The Scottish Government

Air Pollution in Scotland 2016

RICARDO

Ricardo Energy & Environment

1

Introduction

This brochure has been produced as part of the Scottish Air Quality Database (SAQD) project on behalf of the Scottish Government. The 2016 brochure is the 10th 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 2016.

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 2016 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).

Section 2 of this brochure reviews the air quality legislation and policy applicable to Scotland. **Section 3** summarises the air quality monitoring carried out in Scotland and presents an overview of the data from 2016, including exceedances of air quality objectives. **Section 4** deals with trends in air pollution in Scotland and **Section 5** covers spatial patterns of pollution. **Section 6** provides information on educational activities that have taken place and **Section 7** is a summary of some recent developments. **Section 8** highlights all the different ways in which to get information regarding air quality.

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

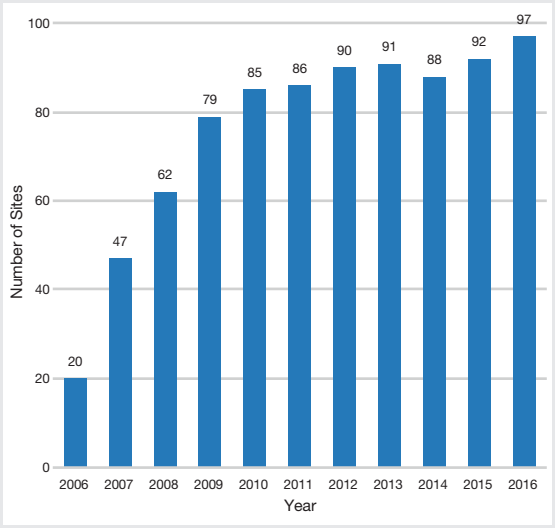


Figure 1.1

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

2

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 of the EU's Member States:

- Directive 2008/50/EC – on ambient air quality and cleaner air for Europe (the Air Quality Directive)
- Directive 2010/75/EC – controls emissions from industrial activities (the Industrial Emissions Directive)

The Scottish Government has duly transposed 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 package, including a new Clean Air programme for Europe 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 practical 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 European 2008 Ambient Air Quality Directive (2008/50/EC) 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 10 µm and 2.5 µm 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
	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
Sulphur dioxide (SO_2)	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

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 recognises 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 $PM_{2.5}$[1].

CAFS outlines six main objectives. The document sets out these 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

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

- 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
- 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 $PM_{2.5}$ monitoring network
- Producing revised and updated Scottish action plans to demonstrate how compliance with the EU ambient 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)
- 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 Framework (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 CAFS objectives 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 CAFS objectives
- 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.

CAFS outlines further changes, such as the adoption of the WHO guideline values for $PM_{2.5}$. This was transposed by the Air Quality Scotland Amendment Regulations 2016 when the annual mean objective for $PM_{2.5}$ was set at 10 µg m^{-3}. 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 Air Quality Management Area (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. One of the main changes was to the LAQM reporting process. An Annual Progress Report (APR) has replaced the previous 3-year cyclical process. 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 39 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 below:

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	5
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 2016:

- 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.

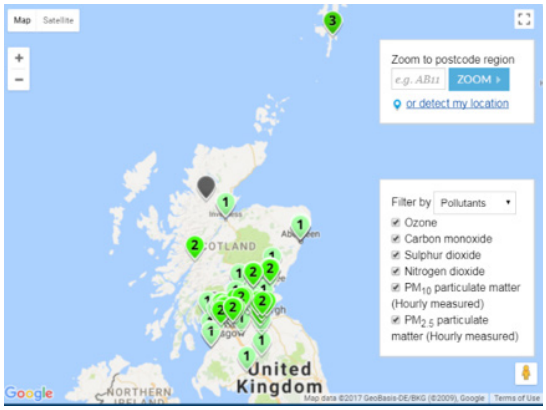


Figure 3.1

Location of automatic monitoring stations

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 metals (such as lead).

Figure 3.2

Automatic monitoring stations (South Lanarkshire Hamilton/Fife Cupar)

3.2 Volatile Correction Model

Across Scotland, 23 monitoring sites use the tapered element oscillating microbalance (TEOM) to measure PM_{10}. The relatively high operating temperature of this instrument (necessary to prevent condensation on the filter) can result in the loss of volatile components of the particulate matter sampled, causing underestimation of the PM_{10} concentration.

However, it is possible to correct for this using the Volatile Correction Model (VCM) developed by King's College London. The VCM uses data from Thermo Scientific 8500 Filter Dynamic Measurement System® (FDMS) PM_{10} analysers in the region (which measure 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 gravimetric reference equivalent. Visit http://www.scottishairquality.co.uk/data/2008-correction for more information.

3.3 Key Results for 2016

This section provides a summary of results from automatic and non-automatic monitoring in Scotland in 2016 – including compliance with AQS objectives. Further information is provided on the Scottish Air Quality 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.

Benzene

This hydrocarbon is a constituent of vehicle exhaust emissions. It 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. Both sites had annual mean concentrations 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. The 2016 annual mean has indicated that the AQS objective was met.

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 2016 (Edinburgh St Leonards and North Lanarkshire Croy). Outdoor concentrations were well within the AQS objective for both sites, as they have been for many years.

Lead

This toxic metal is emitted from some industrial processes (although emissions are now strictly controlled). Lead is monitored at two non-automatic sites in Scotland. Both sites had annual mean concentrations below the AQS objective.

Nitrogen Dioxide

This toxic gas is emitted from most combustion processes including power generation, domestic heating and vehicle engines. It was monitored at 83 automatic sites in Scotland during 2016. Of these, 10 achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean. This was because of instrument faults, site enclosure upgrades, or the site started up or closed down part way through the year.

A total of 12 sites had annual mean concentrations greater than the AQS objective of 40 µg m^{-3} (although one did not meet the AQS data capture target of 90%). The highest annual mean concentrations were measured at Glasgow Kerbside, which is located close to a busy road. Figure 3.3 shows annual mean concentrations at all sites measuring NO_2 across Scotland.

One site exceeded the AQS objective of 200 µg m^{-3} on more than the 18 permitted occasions: This site was east Dunbartonshire Bearsden, which also exceeded the annual mean objective. To determine if these sites represent a location of relevant exposure to the general public, further information can be found within each local authority's Annual Progress Report.

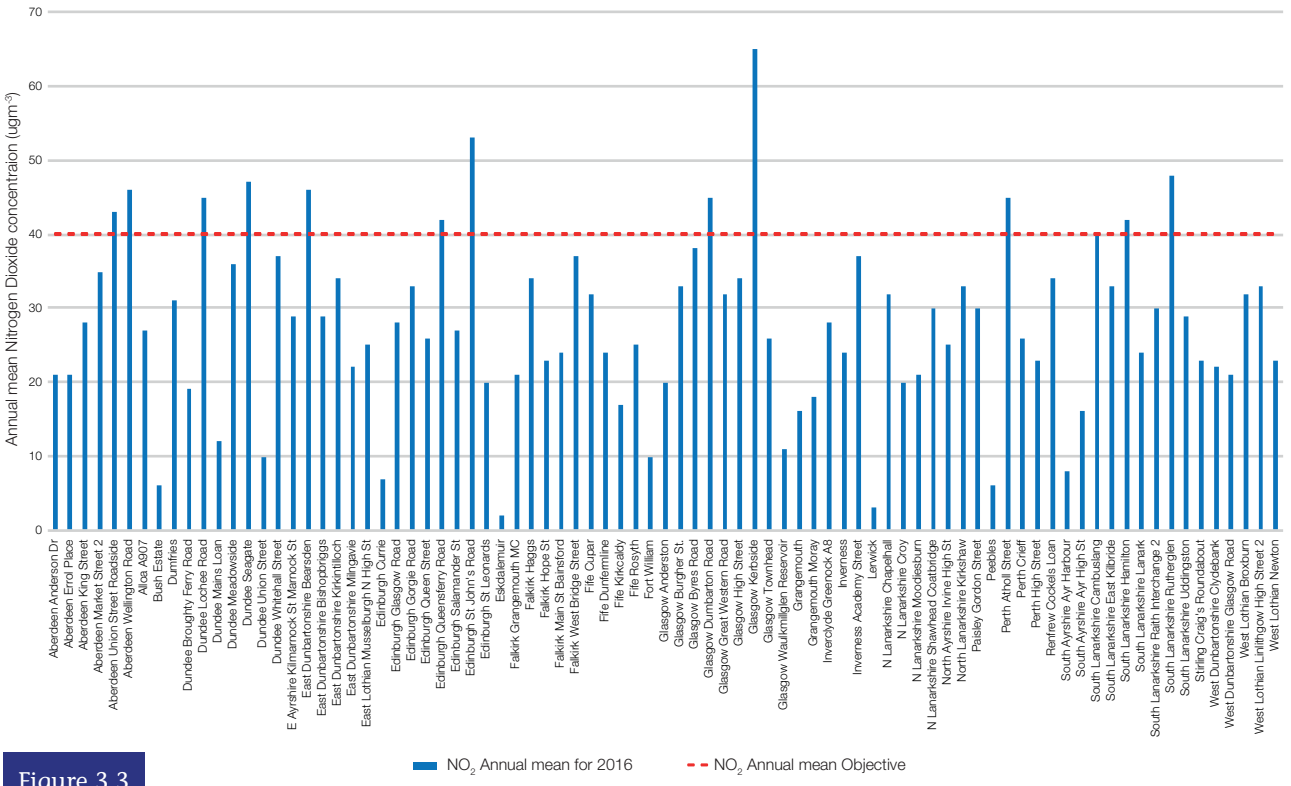


Figure 3.3

Annual mean NO_2 concentrations (2016)

Sulphur dioxide

This gas is emitted when fuels containing small amounts of sulphur (such as oil and coal) are burned. It was monitored at 10 sites in 2016. No sites recorded more than the permitted 35 exceedances of the AQS objective for the 15-minute mean (266 µg m^{-3}) during 2016. This is illustrated in Figure 3.4. No exceedances of the 24-hour mean objective of no more than three exceedances of 125 µg m^{-3} and 1-hour of no more than 24 exceedances of 350 µg m^{-3} were measured at any site.

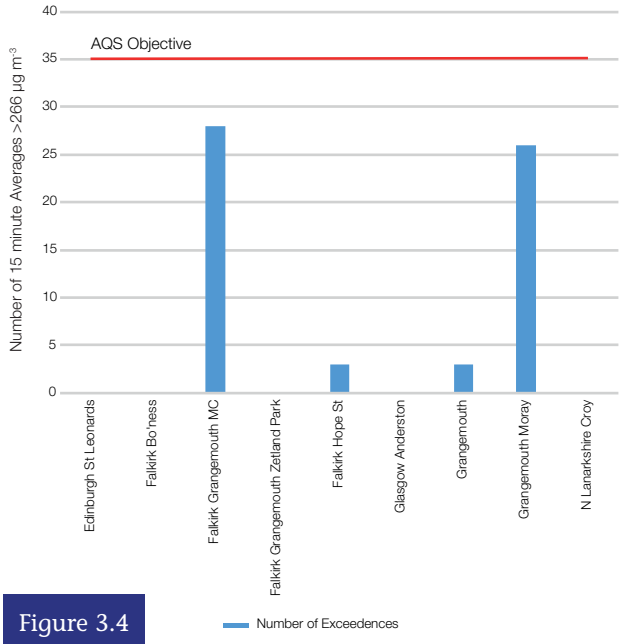


Figure 3.4

Exceedances of 15-min AQS objective for SO_2 (2016)

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 80 Scottish sites in 2016 sites using automatic monitoring and the Partisol™ daily sampler. Of these sites, 17 have less than 75% data capture. No site exceeded the UK AQS objective of 40 µg m^{-3} for the annual mean. However, Scotland has adopted a more stringent annual mean objective of 18 µg m^{-3}.

This objective was exceeded at two sites (Dundee Lochee Road and Edinburgh Queensferry Road) in 2016. See Figure 3.5.

The UK AQS objective for the 24-hour mean PM_{10} concentration is 50 µg m^{-3}, not to be exceeded on more than 35 days per calendar year. The more stringent Scottish objective requires that the daily mean PM_{10} concentrations does not exceed 50 µg m^{-3} on more than 7 days per year. In 2016, no site exceeded the 24-hour mean objective.

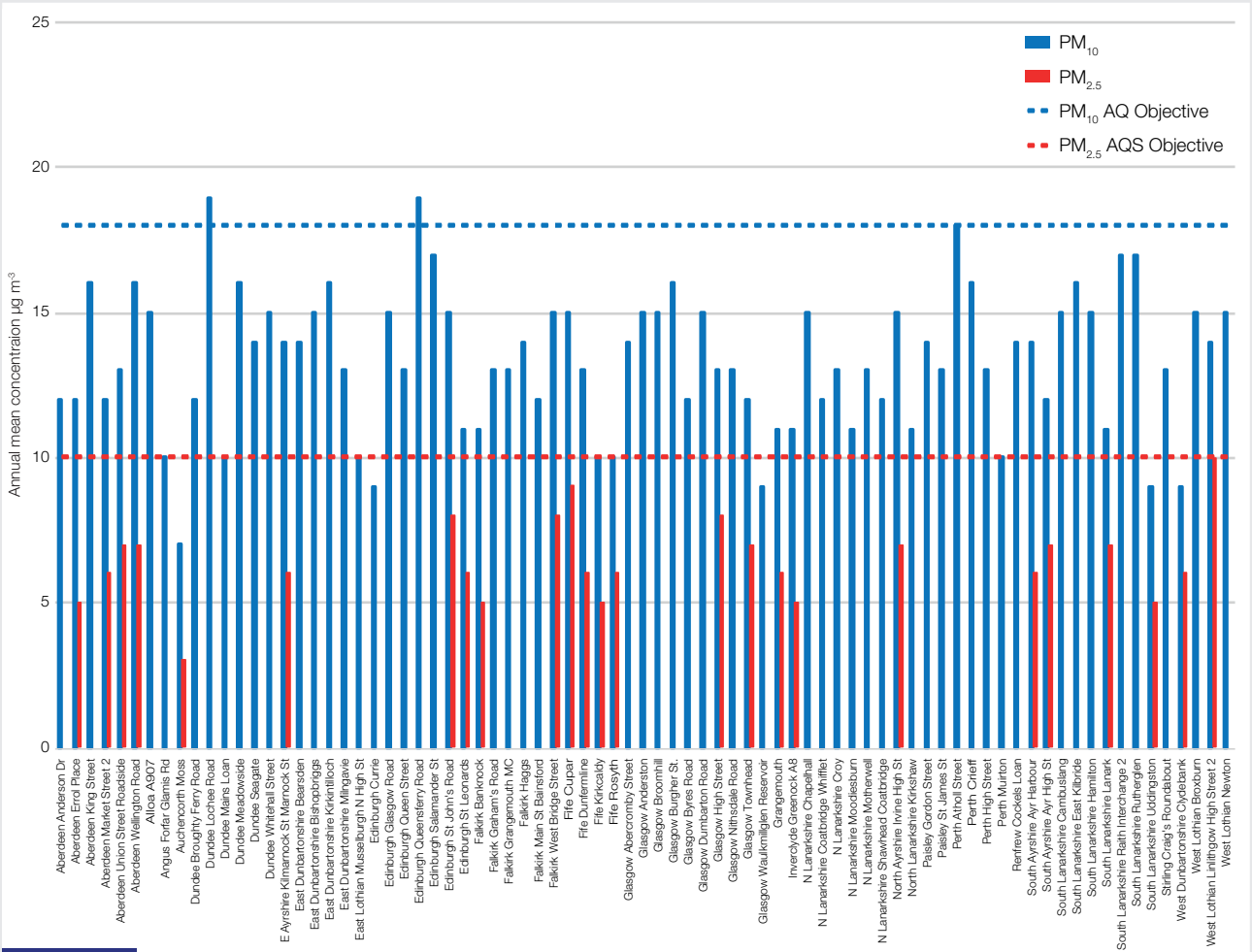


Figure 3.5

Annual average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites (2016)

Particulate Matter as $PM_{2.5}$

TThe finer particulate fraction, $PM_{2.5}$, was monitored at 27 sites in Scotland during 2016 (shown in Figure 3.5). Of these, 12 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 and site enclosure upgrades part way through the year.

On the 1 April 2016, the new Scottish annual average objective of 10 µg m^{-3} was introduced. This objective was not exceeded in 2016 at any site.

Polycyclic Aromatic Hydrocarbons

This group of pollutants is monitored at four sites in Scotland. The AQS objective of 0.25 ng m^{-3} for benzo[a] pyrene was not exceeded at any of the four sites during 2016.

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 2016. The AQS objective of 100 µg m^{-3} as an 8-hour running mean, not to be exceeded more than 10 days, was not exceeded in 2016.

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.

4

Air Quality Trends for Scotland

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 pollutant of interest is nitrogen dioxide.

Automatic monitoring of oxides of nitrogen 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 95 (as of April 2017). The data produced by these monitoring sites have 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 we see 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, for example 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. Visit http://analysistools.scottishairquality.co.uk/ for more information on the openair tools that are available and how to use them.

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 here. 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 and *** 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 3.3 of this report). In particular, the objective of 40 µg m^{-3} for annual mean NO_2 concentration is the most widely exceeded. Therefore, it is important to understand how concentrations of this pollutant vary with time.

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 (2007-2016). 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 2007-2016 – 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. As stated above, where there are gaps in the data, openair fills these in using an interpolation method. Aberdeen Errol Place, Edinburgh St Leonards and Glasgow Anderston showed highly significant negative trends (at the 0.001 level). For Fort William, there was a significant positive trend in NO_2 at the 0.1 level. At Grangemouth, there was a downward trend for NO_2, but it was not statistically significant.

Previously, trend analysis for urban non-roadside sites was based on only three sites – Aberdeen Errol Place, Edinburgh St Leonards and Grangemouth. The inclusion this year of Fort William and Glasgow Anderston has provided additional information and, in particular, the upward trend at Fort William shows that NO_2 concentrations are not decreasing at all urban non-roadside locations.

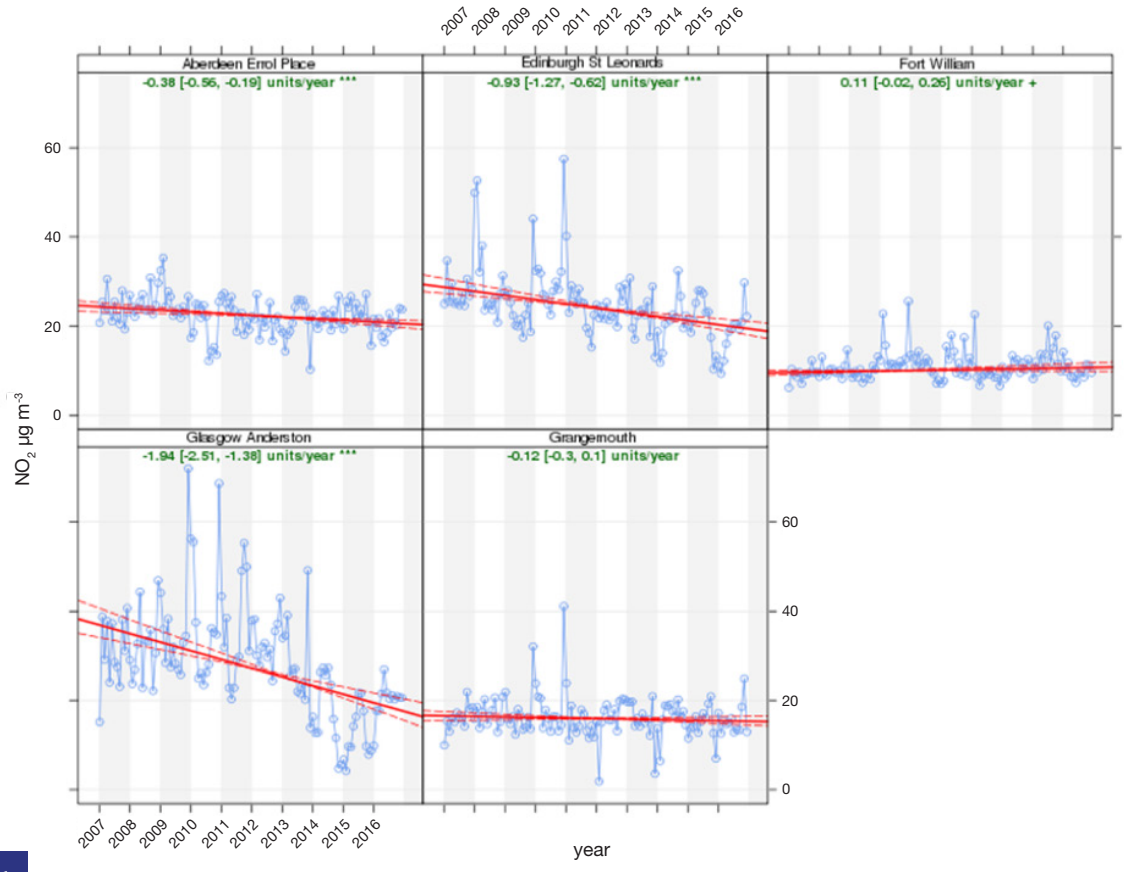


Figure 4.1

Trends in NO_2 concentrations non-roadside sites (2007-2016)

4.1.2 NO_2 at Rural Sites

There are three long-running rural sites that have monitored oxides of nitrogen for the past 10 years – Bush Estate, Eskdalemuir and Glasgow Waukmillglen Reservoir. Figure 4.2 shows trends in NO_2 concentration at these sites.

The sites at Bush Estate and Eskdalemuir showed small, but highly significant downward trends. However, this was not the case for Glasgow Waukmillglen Reservoir, where concentrations were increasing very slightly year-on-year, though the trend was not significant.

4.1.3 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 19 roadside or kerbside monitoring stations that have been in operation for 10 years or more, and are still in operation. These are:

- Aberdeen Anderson Drive
- Aberdeen Union Street
- Dumfries
- Dundee Lochee Road
- Dundee Seagate

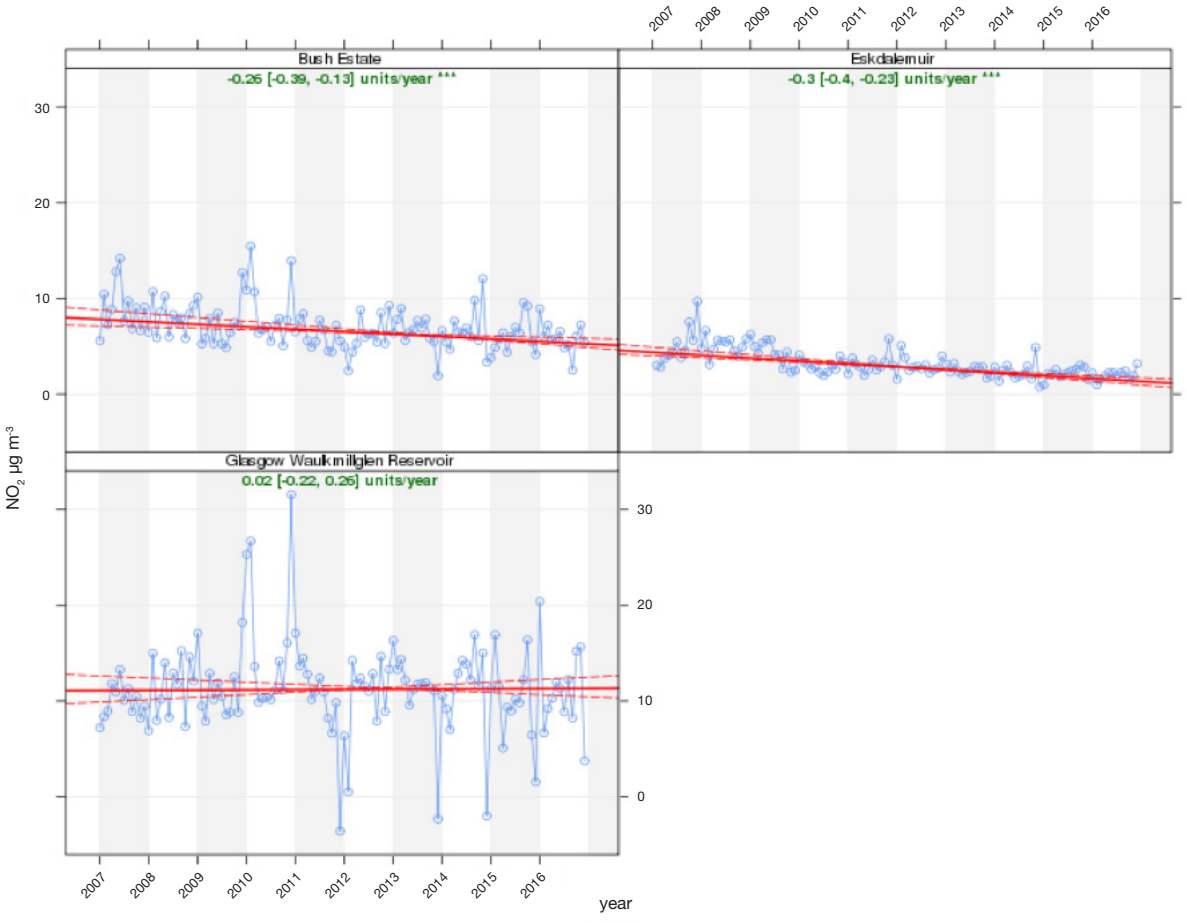


Figure 4.2

Trends in NO_2 concentration at three rural sites (2007-2016)

- Dundee Whitehall Road
- East Dunbartonshire Bearsden
- East Dunbartonshire Bishopbriggs
- Edinburgh Gorgie Road
- Edinburgh Queen Street
- Edinburgh St John's Road
- Fife Cupar
- Falkirk Hope Street
- Glasgow Byres Road
- Glasgow Kerbside
- Inverness
- Perth Atholl Street
- Perth High Street
- West Dunbartonshire Clydebank.

This is a large number of sites so, for the purposes of this report, nine have been selected that have measured exceedances of the Air Quality Strategy objective for annual mean NO_2 (40 µg m^{-3}) in recent years (though not necessarily 2016). These are Aberdeen Union Street, Dundee Lochee Road, Dundee Seagate, Edinburgh Gorgie Road, Edinburgh St John's Road, Glasgow Byres Road, Glasgow Kerbside, East Dunbartonshire Bearsden and Perth Atholl Street.

Figure 4.3 shows the trend plot. Six of the nine sites (Aberdeen Union Street, Dundee Lochee Road, Edinburgh Gorgie Road, Edinburgh St John's Road, Glasgow Kerbside and Perth Atholl Street) showed downward trends in NO_2 concentration, which were highly significant (at the 0.001 level). However, this was not the case at every site – at Glasgow Byres Road the trend was significant only at the 0.05 level; and Dundee Seagate and East Dunbartonshire Bearsden showed no significant trends.

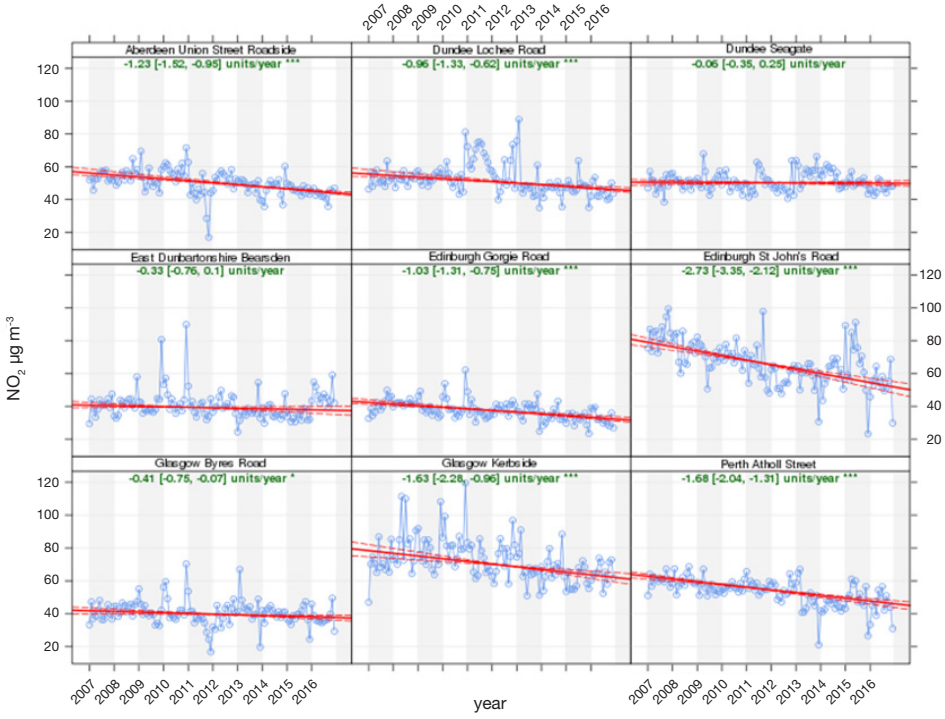


Figure 4.3

Trends in NO_2 concentrations at nine, long-running urban traffic sites with exceedances (2007-2016)

Trends over the most recent 5 complete years, 2012-2016, have also been examined for these sites. These are shown in Figure 4.4. Comparing the 10-year and 5-year trends, the patterns differ from site to site – Aberdeen Union Street, Dundee Lochee Road, Dundee Seagate, Edinburgh Gorgie Road and Glasgow Byres Road show downward trends that have become greater or more statistically significant (or both) during the past 5 years. However, by contrast, for the other four sites – East Dunbartonshire Bearsden, Edinburgh St John's Road, Glasgow Kerbside and Perth Atholl Street – downward trends have become smaller or less statistically significant during this more recent period. In the case of East Dunbartonshire Bearsden and Edinburgh St John's Road, the trend has changed from negative to positive (although not statistically significant at either site). Therefore, it should not be assumed that NO_2 is continuing to improve at all sites.

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

Figure 4.4

Recent trends in NO_2 concentration at nine, long-running urban traffic sites (2012-2016)

5

Maps of Air Quality

As part of the SAQD project, Ricardo Energy & Environment provides mapped concentrations of modelled background air pollutant concentrations on a 1 km x 1 km 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)

They 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, 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 2014 (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 (FDMS, Partisol and VCM-corrected Thermo Scientific 1405-F tapered element oscillating microbalance (TEOM)™ data) and automatic monitoring measurements for NOX and NO_2 in 2014. 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.

In 2009, Ricardo Energy & Environment (previously AEA Technology) undertook a short study[2] on behalf of the Scottish Government, which demonstrated that air pollutant source apportionment data and forward-projected concentrations of air pollutants were required for the Scottish pollution maps. These parameters were calculated for 2009 using Scotland-specific data, for use by Scottish local authorities for their LAQM review and assessment reports. These were subsequently updated to a base year of 2013 and are available at www.scottishairquality.co.uk/maps.php?n_action=data

5.1 Update to Air Quality Maps for Scotland 2016

On Behalf of the Scottish Government, Ricardo is contracted to provide updated mapped concentrations of NOx, NO_2 and PM_{10} for 2015.

During 2016/17, and at the time of writing this report, there are two versions of the UK 2015 modelling:

3. Modelling submitted to the European Commission for the UK compliance assessment in September 2016 (version 2015A)
4. Updated modelling for updates to the NO_2 air quality plans (undertaken at the time of writing this report) due to be published with the updated NO_2 plans in July 2017 (version 2015C)

The major difference between the two is that the 2015C model version uses more up-to-date COPERT vehicle emission factors that are more realistic for real-world driving (the revised, COPERT 5 emission factors are being used for NO_2 and PM_{10}, but the impact of the change is much greater for NO_2).

After consultation, the Scottish Government considered that the best approach for the scheduled 2015 Scottish mapping work would be to use the more up-to-date 2015C modelling being undertaken for the Air Quality Plan for NO_2 in the UK 2017[3], as this incorporates more realistic vehicle emissions. In addition, it is also expected that the Department for Environment, Food and Rural Affairs (Defra) will provide an update to LAQM data (mapped data for all years from the base year to 2030), based on projections from model version 2015C in due course.

In previous years, the Scottish Government updated its version of these data in line with Defra updates. Defra is not expected to update its LAQM data until after September 2017. Scottish local authority data will not be updated until after this time.

[2] Stevenson, K., Kent, A.J., and Stedman, J. (2010). Investigation of the possible effect of the use of Scottish specific air quality maps in the LAQM process in four selected Local Authorities. AEA Report AEAT/ENV/R/2948. www.scottishairquality.co.uk/documents/reports2/258100203_LA_mapping_Report_Issue_1_FINAL.PDF

[3] www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

Providing maps for Scotland that are based on version 2015C and not version 2015A will avoid having different versions of maps for the base-year modelling to be undertaken now and local authority data to be provided in the future.

At the time of writing this report, the updates previously stated were not released. As a result, the Scottish air quality mapping work has not yet been completed.

For reference, the details of the methodology and full results of the most recent mapping study are provided in a separate report[4] and can be found at http://www.scottishairquality.co.uk/assets/documents/ScottishAQmapping2014_final.pdf

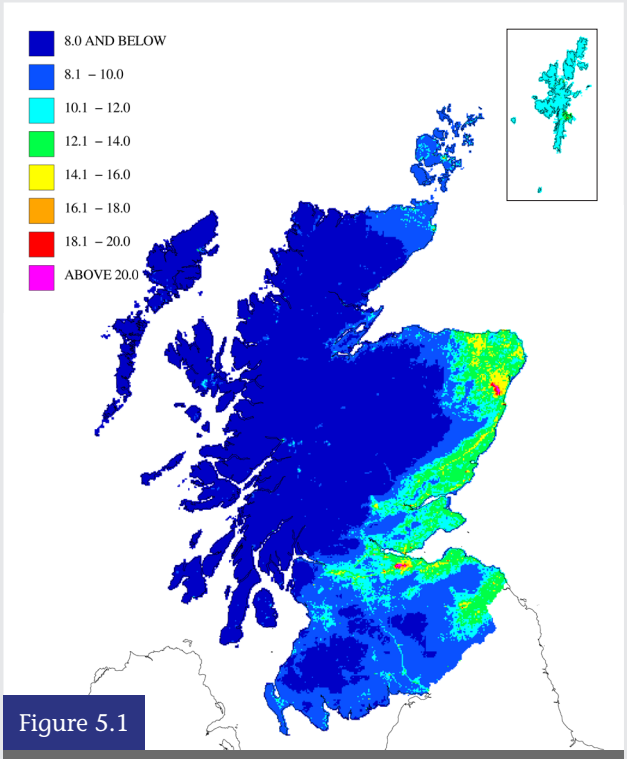


Figure 5.1

Annual mean background NO_2 map (2014)

[4] Rose R.A. (2016). Scottish Air Quality Maps. Pollutant modelling for 2014: annual mean NOX, NO_2, and PM_{10}.

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 7 (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 pupil's 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

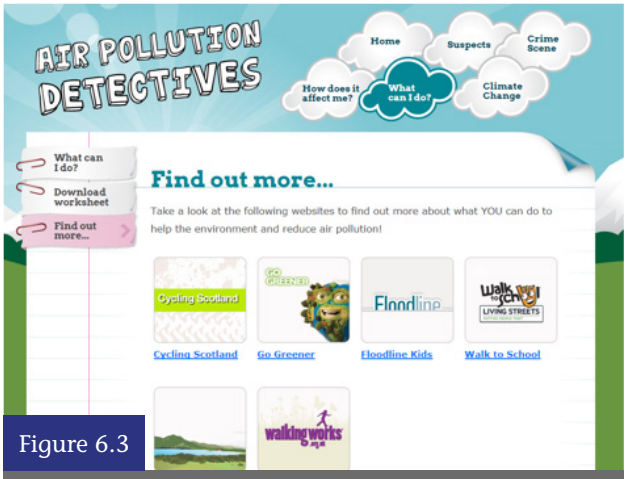


Figure 6.3

Additional information available on the Air Pollution Detectives webpages

The Air Pollution Detectives is available 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. 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 teacher's pack including notes to supplement the monitoring equipment, and webinars to help introduce the concept of local air quality and conduct the monitoring.

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

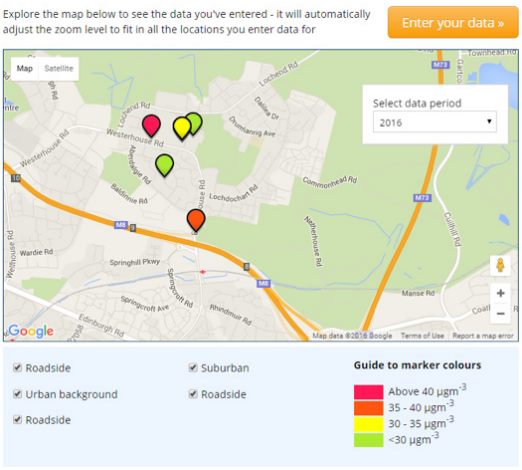


Figure 6.5

Data entry available for each school profile

7

Recent Developments

7.1 Cleaner Air for Scotland (CAFS) & the $PM_{2.5}$ Network

CAFS introduced several important new initiatives for the Scottish Government's commitment for cleaner air, one of which was the 'adoption of World Health Organization (WHO) guideline values for fine particulate matter ($PM_{2.5}$) in Scottish legislation'. Particles are measured in a number of size fractions according to their mean aerodynamic diameter. Finer particles, such as $PM_{2.5}$, can be carried deep into the lungs and blood stream where they can cause inflammation and a worsening of the condition of people with heart and lung diseases.

On 1 April 2016, Scotland introduced the $PM_{2.5}$ annual mean objective of 10 µg m^{-3}, in line with WHO guidelines. Scotland is the first country in Europe to include this WHO guideline value in domestic legislation.

As part of the 2016/17 funding support for local authorities to assist with LAQM monitoring and modelling work, awards were made to fund 13 new $PM_{2.5}$ monitoring stations (Figure 7.1), adding significantly to the existing network of 16 sites and being on track to increase the number of $PM_{2.5}$ analysers by at least 24 throughout Scotland (as per the '$PM_{2.5}$ and PM_{10} in Scotland Report'). $PM_{2.5}$ monitoring sites will continue to grow throughout 2017 as many sites are due an upgrade.

Figure 7.1

Locations of new $PM_{2.5}$ analysers within the SAQD network

Figure 7.2

New site upgrades to the SAQD network

7.2 New SEPA Analytical Tools on Air Quality in Scotland Website

SEPA launched the new data analysis and visualisation tools within the Air Quality in Scotland website at this year's Scottish Air Quality Database Annual Seminar. The tools pull data from the existing database and present it in a simple and pre-analysed format. Air quality data is provided to the public in a visual and informative way, allowing access to the full range of air quality information collected across Scotland. The tools provide simple informative data to local authorities and members of the public to view air quality in their area. There is also a new time-laps tool that illustrates s the movement of transboundary pollution across Scotland and demonstrate the effect such events have on local air quality.

All analytical tools available through the Air Quality in Scotland website are available at http://analysistools.scottishairquality.co.uk/

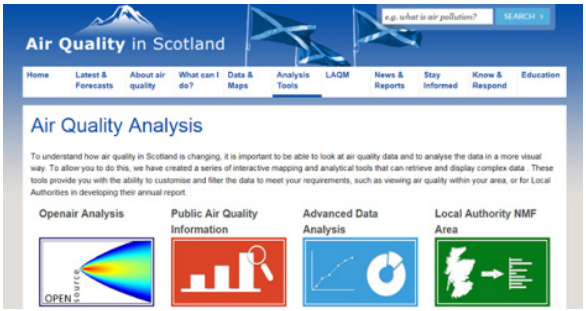


Figure 7.3

Spotfire analysis tools on the Air Quality in Scotland website

Figure 7.4

Spotfire analysis tools

7.3 SAQD Newsletter

In December 2016, the first edition of the Air Quality in Scotland quarterly newsletter was published via the Air Quality Scotland website (www.scottishairquality.co.uk/news/). The newsletter, produced by Ricardo Energy and Environment in conjunction with SEPA, is designed to provide regular updates and news regarding the SAQD and local air quality matters to all stakeholders. This includes updates to the network, new information on air quality issues, updates on changes in policy and procedures, new initiatives and events, and technical reports.

Figure 7.5

illustrates the first edition of the Air Quality in Scotland quarterly newsletter

7.4 Real-world Driving Emissions – Why Remote Sensing?

Air pollutants, such as NO_2 and PM, continue to exceed air quality standards in many towns and cities. Vehicle emissions are the primary cause of air quality standard exceedances in the majority of UK AQMAs.

Vehicles driven under real-world conditions can produce higher emissions than those produced during traditional laboratory-based test procedures. In particular, diesel vehicles have been known to produce significantly higher emissions of NO_x under real-world conditions. It is possible that such discrepancies may have resulted in pollution reduction policies failing to deliver the benefits originally anticipated and uncertainty over how to develop optimum mitigation measures. To address this problem, and to assist the development of future low-emission policy, accurate measurements of real-world driving emissions are needed.

Remote sensing equipment is now available that accurately measures real-world driving emissions from thousands of vehicles, under actual driving conditions, in a short space of time and without interfering with the vehicle whose emissions are being measured.

Remote sensing technology can be configured to measure real-world driving emissions of nitric oxide, nitrogen dioxide, particulate matter, hydrocarbons, carbon monoxide and ammonia. With remote sensing technology, measurement campaigns can be designed to explore real-world driving emissions at locations selected to maximise the benefit to the design of low-emission policies.

Real-world driving emission monitoring programmes have already been undertaken by a number of organisations in Scotland.

7.5 Volcanic Emissions Network

In July 2016, SEPA launched the new Volcanic Emissions Network. The network, funded by the Scottish Government, is specifically designed to detect polluted air mass originating from erupting Icelandic volcanoes, which have the potential to impact on Scotland's air quality.

The network consists of four monitoring stations that are set up to detect ground level sulphur dioxide gas and fine dust resulting from grounding volcanic plumes. The network will act as part of an early warning system, providing information to our health partners and the Scottish Government, enabling them to provide appropriate public health advice and assess potential effects on the Scottish environment.

7.6 Clean Air Day

The Scottish Government and SEPA joined forces to bring Global Action Plan's National Clean Air Day to a school in Edinburgh. Pupils at Sciennes Primary School, Edinburgh have always taken a keen interest in their local environment – from redeveloping the school car park into an all-purpose playground to creating a forest playpark and trail on land adjacent to the school.

The pupils used SEPA's national teaching material (www.learnaboutair.com) to understand and record air pollution around their school. Pupils were keen to learn about what activities contributed to air pollution and deployed the free monitor just outside their playground to record changes in air pollution during the day. By finding higher levels during the morning and afternoon drop-off times the pupils were keen to see what simple changes they could make, and what the Scottish Government was doing to improve air quality.

As part of National Clean Air Day, Cabinet Secretary for Environment, Climate Change and Land Reform Roseanna Cunningham visited Sciennes Primary School and spoke directly with the pupils, answering questions and hearing about their activities. The Environment Secretary was keen to express that:

'National Clean Air Day is an opportunity to think about the small actions we can take, such as choosing to leave the car at home more often or avoiding leaving the engine idling when in the car. There are many challenges ahead, but by working together we can realise the vision of cleaner air in Scotland to create a better environment and healthier society for kids like those at Sciennes Primary.'

During the day, the pupils were provided with some hands-on experiments, taken from the teaching material, to emphasise the issues around air pollution and to promote the actions that the school had adopted. The pupils investigated how their actions were contributing to improvements in air quality.

7.7 VentureJam Tackles Air Pollution

Three teams of innovative young Scots did battle when they pitch their creative ideas to tackle the global problem of air pollution in front of some of the country's leading innovators, entrepreneurs and investors at last year's Venturefest Scotland – Scotland's annual innovation summit.

The teams, known as Futuristic 5, Ninions and Project Airtech, were the winning trio from VentureJam 2016, the official youth strand for Venturefest, which was delivered by Young Scot, Glasgow City of Science and the Scottish Environment Protection Agency (SEPA).

The hackathon-style event saw teams of young people aged 14-20 years design and develop innovative new ideas to help improve Scotland's air quality, whilst driving home the message that we all have a part to play in achieving this goal.

Throughout VentureJam, the would-be entrepreneurs were supported by a team of mentors made up of engineers, creatives and technologists as well as legal and environmental experts.

To build excitement around VentureJam, and to raise awareness of the importance of taking positive action to tackle air pollution, a projected animation by Double Take Projections was beamed onto Glasgow's iconic City Chambers, the Clyde Auditorium and Cineworld IMAX at Glasgow Science Centre.

7.8 Clean Air for Scotland Exhibit

Understanding and reducing air pollution is the theme of a new interactive exhibit launched at the Glasgow Science Centre. It encourages school pupils and the public to consider the causes of air pollution such as traffic congestion and industrial emissions, and how it affects our health and the environment. The exhibit shows that it's the choices we make that are the difference between good and polluted air quality.

The exhibit, developed by the Glasgow Science Centre and SEPA, was funded by the Scottish Government. The exhibit is one of a series of activities of being rolled out to help educate and inform primary and secondary pupils on the issues around air pollution in Scotland.

The exhibit took inspiration from the national teaching package 'Learning About Air Quality', using some of the novel and innovative approaches such as the city model where visitors get the opportunity to control traffic, allowing them to experience how different modes of transport contribute to air pollution in our urban environments (www.learnaboutair.com).

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 and 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

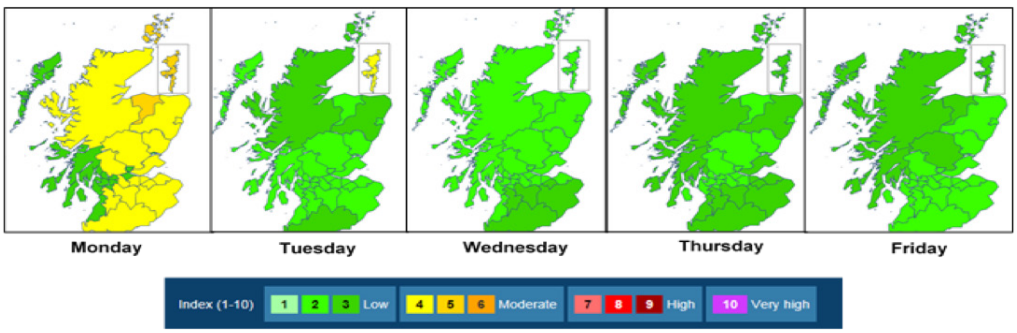
The Air Quality in Scotland app gives the latest air quality levels for each site, forecasts for the day ahead and alerts when air pollution levels increase via the Know & Respond health alerts service. The free Air Quality in Scotland app is available for for most devices mobile devices.

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

New visualisation and data analysis tools are available on the Air Quality in Scotland website as beta test web pages. The tools pull data from the SAQD and present it in several pre-analysed formats. These tools provide you with the ability to customise and filter the data to meet your requirements, such as viewing air quality within your area or for local authorities when preparing annual reports.



8.6 Twitter

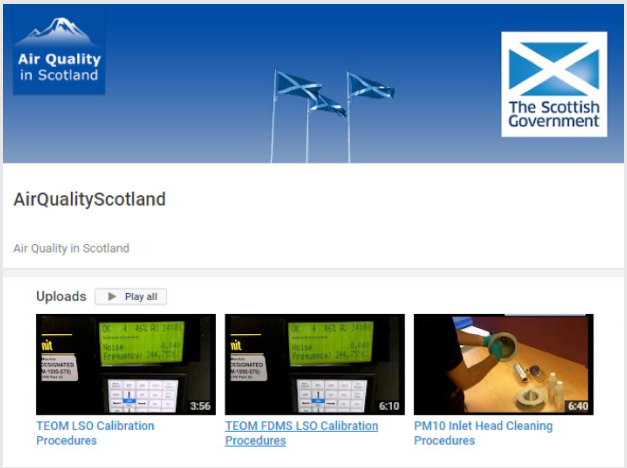
Follow Air Quality in Scotland for on Twitter (@scotairquality) for air quality forecasts and summaries of measurements from Scotland.

The service allows 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.

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 within the Air Quality in Scotland website (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

www.scottishairquality.co.uk