Scottish Air Quality Database

Annual Report 2013

Report for the Scottish Government

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04 September 2014

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Executive Summary

Ricardo-AEA was commissioned by the Scottish Government to undertake a 3-year project (Apr 2007 – Apr 2010) to develop an Air Quality Database and Website for Scotland. The contract was renewed for another 3 years in April 2010 and now a further 3 years in April 2013.

This report presents the activities undertaken during the sixth year of the project - April 2013 to March 2014. In addition to the core work undertaken under the project, there has been significant additional activity and further developments during the year. These have included the launch of the new Scottish Air Quality website (http://www.scottishairquality.co.uk) together with enhanced Social Media feeds through Twitter and You Tube; a new air quality app that can be used with iphone and Android mobile devices, and provides the latest information on current and forecast air quality levels; the Clear Air site aimed at secondary school children, which is used as a teaching tool; and the enhancement of the quality assurance/quality control (QA/QC) regime with a quarterly instead of half-yearly data ratification schedule.

All automatic data within the Scottish Air Quality Database (SAQD) are subject to the same QA/QC procedures as data from the national network air quality monitoring stations within the UK Automatic Urban and Rural Network (AURN). This ensures that all data in the database are quality assured and are traceable to UK national calibration standards for the various pollutants. At the end of 2013 the Scottish Air Quality Database contained data for a total of 91 automatic monitoring sites.

A summary of ratified data for 2013 is provided in this report. The pattern of measured concentrations is similar to previous years in that where exceedances of the Scottish Air Quality Objectives occur, these are in areas where the relevant Local Authority has already declared, or is in the process of declaring an Air Quality Management Area (AQMA). Where Air Quality Management Areas are declared then the Local Authority will produce an Air Quality Action Plan and undertake the necessary actions to move towards compliance with the Air Quality Objectives in the future. By April of 2014 a total of 34 AQMAs were in place in Scotland.

The website and this annual report also contain a summary of data from a wider range of pollutants measured in Scotland as part of several national network monitoring programmes.

Data held within the database covering many years have been used to assess possible trends in air pollution throughout Scotland. In previous years, this assessment has been based on the composite dataset using all sites in the database. However, the addition of new sites to the database in recent years potentially complicates this approach, as the changes in site numbers and site distribution may influence the apparent trends in pollutant concentration. Therefore, for the 2010 and subsequent reports, a different approach was proposed and adopted. The new air quality trends have been examined on the basis of individual monitoring sites, and subsets of long-running sites, rather than the composite data set. For this report, smoothed trend and Theil-Sen analysis has been used; utilising the Openair data analysis tool to quantify pollutant trends at individual sites.

In terms of concentrations of nitrogen oxides (NO_x) from urban non-roadside sites, three urban non-roadside sites have been monitoring NOx for at least ten years (i.e. since 2004 or earlier); Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth (the latter is an urban industrial site). All three sites show a slight negative trend (i.e. decreasing NO_x). The trend is statistically significant at Aberdeen Errol Place and Edinburgh St Leonards. It is most significant (at the 0.001 level) at Aberdeen Errol Place. However, the actual decrease year-on-year is small.

For a subset of five long-running sites (Dumfries, East Dunbartonshire Bishopbriggs, Glasgow Kerbside, Inverness and Perth High Street), three show a downward trend in NO_x (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street). However, Glasgow Kerbside shows no trend, and Inverness shows a slight upward trend.

In the case of nitrogen dioxide (NO_2), trends are also very variable between sites, with the same three sites (Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street) showing highly statistically significant downward trends, and two (Glasgow Kerbside and Inverness) showing small but statistically significant upward trends. Further investigation of trends in NO_2 concentration at traffic-related monitoring sites with at least nine years of data (2005-2013) has revealed no clear patterns, with NO_2 concentrations increasing at some sites and decreasing at others.

The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place, which has been measuring this parameter since late 1999. A smoothed trend plot of de-seasonalised monthly mean PM_{10} concentrations at this site shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013.

Four urban non-roadside sites in Scotland have been in operation since 2006 or earlier. These are Aberdeen Errol Place), Dundee Mains Edinburgh St Leonards, and the urban industrial site Grangemouth (FDMS since 2009). All four sites show a negative trend.

Long-running sites Aberdeen Anderson Drive, Aberdeen Union Street, East Dunbartonshire Bishopbriggs, Glasgow Anderston, Glasgow Byres Road, Glasgow Kerbside, Perth Atholl Street and Perth High Street all show statistically significant downward trends in PM_{10} concentrations.

Three non-roadside sites (Aberdeen Errol Place, Edinburgh St Leonards and Grangemouth) show small upward trends in $PM_{2.5}$ concentrations over the past five years, although only at Aberdeen Errol Place is the trend statistically significant. In contrast, Glasgow Kerbside shows a clear overall downward trend.

Two sites (Bush Estate and Eskdalemuir) show a small but statistically significant upward trend in monthly mean rural ozone concentrations over the past two decades. Edinburgh St Leonards and Aberdeen Errol Place show decreasing trends in ozone concentration in the years since 2003.

As the number of monitoring sites in the database has increased it is now feasible to undertake pollution climate mapping of PM_{10} and NO_2 concentrations throughout Scotland, based on Scottish monitoring data and Scottish meteorological data. The pollution maps and data produced in this study will be made available on the website and a selection of the maps is presented in this report.

This report also includes a summary of pollutant emissions data for Scotland. Data on emissions from all sources are available from the National Atmospheric Emissions Inventory (http://naei.defra.gov.uk/) and more detailed data on industrial emissions for Scotland are available from the Scottish Environment Protection Agency Pollution Release Inventory:

http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

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1 Introduction

The Scottish Government undertakes considerable monitoring of a wide range of air pollutant species as part of a joint UK programme run in conjunction with Defra, the Welsh Government and the Department of the Environment in Northern Ireland. In addition a large number of Local Authorities in Scotland monitor air quality within their geographical boundaries as part of the requirements of the Local Air Quality Review and Assessment process. Prior to 2006, air quality data in Scotland outside of the nationally operated sites were collected by a wide range of organisations for a number of purposes and were widely dispersed. Consequently and following experience gained across the rest of the UK it was recognised that a comprehensive centralised resource providing air quality information for Scotland would serve to improve the quality of research and data analysis required to support and evaluate Scottish air quality policies. Hence, in 2006, the Scottish Government contracted AEA, now Ricardo-AEA, to undertake a pilot programme to develop an air quality database for Scotland.

The pilot study developed the initial Scottish Air Quality Database (SAQD) and Website, undertook stakeholder feedback and assessed the air quality data available across Scotland. The results of this study are discussed in the Pilot Study Report[1]. The key recommendations that were developed from this initial study were based around the methodology for successful harmonisation of existing air quality monitoring data. It was suggested that a programme for Scotland should include the following components:

- Independent audits of every site - to include checks on both the analysers and the site calibration cylinders
- Regular data checks
- Longer term data checking and adjustment where necessary.

Following this pilot study AEA were commissioned to undertake the next stage which was to further develop and extend the SAQD and website incorporating all stakeholder comments and to bring selected Local Authority sites in line with the national QA/QC requirements. Reports relating to earlier years of the project are available on the website (www.scottishairquality.co.uk).

This annual report summarises the progress made during 2013 in the on-going project tasks and also highlights the considerable new work undertaken during 2013.

Section 2 provides information on the launch of the new Air Quality in Scotland website, with **Section 3** providing a brief summary of the Annual Air Quality in Scotland seminar at which the new website, App and twitter account were officially launched.

The overall number of sites in the database with data available for all or part of 2013 increased to 91 and are listed in **Section 4**. The corresponding QA/QC programmes (**Section 5**) have expanded to encompass these additional sites. As in 2009 to 2011, the PM_{10} data from TEOM analysers have been corrected using the Volatile Correction Model for all sites in Scotland. Summary statistics for all of the available data are provided in **Section 6**.

In 2009 a pilot mapping exercise was undertaken including future year projections for 2010, 2015 and 2020. This pilot exercise has been subject to further development in subsequent years and an improved methodology has been used to deliver pollution climate mapping of NO_x, NO_2 and PM_{10} including projections. The Scottish pollution climate mapping work is described in **Section 7**.

Section 8 provides a discussion of trends in pollutant concentrations across Scotland, based on the latest available data. As the number of monitoring sites in Scotland has increased, it has become feasible to undertake pollution climate mapping of NO_x, NO_2 and PM_{10} using solely Scottish measurement data.

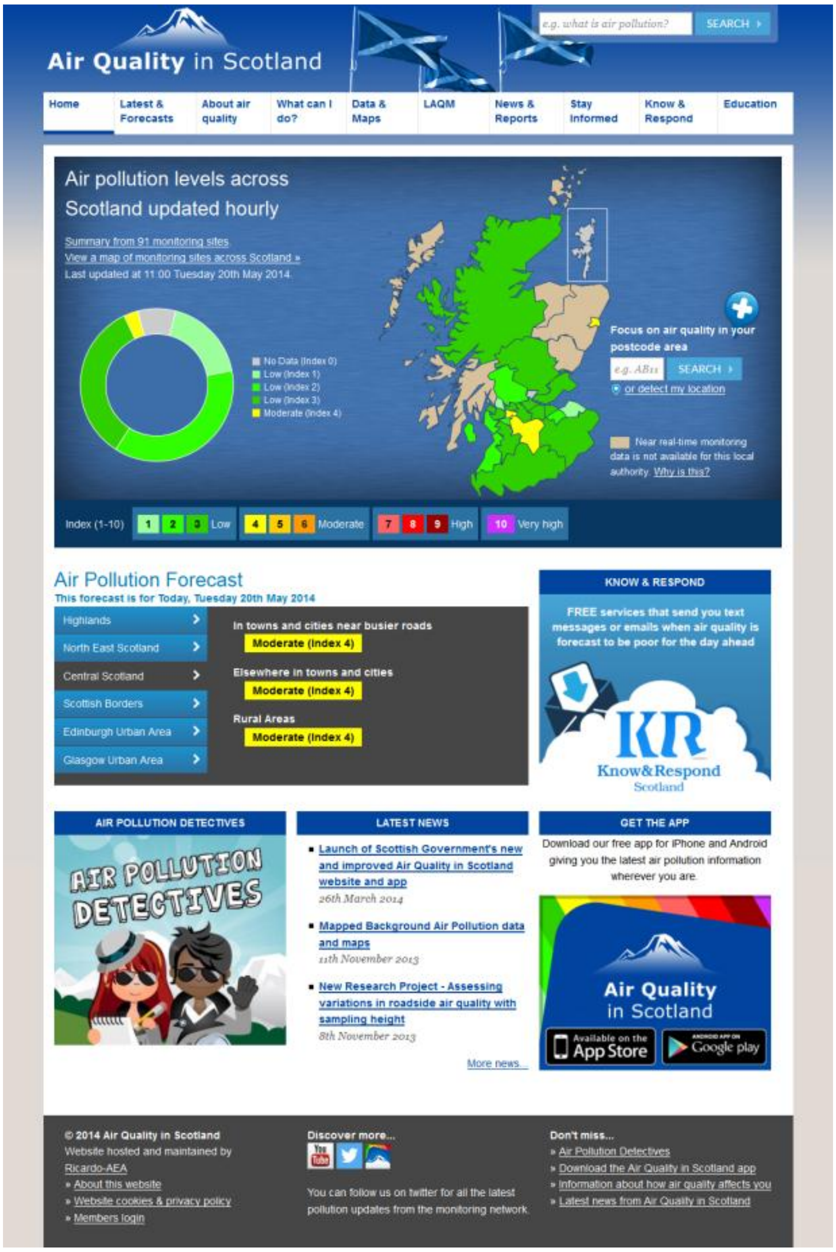
During 2009, the website was upgraded to include links to the SEPA Scottish Pollution Release Inventory (SPRI) in order to provide information on industrial releases of pollutants in Scotland. This data has been updated for 2011 and this report also includes a section on emissions in Scotland with data from both the National Atmospheric Emissions Inventory (NAEI) and the SEPA SPRI (**Section 9**).

2 The New Scottish Air Quality Website

2.1 Air Quality in Scotland Website

The new Air Quality in Scotland website was launched on 26th March 2014 at the annual Air Quality in Scotland Seminar and provides users with a modern redesigned website for air pollution information and measurements (Figure 2.1).

Figure 2.1 Screenshot of new Air Quality in Scotland Website Homepage



The new homepage has an interactive map of local authorities, each coloured according to their current maximum pollution level. This map is complemented by a graphical pie chart illustrating the latest data broken down by AQI index. The homepage also allows other features of the website to be brought to the attention of users which they may not already know about.

Elsewhere on the website, the familiar tools from the previous website have been updated such as the interactive monitoring site map, latest site data and graphing, comprehensive data selector, and Know & Respond alert signup.

The new modern design also adapts itself to work on any screen size on any device (e.g. a tablet or smartphone) ensuring ease of use for as many users as possible.

The following provides an overview of the features of the re-launched Air Quality in Scotland website:

- Summaries by monitoring site and local authority
- Filterable interactive monitoring site map, with “detect my location” functionality for users in Scotland
- Easy access to the latest pollutant graphs
- Regional forecasts
- Comprehensive information about air quality and the health effects of pollution
- Advice to help reduce pollution
- Comprehensive data tools with Openair statistical analysis
- SPRI Emissions-to-air data map with links to the SPRI website
- Air Quality Management Areas (AQMA) maps and information and LAQM tools
- News and reports archive
- Discussion forum
- Email bulletin registration for alerts based on custom event criteria
- Know & Respond alerts based on forecast data
- Links to download the app, get updates via twitter, use the RSS data feeds
- Education section linking to the two sub-sites: Air Pollution Detectives and Clear The Air
- All members’ area tools, including site photo upload, and monitoring site location update tool.

2.2 Social media

Twitter account

Ricardo-AEA successfully manages several twitter accounts for a range of air quality websites and welcomed the opportunity to do the same for Scotland (Figure 2.2).

The new Air Quality in Scotland twitter account (@scotairquality) provides a new way to keep informed about air pollution in Scotland. Automated rules tweet the latest air quality measurement summaries a maximum of three times per day on weekdays (9am, 1pm and 5pm) and two times per day on weekends and bank holidays (10am, 4pm).

In addition, each afternoon a Ricardo-AEA duty forecaster will tweet a summary forecast for the next day ensuring followers are kept informed and can plan their daily activities in advance.

A link to health advice is also tweeted when pollution levels are High or Very High ensuring the user is kept informed.

The branding of the twitter account has been designed to be the same as the main website, providing a consistent and familiar brand to users.

Further details and the twitter account are available at:

http://www.scottishairquality.co.uk/stay-informed/twitter

https://twitter.com/scotairquality

Figure 2.2 Air Quality Scotland Twitter Page

YouTube account

A new YouTube account was launched for Air Quality in Scotland providing a platform for related videos and a way to embed these into the main website. The YouTube account currently hosts the videos for the Local Site Operator manual, although more public focussed videos are planned such as a 'how-to guide' on using the Openair statistical analysis tools.

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

Apps

A new Air Quality in Scotland app has been developed for iPhones and Android phones, creating a new and innovative way to stay informed about pollution levels in Scotland (Figure 2.3).

The app provides the following information:

- Summary of the latest data levels
- Site information for each automatic monitoring site, including a 7 day trend chart
- Air pollution forecast for each zone region
- Health advice

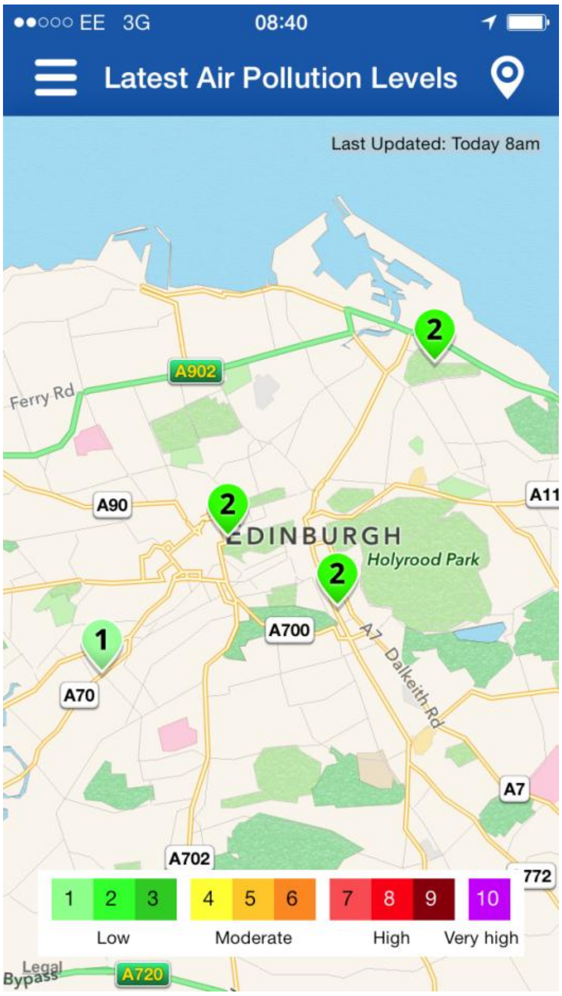
- Advice for increased levels of pollution
- "Locate me" button to quickly locate users if they are in Scotland

In addition, the app integrates the Know & Respond health alerts service allowing app users to subscribe to a specific region and receive push notifications directly to their handset if Moderate (or worse) air pollution is forecast each day.

The app is available to download from the Apple iTunes and Google Play app stores:

- https://itunes.apple.com/en/app/air-quality-in-scotland/id838197830
- https://play.google.com/store/apps/details?id=uk.co.scottishairquality

Figure 2.3 Air Quality in Scotland App



2.3 Clear the Air

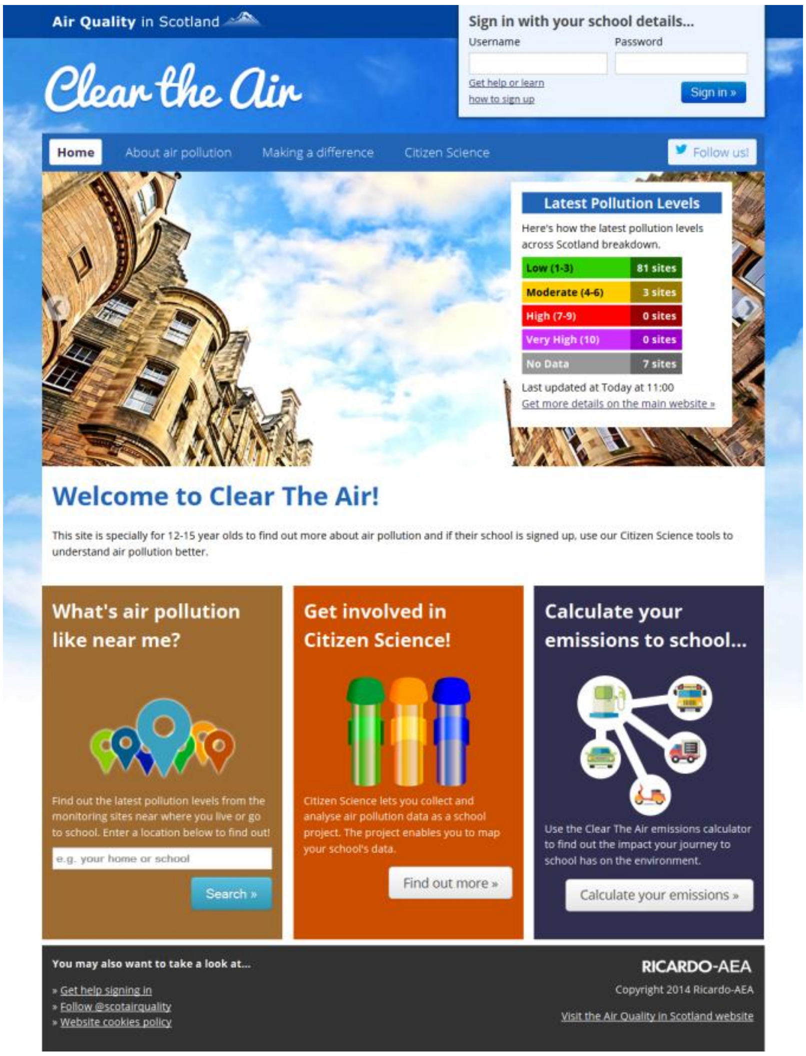
Clear the Air is a new sub-site to complement the existing Air Pollution Detectives and is aimed at secondary school pupils (Figure 2.4).

The public pages provide information on air pollution, impacts on health and how air pollution is monitored. In addition, three key tools allow secondary school pupils to explore and interact with the website:

1. **Emissions Calculator**
   Designed to allow users to find out their emissions on the way to school, the easy-to-use calculator allows the user to enter their mode of transport, distance to school, and number of passengers. A calculation is done and the results are shown with comparison graphs to the other modes of transport providing a comprehensive overview. Full information is provided detailing the assumptions made and equation used for the calculation.
2. **What's air pollution like near me?**
   This interactive tool allows the pupil to enter any location in Scotland and the nearest air quality monitoring stations are shown. All data comes from the main Air Quality in Scotland website and links are provided for the user to explore further.
3. **Citizen Science**
   This brand new pilot programme allows secondary schools across Scotland to sign up and take part in data collection within their School. Registered Citizen Science users can enter diffusion tube measurements and display their data on an interactive map colour coded to visually see trends and measurements.

Clear The Air is linked to from the main Air Quality in Scotland website and can be accessed at: www.cleartheair.scottishairquality.co.uk

Figure 2.4 Clear The Air Webpage



2.4 Database and Website

The 'Air Quality Scotland' database and website (www.scottishairquality.co.uk) has been created to provide a comprehensive resource for information covering all aspects of air pollution in Scotland.

The site is funded by the Scottish Government and is designed to be:

- Accurate and reliable
- Comprehensive
- User-friendly
- Easily navigable
- As interactive as possible, and importantly
- Able to meet the needs of the general public as well as technical, local government and regulatory user communities.

General website and database activities for the past year will be described here, followed by some details of the upgrades which have been developed and launched.

2.4.1 Usage Statistics

Usage of the website is monitored through the on-line tracking tool "awstats", and statistics can be accessed by clicking the following link: http://www.scottishairquality.co.uk/cgi-bin/usage.pl.

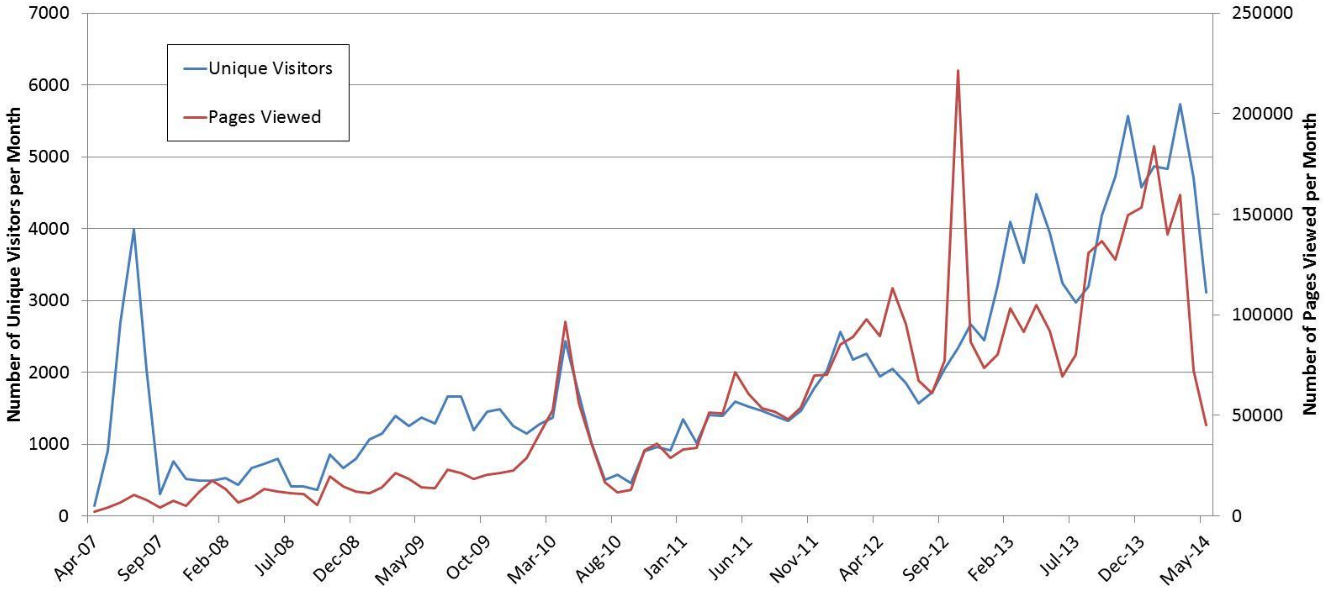
The software tool provides in-depth analysis of the time, date, location and access route of every visit to the website (It does not store any personal information which would require declaring under the Data Protection Act). Figure 2.5 below illustrates how the number of hits has varied during the period April 2007 to May 2014.

The hits will include some automated search engine visits which are required in order to keep the sites' rating on Google and Yahoo as high as possible. However, we have endeavoured as far as possible to configure the site security and tracking software to exclude automated web crawlers which may be attempting to scan the site maliciously for personal information to be used in spamming.

Assuming that hits statistics are genuine, it can therefore be seen that the largest numbers of unique visitors to site were recorded during the months of January to April 2014, with an upward trend in unique visitors and pages viewed between 2007 and 2014. The number of visitors per month during January to April 2014 varied between around 4,700 and 5,700. Whilst the reasons for the distinct trends in activity are not clear, the increased interest in the website during 2013/14 corresponds to an increase in media attention to air quality in general, in addition to the annual cycle of local authority review and assessment activity.

Key users of the website include local authorities, the Scottish Government, SEPA, universities, health professionals, environmental consultants and the general public.

Figure 2.5 Air Quality Scotland Website Hits April 2007 - May 2014



2.4.2 Website Maintenance

On a daily basis the web pages are fully checked by the Ricardo-AEA web team, both manually and using a number of automated software systems, in order to ensure that the website is fully functional with no broken links.

In addition to this a number of routine maintenance tasks are carried on a daily/weekly/monthly basis as required in order to keep the underlying database up-to-date and fully populated. These include:

- Updates to the national AURN sites are made as required (e.g. If new particulate monitoring instruments come on-line or other sites/instruments are changed)
- New local authority monitoring sites are added to the database once agreement is reached with the operators.
- Site photos are added as soon as AEA carry out our QA/QC visits, or they are provided by the local authority.
- Ratified data (or any improved provisional data) load automatically to the website from Ricardo-AEA's data management software on a daily basis.
- Statistics are automatically recalculated every night:
  - ✓ Daily, Monthly & Annual Means etc.
  - ✓ All exceedance statistics
- The LAQM pages are updated with any changes to the status of local authority Air Quality Management Areas.
- New technical guidance documents and reports (including local authority review and assessment reports) are added to the website when made available.

- The news section is updated with any relevant information provided by the Scottish Government or other website stakeholders.

- Requests to subscribe to the discussion forum are reviewed on a daily basis.

We are pleased to report that thanks to the on-going checks and maintenance the web pages were available for over 99% of the time during 2013 with no extended breakdowns or downtime reported.

3 Air Quality Seminar and Newsletter

3.1 Scottish Air Quality Seminar

As part of the Scottish Air Quality Database project, Ricardo-AEA organise, on behalf of Scottish Government, an annual air quality seminar. The latest Scottish Government Annual Air Quality Seminar was held in the Teacher Building conference centre, Glasgow on Wednesday 26th March 2014. The event was attended by over seventy air quality experts representing the Scottish Government, local authorities, Health Protection Scotland, SEPA, consultancy, academia and students. The objective of the seminar was to launch the new Air Quality in Scotland website and to discuss some of the most recent work carried under the Scottish Air Quality Database and Website project, and to consider a number of other topical air quality issues for Scotland.

The new air quality database including the new air quality App and media developments; a study to investigate roadside air quality versus height; and a secondary school pilot study were presented by Ricardo-AEA. In addition, further presentations were given by Dr David Newby (Centre for Cardiovascular Science, University of Edinburgh), Vincent McInally (Glasgow City Council) and Drew Hill (Transport Scotland).

The agenda for the day is shown in Figure 3.1.

3.2 Scottish Air Quality Newsletter

In addition to this report, a short annual newsletter (Air Pollution in Scotland) is also produced as part of this project. This sets the legislative and policy background to air quality control in Scotland and briefly reviews the latest available air quality monitoring and key results. Trends and mapping of air quality are also briefly presented and a list of website addresses for further information provided. A limited number of printed copies of the newsletter are available free of charge from Stuart Sneddon (stuart.sneddon@aeat.co.uk, postal address given at the start of this report).

Figure 3.1 Agenda for the Scottish Air Quality Seminar on 26th March 2014

The Scottish Government RICARDO-AEA

SCOTTISH AIR QUALITY DATABASE AND WEBSITE ANNUAL SEMINAR

Wednesday 26th March 2014

IET Glasgow: Teacher Building, 14 St Enoch Square, Glasgow, G1 4DB

Agenda

09:15	Registration and Coffee	
10:00	Welcome and Introduction	Andrew Taylor – Scottish Government
10:15	Project Overview	Stuart Sneddon – Ricardo-AEA
10:50	Cardiovascular effects of air pollution	David Newby - Centre for Cardiovascular Science, University of Edinburgh
11:20	Tea/Coffee Break	
11:35	The New and Improved Air Quality in Scotland Database and Website	Paul Willis – Ricardo-AEA
12:10	Developments in Air Quality Management in Glasgow	Vincent McInally – Glasgow City Council
12:40	Lunch (Practical Sessions)	
13:25	Media Developments on Air Quality Scotland	Alistair Dorman Smith – Ricardo-AEA
13:55	Air Quality Sensor Rotation Programme	Drew Hill - Transport Scotland
14:25	Tea/Coffee Break	
14:55	PM with Height Study	Stephen Stratton – Ricardo-AEA
15:25	Secondary Schools Pilot Study	Jennifer Simpson – Ricardo-AEA
15:55	Question Time	
16:05	Close	

This event is organised by Ricardo-AEA on behalf of the Scottish Government

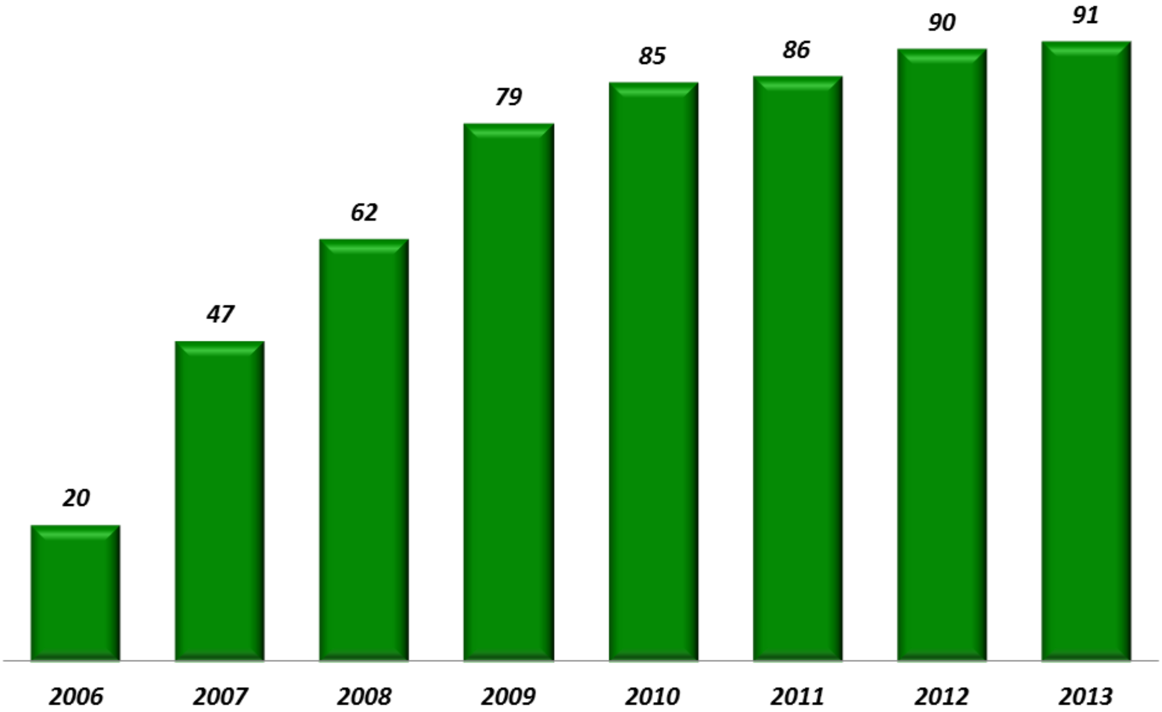
Respondents should be aware that the delegate list for this event is held on a computer. Under the terms of the Data Protection Act, anyone on the mailing list has the right to object to his/her name and address being so held.

4 Data Availability 2013

4.1 Hourly Data for Nitrogen Dioxide, Carbon Monoxide, Sulphur Dioxide, Ozone, PM_{10} and $PM_{2.5}$

At the end of 2013 the Scottish Air Quality Database contained data for a total of 91 automatic monitoring sites. In total, 6 new monitoring sites were incorporated into the database during 2013; Edinburgh Currie, Falkirk Banknock, Glasgow Townhead, South Lanarkshire Hamilton, South Lanarkshire Uddingston and West Lothian Linlithgow High St 2. Five monitoring sites; Angus Forfar, Inverclyde Greenock Dunlop St, Midlothian Pathhead, South Lanarkshire Glespin and West Lothian Linlithgow High St were decommissioned during 2013. As a result, the number of live monitoring sites in the database increased by 1 to 91 sites in 2013. Figure 4.1 shows the growth of the SAQD from 20 sites in 2006 pilot study to 91 sites in 2013.

Figure 4.1 Number of Monitoring Sites within the Scottish Air Quality Database Network 2006 - 2013



For the 16 National Network AURN monitoring stations in the Scottish Database the data are available from the commencement of these stations, which in some cases is as long ago as 1986. However, for Local Authority monitoring stations, data are only available from when the station joined the database project. In many cases the stations commenced much earlier and these earlier data may be available from the relevant Local Authority.

Data availability for 2013, in terms of site, pollutants and months available, is summarised in Table 4.1. The full 12-figure OS grid reference and the site location classification are also provided for each site and the monitoring network the site is affiliated to; either the Scottish Air Quality Database Network or the Automatic Urban and Rural Network (AURN).

Table 4.1 also provides the start date for each site. However, not all pollutants are measured over the same period at all sites – measurements of some pollutants may commence or cease during the lifetime of monitoring at the particular site. The dates of availability of data for each pollutant measured at each site can be found by selecting the site on the 'Latest Data' page of the SAQD website (http://www.scottishairquality.co.uk/latest/) and then selecting the "site details" tab.

In addition, some sites may join a network or change network during their lifetime and hence, earlier data from a site may be available elsewhere. At a small number of sites, different pollutants are in different networks. This is due to the differing requirements of specific networks.

The data from closed sites are available in the database for their period of operation.

Table 4.1 Scottish Air Quality Database Data Availability in 2013

Site Name	Type	East	North	Pollutants	Network	Start Year#	Data in 2013
Aberdeen Anderson Dr	ROADSIDE	392506	804186	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Aberdeen Errol Place	URBAN BACKGROUND	394416	807408	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	1999	Jan – Dec
Aberdeen King Street	ROADSIDE	394333	808770	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Aberdeen Market Street 2	ROADSIDE	394535	805687	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Aberdeen Union St~	ROADSIDE	393655	805984	PM_{10}	SAQD	2005	Jan – Dec
Aberdeen Union Street Roadside~	ROADSIDE	393655	805984	NO_2	AURN	2008	Jan – Dec
Aberdeen Wellington Road	ROADSIDE	394395	804779	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Alloa	ROADSIDE	288750	693150	PM_{10}	SAQD	2006	Jan – Dec
Angus Forfar*	ROADSIDE	345914	750613	PM_{10}	SAQD	2007	No Data
Auchencorth Moss	RURAL	322167	656123	13BD BENZ O_3 PM_{10} $PM_{2.5}$ TOL XYL	AURN	2006	Jan – Dec
Bush Estate	RURAL	324626	663880	NO_2 O_3	AURN	1986	Jan – Dec
Dumbarton Roadside	ROADSIDE	240234	675193	NO_2	AURN	2010	Jan – Dec
Dumfries	ROADSIDE	297012	576278	NO_2	AURN	2001	Jan – Dec
Dundee Broughty Ferry Road	ROADSIDE	341970	730997	PM_{10} SO_2	SAQD	2006	Jan – Dec
Dundee Lochee Road	KERBSIDE	330773	738861	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Mains Loan	URBAN BACKGROUND	340972	731893	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Meadowside	ROADSIDE	340241	730654	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Dundee Seagate	KERBSIDE	340487	730446	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Union Street	KERBSIDE	340236	730090	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Whitehall Street	KERBSIDE	330155	740279	NO_2	SAQD	2006	Jan – Dec
East Ayrshire Kilmarnock John Finnie St	ROADSIDE	242691	638095	NO_2 PM_{10}	SAQD	2010	Jan – Dec
East Ayrshire Kilmarnock St Marnock St	ROADSIDE	242742	637705	NO_2 PM_{10}	SAQD	2012	Feb – Dec
East Dunbartonshire Bearsden	ROADSIDE	254269	672067	NO_2 PM_{10}	SAQD	2005	Jan – Dec
East Dunbartonshire Bishopbriggs	ROADSIDE	260995	670130	NO_2 PM_{10}	SAQD	2003	Jan – Dec
East Dunbartonshire Kirkintilloch	ROADSIDE	265700	673500	NO_2 PM_{10}	SAQD	2007	Jan – Dec
East Dunbartonshire Milngavie	ROADSIDE	255325	674115	NO_2 PM_{10}	SAQD	2011	Jan – Dec
East Lothian Musselburgh N High St	ROADSIDE	333941	672836	NO_2 PM_{10}	SAQD	2008	Jan – Dec
East Renfrewshire Sheddens	ROADSIDE	257459	657114	PM_{10}	SAQD	2008	Jan – Dec
Edinburgh Currie+	URBAN BACKGROUND	317575	667874	NO_2 PM_{10}	SAQD	2013	Sep – Dec
Edinburgh Glasgow Road	ROADSIDE	313101	672651	NO_2 PM_{10}	SAQD	2012	Sep – Dec
Edinburgh Gorgie Road	ROADSIDE	323121	672314	NO_2	SAQD	2005	Jan – Dec
Edinburgh Queen Street	ROADSIDE	324890	674100	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Edinburgh Queensferry Road	ROADSIDE	318734	674931	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Edinburgh Salamander St	ROADSIDE	327621	676342	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Edinburgh St John's Road	KERBSIDE	320100	672890	NO_2	SAQD	2007	Jan – Dec
Edinburgh St Leonards	URBAN BACKGROUND	326250	673132	CO NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	2003	Jan – Dec

Site Name	Type	East	North	Pollutants	Network	Start Year[#]	Data in 2013
				SO_2			
Eskdalemuir	RURAL	323552	603018	NO_2 O3	AURN	1986	Jan – Dec
Falkirk Banknock[+]	ROADSIDE	277247	679026	PM_{10}	SAQD	2013	Jan – Dec
Falkirk Grangemouth MC	URBAN BACKGROUND	292816	682009	NO_2 PM_{10} SO_2	SAQD	2003	Jan – Dec
Falkirk Haggs	ROADSIDE	278977	679271	NO_2	SAQD	2009	Jan – Dec
Falkirk Hope St	ROADSIDE	288688	680218	NO_2 SO_2	SAQD	2007	Jan – Dec
Falkirk Park St	ROADSIDE	288892	680070	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Dec
Falkirk West Bridge Street	ROADSIDE	288457	680064	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Fife Cupar	ROADSIDE	337401	714572	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Fife Dunfermline	ROADSIDE	309912	687738	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Fife Kirkcaldy	ROADSIDE	329143	692986	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Fife Rosyth	ROADSIDE	311752	683515	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Fort William	SUBURBAN	210849	774421	NO_2 O_3	AURN	2006	Jan – Dec
Glasgow Abercromby Street	ROADSIDE	260420	664175	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Anderston	URBAN BACKGROUND	257925	665487	CO NO_2 PM_{10} SO_2	SAQD	2005	Jan – Dec
Glasgow Broomhill	ROADSIDE	255030	667195	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Burgher Street	ROADSIDE	262548	664168	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Glasgow Byres Road	ROADSIDE	256553	665487	CO NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Dumbarton Road	ROADSIDE	255030	666608	NO_2 PM_{10}	SAQD	2012	May – Dec
Glasgow Kerbside	KERBSIDE	258708	665200	BENZ NO_2 PM_{10} $PM_{2.5}$ TOL	AURN	1997	Jan – Dec
Glasgow Nithsdale Road	ROADSIDE	257883	662673	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Townhead[+]	URBAN BACKGROUND	259692	665899	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	2013	Oct – Dec
Glasgow Waulkmillglen Reservoir	RURAL	252520	658095	NO_2 O_3 PM_{10}	SAQD	2005	Jan – Dec
Grangemouth	URBAN INDUSTRIAL	293837	681035	NO_2 PM_{10} $PM_{2.5}$ SO_2	AURN	2001	Jan – Dec
Grangemouth Moray~	URBAN BACKGROUND	293469	681321	NO_2	AURN	2009	Jan – Dec
Grangemouth Moray Scot Gov~	URBAN BACKGROUND	293469	681321	SO_2	SAQD	2007	Jan – Dec
Inverclyde Greenock Dunlop St*	ROADSIDE	226158	675533	NO_2 PM_{10}	SAQD	2010	Jan – Dec
Inverness	ROADSIDE	265720	845680	NO_2 $PM_{10}$$PM_{2.5}$	AURN	2001	Jan – Dec
Lerwick~	RURAL	445337	1139683	O_3	AURN	2005	Jan – Aug
Midlothian Pathhead*^	KERBSIDE	339480	664316	PM_{10}	SAQD	2008	Jan – Jul
N Lanarkshire Chapelhall	ROADSIDE	278174	663124	NO_2 PM_{10}	SAQD	2005	Jan – Dec
N Lanarkshire Coatbridge Whifflet	URBAN BACKGROUND	273668	663938	NO_2 PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Croy	ROADSIDE	272775	675738	CO NO_2 PM_{10} SO_2	SAQD	2006	Jan – Dec
N Lanarkshire Cumbernauld	URBAN BACKGROUND	274182	674065	NO_2 PM_{10} SO_2	SAQD	2011	Jan – Dec
N Lanarkshire Moodiesburn	ROADSIDE	269929	670386	NO_2 PM_{10}	SAQD	2008	Jan – Dec
N Lanarkshire Motherwell	ROADSIDE	275460	656785	PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Shawhead Coatbridge	ROADSIDE	273411	662997	NO_2 PM_{10}	SAQD	2009	Jan – Dec
North Ayrshire Irvine High St	KERBSIDE	232142	638892	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Paisley Central Road	ROADSIDE	248445	664191	NO_2	SAQD	2004	Jan – Dec
Paisley Glasgow Airport	AIRPORT	248296	666544	NO_2	SAQD	2004	Jan – Dec
Paisley Gordon Street	ROADSIDE	248316	663611	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Paisley St James St	ROADSIDE	248175	664311	PM_{10}	SAQD	2010	Jan – Dec
Peebles	SUBURBAN	324812	641083	NO_2 O_3	AURN	2009	Jan – Dec
Perth Atholl Street	ROADSIDE	311582	723931	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Perth Crieff	ROADSIDE	286363	721614	NO_2 PM_{10}	SAQD	2010	Jan – Dec
Perth High Street	ROADSIDE	311688	723625	NO_2 PM_{10}	SAQD	2003	Jan – Dec
Perth Muirton	URBAN	311688	723625	PM_{10}	SAQD	2012	Jul – Dec

Site Name	Type	East	North	Pollutants	Network	Start Year#	Data in 2013
	BACKGROUND						
Shetland Lerwick~	RURAL	445337	1139683	NO_2 SO_2	SAQD	2012	Jan - Aug
South Ayrshire Ayr Harbour	ROADSIDE	233617	622749	NO_2 PM_{10}	SAQD	2012	May – Dec
South Ayrshire Ayr High St	ROADSIDE	233725	622120	NO_2 PM_{10}	SAQD	2007	Jan – Dec
South Lanarkshire East Kilbride	ROADSIDE	264390	655658	NO_2 PM_{10}	SAQD	2008	Jan – Dec
South Lanarkshire Glespin*	ROADSIDE	280521	628154	PM_{10}	SAQD	2010	Jan – Jul
South Lanarkshire Hamilton+^	ROADSIDE	272298	655289	NO_2 PM_{10}	SAQD	2013	Jan – Dec
South Lanarkshire Lanark	ROADSIDE	288427	643701	NO_2	SAQD	2012	Jan – Dec
South Lanarkshire Raith Interchange	ROADSIDE	271108	658235	NO_2 PM_{10}	SAQD	2010	Jan – Dec
South Lanarkshire Rutherglen	ROADSIDE	261113	661690	NO_2 PM_{10}	SAQD	2012	Jan – Dec
South Lanarkshire Uddingston+	ROADSIDE	269657	660305	NO_2	SAQD	2013	Jan – Dec
Stirling Craig's Roundabout	ROADSIDE	279955	693012	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Strath Vaich	ROADSIDE	234829	874785	O_3	AURN	1987	Jan – Dec
West Dunbartonshire Clydebank^	ROADSIDE	249724	672042	NO_2 PM_{10}	SAQD	2007	Jan – Dec
West Lothian Broxburn	ROADSIDE	308364	672248	NO_2 PM_{10}	SAQD	2008	Jan – Dec
West Lothian Linlithgow High Street*	ROADSIDE	299926	677087	NO_2 PM_{10}	SAQD	2008	Jan – Oct
West Lothian Linlithgow High St 2+	ROADSIDE	300419	677120	NO_2 PM_{10}	SAQD	2013	Oct – Dec
West Lothian Newton	ROADSIDE	309258	677728	NO_2 PM_{10}	SAQD	2012	May – Dec

+ Sites added to database in 2013
* Sites closed during 2013
^Changes in number of measured pollutants or monitoring method during 2013
This is the date of the site joining the network. Data for some pollutants may not be available from this date. Also, data for some pollutants may be available from earlier dates from the Local Authority other networks. The period of availability for data for each pollutant measured at each site can be seen on www.scottishairquality.co.uk by selecting the site and the "site details" tab.
~ At these sites, some pollutants are affiliated to the AURN network and some pollutants are affiliated the SAQD Network.

4.1.1 Summary of Changes to Monitoring Sites within the Database During 2013

Details of changes to monitoring sites included within the SAQD are summarised below.

Sites opened during 2013:

- Edinburgh Currie — NO_2, PM_{10} — from 01/01/2013
- Falkirk Banknock — PM_{10} — from 01/01/2013
- Glasgow Townhead — NO_2 O_3 PM_{10} $PM_{2.5}$ — from 07/10/2013
- South Lanarkshire Hamilton — NO_2, PM_{10}* — from 01/01/2013
- South Lanarkshire Uddingston — NO_2 — from 01/01/2013
- West Lothian Linlithgow High St 2 — NO_2, PM_{10} — from 25/10/2013

Sites closed during 2013:

- Angus Forfar — PM_{10} — on 01/01/2013
- Inverclyde Greenock Dunlop St — NO_2, PM_{10} — on 07/12/2013
- Midlothian Pathhead — PM_{10}, SO_2* — on 09/07/2013
- South Lanarkshire Glespin — PM_{10} — on 19/07/2013
- West Lothian Linlithgow High St — NO_2, SO_2 — on 14/10/2013

***Changes to sites during 2013:**

- Monitoring of PM_{10}, in addition to NO_2, started at South Lanarkshire Hamilton on 16/10/2013.
- Monitoring of SO_2 stopped at Midlothian Pathhead on 25/01/2013.
- No monitoring of PM_{10} was carried out at West Dunbartonshire Glasgow Road due to analyser faults.

4.2 Volatile Correction Model

4.2.1 Background

The EU Directive on Ambient Air Quality[1] and the UK Air Quality Strategy[2] set targets and limit values for PM_{10} concentrations in terms of gravimetric measurements referenced to the EU reference method of measurement (EN 12341). It has long been recognised that PM_{10} measurements made with many automatic PM_{10} monitors are not equivalent to the EU reference method. However, these analysers are widely used since they provide hourly resolved data and have many operational advantages over the manual reference method. Hence, correction factors, most noticeably the 1.3 correction factor for the TEOM analyser, have been widely used for many years. In setting the value of 1.3 as a correction factor, it was recognized that this was a conservative factor and that TEOMx1.3 data were likely to overestimate PM_{10} concentrations. In Scotland, a lower correction factor of 1.14, which was based on intercomparison data obtained in Edinburgh, has also been widely used.

The results of the formal UK PM_{10} Equivalence Study[3] carried out in 2006, showed that data from the TEOM could not be considered as equivalent to the EU reference method, whether or not a correction factor was used. The reason for this is that the TEOM heats the filter used to collect PM_{10} to 50°C in order to eliminate the possible interference from water vapour – this heating also removes some of the more volatile components of the particulate matter.

In the new modification to the TEOM – the FDMS TEOM, the volatile fraction of PM_{10} is measured separately and used to correct the data in order to obtain results that are equivalent to the EU reference method. The equivalence of the FDMS TEOM analyser to the EU reference method was confirmed in the UK Equivalence study. Note that this study also showed that a number of other PM_{10} analysers could also provide data equivalent to the EU reference method - Partisol 2025, FDMS Model B, Opsis SM200 Beta Attenuation Monitor (BAM), Opsis SM200 sampler (with slope and intercept correction) and the Met One BAM (with slope correction).

King's College London (KCL) have developed a relationship utilising FDMS purge (volatile PM_{10}) measurements to correct data from nearby TEOM analysers. These corrected data were tested for equivalence with the EU reference method and shown to pass the appropriate criteria. Since then, as additional FDMS data have become available throughout the UK, the geographic range of the model has been extended and on-going tests have shown that any TEOM located within 130km of an FDMS TEOM can be corrected with data from that analyser.

KCL has developed a user-friendly web portal (http://www.volatile-correction-model.info/Default.aspx), to enable the model to be applied in a straightforward step-by-step approach. The model enables the user to input daily or hourly-average pressure, temperature measurements and purge measurements (volatile measurements) from Filter Dynamics Measurement System (FDMS) analysers. The measured volatile fraction is then added to the TEOM measurements giving the corrected data.

4.2.2 Use of the VCM in Scotland

The VCM correction of Scottish PM_{10} data was first undertaken for the 2008 dataset. As the VCM method was relatively new and, hourly meteorological data for pressure were not readily available, the corrections were undertaken on a daily, rather than hourly basis. These corrected data were

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[1] *Directive 2008/50/EC Of The European Parliament and of The Council of 21 May 2008 on ambient air quality and cleaner air for Europe* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

[2] *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007. CM 7169* http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/6116

[3] *UK Equivalence Programme for Monitoring of Particulate Matter. David Harrison Bureau Veritas UK Ltd. June 2006 (BV/AQ/AD202209/DH/2396)* http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf

provided to the local authorities and made available on the Scottish Air Quality website as a separate data spreadsheet.

However, additional refinement of the VCM model has been undertaken and hourly meteorological data for all parameters has been sourced. As a result, VCM correction of the 2009 to 2013 datasets has been undertaken on an hourly basis. This also brings into line the processing of the Scottish local authority data with that of the AURN.

The TEOM measurements are recorded with an inbuilt correction factors of 1.03x+3 (where x is the raw TEOM measurement) as mandated by the US Environmental Protection Agency. This is first removed and the data are then corrected to ambient pressure and temperature (as required by the EU Directive) using meteorological data from met monitoring sites within 260 km of the TEOM.

Data from FDMS analysers within 130 km of the TEOM are then used to provide an estimate of the volatile particle concentration at the TEOM location. This estimated volatile fraction is then added back onto the TEOM measurements to give Gravimetric Equivalent mass concentrations.

The following data were used as inputs to the VCM:

- Hourly average temperatures (°C)
- Hourly average pressures (mbar)
- Hourly average TEOM concentrations ($\mu g\ m^{-3}$)
- Hourly average FDMS purge concentrations ($\mu g\ m^{-3}$)

For the 2013 corrections, temperature and pressure data from Edinburgh Airport meteorological monitoring stations were utilised. This site was selected as a good representation weather conditions in the central belt of Scotland.

Hourly average purge measurements from all Scottish FDMS monitoring sites within the Scottish Government-run network (SAQD) and the UK national network (AURN) were used for the correction. Table 4.2 lists the sites used for correcting hourly TEOM data from Central Scotland and Aberdeen. A total of 3 FDMS sites were used for correcting Aberdeen TEOM data and 34 FDMS sites used for correcting data from TEOM sites located in the central belt of Scotland.

Any outliers in the FDMS purge measurements were identified using Grubbs' Test[4] on daily average data. All hourly data within a day identified as an outlier were then removed from the data set and the average of each hourly purge measurement from the FDMS sites was calculated and used in the VCM calculations.

The corrected data for 2013 and calculated summary statistics have been provided to the local authorities. In addition, the SAQD website database now shows all ratified TEOM data for 2013 as VCM corrected data via an additional selection option in the data download pages.

A flow chart showing the overall process employed for VCM correction of 2013 SAQD TEOM data is shown in Figure 4.2.

However, note that it is not possible to correct historical data with the VCM as measurements of volatile particle concentrations are not available prior to 2008.

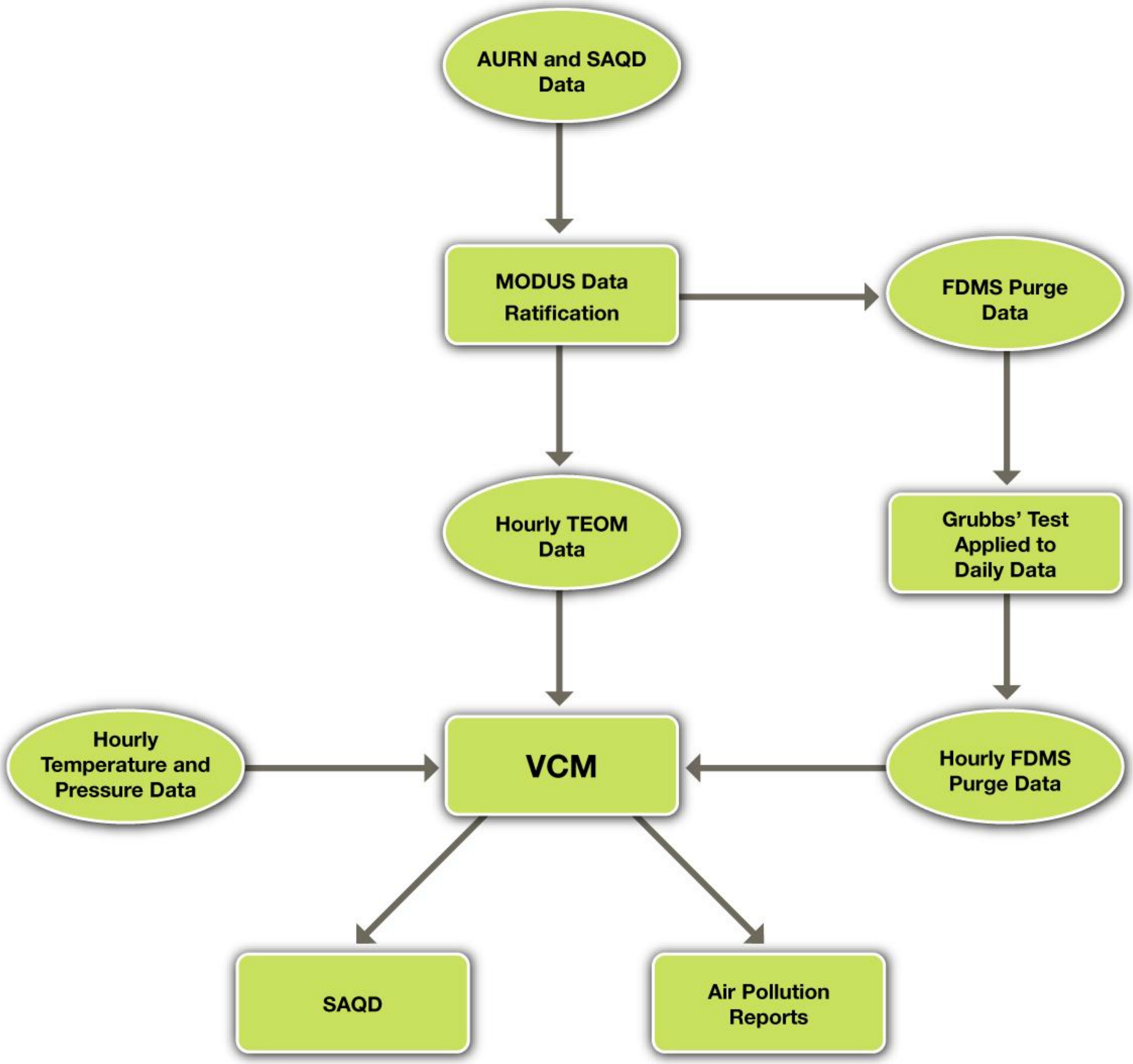
[4] Grubbs' Test is a statistical method for identifying outliers within a dataset. For more information visit the Engineering Statistics Handbook at:

http://www.itl.nist.gov/div898/handbook/eda/section3/eda35h.htm

Table 4.2 FDMS Monitoring Sites used for VCM Correcting TEOM Data 2013

FDMS Sites used in VCM	Monitoring Network
Aberdeen	AURN
Auchencorth Moss PM10 PM25	AURN
East Ayrshire Kilmarnock John	SAQD
East Ayrshire St Marnock St FDMS	SAQD
East Dunbartonshire Kirkintilloch	SAQD
East Dunbartonshire Milngavie	SAQD
East Renfrewshire Sheddens	SAQD
Edinburgh Queensferry Road	SAQD
Edinburgh St Leonards	AURN
Fife Cupar	SAQD
Fife Dunfermline	SAQD
Fife Kirkcaldy	SAQD
Fife Rosyth	SAQD
Glasgow Abercromby Street	SAQD
Glasgow Anderston	AURN
Glasgow Broomhill	SAQD
Glasgow Burgher St	SAQD
Glasgow Byres Road	SAQD
Glasgow Kerbside	AURN
Glasgow Nithsdale Road	SAQD
Grangemouth	AURN
Paisley Gordon Street	SAQD
Paisley St James St	SAQD
Perth Muirton	SAQD
South Ayrshire Ayr Harbour	SAQD
South Ayrshire Ayr High St	SAQD
South Lanarkshire East Kilbride	SAQD
South Lanarkshire Hamilton	SAQD
South Lanarkshire Raith	AURN
South Lanarkshire Rutherglen	SAQD
West Lothian Broxburn	SAQD
West Lothian Linlithgow High St 2	SAQD
West Lothian Linlithgow High	SAQD
West Lothian Newton	SAQD

Figure 4.2 Process used for VCM Correcting SAQD TEOM Data



4.3 National Network Monitoring for other Pollutants in Scotland

In addition to the 17 UK National Network AURN monitoring sites in Scotland, a number of other pollutants are monitored within other national networks during 2013:

- UK Automatic Hydrocarbon Monitoring Network – 1 site
- UK Non-Automatic Monitoring Network – 2 sites
- PAH Monitoring Network – 4 sites
- Heavy Metals Monitoring Networks – 4 sites
- Acid Deposition Network – 11 sites
- Ammonia and Nitric Acid Monitoring Network – 28 sites

Details of these sites are presented in Appendix 1. In this report, we summarise the data available for Air Quality Strategy pollutants from these networks. For non- Air Quality Strategy pollutants, we highlight what species are monitored and where the data can be obtained.

4.4 NO_2 Monitoring with Diffusion Tube Samplers

Monitoring of nitrogen dioxide (NO_2) with diffusion tube samplers is undertaken widely throughout Scotland.

Nitrogen Dioxide (NO_2) diffusion tube samplers measure periodic (typically monthly) concentrations of nitrogen dioxide. Diffusion tubes are easy to use and relatively inexpensive, so they can be deployed in large numbers over a wide area, giving good spatial coverage. They are generally used to complement detailed measurements made at automatic monitoring sites or, in circumstances where hourly measurements from automatic analysers are not required. Many local authorities have large networks of diffusion tubes samplers to assist with identifying any areas where the Objective for NO_2 is exceeded for the purpose of Local Air Quality Management (LAQM). Although there is no longer a national monitoring network based upon NO_2 diffusion tubes, the Scottish Government continues to provide a central web-based NO_2 diffusion tube data collation facility, together with QA/QC support for this monitoring[5, 6].

Available data from these networks are summarised in Section 6.3.1

In addition, CEH Edinburgh operates a network of rural NO_2 diffusion tube sampler sites and data for these sites are summarised in Section 6.3.7.

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[5] Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance: http://www.airquality.co.uk/reports/cat05/0802141004_NO2_WG_PracticalGuidance_Issue1a.pdf

[6] NO_2 Diffusion Tubes for LAQM: Guidance Note for Local Authorities: http://www.airquality.co.uk/reports/cat13/0604061218_Diffusion_Tube_GN_approved.pdf

5 QA/QC of the Scottish Database

In order that all data within the Scottish Air Quality Database are harmonised to the same quality standard, the QA/QC procedures adopted within the UK Automatic and Rural Network (AURN) are provided for all Local Authority sites within the database.

The main elements of the QA/QC programme are on-site analyser and calibration gas inter-calibrations every 6-months, daily automatic data collection and validation and data ratification in 3-monthly blocks.

5.1 On-Site Analyser and Calibration Gas Audits

The automatic air quality monitoring stations located throughout Scotland employ a wide variety of different analyser types and site infrastructure. Intercalibration of the stations provides essential input to the data management process, to ensure that data across Scotland are harmonised, consistent in quality and traceable to a recognised gas calibration standard.

Monitoring station audits evaluate analysers to obtain an assessment of their performance level on the date of test. This information, in conjunction with the full analyser data set and additional calibration and service records, helps ensure data quality specifications have been met during the preceding data period.

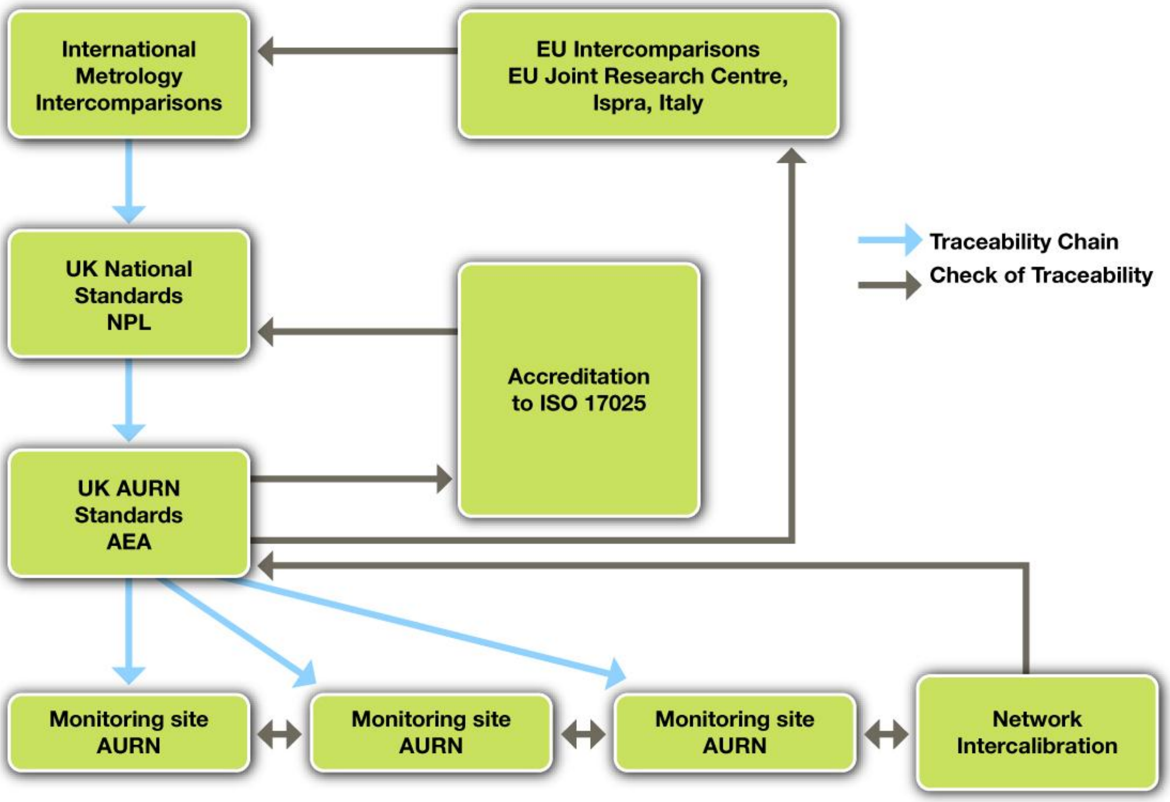
The assessment of the on-site calibration cylinder concentrations against accredited and traceable AEA gas standard cylinders provides the essential final link in the measurement traceability chain (Fig 5.1). This process ensures that all monitoring stations in Scotland are traceable to reference gas standards held at AEA. These in turn are traceable to UK national reference standard gases held by the National Physical Laboratory who, in turn regularly inter-compare these standards internationally. AEA also participate in EU level inter-comparisons at the EU Joint Research Centre at Ispra, Italy. Hence, there is an unbroken traceability chain from each monitoring site in Scotland to internationally agreed gas calibration standards. This check also identifies any unstable gas cylinders which may need to be recertified or discarded.

The aims and objectives of the audit and intercalibration exercise can be summarised as follows:

- Ensure the correct operation of analysers at each monitoring station
- Ensure harmonisation of data throughout the network (i.e. that a NO_X analyser at one station measuring 40 $\mu g\ m^{-3}$ of NO_2 would also measure 40 $\mu g\ m^{-3}$ of NO_2 at any other site)
- Ensure traceability of all stations in the network to national and international standards
- Provide information on any necessary adjustments to data into the ratification process
- Report any faults found to the site operator.

Detailed audit procedures are provided in Appendix 2.

Figure 5.1 Traceability chain for the SAQD monitoring stations



5.2 Data Management

The following sections describe the data management package applied to the data from the Scottish local authority monitoring stations. This is the same data management package, using the same data ratification procedures, that is applied to the AURN network stations across the UK.

The process includes the following tasks:

- Data acquisition
- Data validation
- Ratification

The data acquisition and management system consists of a central computer and telemetry facility that has been developed by Ricardo-AEA specifically for the UK's air quality monitoring programmes. The database used in this system is backed-up on a 24-hour basis to independent network servers to ensure data security.

A wide range of data management activities are routinely performed and these are integrated into the streamlined automatic data management system. Data are retrieved automatically from the Scottish air quality monitoring stations (*data acquisition*). The data are then rapidly processed by applying the latest available calibration factors (*data scaling*) and carefully screened using specifically developed computer algorithms to identify suspect data or equipment faults (*data validation*). These validated data are then appended to the site database and uploaded to the Scottish Database and Website. These operations are carried out automatically by computer systems, with all output manually checked by data management experts.

The validated data are then updated to the Scottish Air Quality Database – and accessible via the web - as provisional data. These data are therefore available to all users on a day-to-day basis. This gives the local authority the opportunity to easily view both their own data and data from other stations throughout Scotland. This will assist in dealing with day-to-day requests for information on specific data or the overall pollution situation either locally or throughout Scotland. In particular the automatic data summary bulletin, available by email from the website, and the plotting package incorporated into this, will be useful to authorities to rapidly evaluate their data against that from other stations.

5.3 Data Ratification

The validated data, which have been screened and scaled, are fit for day-to-day use and provide a good indication of pollution levels. However, the final stage of data management is a comprehensive and detailed critical review of the data and is generally termed 'ratification'. Note that ratification necessarily includes the results from the site audits and inter-calibrations – ratified data must be shown to be traceable to national gas standards.

The aim of data ratification is to make use of all of the available information to identify and remove any faulty data, ensuring that remaining measurement data meet the accuracy and precision specifications of the Scottish Government for detailed Review and Assessment (LAQM.TG(09)).

The policy on data rejection opted by Ricardo-AEA is that all data are assumed to be correct unless there is good evidence to suggest otherwise. This prevents the ratification process from erroneously removing any important air pollution episode data.

The ratification process is comprehensive and is outlined step-by-step in Appendix 2.

Data ratification of the Scottish local authority station data is undertaken on a 3-monthly basis, based on calendar year timetables (January through to December). The process of ratification can take up to six weeks - we therefore aim to have the finalised datasets from all network sites ready by 31st March of the following year. This fits well with the timetable for local authority reporting under the Review and Assessment process.

The ratified data are uploaded to the Scottish Database and overwrite the provisional data. Summary statistics of these ratified data are available from the website to assist local authorities complete their Air Quality Review and Assessment reports.

5.4 QA/QC During 2013

As discussed above, site inter-calibrations and audit visits are undertaken at 6-monthly intervals. However, where a site joins the database part way through a year then it is possible that only one audit will be conducted during the year. Table 5.2 shows the full list of inter-calibrations and audits undertaken on air quality sites in the Scottish Database during 2013.

The majority of analysers and sites were found to be operating satisfactorily during the audits. However, inevitably some problems were identified at some sites, these are summarised in Table 5.1.

Table 5.1 Monitoring site faults identified during the 2013 audits

Fault	Number of Monitoring Sites Winter 2012/13	Number of Monitoring Sites Summer 2013
TEOM** and TEOM FDMS k_0 out by > 2.5%	0	1
Particulate Analyser*** flow out by >10%	6	6
NO_x analyser converter <97% efficiency	1	2
NO cylinder out by >10%	7	13
SO_2 cylinder out by >10%	1	0
CO cylinder out by >10%	1	0
O3 Analyser out by >5%	1	0

* Filter Dynamics Measurement System
** Tapered Element Oscillating Microbalance
*** These include TEOM, FDMS and Beta Attenuation Monitors (BAM)

These are all typical faults that are found during audit and intercalibration exercises as can be seen from the 2013 figures, the number of faults found is stable with the exception of NO cylinder outliers.

In many cases, the results from the audit and intercalibration visits provide the information necessary to correct for these issues at the data ratification stage so that the data can be corrected and retained, rather than being deleted as erroneous data.

Table 5.2 summarises the site inter-calibrations and audits undertaken during 2013, where the period Winter 2012/13 corresponds to Dec-11 to Mar-12 and Summer 2013 corresponds to Jun-12 to Aug-12.

5.4.1 Data Ratification

With the renewal of the Scottish Air Quality Database and Website contract in 2013, data ratification has been brought in line with the AURN schedule and is now undertaken at 3-monthly intervals. Hence, as with the inter-calibrations and audits, if the site joins the database part way through a year then data can only be ratified from the date of the site joining the database.

All ratified data for 2013 have now been uploaded to the Scottish Air Quality website and Table 5.3 summarises the ratification undertaken during 2013. The column headings labelled Q1 – Q4 refer to the quarter periods of the calendar year:

- Q1 = January to March;
- Q2 = April to June;
- Q3 = July to September;
- Q4 = October to December.

Table 5.2 Air quality site intercalibration and audits conducted during 2013

Site Name	Winter 2012/13	Summer 2013	Site Name	Winter 2012/13	Summer 2013
Aberdeen Anderson Dr	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Errol Place	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen King Street	✓	✓	Glasgow Burgher Street	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Centre	✓	✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Dumbarton Road	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Kerbside	✓	✓
Alloa	✓	✓	Glasgow Townhead		✓
Angus Forfar		✓	Glasgow Nithsdale Road	✓	✓
Auchencorth Moss	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	Grangemouth	✓	✓
Bush Estate	✓	✓	Grangemouth Moray	✓	✓
Dumbarton Roadside	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Dumfries	✓	✓	Inverclyde Greenock Dunlop St	✓	✓
Dundee Broughty Ferry Road	✓	✓	Inverness	✓	✓
Dundee Lochee Road	✓	✓	Lerwick	✓	✓
Dundee Mains Loan	✓	✓	Midlothian Pathhead	✓	✓
Dundee Meadowside	✓	✓	N Lanarkshire Chapelhall	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Dundee Union Street	✓	✓	N Lanarkshire Croy	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Cumbernauld	✓	✓
East Ayrshire Kilmarnock John Finnie St	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Ayrshire Kilmarnock St Marnock St	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	North Ayrshire Irvine High St	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	Paisley Central Road	✓	✓
East Dunbartonshire Milngavie	✓	✓	Paisley Glasgow Airport	✓	✓
East Lothian Musselburgh N High St	✓	✓	Paisley Gordon Street	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley St James St	✓	✓
Edinburgh Currie	✓	✓	Peebles	✓	✓
Edinburgh Glasgow Road	✓	✓	Perth Atholl Street	✓	✓
Edinburgh Gorgie Road	✓	✓	Perth Crieff	✓	✓
Edinburgh Queen Street	✓	✓	Perth High Street	✓	✓
Edinburgh Queensferry Road	✓	✓	Perth Muirton	✓	✓
Edinburgh Salamander St	✓	✓	Sout Ayrshire Ayr Harbour	✓	✓
Edinburgh St John's Road	✓	✓	South Ayrshire Ayr High St	✓	✓
Edinburgh St Leonards	✓	✓	South Ayrshire Maybole	✓	✓
Eskdalemuir	✓	✓	South Lanarkshire East Kilbride	✓	✓
Falkirk Banknock	✓	✓	South Lanarkshire Glespin	✓	✓
Falkirk Grangemouth MC	✓	✓	South Lanarkshire Hamilton	✓	✓
Falkirk Haggs	✓	✓	South Lanarkshire Lanark	✓	✓
Falkirk Hope St	✓	✓	South Lanarkshire Raith Interchange	✓	✓
Falkirk Park St	✓	✓	South Lanarkshire Rutherglen	✓	✓
Falkirk West Bridge Street	✓	✓	South Lanarkshire Uddingston	✓	✓
Fife Cupar	✓	✓	Stirling Craig's Roundabout	✓	✓
Fife Dunfermline	✓	✓	Strath Vaich	✓	✓
Fife Kirkcaldy	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Rosyth	✓	✓	West Lothian Broxburn	✓	✓
Fort William	✓	✓	West Lothian Linlithgow High Street	✓	✓
Glasgow Abercromby Street	✓	✓	West Lothian Linlithgow High Street 2		✓
Glasgow Anderston	✓	✓	West Lothian Newton	✓	✓

Table 5.3 Data ratification undertaken during 2013

Site Name	Q1	Q2	Q3	Q4	Site Name	Q1	Q2	Q3	Q4
Aberdeen Anderson Dr	✓	✓	✓	✓	Glasgow Battlefield Road	✓	✓	✓	✓
Aberdeen Errol Place	✓	✓	✓	✓	Glasgow Broomhill	✓	✓	✓	✓
Aberdeen King Street	✓	✓	✓	✓	Glasgow Burgher Street	✓	✓	✓	✓
Aberdeen Market Street 2	✓	✓	✓	✓	Glasgow Byres Road	✓	✓	✓	✓
Aberdeen Union St	✓	✓	✓	✓	Glasgow Centre	✓	✓	✓	✓
Aberdeen Union Street Roadside	✓	✓	✓	✓	Glasgow Dumbarton Road	✓	✓	✓	✓
Aberdeen Wellington Road	✓	✓	✓	✓	Glasgow Kerbside	✓	✓	✓	✓
Alloa	✓	✓	✓	✓	Glasgow Townhead				✓
Angus Forfar					Glasgow Nithsdale Road	✓	✓	✓	✓
Auchencorth Moss	✓	✓	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	✓	✓	Grangemouth	✓	✓	✓	✓
Bush Estate	✓	✓	✓	✓	Grangemouth Moray	✓	✓	✓	✓
Dumbarton Roadside	✓	✓	✓	✓	Grangemouth Moray Scot Gov	✓	✓	✓	✓
Dumfries	✓	✓	✓	✓	Inverclyde Greenock Dunlop St	✓	✓	✓	✓
Dundee Broughty Ferry Road	✓	✓	✓	✓	Inverness	✓	✓	✓	✓
Dundee Lochee Road	✓	✓	✓	✓	Lerwick	✓	✓	✓	✓
Dundee Mains Loan	✓	✓	✓	✓	Midlothian Pathhead	✓	✓	✓	
Dundee Meadowside	✓	✓	✓	✓	N Lanarkshire Chapelhall	✓	✓	✓	✓
Dundee Seagate	✓	✓	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓	✓	✓
Dundee Union Street	✓	✓	✓	✓	N Lanarkshire Croy	✓	✓	✓	✓
Dundee Whitehall Street	✓	✓	✓	✓	N Lanarkshire Cumbernauld	✓	✓	✓	✓
East Ayrshire Kilmarnock John Finnie St	✓	✓	✓	✓	N Lanarkshire Moodiesburn	✓	✓	✓	✓
East Ayrshire Kilmarnock St Marnock St	✓	✓	✓	✓	N Lanarkshire Motherwell	✓	✓	✓	✓
East Dunbartonshire Bearsden	✓	✓	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	✓	✓	North Ayrshire Irvine High St	✓	✓	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	✓	✓	Paisley Central Road	✓	✓	✓	✓
East Dunbartonshire Milngavie	✓	✓	✓	✓	Paisley Glasgow Airport	✓	✓	✓	✓
East Lothian Musselburgh N High St	✓	✓	✓	✓	Paisley Gordon Street	✓	✓	✓	✓
East Renfrewshire Sheddens	✓	✓	✓	✓	Paisley St James St	✓	✓	✓	✓
Edinburgh Currie	✓	✓	✓	✓	Peebles	✓	✓	✓	✓
Edinburgh Glasgow Road	✓	✓	✓	✓	Perth Atholl Street	✓	✓	✓	✓
Edinburgh Gorgie Road	✓	✓	✓	✓	Perth Crieff	✓	✓	✓	✓
Edinburgh Queen Street	✓	✓	✓	✓	Perth High Street	✓	✓	✓	✓
Edinburgh Queensferry Road	✓	✓	✓	✓	Perth Muirton	✓	✓	✓	✓
Edinburgh Salamander St	✓	✓	✓	✓	Sout Ayrshire Ayr Harbour	✓	✓	✓	✓
Edinburgh St John's Road	✓	✓	✓	✓	South Ayrshire Ayr High St	✓	✓	✓	✓
Edinburgh St Leonards	✓	✓	✓	✓	South Ayrshire Maybole	✓	✓	✓	✓
Eskdalemuir	✓	✓	✓	✓	South Lanarkshire East Kilbride	✓	✓	✓	✓
Falkirk Banknock	✓	✓	✓	✓	South Lanarkshire Glespin	✓	✓	✓	
Falkirk Grangemouth MC	✓	✓	✓	✓	South Lanarkshire Hamilton	✓	✓	✓	✓
Falkirk Haggs	✓	✓	✓	✓	South Lanarkshire Lanark	✓	✓	✓	✓
Falkirk Hope St	✓	✓	✓	✓	South Lanarkshire Raith Interchange	✓	✓	✓	✓
Falkirk Park St	✓	✓	✓	✓	South Lanarkshire Rutherglen	✓	✓	✓	✓
Falkirk West Bridge Street	✓	✓	✓	✓	South Lanarkshire Uddingston	✓	✓	✓	✓
Fife Cupar	✓	✓	✓	✓	Stirling Craig's Roundabout	✓	✓	✓	✓
Fife Dunfermline	✓	✓	✓	✓	Strath Vaich	✓	✓	✓	✓
Fife Kirkcaldy	✓	✓	✓	✓	West Dunbartonshire Clydebank	✓	✓	✓	✓
Fife Rosyth	✓	✓	✓	✓	West Lothian Broxburn	✓	✓	✓	✓
Fort William	✓	✓	✓	✓	West Lothian Linlithgow High Street	✓	✓	✓	
Glasgow Abercromby Street	✓	✓	✓	✓	West Lothian Linlithgow High Street 2				✓
Glasgow Anderston	✓	✓	✓	✓	West Lothian Newton	✓	✓	✓	✓

6 Air Pollution in Scotland 2013

In this section we present a statistical summary of the available air quality data for Scotland as follows:

- Section 6.1 - Automatic monitoring of the pollutants NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and O_3 summary data for 2013.

- Section 6.2 - Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and lead - summary statistics for 2010 or 2011 depending on the availability of data.

- Section 6.3 - Other pollutants and/or other methods of monitoring:
    1. NO_2 Diffusion Tube Samplers
    2. Non-methane Volatile Organic Compounds (NMVOC)
    3. Poly-aromatic Hydrocarbons (PAH)
    4. Toxic Organic Micropollutants (TOMPS)
    5. Metals (Urban network)
    6. Metals (Rural and deposition network)
    7. United Kingdom Eutrophying & Acidifying Pollutants Network:
        1. The Precipitation Network
        2. NO_2 Rural Diffusion Tube Network
        3. Acid Gases and Aerosol Network (AGANET)
        4. National Ammonia Monitoring Network

6.1 Automatic monitoring of pollutants NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2 and Ozone

Tables 6.1.1 – 6.1.7 show the 2013 annual average data statistics for NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and O_3 respectively, for the ratified automatic data from monitoring sites included in the Scottish Air Quality Database. These are shown along with the corresponding data capture for the year.

These data will have been used by local authorities to assess air quality within their area as part of the review and assessment process. Where any of the Air Quality Objectives for Scotland have been exceeded, at locations where there is relevant exposure of the general public, then the authority will need to proceed to a Detailed Assessment to confirm the exceedance and estimate its extent. Where the exceedance is confirmed then the authority will declare an Air Quality Management Area (AQMA). At present, 14 Local Authorities in Scotland have declared a total of 34 AQMAs (see http://www.scottishairquality.co.uk/laqm.php) and a number of other authorities are proceeding through the process of declaration.

Based on the data in the database, a brief summary of the air quality situation throughout Scotland, along the lines of that already provided in the Newsletter, is given under each table.

6.1.1 Nitrogen Dioxide

Table 6.1.1 Ratified data annual average concentration and data capture for NO_2 in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	Annual Average NO_2 2013 ($\mu g\ m^{-3}$)	No. hours >200 $\mu g\ m^{-3}$	Data capture NO_2 2013 (%)
Aberdeen Anderson Dr	Roadside	22	0	94
Aberdeen Errol Place	Urban Background	20	0	45
Aberdeen King Street	Roadside	28	0	95
Aberdeen Market Street 2	Roadside	43	1	90
Aberdeen Union Street	Roadside	48	0	100
Aberdeen Wellington Road	Roadside	52	6	91
Bush Estate	Rural	6	0	99
Dumbarton Roadside	Roadside	19	4	98
Dumfries	Roadside	30	1	99
Dundee Lochee Road	Roadside	51	100	99
Dundee Mains Loan	Urban Background	12	0	72
Dundee Meadowside	Roadside	50	0	89
Dundee Seagate	Kerbside	58	60	95
Dundee Union Street	Kerbside	30	0	97
Dundee Whitehall Street	Kerbside	42	0	99
East Ayrshire Kilmarnock John Finnie St	Roadside	39	0	96
East Ayrshire Kilmarnock St Marnock St	Roadside	32	1	71
East Dunbartonshire Bearsden	Roadside	36	5	100
East Dunbartonshire Bishopbriggs	Roadside	31	0	95
East Dunbartonshire Kirkintilloch	Roadside	32	12	92
East Dunbartonshire Milngavie	Roadside	23	0	93
East Lothian Musselburgh N High St	Roadside	24	0	81
Edinburgh Currie	Urban Background	8	0	92
Edinburgh Glasgow Road	Roadside	27	0	98
Edinburgh Gorgie Road	Roadside	38	0	86
Edinburgh Queen Street	Roadside	28	0	98
Edinburgh Queensferry Road	Roadside	46	0	74
Edinburgh Salamander St	Roadside	28	0	96
Edinburgh St John's Road	Kerbside	57	8	91
Edinburgh St Leonards	Urban Background	22	0	99
Eskdalemuir	Rural	2	0	99
Falkirk Grangemouth MC	Urban Background	20	0	99
Falkirk Haggs	Roadside	34	0	87
Falkirk Hope St	Roadside	23	0	99
Falkirk Park St	Roadside	30	0	100
Falkirk West Bridge Street	Roadside	39	0	91
Fife Cupar	Roadside	27	0	75
Fife Dunfermline	Roadside	25	0	93
Fife Kirkcaldy	Roadside	20	0	99
Fife Rosyth	Roadside	25	0	100
Fort William	Suburban	9	0	91

Site Name	Site Classification	Annual Average NO_2 2013 ($\mu g\ m^{-3}$)	No. hours >200 $\mu g\ m^{-3}$	Data capture NO_2 2013 (%)
Glasgow Anderston	Urban Background	28	42	96
Glasgow Burgher St.	Roadside	28	1	98
Glasgow Byres Road	Roadside	44	4	84
Glasgow Dumbarton Road	Kerbside	46	0	79
Glasgow Kerbside	Kerbside	65	12	97
Glasgow Townhead	Urban Background	34	0	13
Glasgow Waulkmillglen Reservoir	Rural	11	0	99
Grangemouth	Urban Industrial	14	0	98
Grangemouth Moray	Urban Background	17	1	100
Inverclyde Greenock Dunlop Street	Roadside	16	0	94
Inverness	Roadside	21	0	98
Lerwick	Roadside	n/a	n/a	0
N Lanarkshire Chapelhall	Roadside	34	0	96
N Lanarkshire Croy	Roadside	20	0	95
N Lanarkshire Cumbernauld	Roadside	26	0	92
N Lanarkshire Moodiesburn	Roadside	20	0	100
N Lanarkshire Shawhead Coatbridge	Roadside	34	0	99
North Ayrshire Irvine High St	Kerbside	32	0	90
Paisley Central Road	Roadside	61	214	97
Paisley Glasgow Airport	Airport	20	0	99
Paisley Gordon Street	Roadside	39	46	52
Peebles	Suburban	8	0	51
Perth Atholl Street	Roadside	48	13	99
Perth Crieff	Roadside	26	0	94
Perth High Street	Roadside	22	0	94
South Ayrshire Ayr Harbour	Roadside	14	0	99
South Ayrshire Ayr High St	Roadside	23	0	79
South Lanarkshire East Kilbride	Roadside	29	5	63
South Lanarkshire Lanark	Roadside	25	0	99
South Lanarkshire Hamilton	Roadside	35	0	99
South Lanarkshire Raith Interchange	Roadside	51	1	93
South Lanarkshire Rutherglen	Roadside	37	1	97
South Lanarkshire Uddingston	Roadside	27	0	97
Stirling Craig's Roundabout	Roadside	31	1	79
West Dunbartonshire Clydebank	Roadside	25	14	90
West Lothian Broxburn	Roadside	39	0	94
West Lothian Linlithgow High Street	Roadside	17	0	78
West Lothian Linlithgow High Street 2	Roadside	38	0	15
West Lothian Newton	Roadside	24	0	85

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedances of Scottish Air Quality Objectives

Table 6.1.1 shows nitrogen dioxide data for 80 sites utilising automatic monitoring in 2013, although data for 10 of these are only available for part of the year and the overall data capture is less than 75%. These include sites which opened or closed during the year, sites which were closed for part of the year due to roadworks etc and sites with instrument problems.

Of the remaining 70 sites with more than 75% data capture, 14 of these (kerbside or roadside sites) exceeded the AQS Objective for the NO_2 annual mean (40 µg m^{-3}). At 4 sites, the AQS Objective of not more than 18 exceedances of 200 µg m^{-3} for the hourly mean was also exceeded, including Glasgow Anderston; an urban background site. The exceedance measured at this site is likely due to still meteorological conditions experienced during late November 2013 resulting in a build-up of NO_2 concentrations close to the M8 motorway.

One site with less that 75% data capture exceeded the NO_2 annual average objective; Edinburgh Queensferry Road with a data capture rate of 74%. In addition, Paisley Gordon Street exceeded the NO_2 hourly average objective with data capture rate of 52%.

The highest annual average concentrations were measured at Glasgow Kerbside, with a measured concentration of 65 µg m^{-3}. The greatest number of exceedances of the hourly mean objective was measured at Paisley Central Road with 214 exceedances.

6.1.2 Particulate Matter – PM_{10}

Table 6.1.2 Ratified data annual average concentration and data capture for PM_{10} in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2013 (µg m^{-3})	No. days > 50µg m^{-3}	Data capture (%)
Aberdeen Anderson Dr	Roadside	TEOM (VCM)	15	1	97
Aberdeen Errol Place	Urban Background	FDMS	13	1	89
Aberdeen King Street	Roadside	BAM (unheated inlet)	19	4	91
Aberdeen Market Street 2	Roadside	BAM (unheated inlet)	35	58	95
Aberdeen Union St	Roadside	TEOM (VCM)	20	4	97
Aberdeen Wellington Road	Roadside	TEOM (VCM)	22	7	97
Alloa	Roadside	TEOM (VCM)	16	0	97
Auchencorth Moss	Rural	Partisol	7	0	64
Auchencorth Moss PM10 PM25	Rural	FDMS	8	0	59
Dundee Broughty Ferry Road	Roadside	TEOM (VCM)	16	4	95
Dundee Lochee Road	Kerbside	BAM (unheated	18	3	96
Dundee Mains Loan	Urban Background	TEOM (VCM)	12	1	95
Dundee Meadowside	Roadside	BAM (unheated inlet)	19	4	91
Dundee Seagate	Kerbside	BAM (unheated) inlet)	16	4	98
Dundee Union Street	Kerbside	TEOM (VCM)	15	1	98
East Ayrshire Kilmarnock John	Roadside	FDMS	16	0	63
East Ayrshire Kilmarnock St Marnock St	Roadside	BAM (unheated inlet)	19	2	88
East Dunbartonshire Bearsden	Roadside	BAM (heated inlet)	12	0	12
East Dunbartonshire	Roadside	BAM (heated inlet)	16	0	14
East Dunbartonshire Kirkintilloch	Roadside	FDMS	17	3	85
East Dunbartonshire Milngavie	Roadside	FDMS	14	0	91
East Lothian Musselburgh N	Roadside	BAM (unheated	16	2	84
East Renfrewshire Sheddens	Roadside	FDMS	14	2	88

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2013 ($\mu g\ m^{-3}$)	No. days > $50\mu g\ m^{-3}$	Data capture (%)
Edinburgh Currie	Urban Background	TEOM (VCM)	13	0	64
Edinburgh Glasgow Road	Roadside	TEOM (VCM)	16	1	97
Edinburgh Queensferry Road	Roadside	FDMS	19	2	77
Edinburgh Queen Street	Roadside	TEOM (VCM)	17	2	96
Edinburgh Salamander St	Roadside	TEOM (VCM)	22	5	94
Edinburgh St Leonards	Urban Background	FDMS	14	3	94
Falkirk Banknock	Urban Background	TEOM (VCM)	15	0	96
Falkirk Grangemouth MC	Urban Background	TEOM (VCM)	15	0	86
Falkirk Haggs	Roadside	TEOM (VCM)	18	4	96
Falkirk Park St	Roadside	TEOM (VCM)	15	1	97
Falkirk West Bridge Street	Roadside	TEOM (VCM)	19	4	97
Fife Cupar	Roadside	FDMS	18	4	62
Fife Dunfermline	Roadside	FDMS	15	2	93
Fife Kirkcaldy	Roadside	FDMS	12	1	100
Fife Rosyth	Roadside	FDMS	14	2	97
Glasgow Abercromby Street	Roadside	FDMS	16	2	92
Glasgow Anderston	Urban Background	FDMS	16	2	92
Glasgow Broomhill	Roadside	FDMS	15	0	90
Glasgow Burgher St.	Roadside	FDMS	17	3	91
Glasgow Byres Road	Roadside	FDMS	13	0	60
Glasgow Dumbarton Road	Roadside	TEOM (VCM)	19	2	91
Glasgow Kerbside	Kerbside	FDMS	23	4	85
Glasgow Nithsdale Road	Roadside	FDMS	18	3	65
Glasgow Townhead	Urban Background	FDMS	12	0	13
Glasgow Waulkmillglen	Rural	TEOM (VCM)	12	0	95
Grangemouth	Urban Industrial	FDMS	14	0	84
Inverclyde Greenock Dunlop	Roadside	TEOM (VCM)	14	0	79
Inverness	Roadside	Partisol	12	0	92
Midlothian Pathhead	Kerbside	TEOM (VCM)	18	1	46
N Lanarkshire Chapelhall	Roadside	TEOM (VCM)	17	0	90
N Lanarkshire Coatbridge Whifflet	Urban Background	TEOM (VCM)	14	0	90
N Lanarkshire Croy	Roadside	TEOM (VCM)	15	3	87
N Lanarkshire Moodiesburn	Roadside	BAM (unheated inlet)	16	2	86
N Lanarkshire Motherwell	Roadside	TEOM (VCM)	16	1	80
N Lanarkshire Shawhead Coatbridge	Roadside	BAM (unheated inlet)	14	0	81
North Ayrshire Irvine High St	Kerbside	BAM (unheated	21	1	69
North Lanarkshire Cumbernauld	Urban Background	TEOM (VCM)	14	0	89
Paisley Gordon Street	Roadside	FDMS	18	2	47
Paisley St James Street	Roadside	FDMS	15	0	93
Perth Atholl Street	Roadside	TEOM (VCM)	22	7	96

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2013 (µg m^{-3})	No. days > 50µg m^{-3}	Data capture (%)
Perth Crieff	Roadside	BAM (unheated inlet)	20	0	93
Perth High Street	Roadside	TEOM (VCM)	16	0	94
Perth Muirton	Urban Background	FDMS	10	0	77
South Ayrshire Ayr Harbour	Roadside	FDMS	17	1	62
South Ayrshire Ayr High St	Roadside	FDMS	15	2	82
South Lanarkshire East Kilbride	Roadside	FDMS	14	0	77
South Lanarkshire Glespin	Roadside	FDMS	12	1	54
South Lanarkshire Hamilton	Roadside	FDMS	13	0	21
South Lanarkshire Raith Interchange	Roadside	FDMS	24	3	65
South Lanarkshire Rutherglen	Roadside	FDMS	19	9	91
Stirling Craig's Roundabout	Roadside	TEOM (VCM)	17	1	91
West Lothian Broxburn	Roadside	FDMS	16	0	79
West Lothian Linlithgow High Street	Roadside	FDMS	15	1	74
West Lothian Linlithgow High Street 2	Roadside	FDMS	16	0	18
West Lothian Newton	Roadside	FDMS	19	4	94

*FDMS data are equivalent to gravimetric and hence are not adjusted
Partisol data are equivalent to gravimetric and hence are not adjusted
BAM (heated inlet) data are adjusted using gravimetric equivalent factor of 1.3
BAM (un-heated inlet) data are adjusted using gravimetric equivalent factor of 0.8333
Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6.1.2 shows the 2013 gravimetric equivalent particulate matter PM_{10} data from 78 sites utilising automatic monitoring and the Partisol daily sampler. Of these sites, 19 have less than 75% data capture. As discussed in Section 4.2.2, all TEOM data have been adjusted using the VCM.

Of the 59 sites with 75% or greater data capture, 15 sites exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3} and a further 2 equaled this Objective. Of these sites 2 also exceeded the Daily Objective of 50 µg m^{-3} not to be exceeded more than 7 times in a year.

The maximum PM_{10} annual mean concentration was measured at Aberdeen Market St 2 with a measured annual mean concentration of 35 µg m^{-3} and 58 exceedances of the daily objective.

Of the 19 sites with less than 75% data capture, North Ayrshire Irvine High St and South Lanarkshire Raith Interchange exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3}.

No site exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10} with the daily objective of 35 exceedances of 50 µg m^{-3} being exceeded at Aberdeen Market St 2.

Note that at the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for PM_{10} (and $PM_{2.5}$). The results for both sites are shown in Table 6.1.2 under the site names of Auchencorth Moss (for measurements using Partisol samplers) and Auchencorth Moss PM_{10} $PM_{2.5}$ (for measurements using FDMS analysers). As can be seen both methods measured similar annual average PM_{10} concentrations of 7 µg m^{-3} and 8 µg m^{-3}. No exceedances of the daily objective were measured at the two sites.

6.1.3 Particulate Matter – $PM_{2.5}$

Table 6.1.3 Ratified data annual average concentration and data capture for $PM_{2.5}$ in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	$PM_{2.5}$ Analyser Type	Annual Average $PM_{2.5}$ 2013 ($\mu g\ m^{-3}$ gravimetric equivalent)	Data capture $PM_{2.5}$ 2013 (%)
Aberdeen Errol Place	Urban Background	FDMS	9	83
Auchencorth Moss	Rural	Partisol	4	98
Auchencorth Moss PM10 PM25	Rural	FDMS	4	62
Edinburgh St Leonards	Urban Background	FDMS	8	98
Glasgow Kerbside	Kerbside	FDMS	16	80
Glasgow Townhead	Urban Background	FDMS	6	13
Grangemouth	Urban Industrial	FDMS	9	73
Inverness	Roadside	Partisol	6	98

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

For compliance with the EU Directive, three $PM_{2.5}$ urban background monitoring sites are required in Scotland. These have been established as part of the AURN in Edinburgh, Glasgow and Aberdeen. In addition, for research purposes, additional monitors have been installed at the kerbside site in Glasgow and at the rural site at Auchencorth Moss. Also, with support from the Scottish Government, the daily gravimetric monitoring of $PM_{2.5}$ continues at Inverness. Data from eight sites in Scotland are therefore available for all or part of 2013.

Data capture rates of less than 75% were measured at Auchencorth Moss PM_{10} PM_{25}, Glasgow Townhead and Grangemouth; Glasgow Townhead was commissioned in October 2013. The Scottish AQS Objective of 12 $\mu g\ m^{-3}$ as an annual mean was exceeded at Glasgow Kerbside with a data capture rate of 80%. Figure 6.1.1 shows the 2013 Annual Average $PM_{2.5}$ and PM_{10} concentrations for all SAQD monitoring sites with more than 75% data capture.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for $PM_{2.5}$. Both the Partisol sampler and FDMS analyser measured annual average $PM_{2.5}$ concentrations of 4 $\mu g\ m^{-3}$ during 2013.

The $PM_{2.5}/PM_{10}$ ratios calculated for each site for the years 2009 to 2013 are shown in Table 6.1.4. The highest $PM_{2.5}/PM_{10}$ ratios during 2013 for sites with greater than 75% data capture was calculated at Aberdeen Errol Place and Glasgow Kerbside with calculated ratios of 0.69 and 0.70, respectively.

Figure 6.1.1 Annual Average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites with more than 75% data capture in 2013

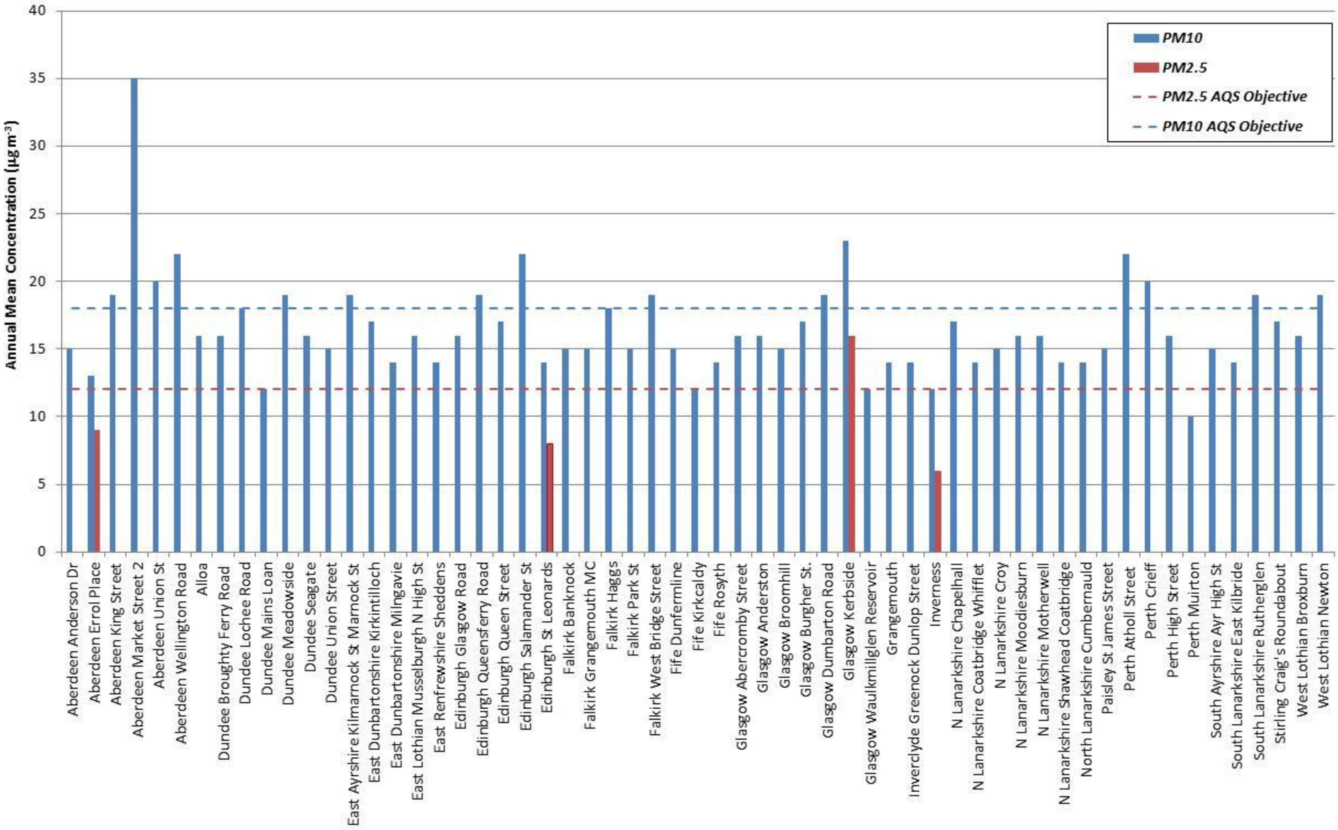


Table 6.1.4 $PM_{2.5}/PM_{10}$ ratios for 2009 - 2013 annual average concentrations

Site Name	Annual Average PM_{10} 2013 (µg m^{-3} gravimetric equivalent)	Annual Average $PM_{2.5}$ 2013 (µg m^{-3} gravimetric equivalent)	Ratio 2013	Ratio 2012	Ratio 2011	Ratio 2010	Ratio 2009
Aberdeen Errol Place	13	9	0.69	0.75	0.57	0.54	0.47
Auchencorth Moss (Partisol)	7	4	0.57	0.57	0.71	0.50	0.64
Auchencorth Moss PM10 PM25	8	4	0.50	0.57	0.50	0.57	0.51
Edinburgh St Leonards	14	8	0.57	0.69	0.80	0.64	0.50
Glasgow Kerbside	23	16	0.70	0.63	0.59	0.52	0.46
Glasgow Townhead	12	6	0.50	0.83	1.22	0.79	0.81
Grangemouth	14	9	0.64	0.79	0.79	0.79	0.68
Inverness (Partisol)	12	6	0.50	0.55	0.50	0.50	0.55

Shaded sites indicate data only available for part year and/or <75% data capture

6.1.4 Carbon Monoxide

Table 6.1.5 Ratified data annual average concentration and data capture for CO in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	Annual Average CO 2013 ($mg\ m^{-3}$)	Max. Running 8hr Mean CO 2013 ($mg\ m^{-3}$)	Data capture CO 2013 (%)
Edinburgh St Leonards	Urban Background	0.2	0.7	82
Glasgow Anderston	Urban Background	0.2	0.6	56
Glasgow Byres Road	Roadside	0.2	1.4	52
N Lanarkshire Croy	Urban Background	0.2	1.1	82

Shaded sites indicate data only available for part year and/or <75% data capture

Table 6.1.5 shows carbon monoxide was monitored using automatic techniques at 4 sites during 2013. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

6.1.5 Sulphur Dioxide

Table 6.1.6 Ratified data annual average concentration and data capture for SO_2 in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	Annual Average SO_2 2013 ($\mu g\ m^{-3}$)	No. 15 min SO_2 > 266$\mu g\ m^{-3}$ 2013	No. 1 hr SO_2 > 350$\mu g\ m^{-3}$ 2013	No. 24 hr SO_2 > 125$\mu g\ m^{-3}$ 2013	Data Capture SO_2 2013 (%)
Dundee Broughty Ferry Road	Roadside	4	0	0	0	97
Edinburgh St Leonards	Urban Background	1	0	0	0	97
Falkirk Grangemouth MC	Urban Background	8	0	0	2	99
Falkirk Hope St	Roadside	3	0	0	0	98
Falkirk Park St	Roadside	3	2	0	0	100
Glasgow Anderston	Urban Background	3	0	0	0	92
Grangemouth	Urban Industrial	4	6	0	0	99
Grangemouth Moray	Urban Background	11	25	0	1	98
Midlothian Pathhead	Kerbside	3	0	0	0	8
N Lanarkshire Croy	Roadside	2	0	0	0	93
N Lanarkshire Cumbernauld	Urban Background	1	0	0	0	92
Shetland Lerwick	Urban Background	1	0	0	0	92

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6.1.6 shows sulphur dioxide data from the 12 sites utilising automatic monitoring for 2013. Midlothian Pathhead was decommissioned on 25/01/2013 and so data are only available for part of the year. All sites in Scotland met the requirements of the Air Quality Strategy for the 15 minute, 1-hour and 24-hour mean objectives SO_2 in 2013.

6.1.6 Ozone

Table 6.1.7 Ratified data annual average concentration and data capture for O_3 in 2013 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	Annual Average O_3 2013 ($\mu g\ m^{-3}$)	No of days with running 8-hr mean >100 ug m^{-3}	Data capture O_3 2013 (%)
Aberdeen Errol Place	Urban Background	47	0	88
Auchencorth Moss	Rural	60	4	99
Bush Estate	Rural	63	13	99
Edinburgh St Leonards	Urban Background	49	2	98
Eskdalemuir	Rural	60	14	100
Fort William	Suburban	53	3	99
Glasgow Townhead	Urban Centre	39	0	13
Glasgow Waulkmillglen Reservoir	Rural	53	0	99
Lerwick	Rural	68	5	66
Peebles	Suburban	52	0	51
Strath Vaich	Remote	70	23	89

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6.1.7 shows ozone data from 11 sites utilising automatic monitoring for 2013. Ozone (O_3) is a secondary pollutant formed by reactions involving other pollutant gases in the presence of sunlight and over several hours; it may persist for several days and be transported over long distances. This means that local authorities have little control over ozone levels in their area. In 2013, the air quality objective of not more than 10 days with a maximum 8 hr running mean greater than 100 $\mu g\ m^{-3}$ was exceeded at Bush Estate, Eskdalemuir and Strath Vaich. No sites with a data capture rate of less than 75% exceeded the Air Quality Objective.

6.2 Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and Lead

In this section, we present a summary of data from a range of national monitoring networks. Summaries are provided for pollutants covered by the Air Quality Strategy. As some of these networks are based on sampler measurement techniques and subsequent chemical analysis there is often a considerable delay in the availability of data. Hence, in some cases, the latest data available at the time of preparing this report is for 2012. Where other pollutants are also monitored in these networks, these pollutants are listed, but the data are not provided in this report.

6.2.1 PAH Monitoring Network[7]

The UK Monitoring and Analysis Network monitor some 39 Poly Aromatic Hydrocarbon (PAH) species at about 30 sites.

PAH monitoring of the compound benzo[a]pyrene is undertaken to provide data in compliance with the EU Air Quality Directive (Directive 2004/107/EC). An air quality Objective for this compound is also set in the Air Quality Strategy. A wide range of other PAH species are also monitored in the particulate phase and in the gaseous phase at some sites, for research purposes. The monthly summary results for all species monitored in the PAH network can be downloaded as spreadsheet summary data from http://uk-air.defra.gov.uk/interactive-map.

The airborne PAH monitoring is undertaken using Digitel DHA-80 Air Sampling System with PM_{10} inlet. Particulate collection is undertaken on a filter and at some sites, vapour-phase collection is also undertaken using polyurethane foam in addition to filter. At two sites, deposition samplers are also used to determine deposited PAH material.

The PAH monitoring sites in Scotland are shown in Table 6.2.1. The sites at Edinburgh and Glasgow are co-located with the Edinburgh St Leonards and Glasgow Centre AURN sites respectively. The Glasgow Centre site was decommissioned in August 2012 and a replacement site, Glasgow Townhead, was commissioned in October 2013. Therefore, PAH data from the Glasgow Centre site have been reported and are only available up to August 2012. The site at Kinlochleven is located close to the closed Aluminium works and the site at Auchencorth Moss is a rural EMEP site as discussed in the automatic hydrocarbon section.

Table 6.2.1 PAH Monitoring Sites in Scotland

Site	Address	Grid Reference
Edinburgh	145 Pleasance, Edinburgh, EH8 9RU	326265, 673136
Glasgow Centre	St Enoch Square, Glasgow, G2 8BX	258964, 665018
Kinlochleven 2	Electrical Substation, Kinlochleven	219305,761905
Auchencorth Moss	Rural site in Scotland, south of Edinburgh	322167,656123

Annual average concentrations for Benzo(a)pyrene (B(a)P) for 2011 and 2012 are shown in Table 6.2.2.

As can be seen the Air Quality Objective for B(a)P of 0.25 ng m^{-3} annual average was exceeded at Kinlochleven in 2011, with no exceedances measured at any site during 2012. However, the EU Directive target value of 1 ng m^{-3} annual average was not exceeded at any monitoring site in Scotland.

Table 6.2.2 Annual Average Benzo(a)Pyrene concentrations for 2011 - 2012 at 4 sites in Scotland

Site	2011 Annual Mean B(a)P Concentration (ng m^{-3})	2012 Annual Mean B(a)P Concentration (ng m^{-3})
Auchencorth Moss A	0.020	0.046
Edinburgh St Leonards	0.099	0.109
Glasgow Centre	0.190	0.115
Kinlochleven	0.280	0.176

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

[7] Conolly C. et al Final Contract Report for the UK PAH Monitoring and Analysis Network (2004-2010) [online] Available at http://uk-air.defra.gov.uk/reports/cat05/1103040911_AEA_PAH_Network_Report_2010_Final_v3.1.pdf [Accessed no 30/05/2012]

6.2.2 Benzene

Non- automatic hydrocarbon monitoring

Monitoring of benzene is undertaken on a two weekly basis with pumped tube samplers at 37 sites throughout the UK – The UK Non-automatic Hydrocarbon Network. Two of these sites are located in Grangemouth and Glasgow Kerbside and are co-located with the Grangemouth and Glasgow Kerbside AURN sites. The non-automatic monitoring network provides benzene data for compliance with the EU air quality Directive.

The benzene monitoring method used in this network involves pumping ambient air at a rate of 10 ml min^{-1} through nominally duplicate tubes containing the sorbent Carbopack X, with subsequent laboratory analysis of the benzene content of the tubes.

Results for this site for 2012 and 2013 are provided in Table 6.2.3.

Table 6.2.3 Annual Mean Benzene Concentrations in 2012 and 2013 at 2 sites in Scotland in the UK Non-automatic Hydrocarbon Network

Site Name	Annual Mean benzene for 2012 (µg m^{-3})	Annual Mean benzene for 2013 (µg m^{-3})
Glasgow Kerbside	0.90	0.89
Grangemouth	2.0	1.14

6.2.3 Automatic Hydrocarbon Monitoring

Table 6.2.4 gives the site details for the one automatic hydrocarbon monitoring station in Scotland - Auchencorth Moss. Automatic monitoring of hydrocarbons stopped at Glasgow Kerbside at the end of 2010. Auchencorth Moss is a rural site south of Edinburgh. The data from this site are used both to provide data for ozone precursor hydrocarbon species, in compliance with the EU Air Quality Directive (2008/50/EC). In addition, this site is one of the 2 European Monitoring and Evaluation Programme (EMEP) level II sites (EMEP “supersites”) in the UK. The other EMEP supersite is located a Harwell in Oxfordshire. A much wider range of hydrocarbon species is monitored at Auchencorth Moss. However, the rural nature of this site means that often the concentrations are below the detection limit and hence, the data capture is low. Data for the full range of hydrocarbon species monitored at Glasgow Kerbside and Auchencorth Moss can be downloaded from www.scottishairquality.co.uk.

Table 6.2.4 Location of Automatic Hydrocarbon monitoring sites in Scotland

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322167,656123

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

Table 6.2.5 Annual Average Benzene concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2013

Site	2013 Benzene Annual mean concentration (µg m^{-3})	2013 Benzene Maximum running annual concentration (µg m^{-3})	2013 % Data Capture
Auchencorth Moss	0.25	0.27	90

Table 6.2.3 and 6.2.5 indicate that it is unlikely that the EU limit value for benzene of 5 µg m^{-3} was exceeded at Auchencorth Moss and that the Scottish Objective of 3.25 µg m^{-3} for the annual running mean concentration is also unlikely to be exceeded.

6.2.4 1,3-Butadiene

The species 1,3-butadiene is also measured as part of the UK Automatic Hydrocarbon Network at the same sites as for Benzene. Measurements of 1,3-butadiene within the non-automatic hydrocarbon network stopped during 2007.

Table 6.2.6. Annual Average 1,3-butadiene concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2013

Site	2013 1,3-butadiene Annual mean concentration (µg m^{-3})	2013 1,3-butadiene maximum running annual concentration (µg m^{-3})	2013 % Data capture
Auchencorth Moss	0.03	0.02	83

Table 6.2.6 indicates that it is unlikely that the Air Quality Objective for 1,3-butadiene of 2.25µgm^{-3} has been exceeded in Scotland in 2013. There is no EU Directive covering 1,3-butadiene.

6.2.5 Lead

Lead and a wide range of other metals are monitored in two UK networks – the UK Heavy Metals Monitoring Network (mainly urban sites) and the National Monitoring Network for Heavy Metals (mostly rural sites). The urban network determines airborne particulate concentrations of 13 metals, including the metals lead, nickel, arsenic, cadmium and mercury which are covered by the EU Directive (Directives 2008/50/EC for lead and Directive 2004/107/EC for other metals). The rural network determines the concentration of more than 20 metals both as airborne particulate matter and as deposited material in rainwater samples. Results for all metals monitored in the UK Heavy Metals Monitoring Network and for a selection of metals monitored in the National Monitoring Network for Heavy Metals are available from annual average spreadsheet summaries at www.uk-air.defra.gov.uk.

Urban Heavy Metals

Monitoring of metals in urban areas is undertaken in compliance with EU Directive 2004/107/EC to determine compliance with the Directive limit values for lead, nickel, arsenic, cadmium and mercury and the Air Quality Objective for lead. Particulate samples are collected using Partisol 2000 instruments fitted with PM_{10} heads and operating at a flow rate of 1 m^3 h^{-1}. Analysis of the samples is undertaken using ICP-MS.

Table 6.2.7 gives details of the monitoring sites in Scotland and Table 6.2.8 provides a summary of the results for the measurement of lead and other metals for 2013.

Table 6.2.7 Heavy Metals Monitoring Network Sites in Scotland 2013

Site	Site type and grid ref	Address	Metals measured
Motherwell South	Urban Background 276140,655515	Our Lady's High School, Dalzell Drive, Motherwell, North Lanarkshire, ML1 2DG	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)

Table 6.2.8 Annual mean metal concentrations 2013 (Urban Network)

Site	Annual Mean Lead concentration (ng m^{-3})	Annual Mean Nickel concentration (ng m^{-3})	Annual Mean Arsenic concentration (ng m^{-3})	Annual Mean Cadmium concentration (ng m^{-3})	Annual Mean Mercury(p)* concentration (ng m^{-3})	Annual Mean Mercury(v)+ concentration (ng m^{-3})
Motherwell South	2.60	0.56	0.30	0.09	0.01	2.10

* mercury in particulate phase
+ total gaseous mercury

Rural Heavy Metals

In the National Monitoring Network for Heavy Metals, particles are collected using either single sample or multiple-sample FH95 samplers which draw air through a PM_{10} head at a flow rate of 1 m^3 h^{-1}. Particulate metals are collected on a filter paper for subsequent analysis. The sampling period is normally one week. Rainwater collectors are used to collect samples for rainwater analysis of metals to determine metal deposition.

Details of the 3 rural sites in Scotland are provided in Table 6.2.9 and data for the measurement of lead in 2013 are provided in Table 6.2.10.

Table 6.2.9 Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322167,656123
Banchory	Rural site, NE Scotland	367671, 798528
Eskdalemuir	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	323552,603018

Table 6.2.10 Annual Mean metal concentrations 2013 (Rural Network)

Site	Annual Mean Lead Concentration (ng m^{-3})	Annual Mean Nickel Concentration (ng m^{-3})	Annual Mean Arsenic Concentration (ng m^{-3})	Annual Mean Cadmium Concentration (ng m^{-3})	Annual Mean Mercury(p)* concentration (ng m^{-3})	Annual Mean Mercury(v)+ concentration (ng m^{-3})
Auchencorth Moss	1.272	0.285	0.213	0.025	n/a	0.883
Banchory	1.214	0.261	0.230	0.035	0.003	0.9
Eskdalemuir	1.083	0.318	0.117	0.029	n/a	1.963

* mercury in particulate phase
+ total gaseous mercury

The results from these networks show that the EU limit value for Lead, and the target values for Nickel, Arsenic and Cadmium are not exceeded at any site in Scotland. The Air Quality Objectives for lead (500 ng m^{-3} for 2004 and 250 ng m^{-3} for 2008) were also not exceeded at any site in Scotland.

6.3 Discussion of additional pollutants monitored and/or other methods of monitoring

This section discusses other air pollution measurements made in Scotland. Detailed results are not provided, but are available in the annual reports of the various networks. The following additional pollutants or additional monitoring methods are discussed:

1. NO_2 diffusion tube samplers
2. Non- methane Volatile Organic Compounds (NMVOC)
3. Poly aromatic hydrocarbons (PAH)
4. Toxic Organic Micropollutants (TOMPS)
5. Metals (Urban network)
6. Metals (Rural and deposition network)
7. United Kingdom Eutrophying & Acidifying Pollutants Network:
    1. The Precipitation Network
    2. NO_2 rural diffusion tube Network
    3. Acid Gases and Aerosol Network (AGANET)
    4. National Ammonia Monitoring Network

6.3.1 NO_2 Diffusion Tube Results

There is no specific requirement for local authorities to provide their NO_2 diffusion tube data to a central storage facility. However, through the local authority Air Quality Support contract, a mechanism has been provided for authorities to provide these data. This data entry system is available from http://airquality.aeat.com/NO2admintools/NO2_logon.php. Where these data are provided by the authorities, they are then available for download from the Scottish air quality website (www.scottishairquality.co.uk).

6.3.2 Non-Methane Volatile Organic Compounds (NMVOC)

As discussed in Section 6.2.3 and 6.2.4 the UK Automatic Hydrocarbon Network monitors a wide range of non-methane volatile organic compounds (NMVOC) in addition to the Air Quality Strategy pollutants of Benzene and 1,3-butadiene. At Glasgow kerbside the following pollutants are monitored.

1,3-Butadiene
Benzene
Toluene
Ethylbenzene
(m+p)-Xylene *
o-Xylene

At Auchencorth Moss a much wider range of NMVOCs are monitored to provide ozone precursor pollutant concentrations in compliance with the EU Directive (2008/50/EC). The following compounds are monitored:

Ethane
Ethene
Propane
Propene
Ethyne
2-Methylpropane
n-Butane
trans-2-Butene
1-Butene
cis-2-Butene
2-Methylbutane
n-Pentane
1,3-Butadiene
trans-2-Pentene
1-Pentene
2-Methylpentane
n-Hexane
Isoprene
Benzene
2,2,4-trimethylpentane
n-Heptane
n-Octane
Toluene
Ethylbenzene
(m+p)-Xylene
o-Xylene
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
1,2,3-Trimethylbenzene

Hourly data for all these species are available on the Scottish Air Quality website.

6.3.3 Poly-Aromatic Hydrocarbons (PAH)

As discussed in Section 6.2.1, a wide range of particulate and gaseous PAH compounds are monitored within the UK PAH network. The following PAH species are sampled on a daily basis (but bulked into monthly results after analysis) at the 4 PAH sites in Scotland:

Benzo(c)phenanthrene
Benzo(a)anthracene
Chrysene
Cyclopenta(c,d)pyrene
Benzo(b)naph(2,1-d)thiophene
5-Methyl Chrysene
Benzo(b+j)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenzo(ah.ac)anthracene
Benzo(ghi)perylene
Anthanthrene
Dibenzo(al)pyrene
Dibenzo (ae)pyrene
Dibenzo(ai)pyrene
Dibenzo(ah)pyrene
Coronene
Cholanthrene

6.3.4 Toxic Organic Micropollutants

Toxic Organic Micropollutants (TOMPs) include Polychlorinated Dibenzo-p-Dioxins, Polychlorinated Dibenzofurans (PCDD/Fs), PAHs, and Polychlorinated Biphenyls (PCBs). PCDD/Fs and PAHs are formed as unwanted by-products during various industrial, chemical and combustion processes. PCBs were formerly manufactured for use in a wide range of electrical and other products until 1986. These highly toxic and persistent species are ubiquitous in the environment, but are normally present at extremely low concentrations, the atmosphere being the principal route for their redistribution in the environment. The TOMPs network provides data on concentrations of these species in the air throughout the UK.

There were six sites in the TOMPs network during 2013; one in Scotland at Auchencorth Moss, a remote background site located in Southern Scotland.

The TOMPs network samples are analysed for PCDD/Fs and PCBs. Portions from the extracts of samples are also analysed for PAHs as part of the PAH network. The sampling method is based around the use of a modified Andersen GPS-1 sampler with subsequent chemical analysis requiring the use of a range of sophisticated chemical analysis techniques. These include gas chromatography coupled with high-resolution mass spectrometry for the PCDD/Fs and for those PCBs with dioxin-like effects and low-resolution mass spectrometry for the other PCBs.

6.3.5 Metals (Urban Network)

As discussed in Section 6.2.5 a wide range of metals are monitored in the Heavy Metals Monitoring Network. At the two sites in Scotland, Eskdalemuir and Motherwell, the following metals are measured:

Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Mangananese (Mn), Nickel (Ni), Lead (Pb), Platinum (Pt), Vanadium (V), Zinc (Zn), Mercury (particulate – Hg(p)) and Mercury (Vapour – Hg(v)).

6.3.6 Metals (Rural and Deposition Network)

As discussed in Section 6.2.5 a wide range of metals are monitored in both air and rainwater within the National Monitoring Network for Heavy Metals. At the three sites in Scotland, Auchencorth Moss, Banchory and Eskdalemuir, the following metals are monitored:

Aluminium (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb), Manganese (Mn), Molybdenum (Mo), Rubidium (Rb), Scandium (Sc), Selenium (Se), Strontium (Sr), Tin (Sn), Titanium (Ti), Tungsten (W), Vanadium (V) and Zinc (Zn).

6.3.7 United Kingdom Eutrophying & Acidifying Pollutant Network (UKEAP)

This network focuses on the measurement of Eutrophying & Acidifying Pollutants in rural areas. The number of sites in Scotland is different for the various species measured.

The UKEAP has 4 component networks:

- The Precipitation Network (PrecipNet),
- NO_2 network (NO_2-Net),
- Acid Gas and Aerosol Network (AGANET)
- National Ammonia Monitoring Network (NAMN).

Each network functions on a national scale, however with differing spatial and temporal resolution which reflects the spatial and temporal heterogeneiety of the atmospheric pollutant concerned.

The Precipitation Network (PrecipNet)

There are 38 sites in PrecipNet at which the chemical composition of precipitation (i.e. rainwater) is measured. Six of the sites, Lochnagar, Llyn Llagi, Scoat Tarn, Loch Chon/Tinker, River Etherow, Beaghs Burn and Crai Reservoir (Head of the Valleys) were specifically located within sensitive ecosystems. The network allows estimates of wet deposition of sulphur and nitrogen chemicals.

Fortnightly precipitation samples are collected at 38 sites throughout the UK, of which, 11 are in Scotland (see Appendix 1). Sampling is undertaken with using a bulk rainwater collector. The collected rainwater samples are analysed for sulphate, nitrate, chloride, phosphate, sodium, magnesium, calcium, potassium, pH and conductivity.

NO_2 Network (NO_2-Net)

The nitrogen dioxide measurements are made at 24 of the 38 PrecipNet composition sites. Diffusion tubes are used to measure nitrogen dioxide. The tubes are mounted on the upright of the rain collector stand and exposed for four or five week periods throughout each year.

Triplicate nitrogen dioxide diffusion tube measurements are run at three AURN sites with co-located automatic instruments (Yarner Wood, Harwell and Eskdalemuir). The annual average NO_2 concentration measured at the Eskdalemuir automatic monitoring site was 2 μg m^{-3} in 2013 with a data capture rate of 99%.

Nitrogen dioxide is measured with diffusion tube samplers at 9 sites in Scotland. The annual average concentrations measured in 2013 are provided in Table 6.3.1.

Table 6.3.1 NO_2 annual average concentrations 2013 at rural monitoring sites

Site	NO_2 (ug m^{-3})	Data Capture (%)
Allt a'Mharcaidh	1.9	100
Balquhidder 2	2.9	100
Eskdalemuir	3.8	100
Forsinain 2	2.3	100
Glensaugh	3.8	100
Loch Dee	3.0	86
Polloch	2.1	100
Strathvaich	1.7	100
Whiteadder	4.6	100

Acid Gas and Aerosol Network (AGANET)

The UK Acid Gases and Aerosols Monitoring Network has been in operation since September 1999, providing monthly measurement data of acid gases and aerosols.

An extension of the CEH DEnuder for Long Term Atmospheric sampling (DELTA) system at the network sites is used to additionally sample gaseous HNO_3, SO_2, HCl and particulate NO^{3-}, SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+}. The new expanded network includes measurements of gaseous SO_2 and particulate SO_4^{2-} .

The 11 sites in this network located in Scotland are listed in Appendix 1.

National Ammonia Monitoring Network (NAMN)

Established in 1996, the objectives of the network are to quantify temporal and spatial changes in air concentrations and deposition in NH3 and NH4+ (included since 1999) on a long term basis. The monitoring provides a baseline in the reduced nitrogen species (NH_3 + NH_4^+), which is necessary for examining responses to changes in the agricultural sector and to verify compliance with targets set by international agreements.

The 23 sites in this network located in Scotland are listed in Appendix 1.

7 Air Quality Mapping for Scotland

As part of the Scottish Air Quality Database project, Ricardo-AEA provide 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, and (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 2012 (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), and
- NO_X and NO_2.

The air pollution measurements used to prepare the maps presented here consists of appropriately scaled PM_{10} monitoring data (FDMS, Partisol and VCM-corrected TEOM data) and automatic monitoring measurements for NO_X and NO_2 in 2012. The model also uses Scottish meteorology observations (from RAF Leuchars) to create the Scotland-specific maps.

In 2009 AEA (now Ricardo-AEA) undertook a short study[8] 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 Local Air Quality Management Review and Assessment reports. Scotland-specific air pollutant source apportionment data and forward-projected concentrations of air pollutants are available at:

http://www.scottishairquality.co.uk/maps.php?n_action=data.

7.1 Air Quality Maps for Scotland 2012

The details of the methodology and full results of the mapping study will be provided in a separate report[9]. In this report, we summarise the main findings of this work.

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[8] 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. http://www.scottishairquality.co.uk/documents/reports2/258100203_LA_mapping_Report_Issue_1_FINAL.PDF

[9] Lingard, J.J.N (2014). Scottish Air Quality Maps. Pollutant modelling for 2012: annual mean NO_X, NO_2, and PM_{10}. To be published.

7.1.2 NO_2 maps for 2012

The 2012 annual mean NO_2 concentrations for Scotland were modelled for background and roadside locations. Figure 7.1 and Figure 7.2 show modelled annual mean NO_2 concentrations in Scotland, for background and roadside locations respectively.

Figure 7.1 Background NO_2 map for 2012, µg m^{-3} (Scotland-specific model)

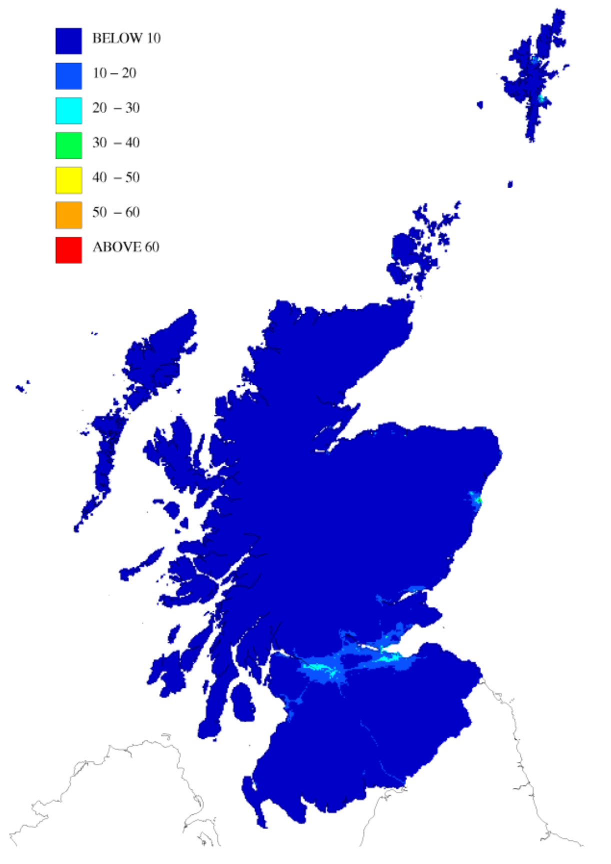
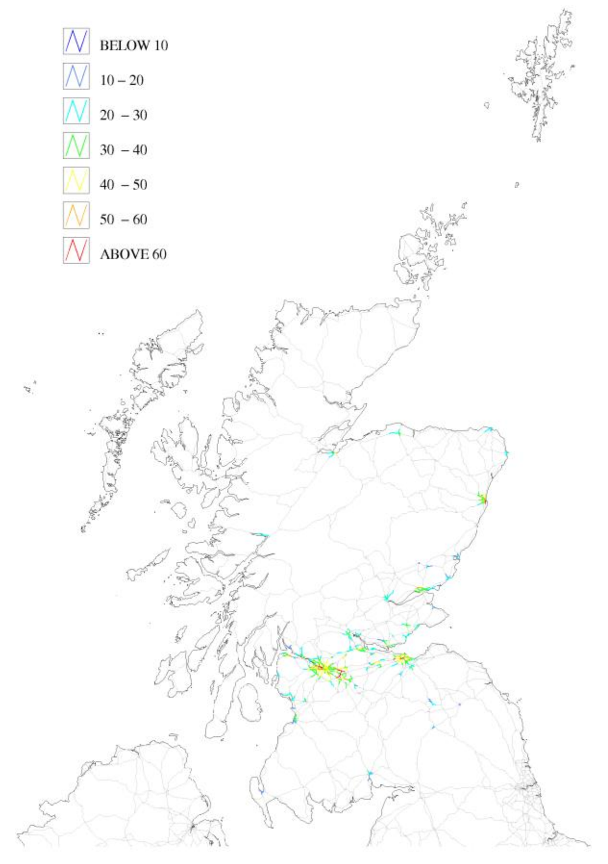


Figure 7.2 Roadside NO_2 map for 2012, µg m^{-3} (Scotland-specific model)

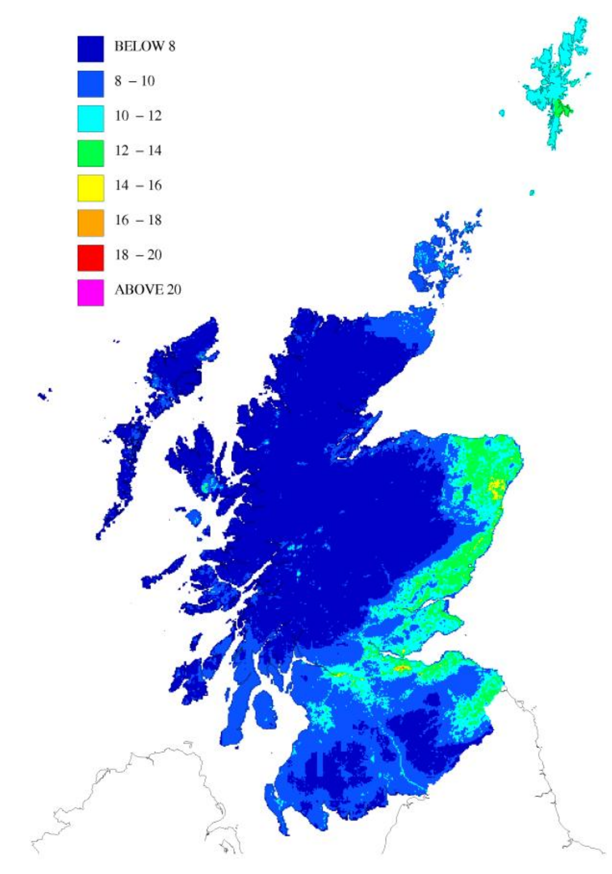
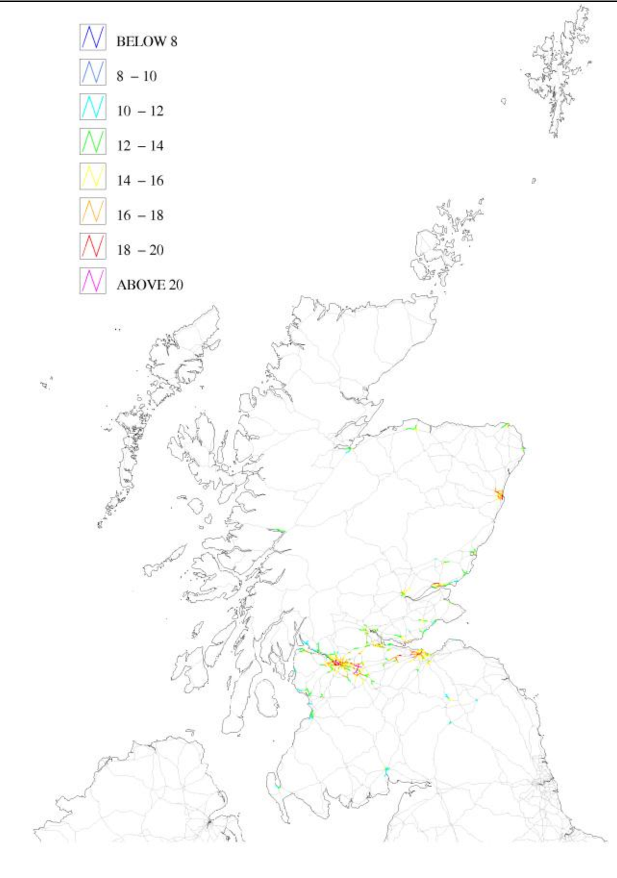


7.1.3 PM_{10} maps for 2012

2012 annual mean PM_{10} concentrations for Scotland were modelled for background and roadside locations. 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 (FDMS, Partisol and VCM corrected TEOM) 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., sulphate, nitrate, ammonium-based particles)
- secondary organic aerosols (SOA)
- primary particles from long-range transport (e.g., soot particles from biomass burning)
- sea salt aerosol, and
- iron and calcium-based dusts.

Maps of the modelled 2012 annual mean PM_{10} concentrations for Scotland's background and roadside locations are shown in Figures 7.3 and 7.4, respectively.

Figure 7.3 Background PM_{10} map for 2012, µg m^{-3} (Scotland-specific model)	Figure 7.4 Roadside PM_{10} map for 2012, µg m^{-3} (Scotland-specific model)
	

8 Air Quality Trends for Scotland

This section of the report summarises how air quality in Scotland has changed in recent years. It focuses on those pollutants for which the Air Quality Strategy Objectives are currently not met at all sites in Scotland (i.e. nitrogen dioxide, particulate matter as PM_{10} and ozone).

Automatic monitoring of oxides of nitrogen and of ozone has been routinely carried out in Scotland since 1987, with automatic PM_{10} monitoring carried out since the 1990s. However, until 2000 there were relatively few automatic monitoring sites: the number of air quality monitoring sites in the Scottish Air Quality database has grown significantly since then. As highlighted in Section 4, the years since 2006 have seen an increase from 20 sites to 91. This increase in the number of monitoring sites has improved our understanding of Scotland's pollution climate. However, it potentially complicates the investigation of trends in air quality. If this investigation is based on all available data, the apparent changes we see in the dataset may not reflect real changes in Scotland's air quality, but rather be due to the changes in the number of sites (and their distribution). Therefore, in reports in this series from 2010 onwards, investigation of trends has been based on subsets of long-running sites. This should lead to a more robust assessment. It is usually considered that at least five consecutive years' data are required from a monitoring site, in order to assess long-term trends.

This section presents trend analysis carried out using Openair: a free, open-source software package of tools for analysis of air pollution data. Openair was developed by King's College London with the University of Leeds. A range of Openair tools are available on the "Air Quality in Scotland website": for more information on the tools and how to use them, please see:

http://www.scottishairquality.co.uk/openair/openair.php

The trend analysis presented here was 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: at least 75% data capture is required for the monthly mean to be included. 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 here, where appropriate.

8.1 Oxides of Nitrogen and Nitrogen Dioxide

In Scotland (as elsewhere in the UK) the largest number of Air Quality Management Areas (AQMAs) has been declared in response to exceedances of the annual mean nitrogen dioxide (NO_2) objective of 40 µg m^{-3}. This is also reflected in the number of monitoring stations recording an exceedance of this objective (see Section 6 of this report). It is therefore important to understand how concentrations of this pollutant are varying with time. Both changes in NO_2 and total oxides of nitrogen (NO_x) have been considered. This is because most combustion sources (such as road vehicles, domestic heating and other fuel burning processes) emit a mixture of NO_2 (so-called "direct" NO_2) and NO: the latter is subsequently oxidised to NO_2 in the ambient air. A large proportion of NO_2 is formed from the oxidation of NO emitted from such sources.

8.1.1 NO_x and NO_2 at Urban Background Sites

Historically, the longest-running urban background site in Scotland to have measured NOx concentrations was the former Glasgow City Chambers site (in operation from 1987 to 2012). This closed before the start of 2013 so is not discussed here. However, trends at this site have been covered in earlier reports in this series, available for download from http://www.scottishairquality.co.uk/reports.php?n_action=report2 .

At the time of writing, the longest-running urban background NOx monitoring site in Scotland is Aberdeen, Errol Place (in operation from late 1999 onwards). This site is also part of the UK's national air quality monitoring network (the Automatic Urban and Rural Network or AURN), in which it is referred to as "Aberdeen".

Figure 8.1 uses a smoothed trend plot to illustrate the variation in measured annual mean NO_x concentrations at Aberdeen Errol Place, from 1999 to 2013. Figure 8.1 shows that NOx concentrations at this site increased slightly in its earlier years of operation but have shown a general decrease since 2002.

Figure 8.1 Smoothed Trend Plot of NOx Concentration at Aberdeen, Errol Place: 1999 – 2013

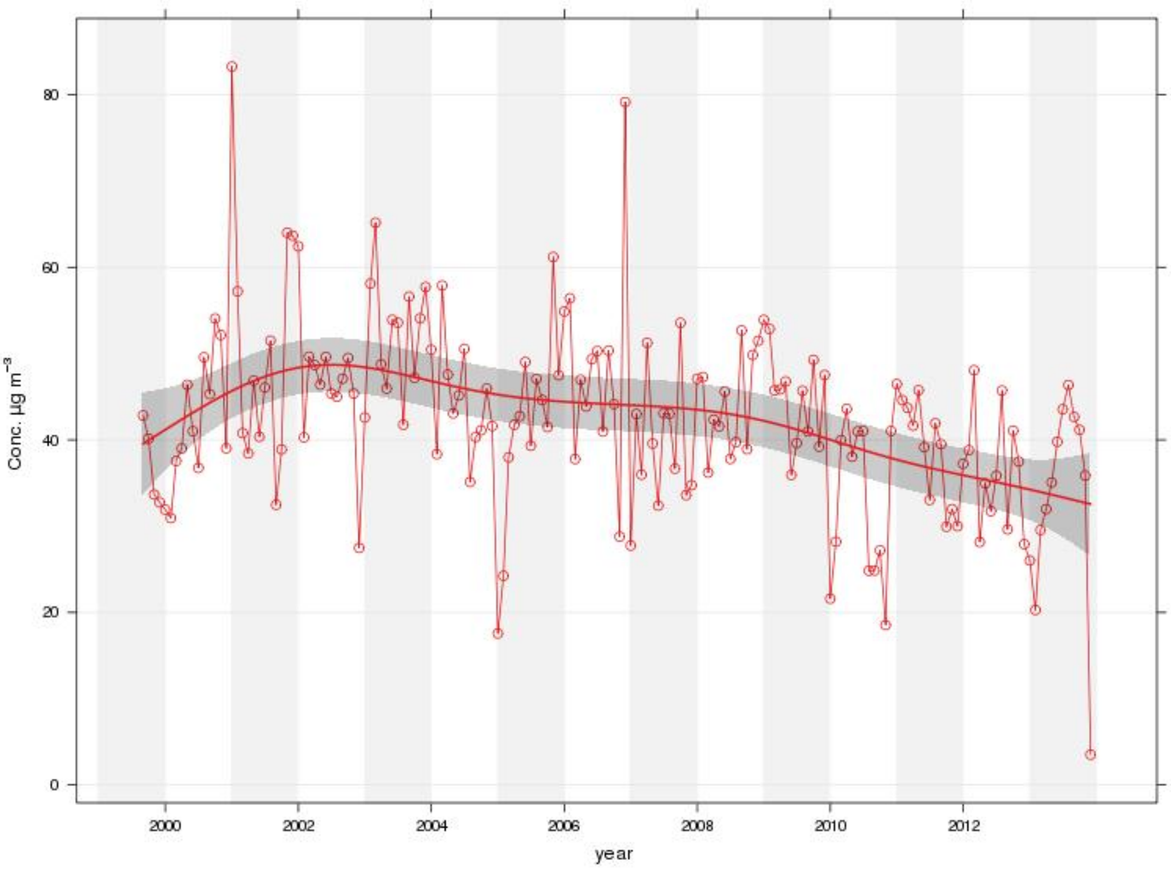
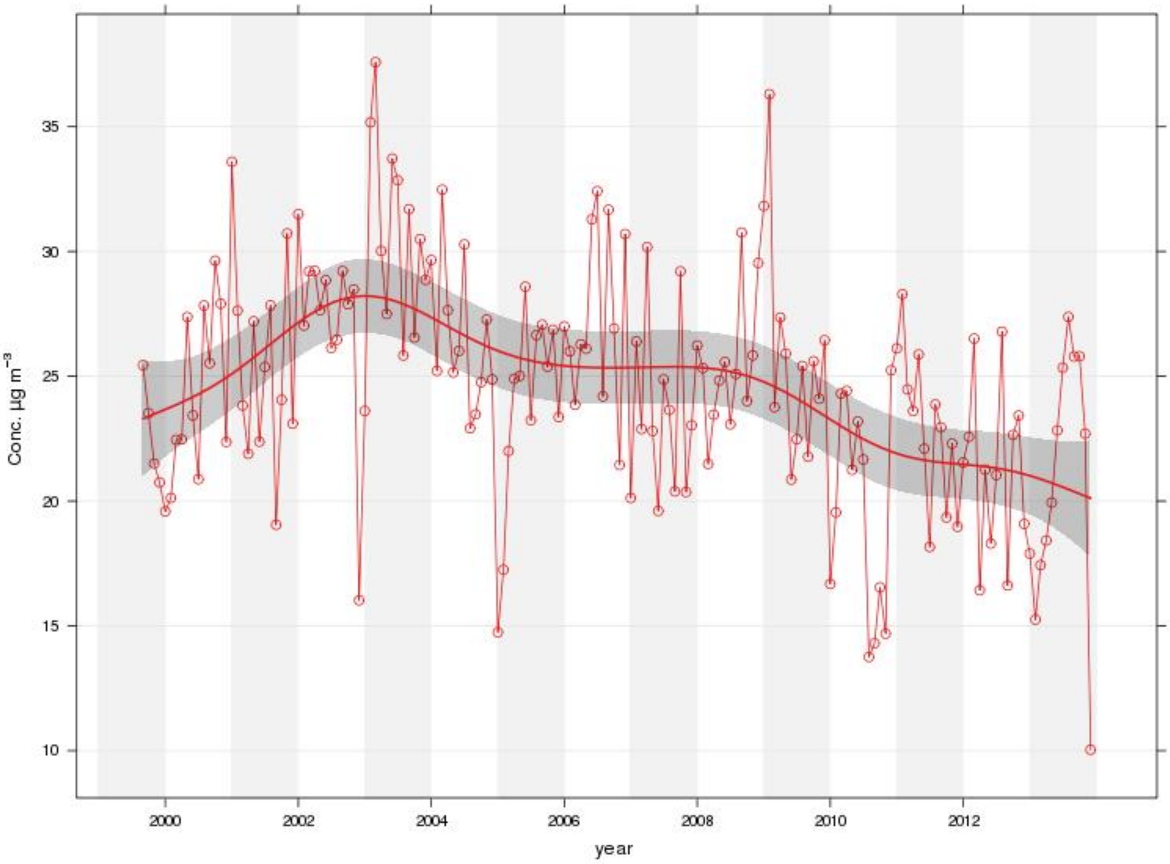


Figure 8.2 shows a smoothed trend plot over the same period for nitrogen dioxide. (Please note these graphs are plotted on different scales.) The graph indicates a similar pattern to that observed for NOx, with a peak around 2002 and subsequent decrease.

Figure 8.2 Smoothed Trend Plot of NO_2 Concentration at Aberdeen Errol Place 1999 - 2013



The Openair Theil-Sen function has been used here to quantify trends in NO_x and NO_2 in more recent years, when a larger number of sites were operating. Three urban non-roadside sites have been monitoring NOx for at least ten years (i.e. since 2004 or earlier). These are Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth (the latter is an urban industrial site).

Trends in NO_x and NO_2 are shown in Figure 8.3 and 8.4 respectively, over the period from 2004 to 2013. 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, with * 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.

All three sites show a slight negative trend (i.e. decreasing NO_x) in Figure 8.3. The trend is statistically significant at Aberdeen Errol Place and Edinburgh St Leonards. It is most significant (at the 0.001 level) at Aberdeen Errol Place. However, the actual decrease year-on-year is small.

In the case of NO_2 (Figure 8.4), the same two sites also show a slight negative trend. However, in the case of Edinburgh St Leonards, this trend is weaker and less significant for NO_2 than for NO_x.

Figure 8.3 Trends in NOx Concentration at Three Long-running Urban Non-Roadside Sites, 2004-2013

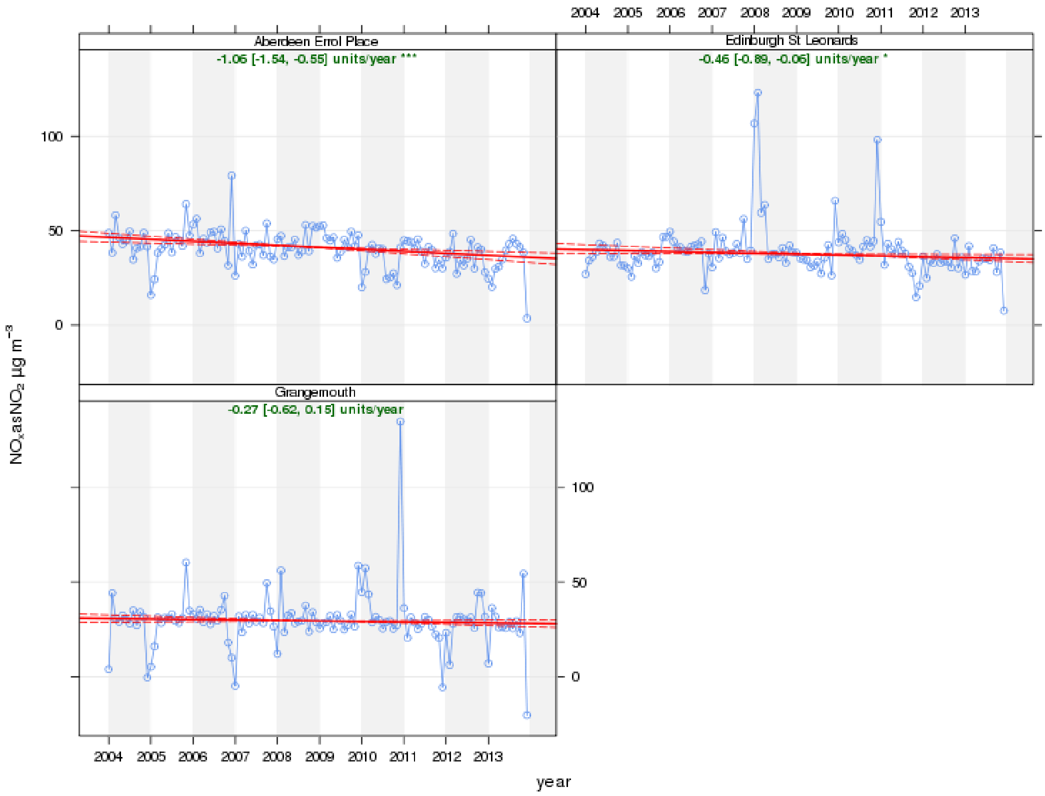
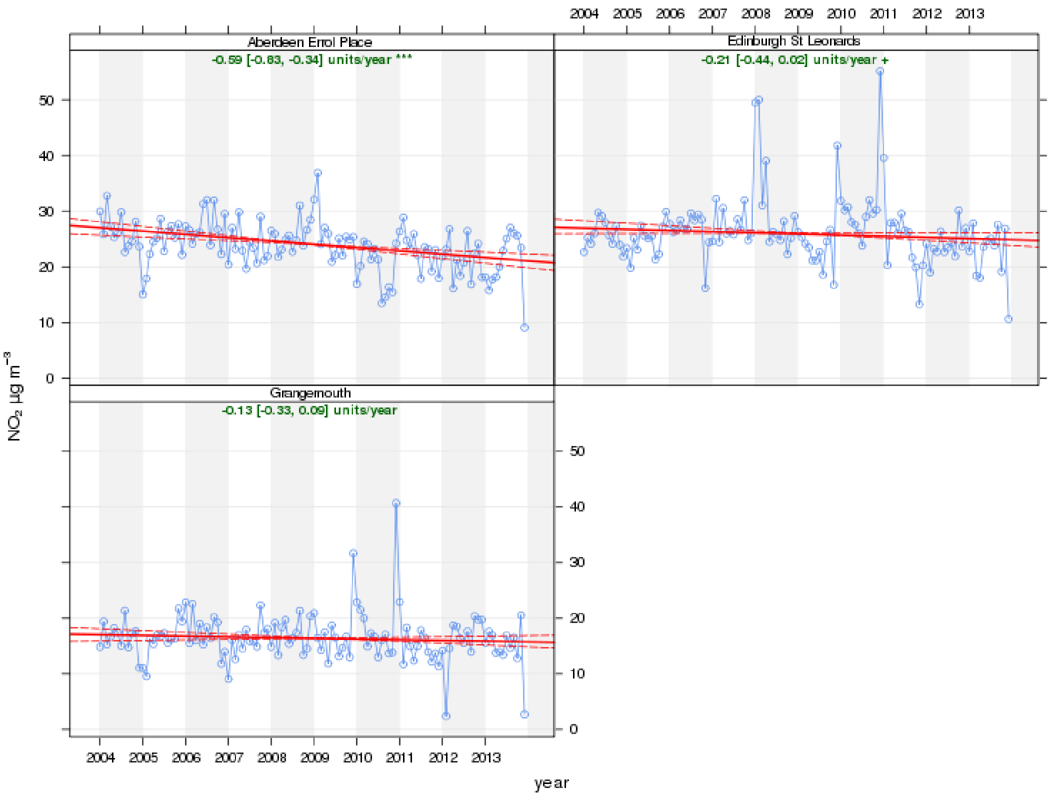
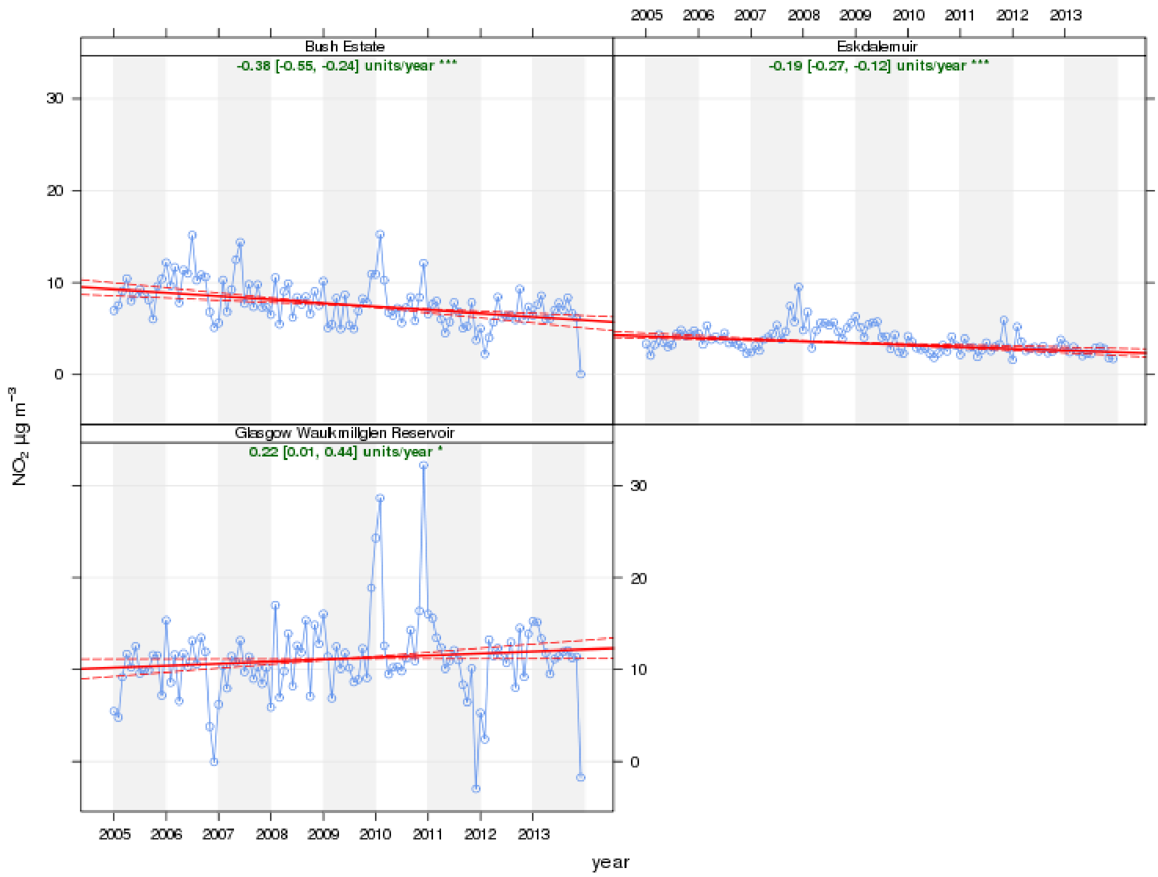


Figure 8.4 Trends in NO_2 Concentration at Three Long-running Urban Non-Roadside Sites, 2004-2013



There are also three rural sites that have all been in operation since 2005 or earlier: Bush Estate (to the south of Edinburgh close to the Pentland Hills National Park), Eskdalemuir and Glasgow Waulkmillglen Reservoir. Figure 8.5 shows trends in NO_2 concentration at these sites. While the sites at Bush Estate and Eskdalemuir show small but highly significant downward trends, this is not the case for Glasgow Waulkmillglen Reservoir (where concentrations are increasing).

Figure 8.5 Example: Trends in NO_2 Concentration at Three Rural Sites, 2005 – 2013



8.1.2 NO_x and NO_2 at Traffic-related Urban Sites

Figure 8.6 and Figure 8.7 show smoothed trend plots of NO_x and NO_2 concentration respectively, at Scotland's longest running traffic-related urban site, Glasgow Kerbside. This site began monitoring NOx in 1997 and is still doing so. There is considerable fluctuation in NO_x at this site, but some indication of an overall downward trend. By contrast, in the case of NO_2, there is no such apparent downward trend over this period.

Figure 8.6 Smoothed Trend Plot of NOx Concentration at Glasgow Kerbside: 1997 – 2013

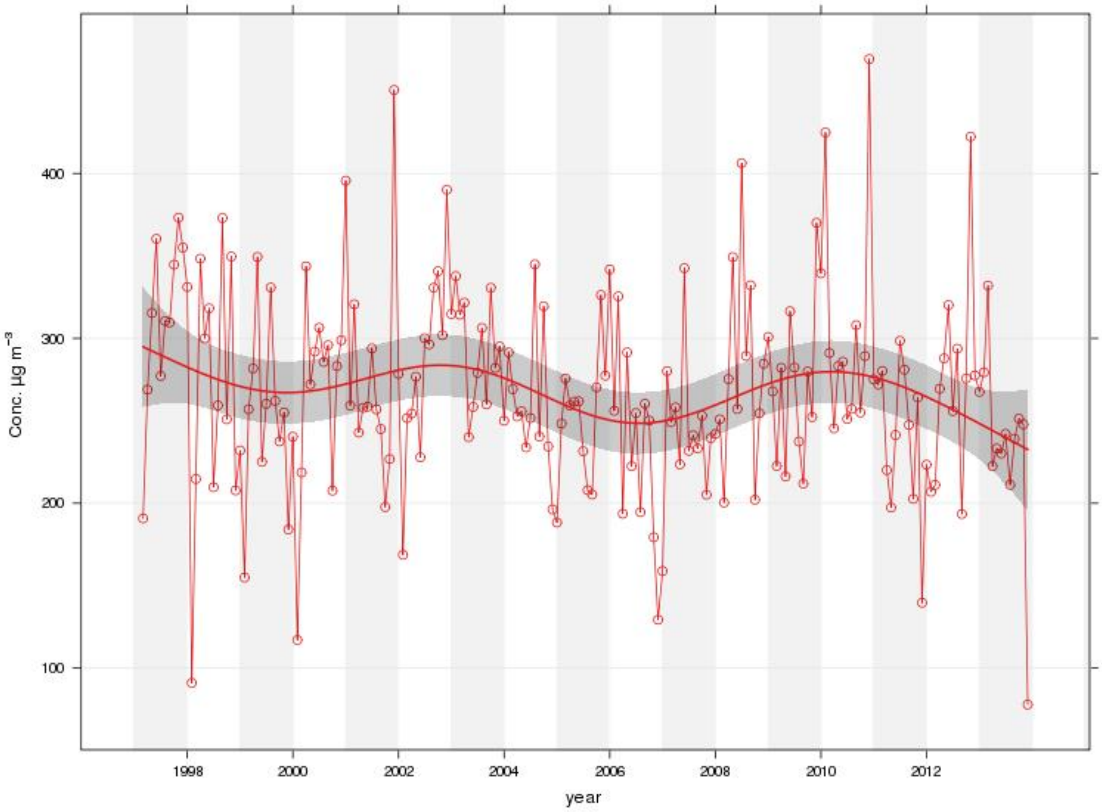
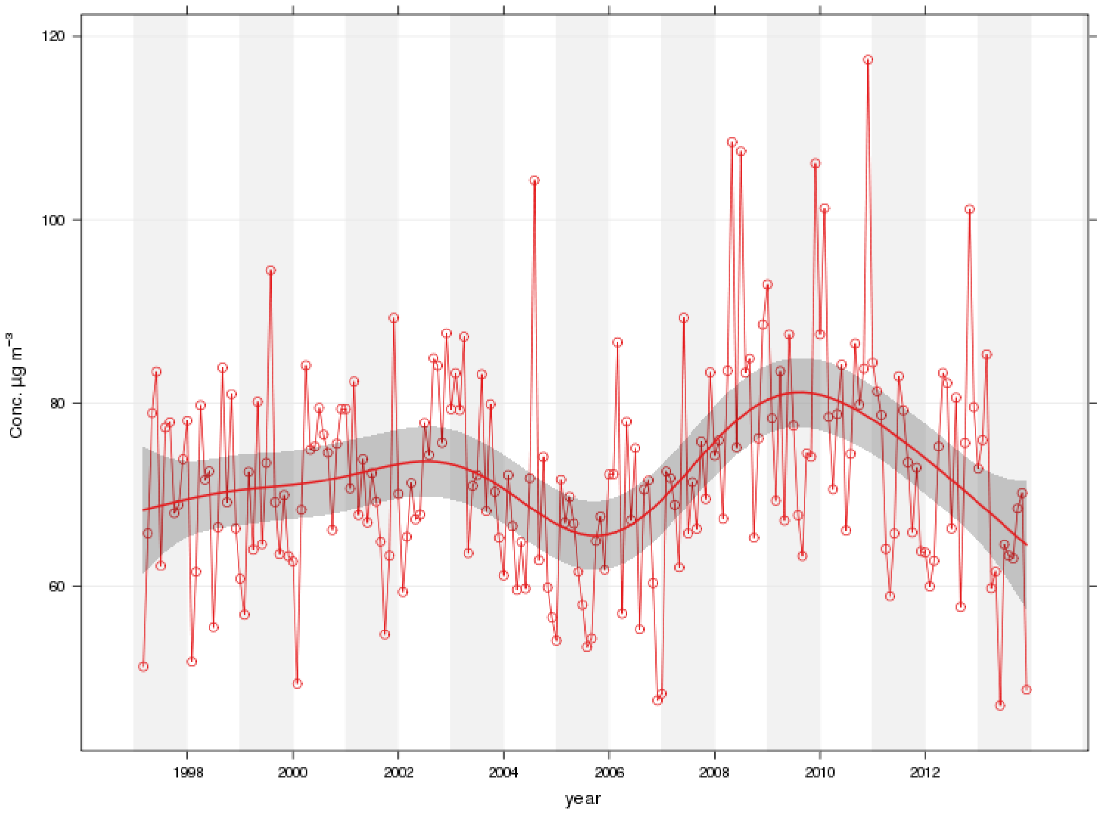


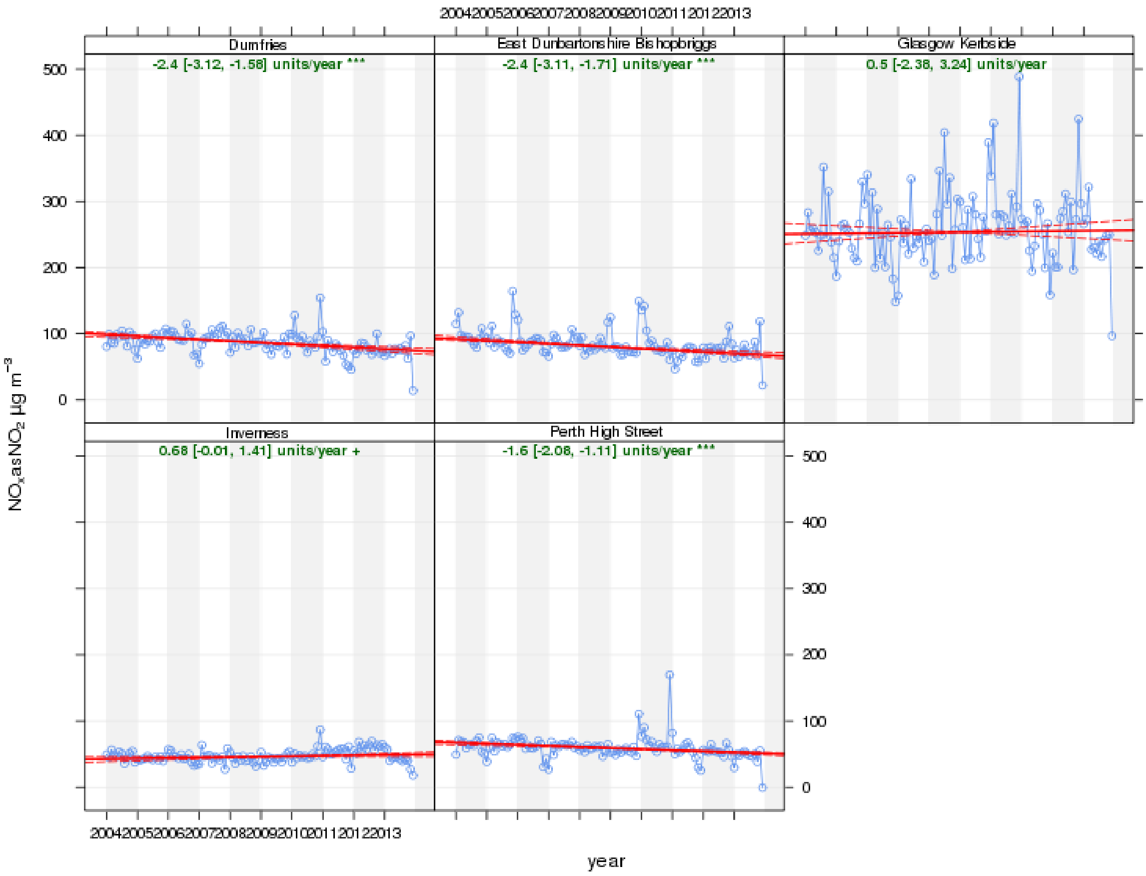
Figure 8.7 Smoothed Trend Plot of NO_2 Concentration at Glasgow Kerbside: 1997 – 2013



As in the case of the urban non-roadside sites, the Openair Theil-Sen function has been used quantify trends in NO_x and NO_2 in more recent years, when more sites were operating.

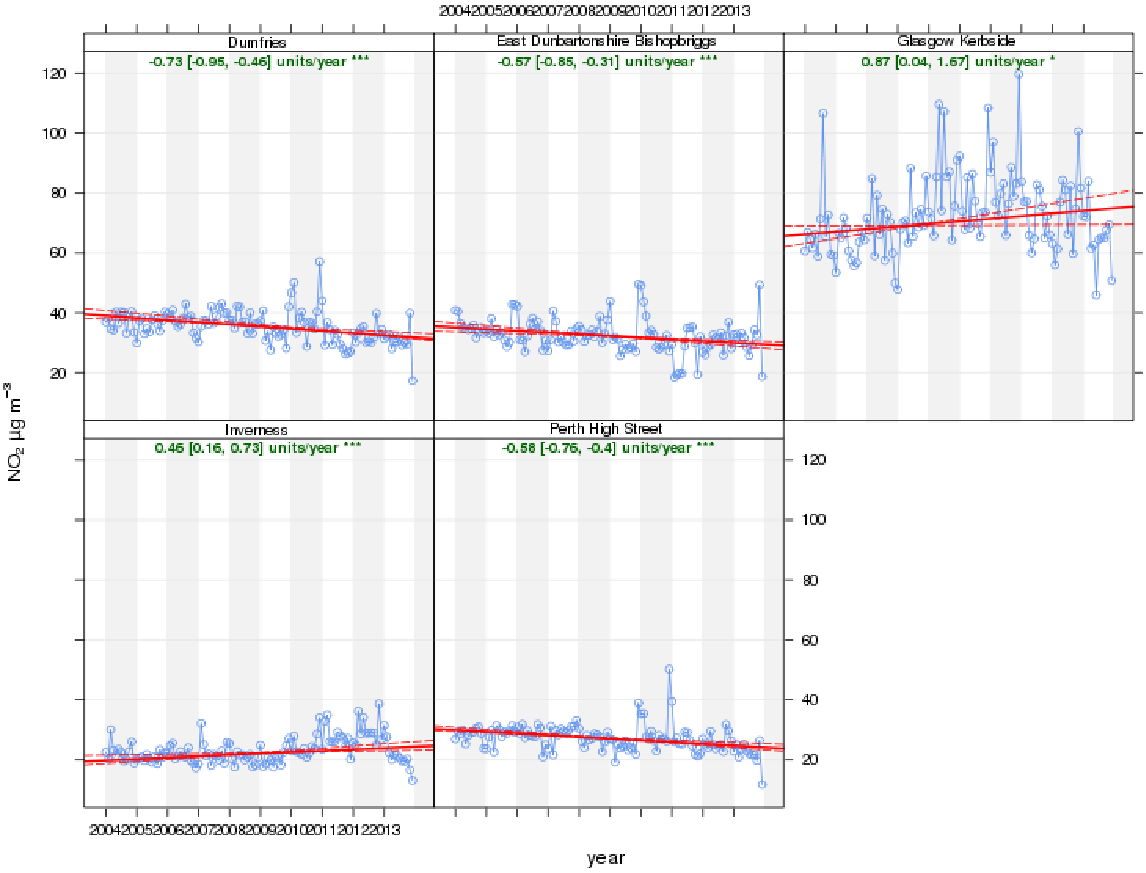
Figure 8.8 and Figure 8.9 show trends in NO_x and NO_2 respectively for a subset of five long-running sites (Dumfries, East Dunbartonshire Bishopbriggs, Glasgow Kerbside, Inverness and Perth High Street), all of which have been in operation since 2004 or earlier. Three of these sites show a downward trend in NO_x (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street). However, Glasgow Kerbside shows no trend, and Inverness shows a slight upward trend.

Figure 8.8 Trends in NOx Concentration at Five Urban Traffic sites: 2004 – 2013



In the case of NO_2, trends are also very variable between sites, with the same three sites (Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street) showing highly statistically significant downward trends, and two (Glasgow Kerbside and Inverness) showing small but statistically significant upward trends. It is notable that Glasgow Kerbside has a weak upward trend for NO_2 despite having no such trend for NOx: this may result from the very variable concentrations at this site.

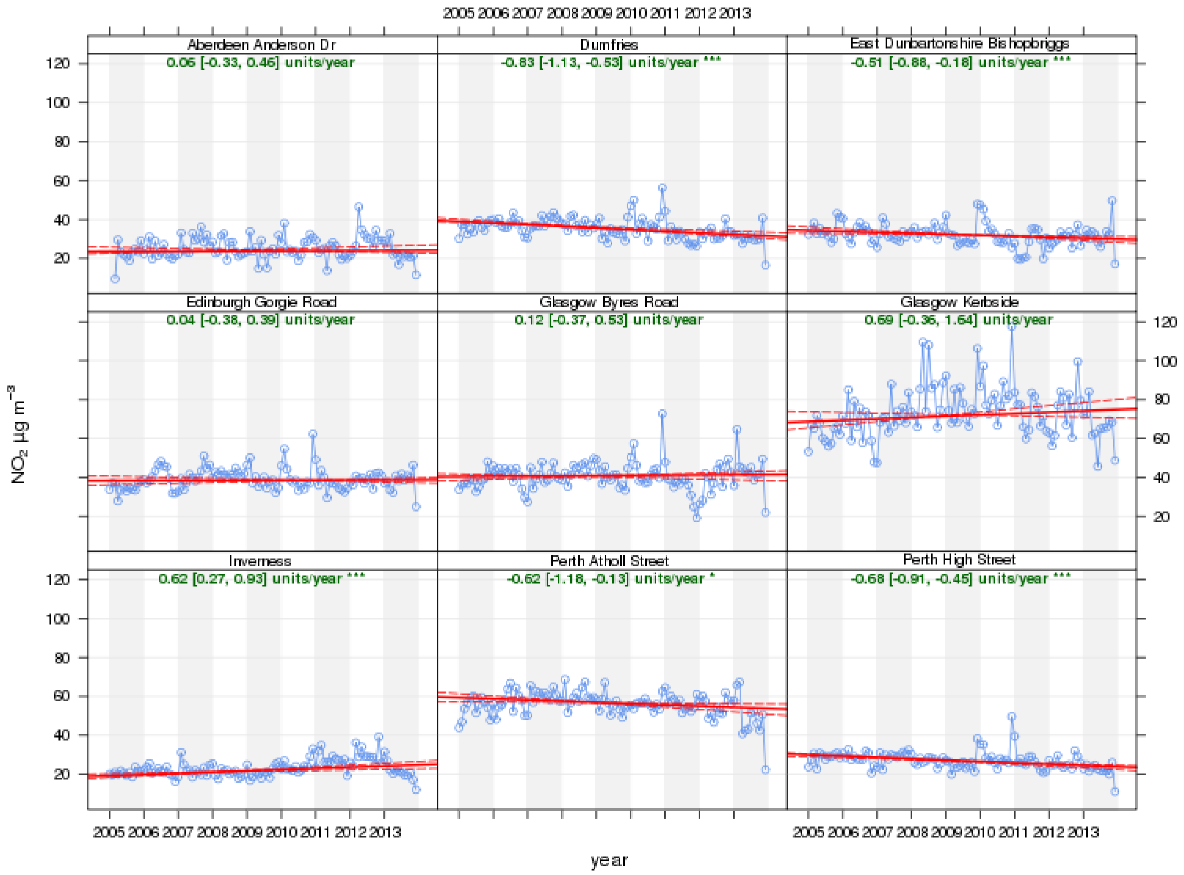
Figure 8.9 Trends in NO_2 Concentration at Five Urban Traffic sites: 2004 – 2013



Further investigation of trends in NO_2 concentration at traffic-related monitoring sites with at least nine years of data (2005-2013) has revealed no clear patterns at the nine sites, with NO_2 concentrations increasing at some sites and decreasing at others (Figure 8.10). While four of these sites do show small but significant downward trends, one (Inverness) shows a significant upward trend and four show no trends at all. This may indicate that trends in concentrations of this pollutant depend greatly on conditions at the various sites.

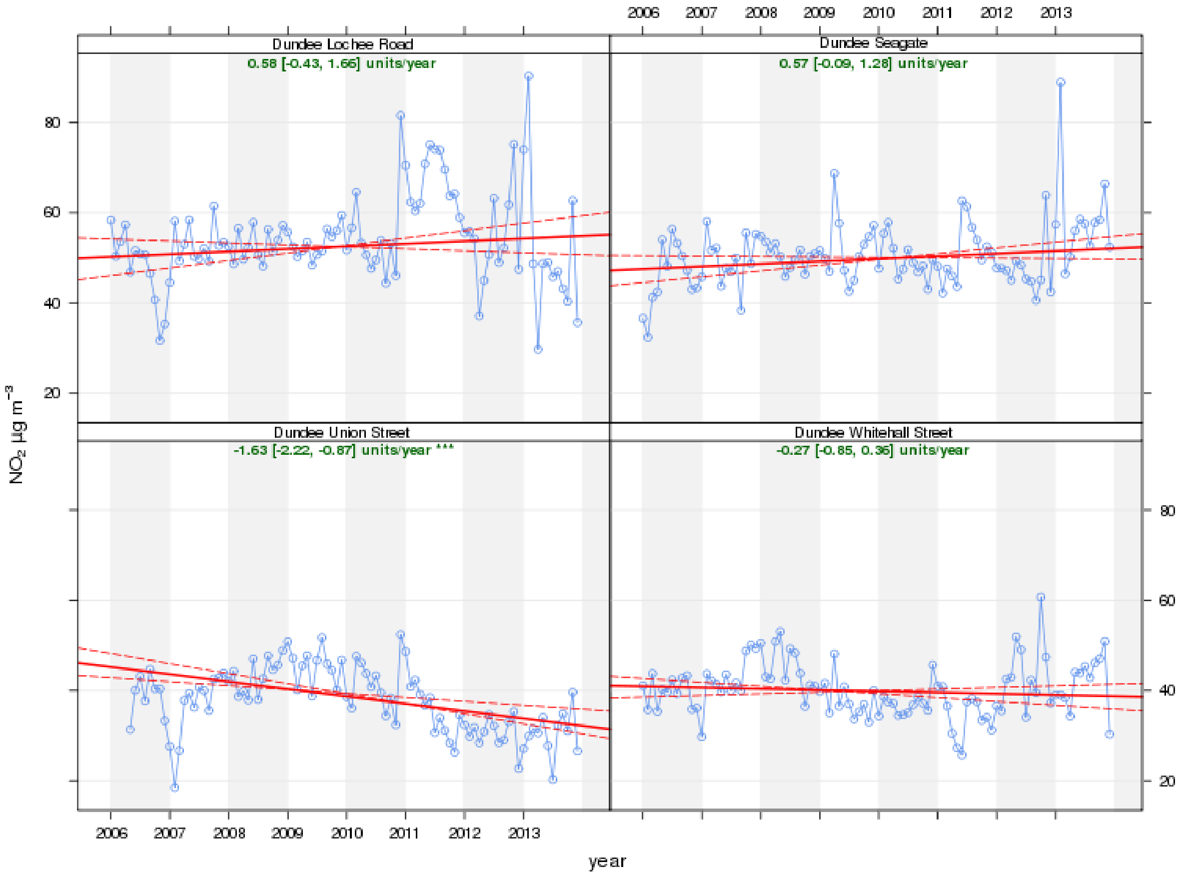
(Also of interest is the difference that the inclusion or exclusion of just one year - 2004 - makes to the trend shown for Glasgow Kerbside - compare Figure 8.9 and Figure 8.10).

Figure 8.10 Trends in NO_2 Concentration at Nine Long-running Urban Traffic sites: 2005 – 2013



There are four traffic-related automatic NO_2 monitoring sites in Dundee, all of which have been in operation since 2006 (Dundee Lochee Road, Dundee Seagate, Dundee Union Street and Dundee Whitehall Street). These are shown in Figure 8.11. Even though all these sites are roadside, and in the same city, they show different trends in NO_2 concentration over the period 2006 to 2013. This also may indicate that trends in concentrations of this pollutant depend greatly on conditions at the various sites.

Figure 8.11 Example: Trends in NO_2 Concentration at Four Urban Traffic sites in Dundee, 2006 – 2013



8.2 Particulate Matter

This pollutant is of great interest because:

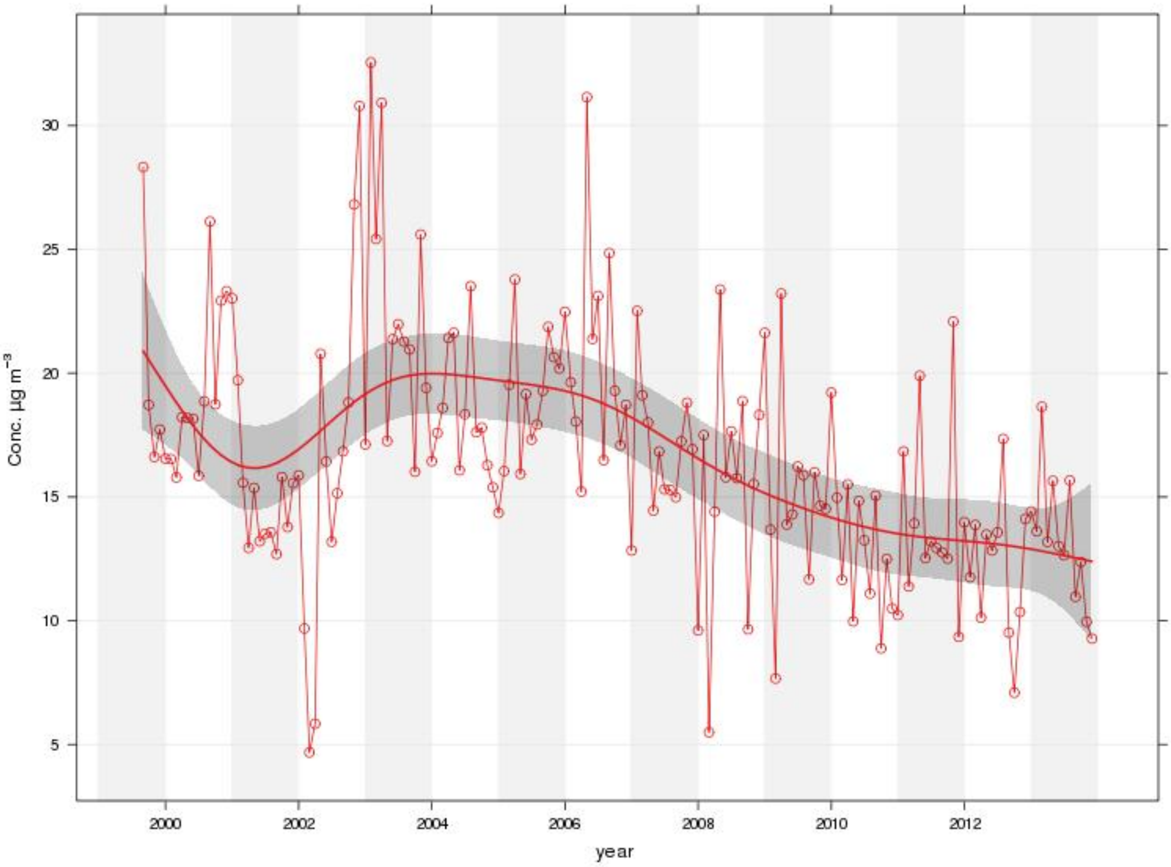
- Scotland has adopted an annual mean PM_{10} objective of 18 µg m^{-3}, which is more stringent than the objective of 40 µg m^{-3} adopted in the rest of the UK.
- Scientists do not believe that there is actually a safe level of this pollutant in terms of human health effects.

Many of Scotland's monitoring sites use the Tapered Element Oscillating Microbalance (TEOM) to monitor PM_{10}. For the reasons discussed in Section 4, it is necessary to correct TEOM data for possible evaporation of the volatile component (due to the high operating temperature of the TEOM, necessary to prevent condensation on the filter). For years up to and including 2008 the conventional way of doing this was to apply a factor of 1.3 to the data, and the data presented here for those years have been adjusted in this way. However, in 2009 a better correction method became available: the King's College Volatile Correction Model (VCM), which can be found at http://www.volatile-correction-model.info/ . This model uses measurements from nearby FDMS-TEOM instruments (which measure both the volatile and non-volatile fraction) to calculate and apply a correction to the daily or hourly dataset. This is now the recommended method, and has been used for the data presented here for years 2009 onwards, from sites where the TEOM is used.

8.2.1 PM_{10} at Urban Background Sites

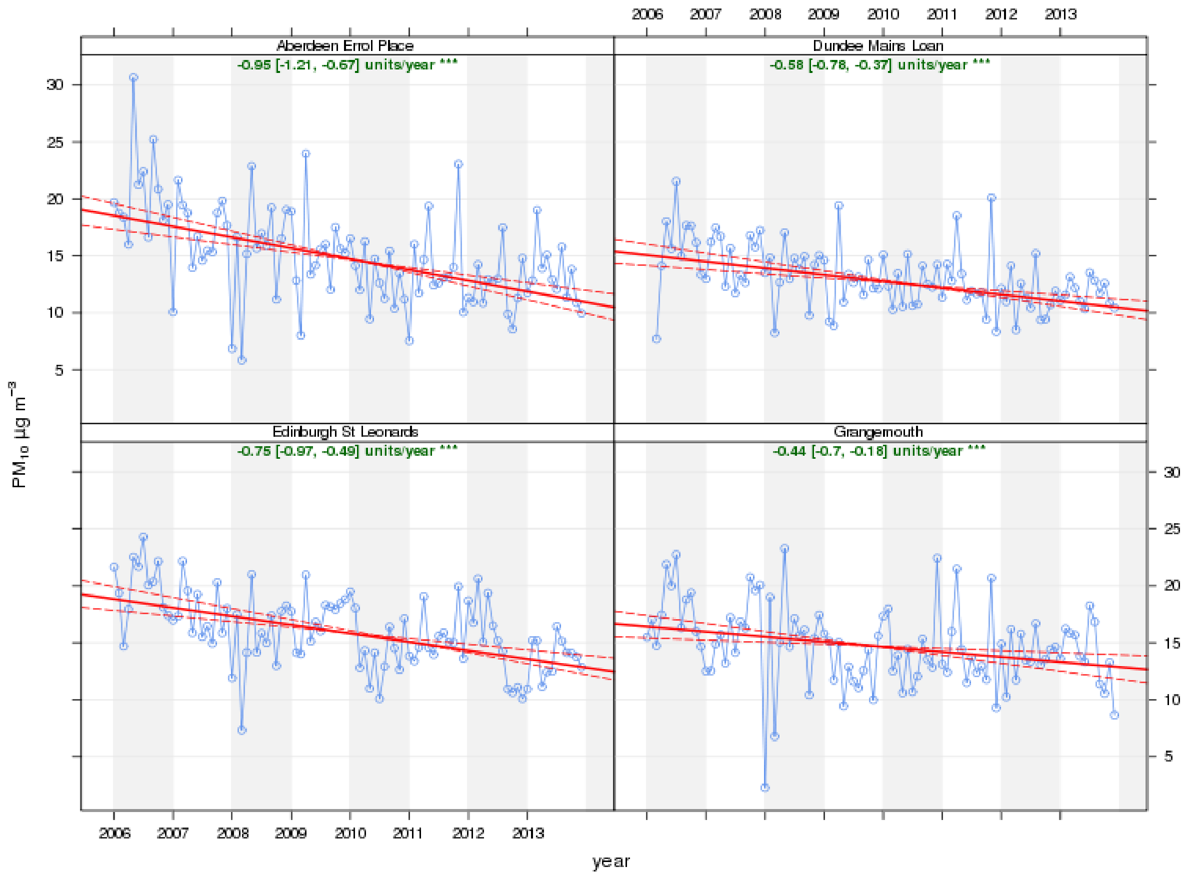
The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place, which has been measuring this parameter since late 1999. A smoothed trend plot of de-seasonalised monthly mean PM_{10} concentrations at this site is shown in Figure 8.12. This shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013.

Figure 8.12 Smoothed Trend Plot of PM_{10} Concentrations at Aberdeen Errol Place, 1999 - 2013



Four urban non-roadside sites in Scotland have been in operation since 2006 or earlier. These are Aberdeen Errol Place (TEOM, converted to FDMS in 2009), Dundee Mains Loan (TEOM, data VCM corrected) Edinburgh St Leonards (FDMS since 2007), and the urban industrial site Grangemouth (FDMS since 2009). Figure 8.13 shows trends in de-seasonalised monthly mean PM_{10} at this subset of long-running sites. All four sites show a negative trend, significant at the 0.001 level (and strongest for Aberdeen Errol Place).

Figure 8.13 Trends in PM_{10} Concentration at Four Long-Running Urban Non-Roadside sites, 2006 – 2013



8.2.2 PM_{10} at Traffic-Related Urban Sites

By far the longest-running traffic-related PM_{10} monitoring site in Scotland is Glasgow Kerbside, which has been monitoring PM_{10} since early 1997. Figure 8.14 shows a smoothed trend plot of de-seasonalised monthly mean PM_{10} at this site. Although concentrations are lower in recent years than in the late 1990s, the decrease has not been consistent.

Trends in de-seasonalised monthly mean PM_{10} concentrations for eight traffic-related sites in operation since 2005 or earlier are shown in Figure 8.15. These are the long-running Aberdeen Anderson Drive, Aberbeen Union Street, East Dunbartonshire Bishopbriggs, Glasgow Anderston, Glasgow Byres Road, Glasgow Kerbside, Perth Atholl Street and Perth High Street. All sites show statistically significant downward trends, significant at the 0.001 level in all but one case, and decreasing by more than 1 µg m^{-3} per year at several of the sites. The trends indicate that PM_{10} is decreasing year on year at these roadside sites.

The average PM_{10} concentration for all traffic-related sites in 2013 was 17 µg m^{-3}: this is within the Scottish AQS Objective of 18 µg m^{-3}. However, not all of the sites met the objective, as discussed in Section 6.

Figure 8.14 Smoothed Trend Plot of PM_{10} at Glasgow Kerbside, 1997 – 2013

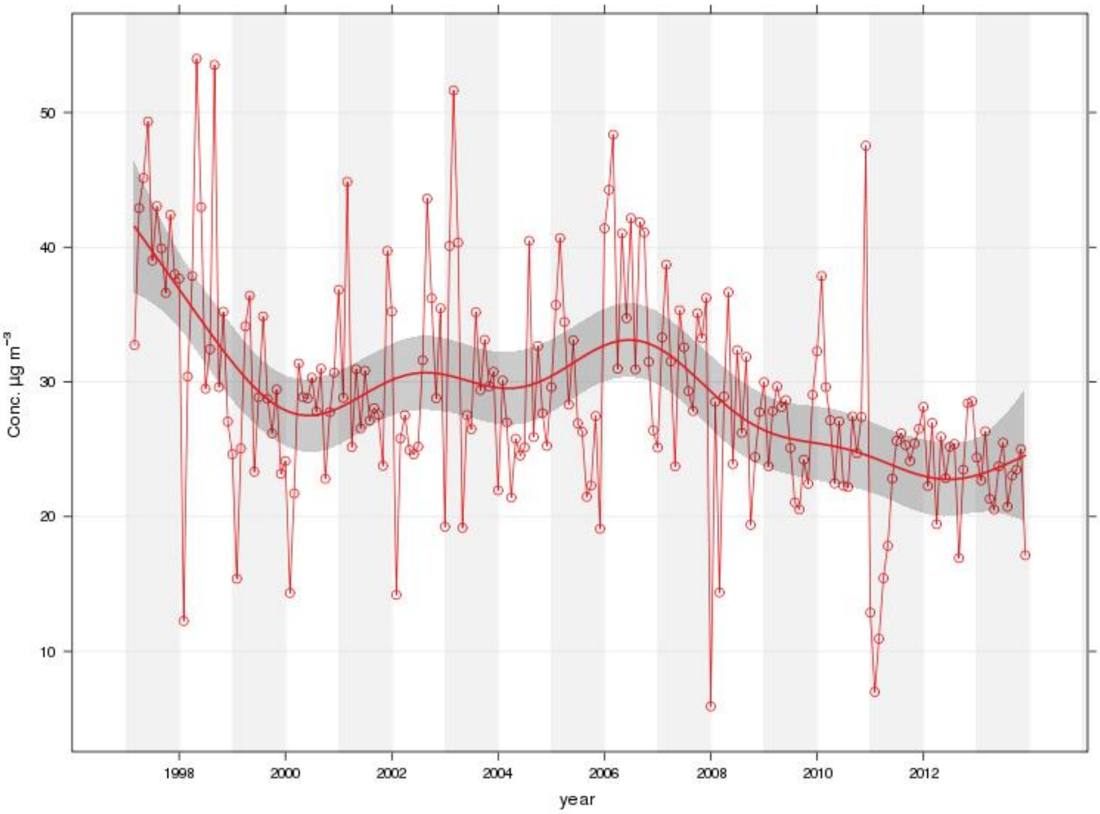
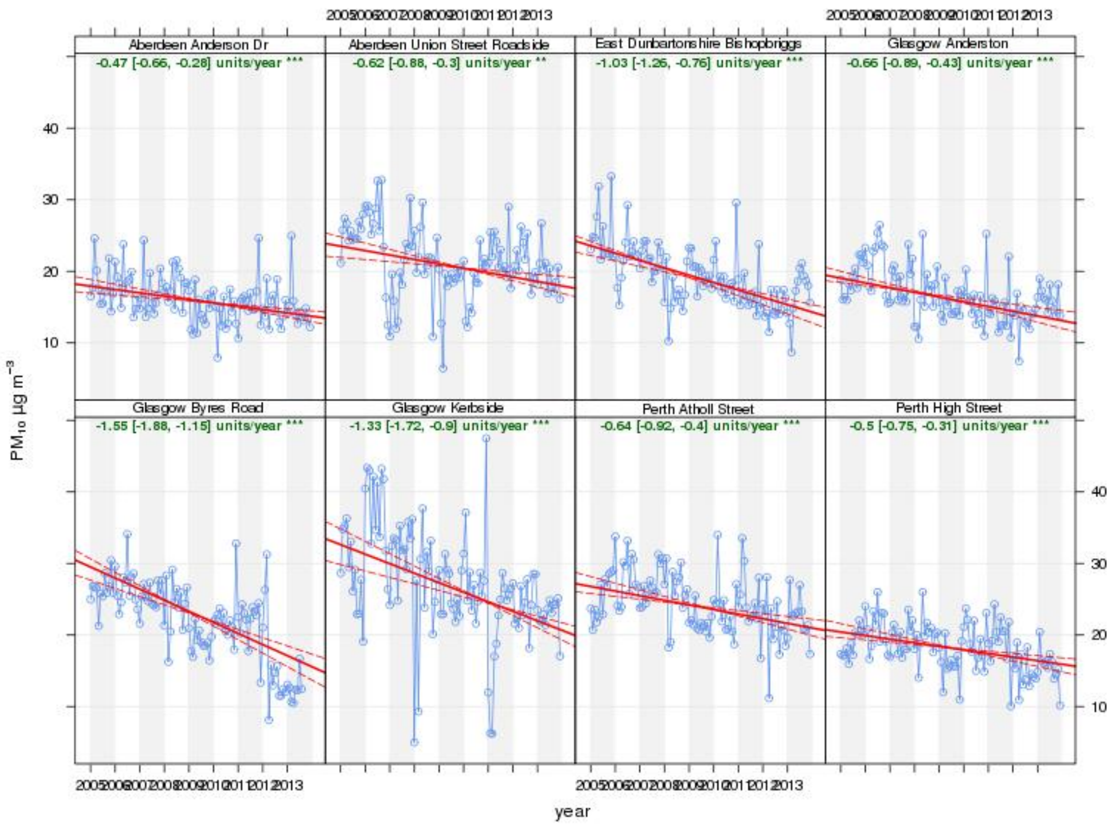


Figure 8.15 Trends in PM_{10} Concentration at Eight Long-Running Urban Traffic Sites, 2005 – 2013



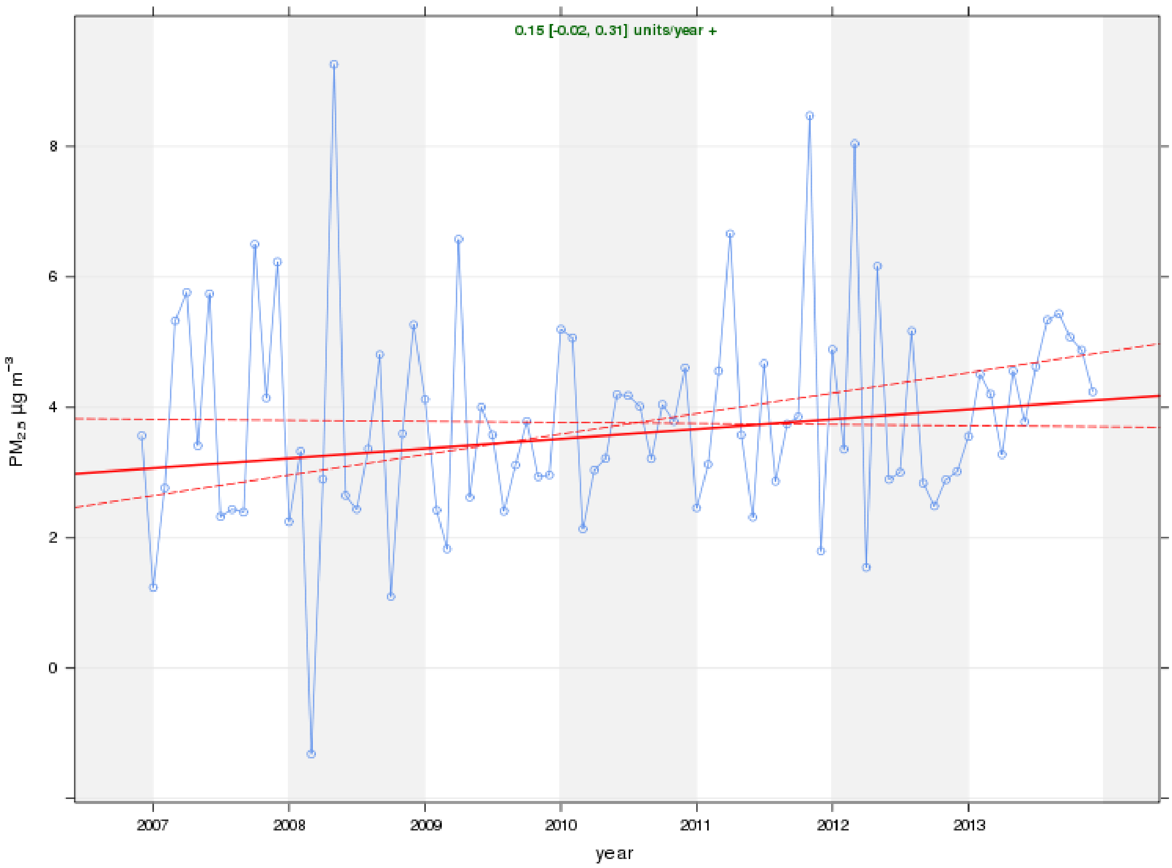
8.2.3 Particulate Matter as $PM_{2.5}$

In earlier years, most monitoring of particulate air pollution has been focussed on the PM_{10} size fraction. However, the finer fractions such as $PM_{2.5}$ are becoming of increasing interest in terms of health effects. Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. They may also carry harmful compounds, absorbed on their surfaces, into the lungs.

There are still relatively few monitoring sites measuring $PM_{2.5}$ compared with the number monitoring PM_{10}. However, 2013 was the first year in which there have been sufficient sites with at least five consecutive years of $PM_{2.5}$ data, for this PM fraction to be included in the discussion of trends.

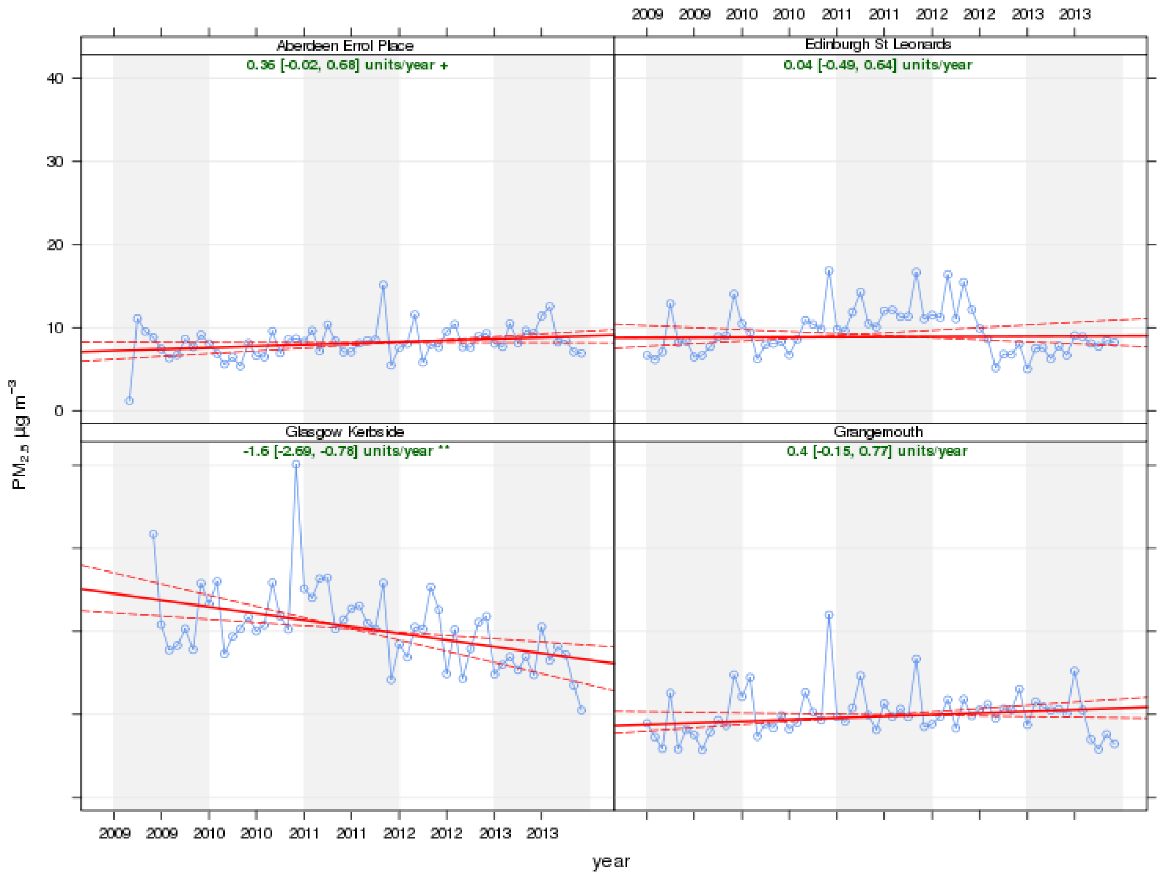
Auchencorth Moss (a rural site in Lothian) has been monitoring $PM_{2.5}$ since 2006 and is thus the longest-running $PM_{2.5}$ monitoring site in Scotland. A trend plot of $PM_{2.5}$ concentration is shown in Figure 8.16. There is a weak upward trend, significant at the 0.1 level: however, overall concentrations are low because of its rural location.

Figure 8.16 Trend Plot of $PM_{2.5}$ Concentration at Auchencorth Moss (rural), 2006 – 2013



There are now four urban sites in Scotland at which $PM_{2.5}$ is monitored using continuous automatic techniques. They all began monitoring this pollutant in late 2008 or early 2009. They are; Aberdeen Errol Place (urban background), Edinburgh St Leonards (urban centre), Glasgow Kerbside (urban traffic) and Grangemouth (urban industrial). Trends in de-seasonalised monthly mean $PM_{2.5}$ concentrations at these four sites (which are all of different types) are shown in Figure 8.17.

Figure 8.17 Trends in $PM_{2.5}$ Concentration at Four Long-Running Urban Monitoring Sites, 2009-2013

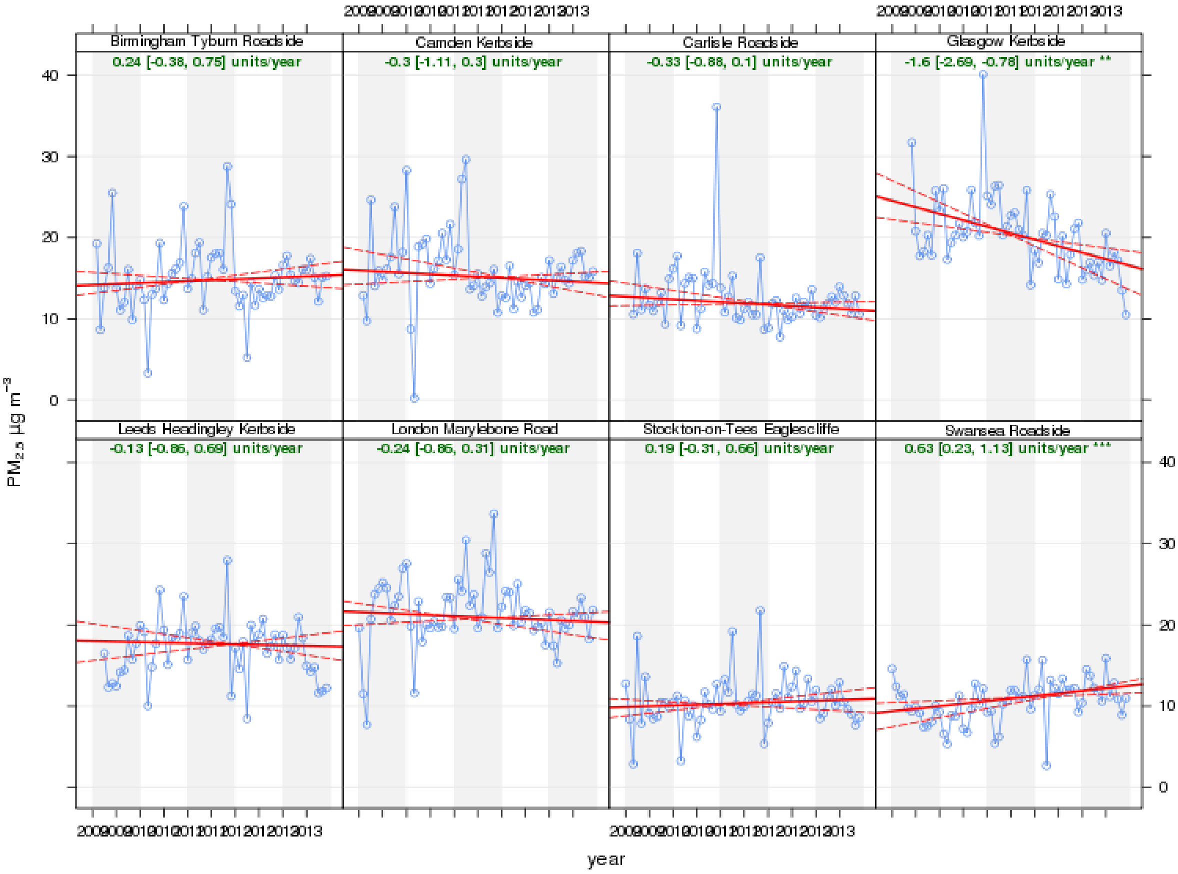


The three non-roadside sites (Aberdeen Errol Place, Edinburgh St Leonards and Grangemouth) show small upward trends over the past five years, although only at Aberdeen Errol Place is the trend statistically significant. This is a similar pattern to the trend at the rural Auchencorth Moss site.

By contrast, Glasgow Kerbside shows a clear overall downward trend (similar in magnitude to that observed for PM_{10}). Although the trend is significant at the 0.01 level, most of the decrease appears to have occurred since the start of 2011.

By comparing the trend at Glasgow Kerbside with that at other similar monitoring sites, it may be possible to tell if the downward trend is typical. Since Glasgow Kerbside is the only site of this classification that currently monitors $PM_{2.5}$ in Scotland, it is necessary to look elsewhere in the UK to find comparable sites. Figure 8.18 compares the $PM_{2.5}$ trend at Glasgow Kerbside with those observed at seven other “urban traffic” air quality monitoring sites in cities in England and Wales. On this basis, it appears that the downward trend at Glasgow Kerbside is not typical. Most of the selected sites do not show a significant upward or downward trend in $PM_{2.5}$ concentration, and there is considerable variation from site to site. This may reflect differing trends in relevant factors influencing $PM_{2.5}$ concentration, such as traffic flow.

Figure 8.18 Comparison of Trends in $PM_{2.5}$ at Urban Traffic sites in Selected UK Cities, 2009-2013

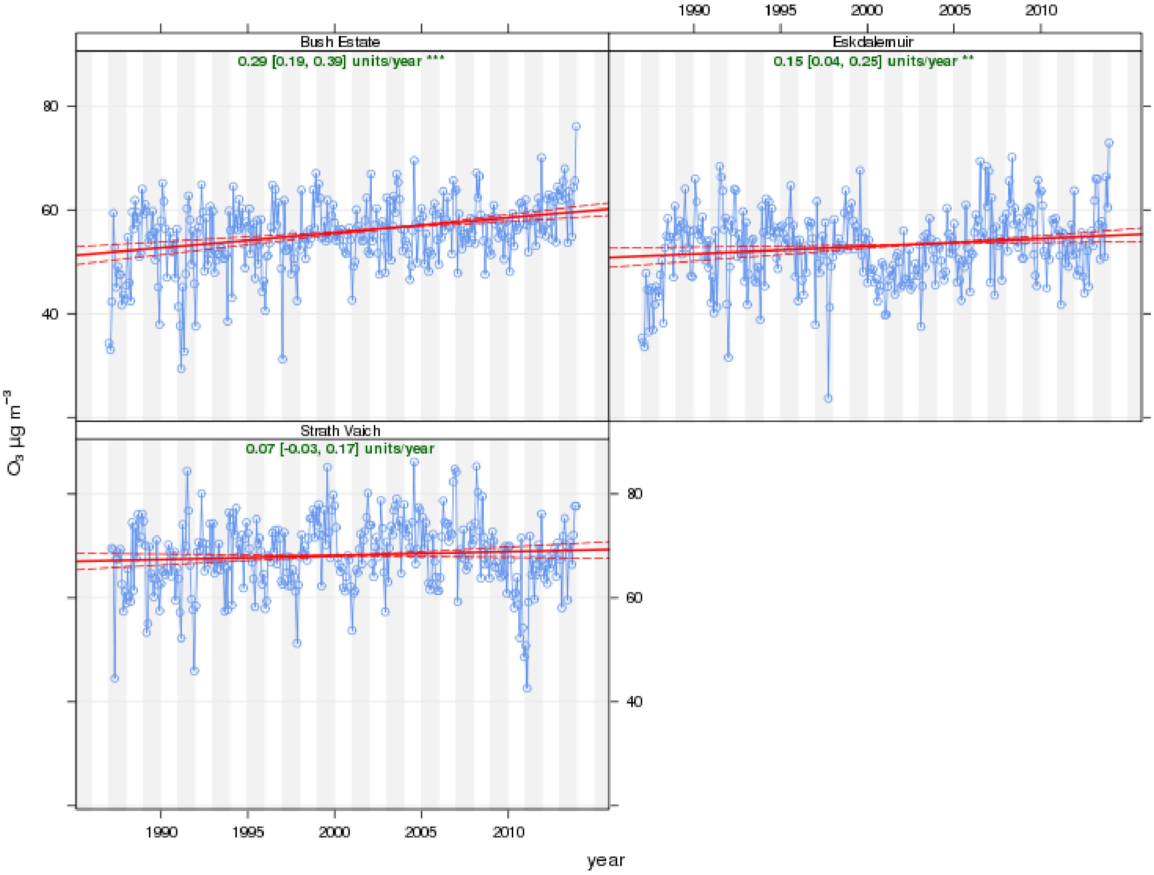


8.3 Ozone

8.3.1 Rural Ozone

Figure 8.19 shows trends in de-seasonalised monthly mean ozone (O_3) concentrations at the three long-running rural monitoring sites in Scotland. These sites have all been in operation since 1987: they are Bush Estate, Eskdalemuir and Strath Vaich. Two of the three sites (Bush Estate and Eskdalemuir) show a small but statistically significant upward trend in monthly mean rural ozone concentrations over the past two decades. The charts also show considerable fluctuation, due to variation in meteorological conditions.

Figure 8.19 Annual Mean O_3 Concentrations at Long-Running Scottish Rural Sites, 1987 – 2013



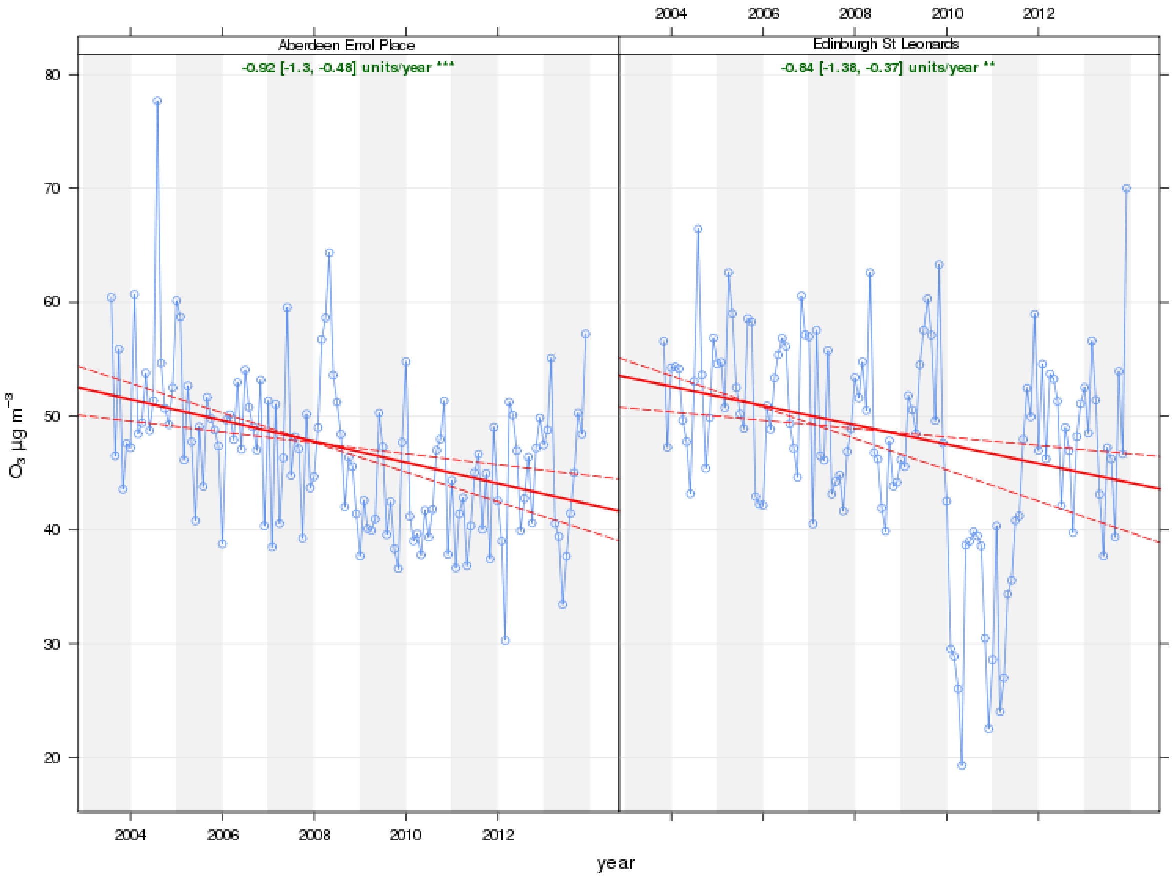
8.3.2 Urban Background Ozone

Figure 8.20 shows trends in de-seasonalised monthly mean ozone concentrations at the two Scottish urban background monitoring sites which currently monitor ozone, and have done so since 2004 or earlier: Edinburgh St Leonards and Aberdeen Errol Place.

Both sites show decreasing trends in ozone concentration in the years since 2003. The trends are statistically significant at both sites.

At Edinburgh St Leonards there is a noticeable dip in measured ozone concentrations throughout 2010 and into 2011. The reason for this is unknown and investigation of these low data has confirmed that the analysers were operating well throughout 2010 – 2011. Since no reason can be found to discard the data, they must be assumed to be genuine.

Figure 8.20 Annual Mean O_3 Concentrations at Long-Running Scottish Urban Background Sites, 2003 – 2013



9 Emissions of Pollutant Species

In this chapter we provide information on emissions of pollutants into the atmosphere in Scotland. The UK National Atmospheric Emissions Inventory (NAEI) calculates total emissions for the UK from a comprehensive range of sources including industry, domestic, transport etc. The UK inventory is now disaggregated into the UK constituent countries[10]. The inventory covers a wide range of pollutants, but in this report we provide information on NO_2 and PM_{10} only. Information on other pollutants can be found at www.naei.org.uk .

Within Scotland, SEPA collate the detailed information on emissions from industrial sources – this includes emissions to water and soil as well as to air – into the Scottish Pollution Release Inventory (SPRI). Full details are available on the SEPA SPRI database:

http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

There is also a link to the SEPA SPRI website on the home page of www.scottishairquality.co.uk . The data from the SPRI form the basis of the industrial emission data for Scotland which are incorporated into the NAEI.

Information provided in Section 9.2 of this report on the main industrial emissions of NOx and PM in Scotland have been compiled from the information presented on SEPA's Scottish Pollution Release Inventory, with permission from SEPA.

9.1 NAEI data for Scotland

The National Atmospheric Emissions Inventory (NAEI) data for Scotland are reported using the Nomenclature for Reporting (NFR) format. The Nomenclature for Reporting is a reporting structure that was introduced in 2001 and is used for submitting data to international organisations such as the United Nations Economic Commission for Europe (UNECE) and the European Monitoring and Evaluation Programme *(*EMEP).

9.1.1 Scotland NO_X Inventory by NFR Sector, 1990-2011

Table 9.1 and Figure 9.1 provide a summary of the NO_X emissions in Scotland by broad NFR sector categories. The detailed data are available in the report and website cited in the introduction to this Chapter.

[10] Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2010 http://naei.defra.gov.uk/reports/reports?report_id=709

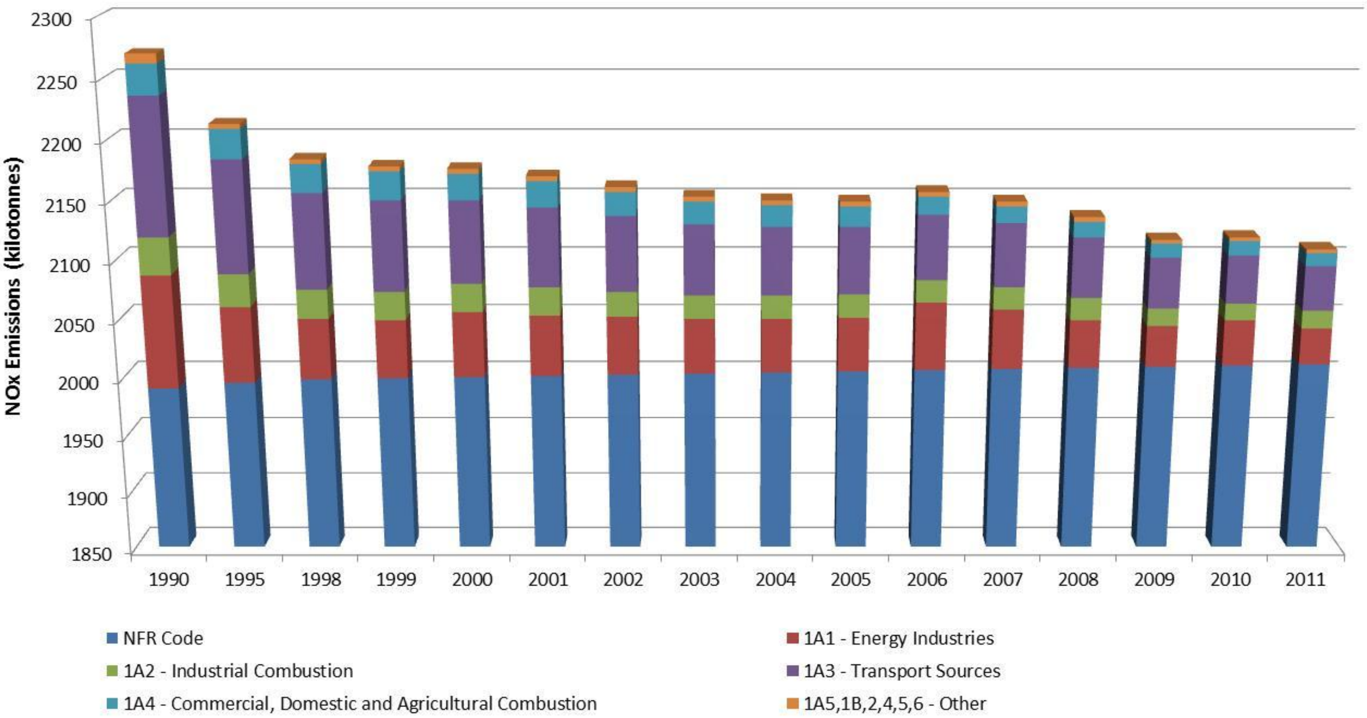
Table 9.1 Scotland emissions of NO_X by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003
1A1 - Energy Industries	97	65	52	50	56	52	50	47
1A2 - Industrial Combustion	32	28	25	24	24	24	21	20
1A3 - Transport Sources	117	96	81	77	70	67	64	60
1A4 - Commercial, Domestic and Agricultural Combustion	26	25	24	24	22	22	20	19
1A5,1B,2,4,5,6 - Other	8	4	4	4	4	4	4	4
Total:	**280**	**218**	**186**	**178**	**177**	**169**	**159**	**150**

NFR Code	2004	2005	2006	2007	2008	2009	2010	2011	2011(%)
1A1 - Energy Industries	46	46	58	51	41	35	39	31	32%
1A2 - Industrial Combustion	20	20	19	19	19	15	14	15	15%
1A3 - Transport Sources	58	57	55	54	51	43	41	38	39%
1A4 - Commercial, Domestic and Agricultural Combustion	18	17	15	14	13	12	12	11	11%
1A5,1B,2,4,5,6 - Other	4	4	4	4	4	3	3	3	3%
Total:	**146**	**144**	**152**	**142**	**127**	**108**	**110**	**98**	**100%**

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2011

Figure 9.1 Time series of Scotland NO_x emissions 1990-2011



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2011

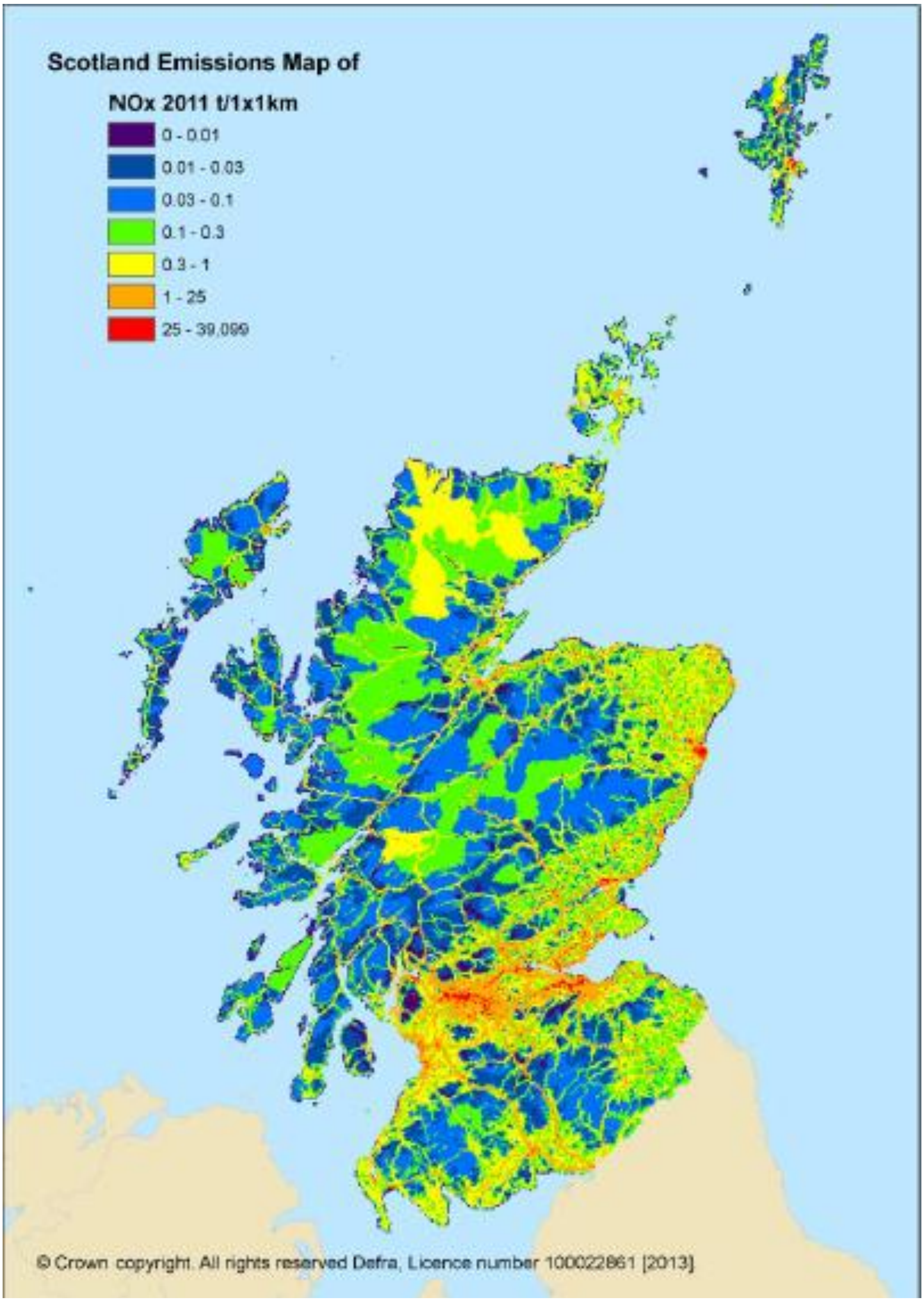
Scotland's NO_x emissions have declined by 65% since 1990 and currently account for 10% of the UK total. Power generation (1A1a) is a very significant source of NO_x emissions, accounting for 25% of the Scotland total in 2011; although emissions from this source have reduced by 71% since 1990. *(Note that in the table and figure above, the sector 1A1 includes power generation, petroleum refining and other energy industries such as collieries and gas processing).*

Recent trends in electricity generation have dominated the overall trends the inventory. In Scotland, coal-fired generation increased to a peak in 2006, this decreased by 56% up to 2011. Over the same period, NOx emissions from gas-fired power stations have declined by 34%, reflecting a decline in gas-fired electricity generation since 2006.

A further 29% of NO_x emissions in Scotland arise from road transport sources (1A3bi-iv: down by 73% since 1990), 13% stem from industrial combustion (1A2: down 51% since 1990) and 5% is from agricultural mobile machinery (1A4cii, down 65% since 1990). Increases in emissions are apparent mostly in relatively minor source sectors such as domestic and international aviation landing and takeoff (LTO) (1A3ai(i): up by 141% since 1990). Emissions from rail have also increased by 145% since 1990, now contributing 3% to the total emissions in Scotland. This is due to increases in fuel oil consumption by the rail sector from 1990 due to rise in passenger train km and freight train km during this time.

Figure 9.2 shows a map of Scotland's NO_X emissions.

Figure 9.2 Map of NO_X Emissions in Scotland, 2011



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2011

9.1.2 Scotland PM_{10} Inventory by NFR Sector, 1990-2011

The table and graph below give a summary of the PM_{10} emissions in Scotland by broad NFR sector categories. The detailed data are available in report and website cited in the introduction to this Chapter.

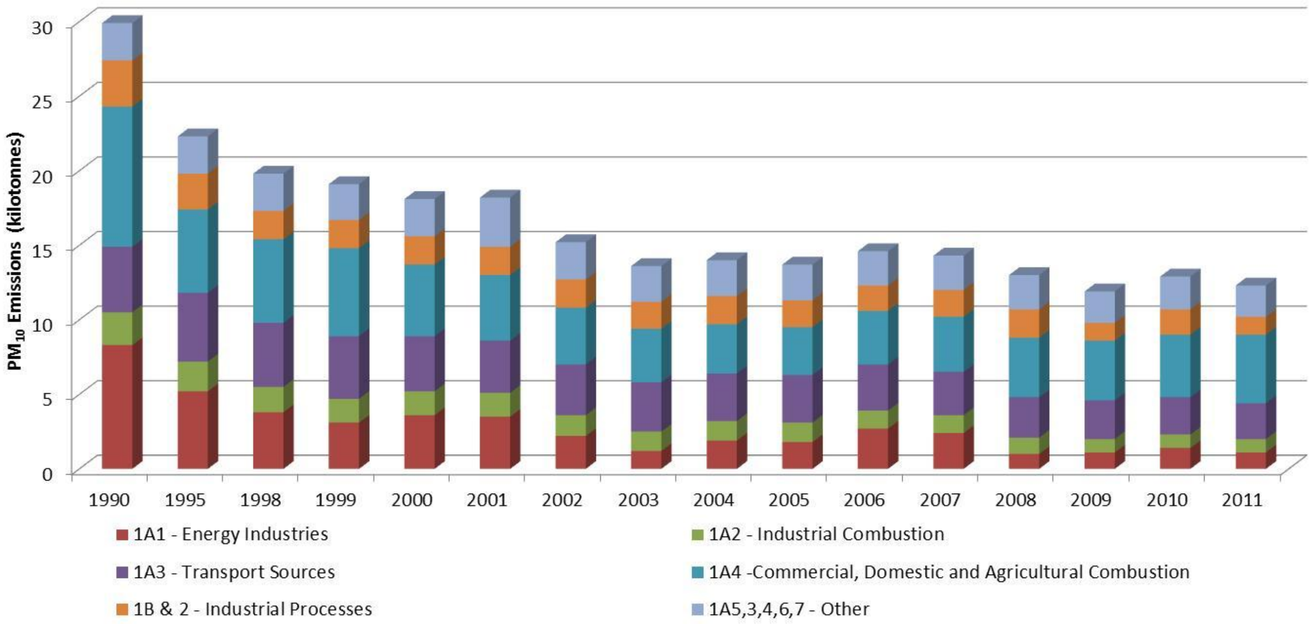
Table 9.2 Scotland's emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003
1A1 - Energy Industries	8.3	5.2	3.8	3.1	3.6	3.5	2.2	1.2
1A2 - Industrial Combustion	2.2	2.0	1.7	1.6	1.6	1.6	1.4	1.3
1A3 - Transport Sources	4.4	4.6	4.3	4.2	3.7	3.5	3.4	3.3
1A4 -Commercial, Domestic and Agricultural Combustion	9.4	5.6	5.6	5.9	4.8	4.4	3.8	3.6
1B & 2 - Industrial Processes	3.1	2.4	1.9	1.9	1.9	1.9	1.9	1.8
1A5,3,4,6,7 - Other	2.5	2.5	2.5	2.4	2.5	3.3	2.5	2.4
Total:	**29.9**	**22.2**	**19.8**	**19.0**	**18.0**	**18.2**	**15.2**	**13.6**

NFR Code	2004	2005	2006	2007	2008	2009	2010	2011	2011 (%)
1A1 - Energy Industries	1.9	1.8	2.7	2.4	1.0	1.1	1.4	1.1	11%
1A2 - Industrial Combustion	1.3	1.3	1.2	1.2	1.1	0.9	0.9	0.9	7%
1A3 - Transport Sources	3.2	3.2	3.1	2.9	2.7	2.6	2.5	2.4	19%
1A4 -Commercial, Domestic and Agricultural Combustion	3.3	3.2	3.6	3.7	4.0	4.0	4.2	4.6	33%
1B & 2 - Industrial Processes	1.9	1.8	1.7	1.8	1.9	1.2	1.7	1.2	13%
1A5,3,4,6,7 - Other	2.4	2.4	2.3	2.3	2.3	2.1	2.2	2.1	17%
Total:	**14.0**	**13.6**	**14.5**	**14.2**	**13.0**	**11.9**	**12.9**	**12.3**	**100%**

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2010

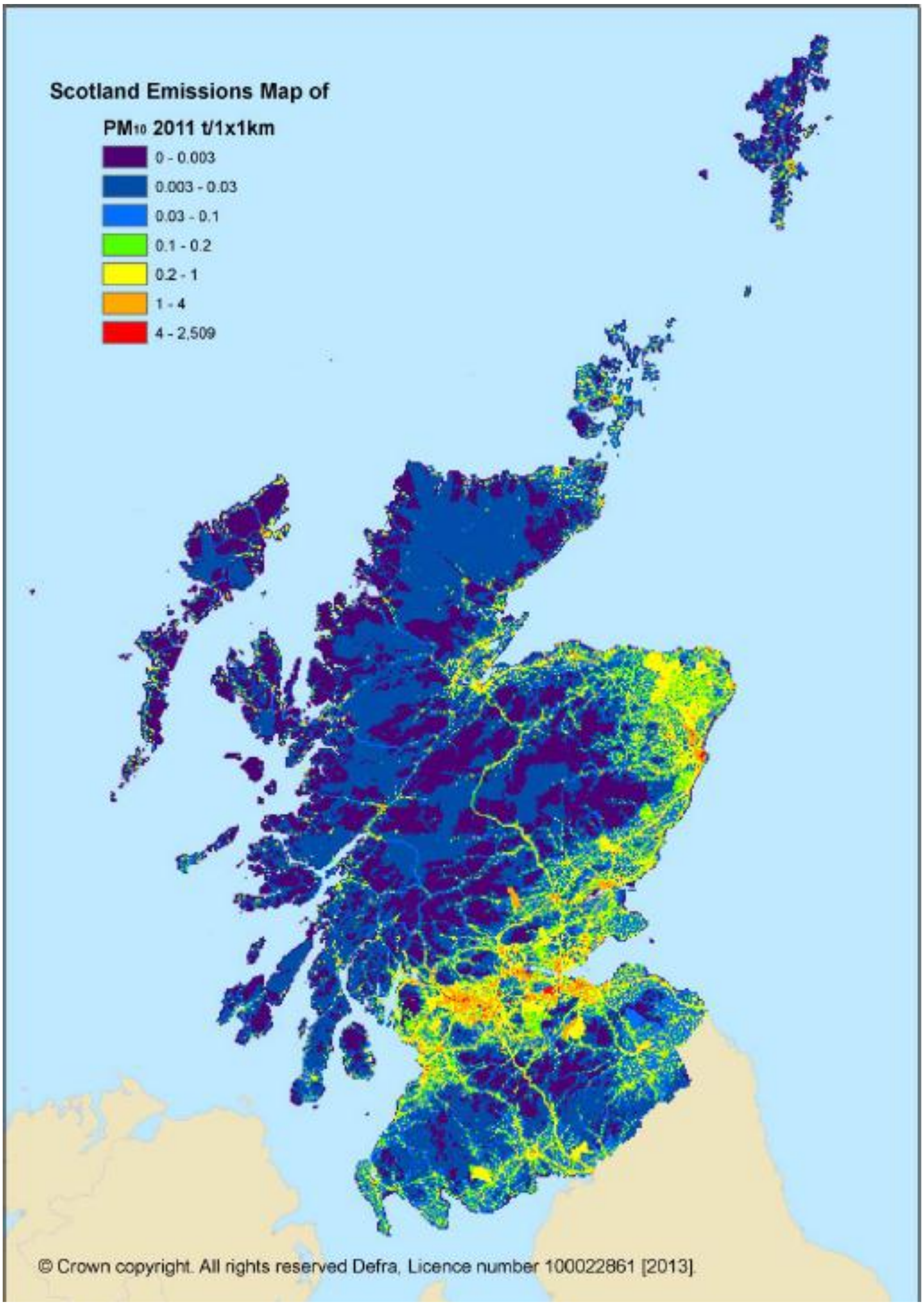
Figure 9.3 Time series of Scotland's PM_{10} emissions 1990-2011



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2010

Scotland's PM_{10} emissions have declined by 58% since 1990 and account for 11% of the UK total. 17% of PM_{10} emissions in Scotland come from transport (1A3) sources (down by 32% since 1990), whilst 38% stem from commercial, domestic and agricultural combustion (down by 52% since 1990, mostly due to a decline in coal and solid fuels). Emissions from power generation (1A1a) were 25% of the Scotland total emission in 1990, but have been reduced to 8% of the Scotland total in 2011. Figure 9.4 shows a map of Scotland's emissions.

Figure 9.4 Map of PM_{10} Emissions in Scotland, 2011



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2011

9.2 SEPA SPRI data for Scotland (Releases to Air)

Data from SEPA-regulated processes in Scotland are available on the SPRI website (http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx. The sections below provide information on the largest industrial sources of NO_x and PM_{10}. Note, however, that these releases generally arise from tall chimneys and are well dispersed before reaching ground level. In towns and cities, more local emissions at low-level from, for example, vehicles may be much more significant in relation to the contribution to ambient pollution concentrations.

9.2.1 Industrial sources of NOx in Scotland

The majority of Scotland's industrial NOx emissions are generated in east central Scotland, where the largest emitters of NOx are the Longannet and Cockenzie power stations near Edinburgh. The annual mass emissions from the 10 largest industrial sources of NOx in Scotland (based on 2012 SPRI data) are presented below in Table 9.3.

(Note that in Table 9.3 the annual mass emissions for previous years have been filled in where data is available, some sites may have existed prior to the years where data is provided under a different name or industry)

Table 9.3 Largest industrial sources of NO_x emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012
Scottish Power Generation Ltd. Longannet PS Kincardine Alloa Clackmannan	23,500	19,400	19,087	22,731	14,876	14,086	15,170	15,246	16,345	16,632
Scottish Power Plc. Cockenzie PS Prestonpans East Lothian	10,700	12,100	11,400	20,294	22,054	13,016	8,575	10,718	2,466	4,183
INEOS Manufacturing Scotland Limited. Petroineos Manufacturing Scotland Ltd	-	-	-	4,577	6,296	4,102	3,567	3,572	2,015	2,180
SSE Generation Limited. SSE Generation Lerwick P/Station Shetland	2,650	3,060	1,946	1,644	1,676	1,767	1,658	1,832	1,644	1,612
SSE Generation Limited. SSE Gen Peterhead Power Station Peterhead	1,990	1,980	2,130	2,750	2,110	2,110	1,400	981	1,170	505
ExxonMobil Chemical Limited. Fife Ethylene Plant MossmorranCowdenbeath	1,500	1,840	1,594	1,651	798	864	809	1,060	1,025	1,038
INEOS Manufacturing Scotland Limited. INEOS Infrastructure (Grangemouth) Ltd	-	-	-	-	-	-	-	-	717	707
Ardagh Glass Limited. Ardagh Glass Portland Place Irvine	962	638	475	742	994	928	995	978	716	582
INEOS Chemicals Grangemouth Limited. INEOS Chemicals Grangemouth Ltd	-	-	-	-	-	-	-	-	691	676
Lafarge Cement UK Limited. Lafarge Tarmac Ltd Dunbar Wks E.Lothian	1,110	1,695	1,270	1,221	1,459	1,434	724	623	671	640

9.2.2 Industrial sources of PM_{10} in Scotland

The majority of the PM_{10} emitted from industrial processes in Scotland are generated in east central Scotland, with the largest contributions coming from the power generation sector. However, SEPA have previously stated that there is no evidence to show that these sources are having a detrimental impact on local air quality. Table 9.4 lists the annual mass emissions from the 10 largest industrial sources of PM_{10} in Scotland on the basis of SPRI data for 2012.

(Note that as with Table 9.3 in Table 9.4 the annual mass emissions for previous years have been filled in where data is available, some sites may have existed prior to the years where data is provided under a different name or industry)

Table 9.4 Largest industrial sources of PM_{10} emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012
Scottish Power Generation Ltd. Longannet PS Kincardine Alloa Clackmannan	1,140	700	662	943	555	313	459	587	590	476
Aggregate Industries UK Limited. Glensanda Quarry Operations Morvern Argyll	-	-	-	-	-	-	-	180	186	171
Scottish Power Plc. Cockenzie PS Prestonpans East Lothian	637	738	697	1,258	1,324	331	258	450	155	294
The Cheese Company Limited. Arla Foods Lockerbie Creamery	-	-	-	95	98	82	48	69	83	77
INEOS Manufacturing Scotland Limited. Petroineos Manufacturing Scotland Ltd	-	-	-	354	345	100	104	108	77	80
The Caledonian Cheese Company Ltd. The Creamery Commerce Rd Stranraer Wigtown	-	-	-	-	74	105	103	72	76	67
INEOS Chemicals Grangemouth Limited. INEOS Chemicals Grangemouth Ltd	-	-	-	-	-	-	-	-	75	90
SSE Generation Limited. SSE Generation Lerwick P/Station Shetland	-	50	25	21	23	31	30	66	50	37
SSE Generation Limited. SSE Gen Peterhead Power Station Peterhead	-	20	67	64	68	79	50	38	38	22
Alcan Aluminium UK Limited. Alcan SmeltingLochaber SmelterFort William	-	35	35	35	32	35	30	30	36	54

10 Conclusions

On the 26th March 2014, Ricardo-AEA on behalf of the Scottish Government launched the new Air Quality in Scotland website and is continuing the development and enhancement of the associated Scottish Air Quality Database. The website and database are available at: www.scottishairquality.co.uk.

Website Developments During 2013

The new Air Quality in Scotland website was launched on 26th March 2014 at the annual Air Quality Seminar and provides users with a modern redesigned website for air pollution information and measurements. As part of the website redesign a number of enhancements were made.

The new Air Quality in Scotland twitter account (@scotairquality) provides a new way to keep informed about air pollution in Scotland. Automated rules tweet the latest air quality measurement summaries a maximum of three times per day on weekdays (9am, 1pm and 5pm) and two times per day on weekends and bank holidays (10am, 4pm).

A new YouTube account was launched for Air Quality in Scotland providing a platform for related videos and a way to embed these into the main website. The YouTube account currently hosts the videos for the Local Site Operator manual, although more public focussed videos are planned such as a 'how-to guide' on using the Openair statistical analysis tools.

Clear the Air is a new sub-site to complement the existing Air Pollution Detectives and is aimed at secondary school pupils.

An upward trend in unique visitors and pages viewed between 2007 and 2014 has been seen with the number of visitors per month during Jan-14 to Apr-14 varying between around 4,700 and 5,700. Whilst the reasons for the distinct trends in activity are not clear, the increased interest in the website during 2013/14 corresponds to an increase in media attention to air quality in general, in addition to the annual cycle of local authority review and assessment activity.

Automatic Monitoring Data 2013

Air pollution data for 91 automatic monitoring sites throughout Scotland are available in the database for all or part of 2013. All automatic data within the Scottish database are subject to the same QA/QC procedures as at the national network air quality monitoring stations within the UK Automatic Urban and Rural Network. This ensures that all data in the database are quality assured and traceable to UK national calibration standards for the various pollutants.

A summary of ratified data for 2013 is provided. Where exceedances of the Scottish Air Quality Objectives occur then these are in areas where the relevant local authority has already declared, or is in the process of declaring, an Air Quality Management Area. At present, 14 local authorities in Scotland have declared a total of 34 AQMAs. Where AQMAs are declared then the local authority will produce an Air Quality Action Plan and undertake the necessary actions to move towards compliance with the Air Quality Objectives in the future. We have also provided, in this report, a summary of data for a much wider range of pollutant species which are currently monitored within Scotland.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) data were collected from 80 sites utilising automatic monitoring in 2013, although data for 10 of these are only available for part of the year and at these sites the overall data capture is less than 75%. These include sites which opened or closed during the year, sites which were closed for part of the year due to roadworks etc and sites with instrument problems.

Of the remaining 70 sites with more than 75% data capture, 14 of these (kerbside or roadside sites) exceeded the AQS Objective for the NO_2 annual mean (40 µg m^{-3}). At 4 sites, the AQS Objective of not more than 18 exceedances of 200 µg m^{-3} for the hourly mean was also exceeded, including Glasgow Anderston; an urban background site. The exceedance measured at this site is likely due to still meteorological conditions experienced during late November 2013 resulting in a build-up of NO_2 concentrations close to the M8 motorway.

One site with less that 75% data capture exceeded the NO_2 annual average objective; Edinburgh Queensferry Road with a data capture rate of 74%. In addition, Paisley Gordon Street exceeded the NO_2 hourly average objective with a data capture rate of 52%.

The highest annual average concentrations were measured at Glasgow Kerbside, with a measured concentration of 65 µg m^{-3}. The greatest number of exceedances of the hourly mean objective was measured at Paisley Central Road with 214 exceedances

Particulate Matter

Gravimetric equivalent particulate matter (PM_{10}) data were collected from 78 sites utilising automatic monitoring and the Partisol daily sampler. Of these sites, 19 had less than 75% data capture during 2013.

Of the 59 sites with 75% or greater data capture, 15 sites exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3} and a further 2 equaled this Objective. Of these sites 2 also exceeded the Daily Objective of 50 µg m^{-3} not to be exceeded more than 7 times in a year.

The maximum PM_{10} annual mean concentration was measured at Aberdeen Market St 2 with a measured annual mean concentration of 35 µg m^{-3} and 58 exceedances of the daily objective.

Of the 19 sites with less than 75% data capture, North Ayrshire Irvine High St and South Lanarkshire Raith Interchange exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3}.

No site exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10} with the daily objective of 35 exceedences of 50 µg m^{-3} being exceeded at Aberdeen Market St 2.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for PM_{10} (and $PM_{2.5}$). The results for both sites are shown in Table 6.1.2 under the site names of Auchencorth Moss (for measurements using Partisol samplers) and Auchencorth Moss PM_{10} $PM_{2.5}$ (for measurements using FDMS analysers). Both methods measured similar annual average PM_{10} concentrations of 7 µg m^{-3} and 8 µg m^{-3}. No exceedances of the daily objective were measured at the two sites.

Data capture rates of less than 75% were measured at Auchencorth Moss PM10 PM25, Glasgow Townhead and Grangemouth; Glasgow Townhead was commissioned in October 2013. The Scottish AQS Objective of 12 µg m^{-3} as an annual mean was exceeded at Glasgow Kerbside with a data capture rate of 80%.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for $PM_{2.5}$. Both the Partisol sampler and FDMS analyser measured annual average $PM_{2.5}$ concentrations of 4 µg m^{-3} during 2013.

Carbon Monoxide

Carbon monoxide (CO) was monitored using automatic techniques at 4 sites during 2013. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

Sulphur Dioxide

Sulphur dioxide (SO_2) was monitored using automatic techniques at 12 sites for 2013. Midlothian Pathhead was decommissioned on 25/01/2013 and so data are only available for part of the year. All sites in Scotland met the Air Quality Strategy objectives for the number of exceedances of 15 minute, 1-hour and 24-hour mean SO_2 concentrations in 2013.

Ozone

Ozone (O_3) was monitored at 11 sites utilising automatic monitoring during 2012. Ozone (O_3) is a secondary pollutant formed by reactions involving other pollutant gases in the presence of sunlight and over several hours; it may persist for several days and be transported over long distances. This means that local authorities have little control over ozone levels in their area. In 2013, the air quality objective of not more than 10 days with a maximum 8 hr running mean greater than 100 $\mu g\ m^{-3}$ was exceeded at Bush Estate, Eskdalemuir and Strath Vaich. No sites with a data capture rate of less than 75% exceeded the air quality Objective.

Air Quality Mapping

For the fifth year in a row, Scotland-specific monitoring data have been used to produce pollution climate maps for both nitrogen dioxide (NO_2) and particulate matter (PM_{10}) for both background and roadside locations. In addition, source apportionment and annual projection factors, based on Scottish data, will be produced to accompany these maps.

The projected annual mean background NO_2 concentrations for 2015, 2020, 2025 and 2030 predict a progressive decrease in the background annual mean NO_2 concentration between 2011 and 2030; by 2030 it is predicted that, away from roadsides or other specific sources, annual mean NO_2 concentrations greater than 20 $\mu g\ m^{-3}$ will only be found in the central areas of Scotland's major cities. This is due to the predicted reduction in primary NO_X and oxidant emissions, which contribute to the formation of NO_2. However, the accuracy of the forward projection maps presented here is closely dependent on the future emission projections used to prepare the background pollutant maps.

The projected annual mean PM_{10} concentration for 2015, 2020, 2025 and 2030 show that background concentrations of PM_{10} are predicted to decrease up to 2030. This is expected because of a predicted reduction in both primary PM_{10} emissions and secondary PM_{10} formation, over the next two decades.

Higher PM_{10} concentrations (10-14 $\mu g\ m^{-3}$) are predicted to persist along the eastern coast of Scotland. This is believed to be due to the increase in the annual mean background PM_{10} concentrations due to contributions from wind-blown soil dusts. However, again the accuracy of the forward projection maps presented here is closely dependent on the future emission projections used to prepare the background pollutant maps.

Air Quality Trends

Data held within the database covering many years have been used to assess possible trends in air pollution throughout Scotland. Prior to the 2011 report, this has been based on the composite dataset from all sites in the database. However, the addition of new sites to the database in recent years potentially complicates this approach, as the changes in site numbers and site distribution may influence the apparent trends in pollutant concentration. Therefore, for the 2010 and subsequent reports, a different approach was proposed and adopted. The new air quality trends have been examined on the basis of individual monitoring sites, and subsets of long-running sites, rather than the composite data set. For this report smoothed trend and Theil-Sen analysis has been used; utilising the Openair data analysis tool to quantify pollutant trends at individual sites.

In terms of concentrations of NO_x from urban non-roadside sites, three urban non-roadside sites have been monitoring NOx for at least ten years (i.e. since 2004 or earlier); Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth (the latter is an urban industrial site). All three sites show a slight negative trend (i.e. decreasing NO_x). The trend is statistically significant at Aberdeen Errol Place and Edinburgh St Leonards. It is most significant (at the 0.001 level) at Aberdeen Errol Place. However, the actual decrease year-on-year is small.

For a subset of five long-running sites (Dumfries, East Dunbartonshire Bishopbriggs, Glasgow Kerbside, Inverness and Perth High Street), three show a downward trend in NO_x (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street). However, Glasgow Kerbside shows no trend, and Inverness shows a slight upward trend.

In the case of NO_2, trends are also very variable between sites, with the same three sites (Dumfries, East Dunbartonshire Bishopbriggs and Perth High Street) showing highly statistically significant downward trends, and two (Glasgow Kerbside and Inverness) showing small but statistically significant upward trends. Further investigation of trends in NO_2 concentration at traffic-related monitoring sites with at least nine years of data (2005-2013) has revealed no clear patterns, with NO_2 concentrations increasing at some sites and decreasing at others.

The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place, which has been measuring this parameter since late 1999. A smoothed trend plot of de-seasonalised monthly mean PM_{10} concentrations at this shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013.

Four urban non-roadside sites in Scotland have been in operation since 2006 or earlier. These are Aberdeen Errol Place (TEOM, converted to FDMS in 2009), Dundee Mains Loan (TEOM, data VCM corrected) Edinburgh St Leonards (FDMS since 2007), and the urban industrial site Grangemouth (FDMS since 2009). All four sites show a negative trend.

Long-running Aberdeen Anderson Drive, Aberbeen Union Street, East Dunbartonshire Bishopbriggs, Glasgow Anderston, Glasgow Byres Road, Glasgow Kerbside, Perth Atholl Street and Perth High Street all show statistically significant downward trends in PM_{10} concentrations.

Three non-roadside sites (Aberdeen Errol Place, Edinburgh St Leonards and Grangemouth) show small upward trends in $PM_{2.5}$ concentrations over the past five years, although only at Aberdeen Errol Place is the trend statistically significant. In contrast, Glasgow Kerbside shows a clear overall downward trend.

Two rural sites (Bush Estate and Eskdalemuir) show a small but statistically significant upward trend in monthly mean ozone concentrations over the past two decades. Edinburgh St Leonards and Aberdeen Errol Place show decreasing trends in ozone concentration in the years since 2003.

Emissions of Pollutants

Scotland's NO_x emissions have declined by 65% since 1990 and currently account for 10% of the UK total. Power generation is a very significant source of NO_x emissions, accounting for 25% of the Scotland total in 2011; although emissions from this source have reduced by 71% since 1990.

Scotland's PM_{10} emissions have declined by 58% since 1990 and account for 11% of the UK total. 17% of PM_{10} emissions in Scotland come from transport sources (down by 32% since 1990), whilst 38% stem from commercial, domestic and agricultural combustion (down by 52% since 1990, mostly due to a decline in coal and solid fuels). Emissions from power generation were 25% of the Scotland total emission in 1990, but have been reduced to 8% of the Scotland total in 2011.

Appendices

Appendix 1: National Monitoring Networks in Scotland 2013

Appendix 2: Intercalibration, Audit and Data Ratification Procedures

Appendix 1 – National Monitoring Networks in Scotland 2013

Table A1.1. AURN Measurement Sites in Scotland 2013

Site Name	Site Type	Species Measured	Grid Reference
Aberdeen	URBAN BACKGROUND	NO NO_2 NO_X O_3 PM_{10}, $PM_{2.5}$	394416,807408
Aberdeen Union St Roadside[1]	ROADSIDE	NO NO_2 NO_X	396345,805947
Auchencorth Moss	RURAL	O_3 PM_{10}(grav) $PM_{2.5}$(grav)	322167, 656123
Bush Estate	RURAL	NO NO_2 NO_X O_3	324500,663500
Dumbarton Roadside	ROADSIDE	NO NO_2 NO_X	240234,675193
Dumfries	ROADSIDE	NO NO_2 NO_X	297012,576278
Edinburgh St Leonards[2]	URBAN BACKGROUND	CO NO NO_2 NO_X O_3 PM_{10} $PM_{2.5}$ SO_2	326265, 673136
Eskdalemuir	RURAL	NO NO_2 NO_X O_3	323500,602800
Fort William	RURAL	NO NO_2 NO_X O_3	210830,774410
Glasgow Kerbside	KERBSIDE	NO NO_2 NO_X PM_{10}, $PM_{2.5}$	258708,665200
Glasgow Townhead[3]	KERBSIDE	NO NO_2 NO_X PM_{10}, $PM_{2.5}$	259692, 665899
Grangemouth	URBAN INDUSTRIAL	NO NO_2 NO_X PM_{10}, $PM_{2.5}$, SO_2	293840,681032
Grangemouth Moray[4]	URBAN BACKGROUND	NO NO_2 NO_X PM_{10}	296436,681344
Inverness	ROADSIDE	PM_{10}(grav), $PM_{2.5}$(grav), NO NO_2 NO_X	265720,845680
Lerwick	RURAL	O_3	445337,113968
Peebles	SUBURBAN	NO NO_2 NO_X O_3	324812,641083
Strath Vaich	REMOTE	O_3	234787,875022

1 PM_{10} at this site is part of Scottish Government Network
2 PM_{10} at this site is part of Scottish Government Network.
3. Site commissioned in October 2013
4 SO_2 at this site are part of the Scottish Government Network

Table A1.2. Automatic Hydrocarbon Network Sites in Scotland 2013

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322167, 656123

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

Table A1.3. Non-Automatic Hydrocarbon Network Sites in Scotland 2013

Site Name	Site Type	Species Measured	Grid Reference
Glasgow Kerbside$^{\alpha}$	KERBSIDE	Benzene	258708, 665200
Grangemouth	URBAN INDUSTRIAL	Benzene	293840,681032

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

$^{\alpha}$Non-Automatic Monitoring of Benzene started at this site on 01/09/10.

Table A1.3. PAH Monitoring Sites in Scotland 2013

Site	Address	Grid Reference
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow Townhead	Townhead Glasgow G4 0PH	259692, 665899
Kinlochleven 2	Electrical Substation Kinlochleven	219280, 761986
Auchencorth Moss	Rural site in Scotland, South of Edinburgh	322167, 656123

Table A1.4. Heavy Metals Monitoring Network Sites in Scotland 2013

Site	Site type and grid ref	Address	Metals measured
Eskdalemuir	Rural 323588,602997	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn
Motherwell	Urban Background 275764,656282	Civic centre, Motherwell	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn

Table A1.5. Rural Network Metals Monitoring Sites in Scotland 2013

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322167, 656123
Banchory	Rural site, NE Scotland	367650,798550

Table A1.6. Rural Metal Deposition Monitoring sites in Scotland 2013

Site	Location Grid Ref.	Heavy metals			Mercury	
		In Particles	In Rain	In Cloud	In Air	In Rain
Inverpolly	218776,908833		✓			
Banchory	367694,798519	✓	✓		✓	✓
Bowbeat	328289,647302		✓	✓		
Auchencorth Moss	322167, 656123	✓	✓		✓	✓

United Kingdom Eutrophying & Acidifying Network (UKEAP)

Table A1.7 The Precipitation Network (PrecipNet) Sites in Scotland 2013

Site Name	Grid Ref	Species included
Shetland	445449,113965	HNO_3, SO_2, HCl (gases) NO_3, NO_2, SO_4^{2-}, Cl^- (aerosols) Ca, Mg, Na (base cations)
Rum	140865,799220	
Halladale	290285,948838	
Strathvaich Dam	234787,875022	
Lagganlia	285684,803720	
Glensaugh	366329,780027	
Edinburgh St Leonards	326265, 673136	
Bush	324588,663503	
Auchencorth Moss	322188,656202	
Carradale	179870,637801	
Eskdalemuir	323588,602997	

Table A1.8. Acid Gas and Aerosol Network (AGANet) and Ammonia Network (NAMN) Sites in Scotland 2013

Name	Grid Ref	Ammonia	Nitric Acid
Shetland	445449,113965	✓	✓
Halladale	290285,948838	✓	✓
Inverpolly B	218776,908733	✓	
Strathvaich Dam	234787,875022	✓	✓
Ellon Ythan	394500,830400	✓	
Oldmeldrum	383297,827323	✓	
Pitmedden	388300,827800	✓	
Lagganlia	285684,803720	✓	✓
Allt a Mharcaidh	289184,804320	✓	
Rum	140865,799220	✓	✓
Glensaugh	366329,780027	✓	✓
Glenshee Hotel	311187,769916	✓	
Glen Shee	312187,769016	✓	
Tummel	274483,761116	✓	
Rannoch	260380,753315	✓	
Loch Awe	196673,711509	✓	
Edinburgh Johnston Terrace	325389,673404	✓	
Edinburgh Medical School	326388,672605	✓	
Edinburgh St Leonards	326265, 673136	✓	
Bush 2	324789,663804	✓	
Bush 1	324671,663524	✓	✓
Auchencorth Moss	322188,656202	✓	✓
Carradale	179870,637801	✓	✓
Auchincruive B	238478,622899	✓	
Auchincruive 3	237977,623399	✓	
Sourhope	386796,621798	✓	
Eskdalemuir	323588,602997	✓	✓
Dumfries	254679,565792	✓	

Appendix 2 – Intercalibration, Audit and Data Ratification Procedures

A2.1 Intercalibration and Audit procedures

The audit and intercalibration procedures adopted by Ricardo-AEA rely upon the principle that a set of recently certified gas cylinders (called "audit gas") is taken to all the stations in a monitoring network. This gas is certified at the Ricardo-AEA Gas Calibration Laboratory. At each station, analyser response to audit gas is recorded to check if the expected concentration (i.e. the certified value for the cylinder) is obtained. The analyser response to audit gas is obtained using calibration factors obtained from the site operator. The audit procedure checks the validity of the provisional data, the correct overall operation of the analyser and the reliability of calibrations undertaken routinely at that station. These site audit procedures are compliant with the requirements of the CEN standard methods of measurement and are used throughout the UK AURN network.

The results of the audit exercises form an integral part of the data management system and are fed directly into the data ratification process.

After the audit exercise, data from all the stations visited are traceable to recently calibrated UKAS accredited gas calibration standards (the audit gas).

A2.1.1 Detailed instrumentation checks

The following instrument functional checks are undertaken at an audit:

- Analyser accuracy and precision, as a basic check to ensure reliable datasets from the analysers.
- Instrument linearity, to check that doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser is not linear, data cannot be reliably scaled into concentrations.
- Ozone analyser calibration against a traceable ozone photometer
- Instrument signal noise, to check for a stable analyser response to calibration gases.
- Analyser response time, to check that the analyser responds quickly to a change in gas concentrations.
- Leak and flow checks, to ensure that ambient air reaches the analysers, without being compromised in any way.
- NO_X analyser converter efficiency, via gas phase titration, to ensure reliable operation. The converter must be more than 95% efficient to ensure that the NO_2 data are of the required accuracy.
- TEOM k_0 evaluation. The factor is used to calculate particulate mass concentrations.
- Particulate analyser flowrates. Any error in the flow through these particulate analysers is directly reflected in an error in the final measure of particulate concentration.

- SO_2 analyser hydrocarbon interference, certain hydrocarbons are known to interfere with the SO_2 detector.

- Evaluation of site cylinder concentrations, with reference to the certified audit gas taken to the stations. This procedure allows for the correction of data from stations where the site calibration cylinder concentration is slowly changing and for identification of any unstable cylinders that require replacement.

- Assessing changes in local site environment. During the visit, a record of any changes in the site environment, for example any increase or decreased traffic flow due to road layout changes, construction activity, encroachment of the site by vegetation etc.

- Assessment of station infrastructure and operational procedures. Any deficiencies in site infrastructure or operational procedures, which may affect data quality or safe operation of the site, are noted.

- Ensure Local Site Operators (LSO) understand calibration procedures correctly. It is the calibrations by the LSOs that are used to scale pollution datasets and hence, it is important to check that these are undertaken reliably.

The procedures used to determine instrument performance are documented in Ricardo-AEA Work Instructions. These methods are regularly updated and improved and have been evaluated by the United Kingdom Accreditation Service (UKAS). Tests are performed on the analysers, cylinders and ambient air inlet systems. Checks are made on the environment around the site, including the continued representative nature of the site and safety assessments. The data collected from the instrument and cylinder tests are collated on site, using a controlled and protected Excel spreadsheet, which automatically undertakes all calculations and alerts the audit staff to any unusual results. The completed spreadsheets are then returned for further checking, before being used within the data management process and in production of accredited Certificates of Calibration.

A2.1.2 UKAS Accreditation

Ricardo-AEA holds UKAS accreditation to ISO 17025 for the on-site calibration of the gas analysers (NO_X, CO, SO_2, O_3), for flow rate checks on particulate (PM_{10}) analysers and for the determination of the spring constant, k_0, for the TEOM analyzer.

ISO17025 accreditation provides complete confidence that the analyser calibration factors are traceable to national metrology standards, that the calibration methods are sufficient and fit for purpose, and that the uncertainties are appropriate for data reporting purposes.

Ricardo-AEA also holds ISO17025 accreditation for laboratory certification of NO, NO_2, CO and SO_2 gas cylinders.

A2.1.3 Zero air

The reliability of the zero air supply at each station is of fundamental importance in the determination of ambient concentrations. A reference zero air source is held at the Ricardo-AEA Gas Calibration Laboratory, which is traceable to international standards. A transfer standard, checked against this standard, is used to evaluate the site zero sources at the QA/QC audits. The zero air supply at a site will be either:

- A zero air cylinder.
- A series of chemical scrubbers, connected to a pumped delivery system.
- A pollutant specific chemical scrubber system to connect directly into the analyser.

A2.1.4 Ozone photometers

Ozone photometers are calibrated every six months against the NIST Reference Photometer, held at NPL, before use at the station audits.

A2.2 Data Acquisition and Processing

The Scottish local authority monitoring stations are polled three times a day to retrieve 15-minute averages of raw output from instruments. This is a balance between regular updating of the database and web site yet minimising the associated telecoms costs. UK National network stations are polled hourly as these data are used for the air quality forecast system.

The data are transmitted via MODEM or internet connection, depending on type of logging system used at the site, and automatically appended to the air quality site database.

The results of automatic overnight autocalibration checks are also retrieved and databased.

Appropriate scaling factors, based on the most recent calibration information are applied to the pollutant measurements to produce concentrations in the relevant units.

From the 15-minute values, the hourly averaged results are calculated. This is the averaging period used for the reporting of both validated and ratified data for all pollutants. Additionally the 15-minute data files are provided for SO_2 to allow direct comparison with the 15-minute objective.

Once the raw data from the stations has been acquired the next step in the data management process is data validation.

A2.2.1 Validation of Data

All incoming data from the monitoring station are automatically screened prior to the release of validated data sets. Experienced staff will check the data daily, to monitor satisfactory data acquisition and to investigate instances of suspect data. This daily checking ensures rapid diagnosis of any instrument malfunctions.

The automatic screening procedures, and many years' experience of our staff, enables us to ensure that only the highest quality data are released to the Scottish Air Quality Database and Website as validated data.

Should equipment or site problems be identified, it is possible for data management staff to contact the monitoring station manually, in order to access further information. If necessary, the relevant LSO is contacted to undertake further investigation.

A2.3 Data ratification

This section provides details of the procedures and the software tools we use for data ratification.

Our software runs a number of protocols to automatically flag data anomalies in the provisional data received from the stations, these are examined in detail during the ratification process. These include identifying the following:

- Negative data
- High data peaks
- Calibrations which are more than 5% different from previous values
- Peaks with a maximum 15-minute concentration significantly above the hourly mean value
- Measurements which are outside the normal range of expected data e.g. elevated ozone concentrations during the winter months
- Long periods of constant or zero concentrations
- Data gaps of more than six hours.

A2.3.1 Ratification tasks and output

When ratifying data the following are closely examined:

- Issues that have been flagged up automatically by the software
- zero and sensitivity factors used on each day
- General review of the result to make sure that there are no other anomalies.

A2.3.2 Ratified Data Checking

Once the data have been initially ratified proforma reports is produced and passed to the data checker The role of the data checker is to:

- Assess if there are any station problems if not the data can be marked as ratified.
- Return the station to the data ratifier if there are any issues requiring further action by the data ratifier.
- Forward the report to the project Quality Circle if there are data quality issues which require a group discussion to resolve.

Following the Quality Circle meeting the data are then corrected if required and uploaded as ratified to the database and web site.

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