland App Interactive AQMA map

8

Stay Informed

8.1 Scotland Air Pollution Forecast

A 5-day forecast for each local authority in Scotland is available on the Air Quality in Scotland website. The forecasts provide a greater level of detail, which can benefit the public – particularly those with health issues. Forecasts are displayed through a summary table and a map. The 5-day forecast map and summary table are available at www.scottishairquality.co.uk/latest/forecast

8.2 Know and Respond

Know & Respond is a free service providing alerts when pollution levels are forecast to increase. Users can subscribe to a specific local authority and will receive push notifications directly to their device if 'moderate' or higher air pollution is forecast each day. Users can choose to receive alerts by text, voicemail or email. Know & Respond alerts are also available via the Air Quality in Scotland app.

8.3 Air Quality in Scotland App

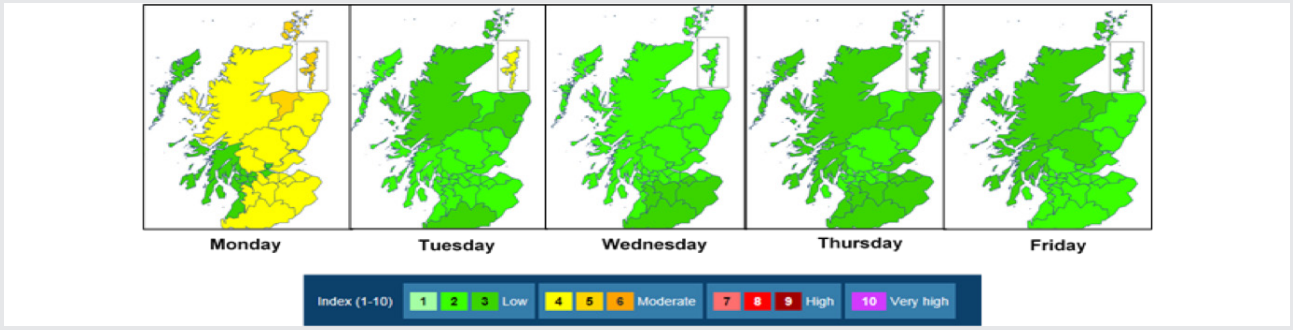
The Air Quality in Scotland app gives the latest air quality levels for each site, forecasts for the day ahead and alerts when air pollution levels increase via the Know & Respond health alerts service. The free Air Quality in Scotland app is available for most mobile devices.

8.4 Email Alerts

Sign up to our email bulletins and receive summaries directly to your inbox. You can choose how frequently you receive them and what type of summary you are interested in.

8.5 Interactive Mapping and Analytical Tools

Visualisation and data analysis tools are available on the Air Quality in Scotland website. The tools pull data from the SAQD and present it in several pre-analysed formats. These tools enable the data to be customised and filtered to meet individual, requirements, such as viewing air quality in a particular area or for local authorities when preparing annual reports.



8.6 Twitter

Follow Air Quality in Scotland on Twitter (@scotairquality) for air quality forecasts and summaries of measurements from Scotland.

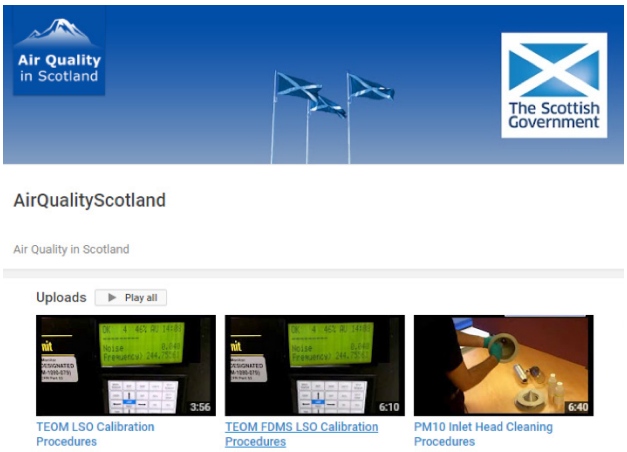
The service enables you to stay informed about current and forecast air quality including the occurrence of air quality episodes. Health advice and information on the UK Air Quality Index should be considered in conjunction with the tweets, particularly when air pollution is elevated.

@scotairquality

8.7 Youtube™

The Air Quality in Scotland YouTube account was initially launched to provide a platform for related videos and it hosts the 'How To' videos for the Local Site Operator manual.

Each video is available through the YouTube website itself, but can also be accessed directly on the Air Quality in Scotland website (https://www.youtube.com/user/AirQualityScotland).



The Scottish Government

Ricardo Energy & Environment

This report has been produced by Ricardo Energy and Environment on behalf of the Scottish Government.

Its main authors are Alison Loader, David Hector, Dr Colin Gillespie (SEPA), Ashleigh Norrie, Stephen Stratton, Stephen Gray, and Ellis Marshall Padkin

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