The Scottish Government

Air Pollution in Scotland 2011

RICARDO-AEA

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Customer	The Scottish Government
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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.

This report presents the activities undertaken during the fourth year of the project – April 2010 – April 2011. 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 further enhancements of the website including the addition of new monitoring sites to the database, and the development and launch of the Know and Respond-Scotland Air Quality Alert System.

The database and website were launched on the 2nd of April 2007 and have continued to expand and develop in the following years. Further enhancements are planned throughout the duration of the project, including the enhancement of the Open Air data analysis tool through the provision of modeled meteorological data for sites included within the database and continuous improvement of the functionality of the database to make it as useful and user friendly as possible.

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 2011 the Scottish Air Quality Database contained data for a total of 86 automatic monitoring sites.

A summary of ratified data for 2011 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 the end of 2011 a total of 26 AQMAs were in place in Scotland.

This annual report also contains a summary of data from a wider range of pollutants measured in Scotland as part of several national network monitoring programmes. As many of these monitoring networks rely on chemical analysis of samples collected, in some cases, the full dataset for 2011 was not yet available at the time of preparation and data for 2010 are provided in this report.

Data held within the database covering many years have been used to assess for possible trends in air pollution throughout Scotland. In previous years, 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 report, a different approach was proposed and adopted. This approach has been retained in this report. 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.

In terms of concentrations of NOx from urban background sites, prior to 2000, the three long-running sites in this category (Glasgow City Chambers, Edinburgh Centre and Glasgow Centre) indicate a long-term improvement in NO_x concentrations. However since 2000, data from other sites appear to indicate a flattening-off of this downward trend. From 2004 onwards, the average NO_x concentration based on data from the three long-running sites (Aberdeen, Edinburgh St Leonards and Grangemouth) indicates that average NO_x concentrations have been relatively stable from 2004, although possibly increasing around 2007. 2011 appears to have been a lower year for NO_x, after a high year in 2010.

In terms of annual mean concentrations of NOx at traffc-related site, no clear trend was discernible with annual mean concentrations of total NO_x at traffic-related sites appearing stable in recent years. 2011 appears to have been a slightly lower year for NO_x, after a higher year in 2010.

In comparison, concentrations of NO_2 at the same set of long-running urban background monitoring sites generally show a less marked decline in concentrations. Glasgow City Chambers (which has been operating for over 20 years) shows a general decline in NO_2, but the decrease is much more gradual than concentrations of NO_x. Similarly, Edinburgh Centre (between 1993 and 2002) and Glasgow Centre (1997 to 2008) show a less clear downward trend for NO_2 than for NOx. The mean for the three long-running sites in operation since 2004 (Aberdeen, Edinburgh St Leonards and Grangemouth) indicates that urban background NO_2 concentrations have remained relatively stable over the past eight years. The mean for the five sites in operation since 2007 (Aberdeen, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth) shows a similar pattern, with no clear upward or downward trend.

All urban background sites in Scotland recorded annual mean NO_2 concentrations well below the AQS Objective of 40 μgm^{-3} in 2011, with the exception of Glasgow City Chambers (which closed in March 2011 and was only in operation for 20% of the year).

Monitoring of PM_{10} is undertaken at comparatively fewer sites across Scotland, with most sites only having been established post-2005. Assessment of trends at in PM_{10} concentrations at urban background sites indicated a general decrease in annual mean PM_{10} concentration since the early 1990s, although individual sites did show considerable fluctuation year on year. The average of the three sites in operation since 2004 indicated a decrease between 2006 and 2010 (although 2011 appears to have been a slightly higher year). This is also reflected in the mean of the five sites in operation since 2007. The average PM_{10} concentration for all urban background sites in 2011 was 15 μgm^{-3}, well within the Scottish AQS Objective of 18 μgm^{-3}. All the individual sites met this objective.

In comparison, whilst the assessment of trends in PM_{10} concentrations at traffic-related urban sites indicated of a general decrease since the early 2000s, this was less pronounced than in the case of the urban background sites. Also, there was clearly substantial fluctuation from year to year. The average PM_{10} concentration for all traffic-related sites in 2011 was 17 μgm^{-3} which is just below the Scottish AQS Objective of 18 μgm^{-3}. However, not all of the sites met the objective.

The assessment of trends in ozone concentrations recorded across Scotland demonstrated significant fluctuations from year to year, due to variation in meteorological conditions.

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 have been made available on the website and a selection of the maps are 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 Environmental Protection Agency Pollution Release Inventory (http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx).

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Appendices

1 Introduction

The Scottish Government undertakes considerable monitoring of a wide range of air pollutant species as part of joint UK wide programmes 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 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 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 RICARDO-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. The reports relating to the first four years of the project, 2007-2010 are available on the website (www.scottishairquality.co.uk).

This is the fifth annual report of this project and summarises the progress made during 2011 in the on-going project tasks and also highlights the considerable new work undertaken during 2011.

Chapter 2 provides information on significant enhancements to the website during 2011. These include the development and launch of the Know and Respond Air Quality Alert Service and the implementation of the new Daily Air Quality Indicator.

The overall number of sites in the database with data available for all or part of 2011 increased to 86. The corresponding QA/QC programmes (**Chapter 5**) have expanded to encompass these additional sites. As in 2009 and 2010, 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 **Chapter 6**.

Chapter 7 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. 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 **Chapter 8.**

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 now 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 (**Chapter 9**).

2 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.

Development of the website undertaken during 2011/12 has focussed on making the database compliant with the requirements of the INSPIRE Directive, providing improved interfaces to facilitate more detailed data analysis and on the launch of Scotland Air Quality Alert Service – Know and Respond-Scotland.

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.

2.1 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 2-1 below illustrates how the number of hits varied during 2011.

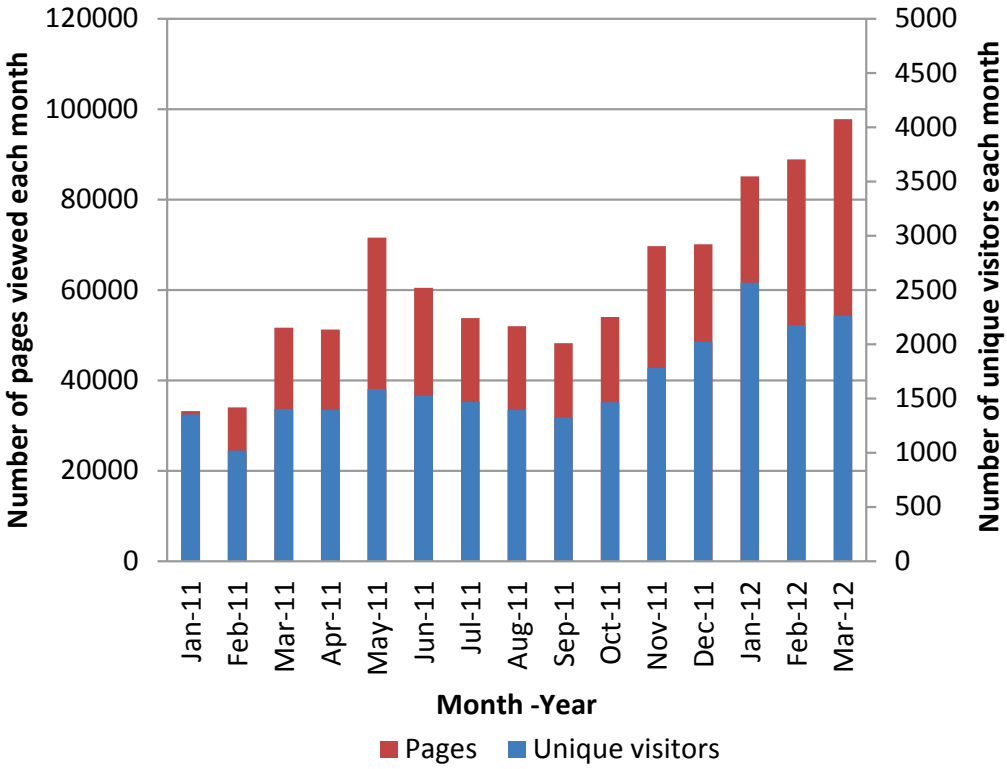
The hits will include some automated search engine visits which are required in order to keep the sites' rating on Google and Yahoo as high as possible. However, we have endeavoured as far as possible to configure the site security and tracking software to exclude automated web crawlers which may be 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 March 2012. The number of visitors per month during this period varied between around 2200 and 2600. Whilst the reasons for the distinct trends in activity are not clear, the enhanced interest in the website during early 2012 corresponds to the launch of the Know and Respond Alert Service and its coverage on the BBC news. Other possible reasons for increased usage of the website during early 2012 include:

- The annual cycle of local authority review and assessment activity
- Release of website improvements and reports.

The monthly activity remains lower than the initial 3000 or more unique visitors that visited the site just after its launch, but has shown a consistent increase from the 500 visitors per month level recorded at the end of 2007 and a significant increase following the launch of the Know and Respond-Scotland Alert Service. Key users of the website include Local Authorities, the Scottish Government, SEPA, universities, health professionals, environmental consultants and the general public.

Figure 2-1 Air Quality Scotland Website Hits Jan 2011-March 2012



2.2 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 RICARDO-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 2011 with no extended breakdowns or downtime reported.

2.3 Website Upgrades During 2011

A number of enhancements to the website were carried out in 2011, at the request of Scottish Government and other website users in order to stay up to date with developments in national policy and to improve the appearance and functionality of the pages. Some of these developments are discussed below:

2.3.1 Update of the Daily Air Quality Index

In June 2011, the Committee on the Medical Effects of Air Pollutants (COMEAP) published its report *Review of the UK Air Quality Index*[1], recommending changes to the original UK Index which had remained unchanged for 12 years. The Scottish Government, Defra and the other devolved administrations have considered the recommendations of the report and following consultation with users of the index, have implemented several changes. The new index has been named the Daily Air Quality Index (DAQI) and was adopted by the Scottish Government and implemented on the Scottish Air Quality Database and website on the 1st of January 2012. The changes to the index are summarized briefly below:

1. Provision of updated health advice to provide more focused and clearer information. The Daily Air Quality Index comes in three parts and includes advice on how the index should be used, and additional advice for susceptible individuals alongside advice for the general population:
2. Changes to the index bands (Low, Moderate, High and Very High) for particulate matter (PM_{10}), nitrogen dioxide (NO_2), and ozone (O_3) to make them more stringent. Details of the index bands are presented in Table 2-1[2].
3. Fine particulate matter ($PM_{2.5}$) is included in the DAQI;
4. Carbon monoxide (CO) has been removed from the DAQI in view of the dramatic reductions in outdoor concentrations of CO;
5. There have been changes to the presentation of the index with a 10-point scale with four bands of Low, Moderate, High, and Very High being introduced. The banding is colour-coded to aid the interpretation of the DAQI.
6. Trigger values are included in the DAQI to allow for the prediction of episodes of elevated air pollution in real time as they emerge.
7. The index also provides links to long-term health effects of air pollution, but noting that the DAQI itself only addresses the health effects of short term exposure to elevated levels.

[1] http://comeap.org.uk/images/stories/Documents/Reports/comeap%20review%20of%20the%20uk%20air%20quality%20index.pdf
[2] Please note that the bands for O_3 differ slightly to those recommended by COMEAP

Table 2-1: Daily Air Quality Index bands

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	$PM_{2.5}$ Particles	PM_{10} Particles
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour mean	24 hour mean
		μgm^{-3}	μgm^{-3}	μgm^{-3}	μgm^{-3}	μgm^{-3}
LOW						
	1	0-33	0-66	0-88	0-11	0-16
	2	34-65	67-133	89-176	12-23	17-33
	3	66-99	134-199	177-265	24-34	34-49
MODERATE						
	4	100-120	200-267	266-354	35-41	50-58
	5	121-140	268-334	355-442	42-46	59-66
	6	141-159	335-399	443-531	47-52	67-74
HIGH						
	7	160-187	400-467	532-708	53-58	75-83
	8	188-213	468-534	709-886	59-64	84-91
	9	214-239	535-599	887-1063	65-69	92-99
VERY HIGH						
	10	240 or more	600 or more	1064 or more	70 or more	100 or more

Further details on the DAQI can be found at:
http://www.scottishairquality.co.uk/about.php?n_action=standards#band

2.3.2 Launch of Know and Respond-Scotland

The Scottish Government's Air Quality Alert Service **'Know and Respond-Scotland'** was launched on the 27th January 2012 with coverage on BBC-Scotland TV, radio and website. The system comprises of a SMS, email and Voicemail text alert service to which people can register to be informed (free-of-charge in the UK) of any forecast concentrations of pollutants (SO_2, NO_2, PM_{10} and O_3) above the Moderate health alert threshold values within each of the zones and agglomerations in Scotland.

27 January 2012 Last updated at 14:25

Share

Pollution alert system launched in Scotland

By Eleanor Bradford
BBC Scotland Health Correspondent

+07742
The air pollution forecast for Central Scotland, Glasgow is Moderate. Please visit www.scottishairquality.co.uk/kr.
Close Reply

Scotland is to become the first part of the UK to offer a pollution alert system which could be incorporated into weather forecasts

Scotland is to become the first UK nation to offer pollution alerts.

The alerts will be sent via text message or email to those who sign up to the new system.

"People can subscribe to the service through the Scottish Air Quality website," explained climate expert Stuart Sneddon from AEA Scotland.

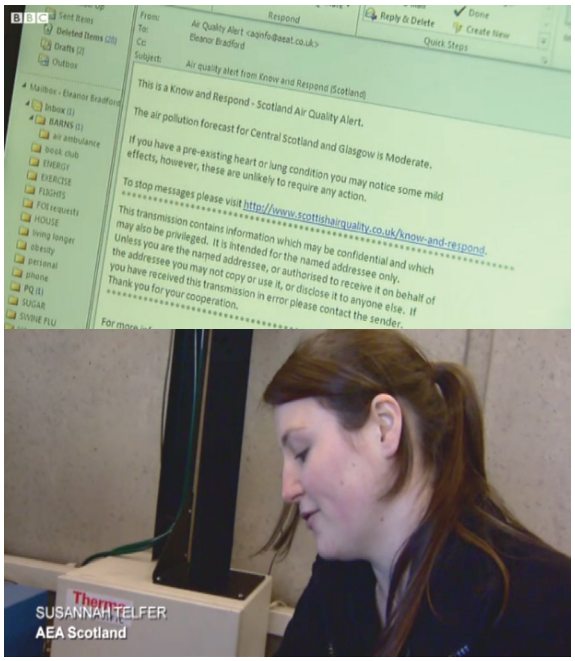
"The forecasting is done every day by ourselves. When we forecast

Related Stories

City pollution 'at danger levels'

Air quality 'puts lives at risk'

Diesel fumes 'raise heart risks'



The alerts are based on the well-established UK AQ Forecasting service operated by RICARDO-AEA on behalf of the Scottish Government, Defra and the other devolved administrations, with the content of alert messages (SMS, email and Voicemail) having been agreed with the Scottish Government, Health Protection Scotland and other medical practitioners. The messages have been designed to inform subscribers of episodes of Moderate, High or Very High air pollution within specific geographical areas and to provide guidance in terms of the actions they may wish to take.

People can sign up to the Service for themselves or on behalf of patients, friends or relatives at a simple registration page on the Scottish Air Quality Database http://www.scottishairquality.co.uk/know-and-respond/alert.php.

Since the development of the service considerable work and consultation has been undertaken with health professionals and the media to facilitate the promotion of the service, particularly to groups that are highly sensitive to air pollution.

2.4 Website and Database Developments Planned for 2012

Numerous developments of the database and website have been planned for 2012; some of the more interesting developments include the provision of enhanced Local Site Operator Training and the development of the openair analysis package on the Air Quality Scotland to include modelled meteorological data for sites in included in the database.

2.4.1 Local Site Operator Training

During the next year of the project RICARDO-AEA monitoring team will be contacting local authorities to organise detailed training in undertaking LSO duties. Each of the authorities that wish to undertake the training will be visited by two representatives from RICARDO-AEA who will deliver a presentation covering all aspects of the duties and responsibilities expected of local site operators. This will be supplemented with an actual visit to a monitoring site to provide hands on training of all the required aspects.

A Scotland-specific LSO manual will also be produced and provided to each authority in electronic format. The manual will also be available for download from the website. Furthermore, a series of short LSO training videos will be produced that will provide detailed guidance on undertaking on-site

activities. The videos will be available from the website and links will also be embedded into the manual.

2.4.2 Openair developments

The **openair** project is a Natural Environment Research Council knowledge exchange project that aims to provide a collection of open-source tools for the analysis of air pollution data. An openair capability was added to the Scottish Air Quality Database in 2010 and has proved to be a valuable tool for anyone undertaking research and studies of air quality in Scotland. However, many of the more advanced analysis tools of openair require meteorological data, which is not currently available through the database. In order to further enhance the usability of openair for undertaking data analysis on the database we will be making modelled meteorological data for sites included in the database available via the website. This data will make openair on the Scottish Air Quality Database a much more valuable tool for undertaking screening analysis of air quality data.

3 Annual 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 Glasgow's Royal Concert Hall on Wednesday 28 March 2012. The event was attended by over sixty air quality experts representing the Scottish Government, local authorities, Health Protection Scotland, SEPA, consultancy, academia and students. The objective of the seminar was 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 latest progress on the air quality database including the Know and Respond-Scotland alert service, openair capability and emerging issues in terms of particulate matter were presented by RICARDO-AEA. In addition, further presentations were given by Dr Ken Anderson (NHS), Jim Mills (Air Monitors), Fiona Maguire (North Lanarkshire Council), Sofia Girnary (TTR), Janet Brown (City of Edinburgh Council) and Kathye Ann Henderson (EMINOX).

The agenda for the day is shown in Figure 3-1-1. All of the presentations from the seminar are available to download at http://www.scottishairquality.co.uk/reports.php?n_action=seminar.

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. The newsletter for 2011 was distributed at the Annual Seminar. 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@ricardo-aea.com), postal address given at the start of this report). Electronic copies in pdf format are available for download at http://www.scottishairquality.co.uk/reports.php?n_action=report2.

Figure 3-1 Agenda for the Scottish Air Quality Seminar on 28 March 2012

The Scottish Government

AEA

SCOTTISH AIR QUALITY DATABASE AND WEBSITE ANNUAL SEMINAR

Wednesday 28 March 2012

The Glasgow Royal Concert Hall, 2 Sauchiehall Street, Glasgow, G2 3NY

Agenda

09:15	Registration and Coffee	
09:30	Welcome and Introduction	Andrew Taylor, SG
09:45	General Updates to the Database and Website – including brief QA / QC	Stuart Sneddon, AEA
10:20	Particulate Matter – Emerging Issues	Stephen Stratton/ David Hector, AEA
10:50	Carbotraf	Jim Mills Air Monitors
11:10	Tea/Coffee Break	
11:30	Open Air – enhanced functionality on SAQD	Scott Hamilton, AEA
12:05	LAQM Appraisal Team	Sofia Girnary Transport and Travel Research Ltd
12:35	Revocation of Harthill AQMA	Fiona Maguire, North Lanarkshire Council
12:55	Lunch	
13:45	Health Impacts of Air Quality	Dr Ken Anderson MD FRCP Consultant Physician Crosshouse Hospital
14:20	Air Quality Forecasting and the Know and Respond Alert System	Paul Willis, AEA
14:55	Tea/Coffee Break	
15:10	Upgrading City Buses to Reduce NOx Emissions	Gavin Martin and Kathye-Ann Henderson Edinburgh City Council and EMINOX
15:45	Questions and Answers	
16:00	Closing Comments	Andrew Taylor

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

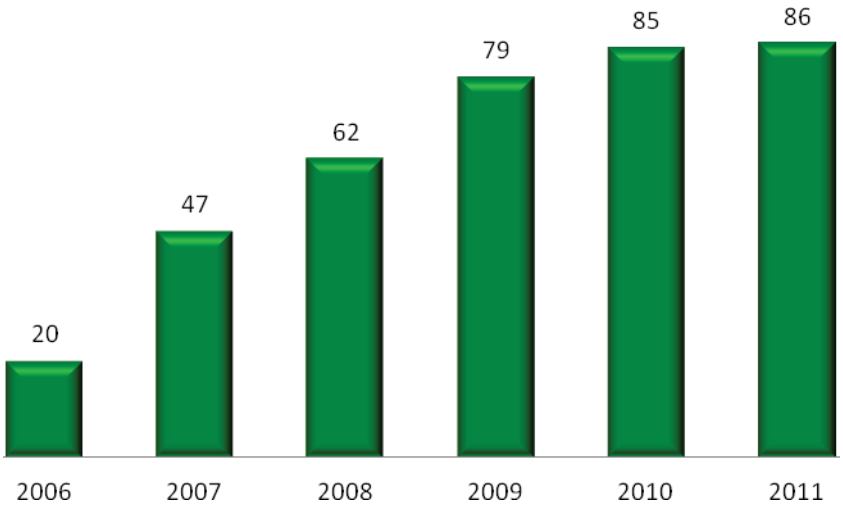
Respondents should be aware that the delegate list for this event is held on a computer. Under the terms of the Data Protection Act, anyone on the mailing list has the right to object to his/her name and address being so held.

4 Data Availability in 2011

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

At the end of 2011 the Scottish Air Quality Database contained data for a total of 86 automatic monitoring sites. In total, 6 new sites were incorporated into the database during 2011; East Dunbartonshire Milngavie, Dundee Meadowside, Edinburgh Queensferry Road, Fife Kircaldy, Glasgow Burgher Street and North Lanarkshire Cumbernauld. Four sites, Edinburgh Roseburn, Glasgow City Chambers, Lerwick Staney Hill and Midlothian Dalkeith were decommissioned during 2011. As a result, the number of live sites in the database increased by 1 from 85 sites in 2010. Figure 4-1 shows how the SAQD has grown from 47 sites in 2007 to 86 sites in 2011.

Figure 4-1 Number of Monitoring Sites within the Scottish Air Quality Database Network 2007 - 2011



For the 17 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 2011, in terms of site, pollutants and months available, is summarised in Table 4-2. The full 12-figure OS grid reference and the site location classification are also provided for each site.

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 Homepage of www.scottishairquality.co.uk 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 2011

Site Name	Type	East	North	Pollutants	Network	Start date#	Data in 2011
Aberdeen	URBAN BACKGROUND	394416	807408	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	1999	Jan – Dec
Aberdeen Anderson Dr	ROADSIDE	392506	804186	NO_2 PM_{10}	SAQD	2004	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	Jan - Dec
Auchencorth Moss	RURAL	322167	656123	13BD BENZ O_3 PM_{10} $PM_{2.5}$ TOL XYL	AURN	2006	Jan – Dec
Auchencorth Moss PM_{10} $PM_{2.5}$	RURAL	322167	656123	PM_{10} $PM_{2.5}$	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	Jun – 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 - Jun
East Ayrshire Kilmarnock John Finnie St	ROADSIDE	242691	638095	NO_2 PM_{10}	SAQD	2010	Jan – Dec
East Ayrshire New Cumnock*	URBAN BACKGROUND	261812	613503	NO_2 PM_{10}	SAQD	2009	Jan – Nov
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	Aug - 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+	SAQD	2008	Jan - 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 Roseburn*	ROADSIDE	322900	673260	NO_2 PM_{10}	SAQD	2006	Jan – Aug
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} $PM_{2.5}$ SO_2	AURN	2003	Jan – Dec
Eskdalemuir	RURAL	323552	603018	NO_2 O3	AURN	1986	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

Site Name	Type	East	North	Pollutants	Network	Start date#	Data in 2011
Glasgow Battlefield Road	ROADSIDE	258425	661390	NO_2 PM_{10}	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	Aug – Dec
Glasgow Byres Road^	ROADSIDE	256553	665487	CO NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Centre	URBAN CENTRE	258902	665028	CO NO_2 O_3 PM_{10} $PM_{2.5}$ SO_2	AURN	1996	Jan – Dec
Glasgow City Chambers*	URBAN BACKGROUND	259528	665308	NO_2	AURN	1987	Jan – Mar
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 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 – Dec
Lerwick Staney Hill*	URBAN BACKGROUND	446562	1142361	NO_2 SO_2	SAQD	2008	Jan – Apr
Midlothian Dalkeith*	ROADSIDE	331159	667298	NO_2 PM10 SO_2	SAQD	2008	Jan – Jul
Midlothian Pathhead	KERBSIDE	339480	664316	PM_{10} SO_2	SAQD	2008	Jan – Dec
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
South Ayrshire Ayr High St	ROADSIDE	233725	622120	NO_2 PM_{10}	SAQD	2007	Jan - Dec
South Ayrshire Maybole	ROADSIDE	229235	609598	NO_2 PM_{10}	SAQD	2010	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 – Sep
South Lanarkshire Raith Interchange	ROADSIDE	271108	658235	NO_2 PM_{10}	SAQD	2010	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 Dunbartonshire Glasgow Road*	ROADSIDE	240234	675193	NO_2	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 – Dec
West Lothian Whitburn	ROADSIDE	294657	664941	NO_2 PM_{10}	SAQD	2010	Jan – Dec

+ Sites added to database in 2011
* Sites closed during 2011
^Changes in number of measured pollutants or monitoring method during 2011
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.

Please note that Grangemouth Moray (NO_2 - AURN) and Grangemouth Moray Scot Gov (SO_2 and PM_{10} - SAQD) are the same site, as are Aberdeen Union St (PM_{10} - SAQD) and Aberdeen Union Street Roadside (NO_2 – AURN).

Data summaries for all of these monitoring sites are provided on a pollutant-by-pollutant basis in Section 6.1

4.1.1 Changes to Monitoring Sites within the Database during 2011

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

Sites opened during 2011:

- East Dunbartonshire Milngavie NO_2, PM_{10} from 16/08/11
- Dundee Meadowside NO_2, PM_{10} from 22/06/11
- Edinburgh Queensferry Road NO_2, PM_{10} from 01/01/11
- Fife Kirkcaldy NO_2, PM_{10} from 08/02/11
- Glasgow Burgher Street PM_{10} from 04/08/11
- North Lanarkshire Cumbernauld NO_2, PM_{10}, SO_2 from 01/01/11

Sites closed during 2011:

- East Ayrshire New Cumnock NO_2, PM_{10} on 10/11/11
- Edinburgh Roseburn NO_2, PM_{10} on 15/08/11
- Glasgow City Chambers NO_2 on 16/03/11
- Lerwick Staney Hill NO_2, SO_2 on 31/12/11
- Midlothian Dalkeith NO_2, PM_{10}, SO_2 on 07/07/11

East Ayrshire New Cumnock, Edinburgh Roseburn, Lerwick Staney Hill and Midlothian Dalkeith monitoring sites are in the process of being moved to new locations. Glasgow City Chambers has been decommissioned.

Changes to sites during 2011:

- Dundee Lochee Road started monitoring PM_{10} in addition to NO_2 on 08/04/11
- Dundee Mains Loan started monitoring NO_2 in addition to PM_{10} on 30/03/11
- Dundee Seagate started monitoring PM_{10} in addition NO_2 on 09/05/11
- Falkirk Hope Sttreet stopped monitoring PM_{10} on 02/10/11
- Fife Dunferline started monitoring PM_{10} in addition to NO_2 on 12/04/11
- Glasgow Anderston PM_{10} analyser was upgraded to an FDMS from a TEOM on 19/04/11
- Glasgow Byres Road PM_{10} analyser was upgraded to an FDMS from a TEOM on 24/06/11
- Grangemouth Moray Scot Gov stopped monitoring PM_{10} on 04/10/11

4.2 Volatile Correction Model for PM_{10}

4.2.1 Background

The EU Directive on Ambient Air Quality[3] and the UK Air Quality Strategy[4] 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[5] 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 have now 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 provided to the Local Authorities and made available on the Scottish Air Quality website as a separate data spreadsheet.

[3] *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

[4] *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

[5] *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

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 2011 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 2011 corrections, temperature and pressure data from both Aberdeen Dyce Airport and Edinburgh Gogarbank meteorological monitoring stations were utilised. These two sites were selected as a good representation of weather conditions in Aberdeen and the central belt of Scotland, respectively.

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 27 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[6] 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.

[6] 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 in VCM Correcting TEOM Data from Aberdeen and Central Scotland Monitoring Sites

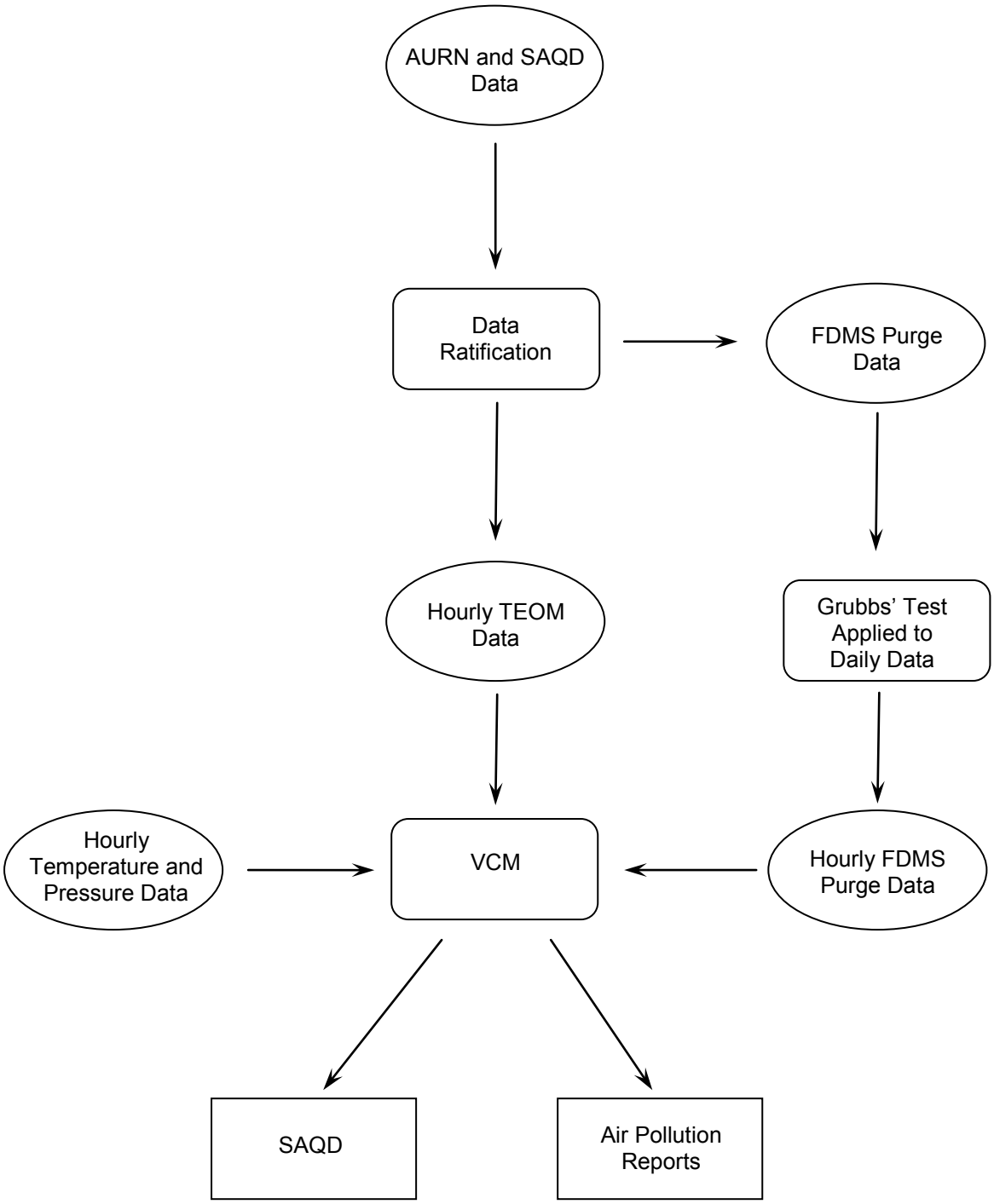
TEOM Locations	PM_{10} FDMS Sites used in VCM	Monitoring Network
Aberdeen	Aberdeen	AURN
	Angus Forfar	SAQD
	Fife Cupar	SAQD
Central Scotland	Angus Forfar	SAQD
	Auchencorth Moss	AURN
	East Dunbartonshire Kirkintilloch	SAQD
	East Dunbartonshire Milngavie	SAQD
	East Renfrewshire Sheddens	SAQD
	Edinburgh St Leonards	AURN
	Fife Cupar	SAQD
	Fife Dunfermline	SAQD
	Fife Kirkcaldy	SAQD
	Fife Rosyth	SAQD
	Glasgow Abercromby Street	SAQD
	Glasgow Anderston	SAQD
	Glasgow Broomhill	SAQD
	Glasgow Burgher St	SAQD
	Glasgow Byres Road	SAQD
	Glasgow Centre	AURN
	Glasgow Kerbside	AURN
	Glasgow Nithsdale Road	SAQD
	Grangemouth	AURN
	Paisley Gordon Street	SAQD
	Paisley St James St	SAQD
	South Lanarkshire East Kilbride	SAQD
	South Lanarkshire Raith Interchange	SAQD
	West Dunbartonshire Clydebank	SAQD
	West Lothian Broxburn	SAQD
	West Lothian Linlithgow High Street	SAQD
	West Lothian Whitburn	SAQD

The corrected data for 2011 and calculated summary statistics have been provided to the local authorities. If a PM_{10} analyser was upgraded to an FDMS from a TEOM during 2011, the statistics quoted are calculated using the combination of VCM corrected data and FDMS data. The SAQD website database now shows all ratified TEOM data for 2011 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 2011 SAQD TEOM data is shown in Figure 4-2. The monitoring sites where VCM correction of PM_{10} data have been undertaken for all or part of the year are indicated in Table 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.

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 2011:

- 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. It has not been possible to load all of these data onto the Scottish database, but as the database develops, these data will be loaded, or links provided to other locations and hence, the database will become a consolidation of air quality data from a wide variety of sources. Data will then be available from one easily accessible web portal. 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[7, 8].

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.

[7] Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance
http://www.airquality.co.uk/reports/cat05/0802141004_NO2_WG_PracticalGuidance_Issue1a.pdf
[8] 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 intercalibrations every 6 months, daily automatic data collection and validation and data ratification in 6-monthly blocks.

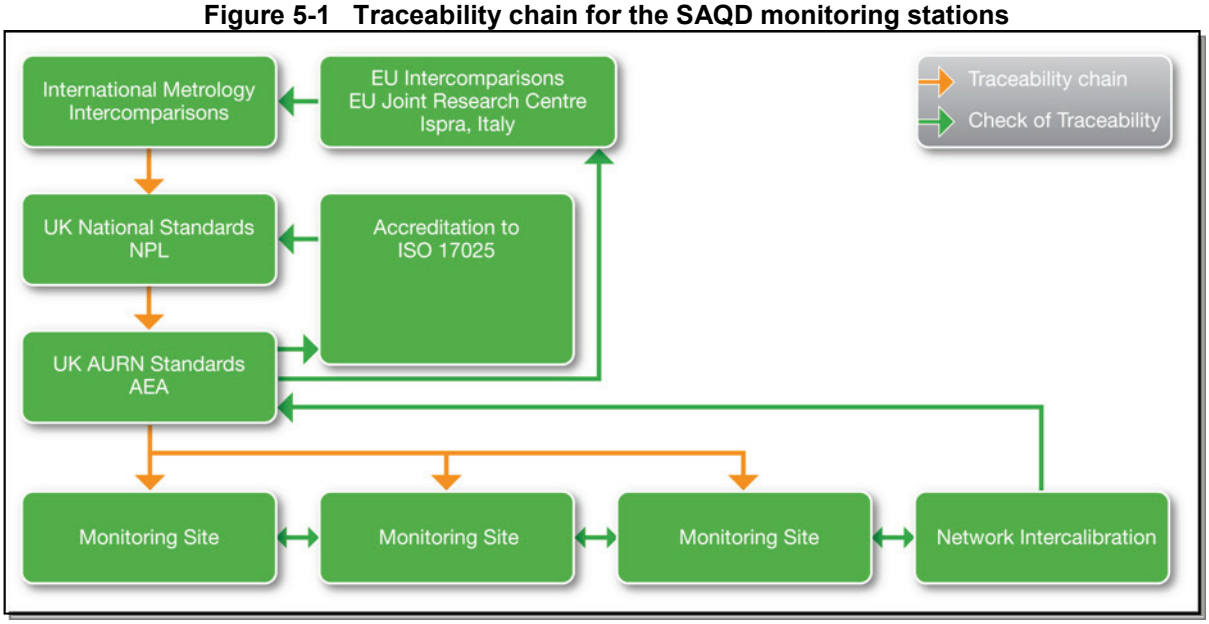
5.1 On-site analyser and calibrations gas audits

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 intercompare these standards internationally. AEA also participate in EU level intercomparisons 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.

Figure 5-1 Traceability chain for the SAQD monitoring stations



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.

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 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 intercalibrations – 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 local authority review and assessment work as detailed in the technical guidance 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 6-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 31 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 2011

5.4.1 Site Intercalibrations and Audits

As discussed above, site intercalibrations 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 intercalibrations and audits undertaken on air quality sites in the Scottish Database during 2011.

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 2010 Audits

Fault	Number of Monitoring Sites Winter 2010/11	Number of Monitoring Sites Summer 2011
FDMS* pump vacuum <21”Hg	4	2
TEOM** and TEOM FDMS k_0 out by > 2.5%	2	3
Particulate Analyser*** flow out by >10%	11	9
NO_x analyser converter <97% efficiency	0	0
NO cylinder out by >10%	6	8
SO_2 cylinder out by >10%	0	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 2011 figures, the number of faults found is stable.

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 intercalibrations and audits undertaken during 2011.

Table 5.2 Air Quality Site Intercalibration and Audits Conducted During 2011

	Jan - Jun 2011	Jul – Dec 2011		Jan - Jun 2011	Jul – Dec 2011
Aberdeen	✓	✓	Glasgow Abercromby Street	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Anderston	✓	✓
Aberdeen King Street	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Union St	✓	✓	Glasgow Burgher Street		✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Centre	✓	✓
Alloa	✓	✓	Glasgow City Chambers	✓	
Angus Forfar	✓	✓	Glasgow Kerbside	✓	✓
Auchencorth Moss	✓	✓	Glasgow Nithsdale Road	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Bush Estate	✓	✓	Grangemouth	✓	✓
Dumbarton Roadside	✓	✓	Grangemouth Moray	✓	✓
Dumfries	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Dundee Broughty Ferry Road	✓	✓	Inverclyde Greenock Dunlop St	✓	✓
Dundee Lochee Road	✓	✓	Inverness	✓	✓
Dundee Mains Loan	✓	✓	Lerwick	✓	✓
Dundee Meadowside	✓	✓	Lerwick Staney Hill	✓	
Dundee Seagate	✓	✓	Midlothian Dalkeith	✓	✓
Dundee Union Street	✓	✓	Midlothian Pathhead	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Chapelhall	✓	✓
East Ayrshire Kilmarnock John Finnie St	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
East Ayrshire New Cumnock	✓	✓	N Lanarkshire Croy	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Cumbernauld	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Milngavie		✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Lothian Musselburgh N High St	✓	✓	North Ayrshire Irvine High St	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley Central Road	✓	✓
Edinburgh Gorgie Road	✓	✓	Paisley Glasgow Airport	✓	✓
Edinburgh Queen Street	✓	✓	Paisley Gordon Street	✓	✓
Edinburgh Queensferry Road	✓	✓	Paisley St James St	✓	✓
Edinburgh Roseburn	✓	✓	Peebles	✓	✓
Edinburgh Salamander St	✓	✓	Perth Atholl Street	✓	✓
Edinburgh St John's Road	✓	✓	Perth Crieff	✓	✓
Edinburgh St Leonards	✓	✓	Perth High Street	✓	✓
Eskdalemuir	✓	✓	South Ayrshire Ayr High St	✓	✓
Falkirk Grangemouth MC	✓	✓	South Ayrshire Maybole	✓	✓
Falkirk Haggs	✓	✓	South Lanarkshire East Kilbride	✓	✓
Falkirk Hope St	✓	✓	South Lanarkshire Glespin	✓	✓
Falkirk Park St	✓	✓	South Lanarkshire Raith Interchange	✓	✓
Falkirk West Bridge Street	✓	✓	Stirling Craig's Roundabout	✓	✓
Fife Cupar	✓	✓	Strath Vaich	✓	✓
Fife Dunfermline	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Kirkcaldy	✓	✓	West Lothian Broxburn	✓	✓
Fife Rosyth	✓	✓	West Lothian Linlithgow High Street	✓	✓
Fort William	✓	✓	West Lothian Whitburn	✓	✓

5.4.2 Data ratification

Data ratification is undertaken on 6-month data blocks at 6-monthly intervals. Hence, as with the intercalibrations 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 2011 have now been uploaded to the Scottish Air Quality website and Table 5-3 summarises the ratification undertaken during 2011.

Table 5-3 Data Ratification undertaken during 2011

	Jan - Jun 2011	Jul – Dec 2011		Jan - Jun 2011	Jul – Dec 2011
Aberdeen	✓	✓	Glasgow Abercromby Street	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Anderston	✓	✓
Aberdeen King Street	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Union St	✓	✓	Glasgow Burgher Street		✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Centre	✓	✓
Alloa	✓	✓	Glasgow City Chambers	✓	
Angus Forfar	✓	✓	Glasgow Kerbside	✓	✓
Auchencorth Moss	✓	✓	Glasgow Nithsdale Road	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Bush Estate	✓	✓	Grangemouth	✓	✓
Dumbarton Roadside	✓	✓	Grangemouth Moray	✓	✓
Dumfries	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Dundee Broughty Ferry Road	✓	✓	Inverclyde Greenock Dunlop St	✓	✓
Dundee Lochee Road	✓	✓	Inverness	✓	✓
Dundee Mains Loan	✓	✓	Lerwick	✓	✓
Dundee Meadowside	✓	✓	Lerwick Staney Hill	✓	
Dundee Seagate	✓	✓	Midlothian Dalkeith	✓	✓
Dundee Union Street	✓	✓	Midlothian Pathhead	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Chapelhall	✓	✓
East Ayrshire Kilmarnock John Finnie St	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
East Ayrshire New Cumnock	✓	✓	N Lanarkshire Croy	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Cumbernauld	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Milngavie		✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Lothian Musselburgh N High St	✓	✓	North Ayrshire Irvine High St	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley Central Road	✓	✓
Edinburgh Gorgie Road	✓	✓	Paisley Glasgow Airport	✓	✓
Edinburgh Queen Street	✓	✓	Paisley Gordon Street	✓	✓
Edinburgh Queensferry Road	✓	✓	Paisley St James St	✓	✓
Edinburgh Roseburn	✓	✓	Peebles	✓	✓
Edinburgh Salamander St	✓	✓	Perth Atholl Street	✓	✓
Edinburgh St John's Road	✓	✓	Perth Crieff	✓	✓
Edinburgh St Leonards	✓	✓	Perth High Street	✓	✓
Eskdalemuir	✓	✓	South Ayrshire Ayr High St	✓	✓
Falkirk Grangemouth MC	✓	✓	South Ayrshire Maybole	✓	✓
Falkirk Haggs	✓	✓	South Lanarkshire East Kilbride	✓	✓
Falkirk Hope St	✓	✓	South Lanarkshire Glespin	✓	✓
Falkirk Park St	✓	✓	South Lanarkshire Raith Interchange	✓	✓
Falkirk West Bridge Street	✓	✓	Stirling Craig's Roundabout	✓	✓
Fife Cupar	✓	✓	Strath Vaich	✓	✓
Fife Dunfermline	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Kirkcaldy	✓	✓	West Lothian Broxburn	✓	✓
Fife Rosyth	✓	✓	West Lothian Linlithgow High Street	✓	✓
Fort William	✓	✓	West Lothian Whitburn	✓	✓

6 Air Pollution in Scotland 2011

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 2011.

- Section 6.2 - Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and lead - summary statistics for 2008 or 2009 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 the pollutants NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2 and Ozone

Tables 6-1-1 to 6-1-7 show the 2011 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 Local Air Quality 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 exceedence and estimate its extent. Where the exceedence is confirmed then the Authority will declare an Air Quality Management Area (AQMA). At present, 13 Local Authorities in Scotland have declared 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 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2011 ($\mu g\ m^{-3}$)	No. hours > 200 $\mu g\ m^{-3}$	Data capture NO_2 2011 (%)
Aberdeen Anderson Drive	ROADSIDE	23	0	95
Aberdeen Errol Place	URBAN BACKGROUND	23	0	96
Aberdeen King St	ROADSIDE	32	0	95
Aberdeen Market Street 2	ROADSIDE	40	1	95
Aberdeen Union Street	ROADSIDE	44	6	86
Aberdeen Wellington Road	ROADSIDE	51	4	94
Bush Estate	RURAL	6	0	99
Dumbarton Roadside	ROADSIDE	18	0	99
Dumfries	ROADSIDE	32	2	99
Dundee Lochee Road	ROADSIDE	74	43	39
Dundee Mains Loan	URBAN BACKGROUND	10	0	75
Dundee Meadowside	ROADSIDE	58	0	52
Dundee Seagate	KERBSIDE	52	2	81
Dundee Union Street	KERBSIDE	36	0	100
Dundee Whitehall Street	KERBSIDE	35	0	84
East Ayrshire Kilmarnock John Finnie St	ROADSIDE	33	1	85
East Ayrshire New Cumnock	URBAN BACKGROUND	9	0	57
East Dunbartonshire Bearsden	ROADSIDE	39	0	100
East Dunbartonshire Bishopbriggs	ROADSIDE	28	0	65
East Dunbartonshire Kirkintilloch	ROADSIDE	43	0	87
East Dunbartonshire Milngavie	ROADSIDE	21	0	37
East Lothian Musselburgh N High St	ROADSIDE	24	0	87
Edinburgh Gorgie Road	ROADSIDE	37	0	93
Edinburgh Queen Street	ROADSIDE	29	0	99
Edinburgh Queensferry Road	ROADSIDE	41	0	93
Edinburgh Roseburn	ROADSIDE	25	0	62
Edinburgh Salamander St	ROADSIDE	29	0	98
Edinburgh St John's Road	KERBSIDE	65	52	91
Edinburgh St. Leonards	URBAN BACKGROUND	25	0	98
Eskdalemuir	RURAL	3	0	92
Falkirk Grangemouth MC	URBAN BACKGROUND	22	0	98
Falkirk Haggs	ROADSIDE	34	0	94
Falkirk Hope St	ROADSIDE	24	0	97
Falkirk Park St	ROADSIDE	28	0	95
Falkirk West Bridge Street	ROADSIDE	38	0	61
Fife Cupar	ROADSIDE	30	0	89
Fife Dunfermline	ROADSIDE	30	0	94
Fife Kirkcaldy	ROADSIDE	19	0	89
Fife Rosyth	ROADSIDE	28	0	99
Fort William	SUBURBAN	12	0	64

Site Name	Type	Annual Average NO_2 2011 ($\mu g\ m^{-3}$)	No. hours > 200 $\mu g\ m^{-3}$	Data capture NO_2 2011 (%)
Glasgow Anderston	URBAN BACKGROUND	36	4	90
Glasgow Battlefield Road	ROADSIDE	26	20	92
Glasgow Burgher St.	ROADSIDE	35	52	41
Glasgow Byres Road	ROADSIDE	42	0	42
Glasgow Centre	URBAN CENTRE	34	0	96
Glasgow City Chambers	URBAN BACKGROUND	50	0	20
Glasgow Kerbside	KERBSIDE	72	31	98
Glasgow Waulkmillglen Reservoir	RURAL	11	0	91
Grangemouth	URBAN INDUSTRIAL	15	0	95
Grangemouth Moray	URBAN BACKGROUND	17	0	97
Inverclyde Greenock Dunlop St	ROADSIDE	19	0	99
Inverness	ROADSIDE	27	0	97
Lerwick Staney Hill	URBAN BACKGROUND	-	-	-
Midlothian Dalkeith	ROADSIDE	21	0	49
N Lanarkshire Chapelhall	ROADSIDE	41	2	99
N Lanarkshire Croy	ROADSIDE	21	0	83
N Lanarkshire Cumbernauld	ROADSIDE	30	0	94
N Lanarkshire Moodiesburn	ROADSIDE	25	0	98
N Lanarkshire Shawhead Coatbridge	ROADSIDE	36	0	100
North Ayrshire Irvine High St	KERBSIDE	31	0	89
Paisley Central Road	ROADSIDE	52	2	100
Paisley Glasgow Airport	AIRPORT	21	0	100
Paisley Gordon Street	ROADSIDE	39	1	71
Peebles	SUBURBAN	7	0	91
Perth Atholl Street	ROADSIDE	57	17	98
Perth Crieff	ROADSIDE	34	0	95
Perth High Street	ROADSIDE	27	2	94
South Ayrshire Ayr High St	ROADSIDE	20	0	84
South Ayrshire Maybole	ROADSIDE	9	0	93
South Lanarkshire East Kilbride	ROADSIDE	42	12	99
South Lanarkshire Raith Interchange	ROADSIDE	56	0	100
Stirling Craig's Roundabout	ROADSIDE	29	1	94
West Dunbartonshire Clydebank	ROADSIDE	21	0	95
West Lothian Broxburn	ROADSIDE	43	0	91
West Lothian Linlithgow High Street	ROADSIDE	18	0	100
West Lothian Whitburn	URBAN BACKGROUND	22	0	93

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

Table 6-1-1 shows nitrogen dioxide data for the 76 sites utilising automatic monitoring in 2011, although data for 13 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 63 sites with more than 75% data capture, 13 of these (13 kerbside or roadside sites) exceeded the AQS Objective for the NO_2 annual mean (40 $\mu g\ m^{-3}$). At 2 sites, the AQS Objective of not more than 18 exceedences of 200 $\mu g\ m^{-3}$ for the hourly mean was also exceeded.

One site, Aberdeen Market St 2, equaled the annual average objective, but did not exceed. Of the sites with less that 75% data capture, Dundee Lochee Road, Dundee Meadowside, Glasgow Byres Road and Glasgow City Chambers exceeded the NO_2 annual average. Two sites, Lochee Road and Glasgow Burgher Street exceeded hourly average objectives with data capture rates of 39% and 41% respectively.

The highest annual average concentrations were measured at Glasgow Kerbside, with a measured concentration of 72 µg m^{-3}. The greatest number of exceedences of the hourly mean objective was measured at Edinburgh St John's Road with 52 exceedences. Both sites sit close to extremely busy roads.

6.1.2 Particulate Matter – PM_{10}

Table 6-1-2 Ratified data annual average concentration and data capture for PM_{10} in 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2011 (µg m^{-3} gravimetric equivalent)*	No. days > 50µg m^{-3} (**)	Data capture PM_{10} 2011 (%)
Aberdeen Anderson Dr	ROADSIDE	TEOM (VCM)	16	0	98
Aberdeen Errol Place	URBAN BACKGROUND	FDMS	14	1	95
Aberdeen King St	ROADSIDE	BAM (unheated inlet)	20	8	83
Aberdeen Market St 2	ROADSIDE	BAM (unheated inlet)	22	13	94
Aberdeen Union St	ROADSIDE	TEOM (VCM)	22	4	97
Aberdeen Wellington Road	ROADSIDE	TEOM (VCM)	24	8	94
Alloa	ROADSIDE	TEOM (VCM)	16	2	99
Angus Forfar	ROADSIDE	FDMS	18	0	94
Auchencorth Moss	RURAL	Partisol	8	0	91
Auchencorth Moss PM10 PM25	RURAL	FDMS	7	0	80
Dundee Broughty Ferry Road	ROADSIDE	TEOM (VCM)	16	0	99
Dundee Lochee Road	KERBSIDE	BAM (unheated inlet)	19	2	72
Dundee Mains Loan	URBAN BACKGROUND	TEOM (VCM)	13	0	93
Dundee Meadowside	ROADSIDE	BAM (unheated inlet)	21	4	51
Dundee Seagate	KERBSIDE	BAM (unheated inlet)	16	1	62
Dundee Union Street	KERBSIDE	TEOM (VCM)	19	1	99
East Ayrshire Kilmarnock John Finnie St	ROADSIDE	BAM (unheated inlet)	20	1	87
East Ayrshire New Cumnock	URBAN BACKGROUND	BAM (unheated inlet)	11	0	83
East Dunbartonshire Bearsden	ROADSIDE	BAM (heated inlet)	20	3	97
East Dunbartonshire Bishopbriggs	ROADSIDE	BAM (heated inlet)	17	2	96
East Dunbartonshire Kirkintilloch	ROADSIDE	FDMS	19	6	91
East Dunbartonshire Milngavie	ROADSIDE	FDMS	15	1	36
East Lothian Musselburgh N High St	ROADSIDE	BAM (unheated inlet)	13	1	82
East Renfrewshire Sheddens	ROADSIDE	FDMS	14	0	89
Edinburgh Queen Street	ROADSIDE	TEOM (VCM)	16	0	94
Edinburgh Queensferry Road	ROADSIDE	FDMS	21	2	63
Edinburgh Roseburn	ROADSIDE	TEOM (VCM)	17	0	61
Edinburgh Salamander St	ROADSIDE	TEOM (VCM)	26	22	97

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2011 ($\mu g\ m^{-3}$ gravimetric equivalent)*	No. days > 50$\mu g\ m^{-3}$ (**)	Data capture PM_{10} 2011 (%)
Edinburgh St Leonards	URBAN BACKGROUND	FDMS	15	0	99
Falkirk Grangemouth MC	URBAN BACKGROUND	TEOM (VCM)	15	2	87
Falkirk Hope St	ROADSIDE	TEOM (VCM)	17	1	72
Falkirk Park St	ROADSIDE	TEOM (VCM)	16	2	93
Falkirk West Bridge St	ROADSIDE	TEOM (VCM)	19	5	76
Fife Cupar	ROADSIDE	FDMS	19	0	85
Fife Dunfermline	ROADSIDE	FDMS	16	0	64
Fife Kirkcaldy	ROADSIDE	FDMS	13	0	85
Fife Rosyth	ROADSIDE	FDMS	20	3	93
Glasgow Abercromby Street	ROADSIDE	FDMS	18	9	95
Glasgow Anderston	URBAN BACKGROUND	TEOM (VCM)/FDMS	16**	2	65
Glasgow Battlefield Road	ROADSIDE	TEOM (VCM)	17	6	91
Glasgow Broomhill	ROADSIDE	FDMS	18	6	95
Glasgow Burgher St.	ROADSIDE	FDMS	20	10	40
Glasgow Byres Road	ROADSIDE	TEOM (VCM)/FDMS	28**	2	31
Glasgow Centre	URBAN CENTRE	FDMS	17	2	91
Glasgow Kerbside	KERBSIDE	FDMS	18	0	43
Glasgow Nithsdale Road	ROADSIDE	FDMS	18	6	99
Glasgow Waulkmillglen Reservoir	RURAL	TEOM (VCM)	12	0	84
Grangemouth	URBAN INDUSTRIAL	FDMS	14	2	99
Grangemouth Moray	URBAN BACKGROUND	TEOM (VCM)	15	0	74
Inverclyde Greenock Dunlop Street	ROADSIDE	TEOM (VCM)	14	0	99
Inverness	ROADSIDE	Partisol	12	0	88
Midlothian Dalkeith	ROADSIDE	TEOM (VCM)	23	0	44
Midlothian Pathead	KERBSIDE	TEOM (VCM)	17	1	85
N Lanarkshire Chapelhall	ROADSIDE	TEOM (VCM)	19	6	91
N Lanarkshire Coatbridge Whifflet	URBAN BACKGROUND	TEOM (VCM)	15	1	91
N Lanarkshire Croy	ROADSIDE	TEOM (VCM)	15	1	83
N Lanarkshire Moodiesburn	ROADSIDE	BAM (unheated inlet)	17	4	74
N Lanarkshire Motherwell	ROADSIDE	TEOM (VCM)	19	5	83
N Lanarkshire Shawhead Coatbridge	ROADSIDE	BAM (unheated inlet)	19	3	89
North Ayrshire Irvine High St	KERBSIDE	BAM (unheated inlet)	18	0	94
North Lanarkshire Cumbernauld	URBAN BACKGROUND	TEOM (VCM)	14	1	83
Paisley Gordon Street	ROADSIDE	FDMS	16	6	89
Paisley St James Street	ROADSIDE	FDMS	17	4	94
Perth Atholl Street	ROADSIDE	TEOM (VCM)	25	17	99
Perth Creiff	ROADSIDE	BAM (unheated inlet)	19	0	92
Perth High Street	ROADSIDE	TEOM (VCM)	19	3	99
South Ayrshire Ayr High St	ROADSIDE	FDMS	13	0	53
South Ayrshire Maybole	ROADSIDE	FDMS	13	0	87
South Lanarkshire East Kilbride	ROADSIDE	FDMS	16	2	94

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2011 ($\mu g\ m^{-3}$ gravimetric equivalent)*	No. days > 50$\mu g\ m^{-3}$ (**)	Data capture PM_{10} 2011 (%)
South Lanarkshire Glespin	ROADSIDE	FDMS	9	0	59
South Lanarkshire Raith Interchange	ROADSIDE	FDMS	26	21	82
Stirling Craig's Roundabout	ROADSIDE	TEOM (VCM)	16	1	89
West Dunbartonshire Clydebank	ROADSIDE	TEOM (VCM)	17	5	92
West Lothian Broxburn	ROADSIDE	FDMS	18	3	94
West Lothian Linlithgow High St	ROADSIDE	FDMS	13	1	94
West Lothian Whitburn	URBAN BACKGROUND	FDMS	13	2	82

* 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
** Weighted average of FDMS and VCM corrected TEOM data
Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedence of Scottish Air Quality Objectives

Table 6-1-2 shows the 2011 gravimetric equivalent particulate matter PM_{10} data from 76 sites utilising automatic monitoring and the Partisol daily sampler. Of these sites, 17 have less than 75% data capture. As discussed in Section 4.2.2, all TEOM data have been adjusted using the VCM.

Of the 60 sites with more than 75% data capture, 19 sites exceeded the Annual Average PM_{10} Objective of 18 $\mu g\ m^{-3}$ and a further 6 equaled this Objective. Of these sites 7 also exceeded the Daily Objective of 50 $\mu g\ m^{-3}$ not to be exceeded more than 7 times a year.

The maximum PM_{10} annual mean concentration was measure at Edinburgh Salamander Street with a measured concentration of 26 $\mu g\ m^{-3}$ and 22 exceedences of the daily mean objective.

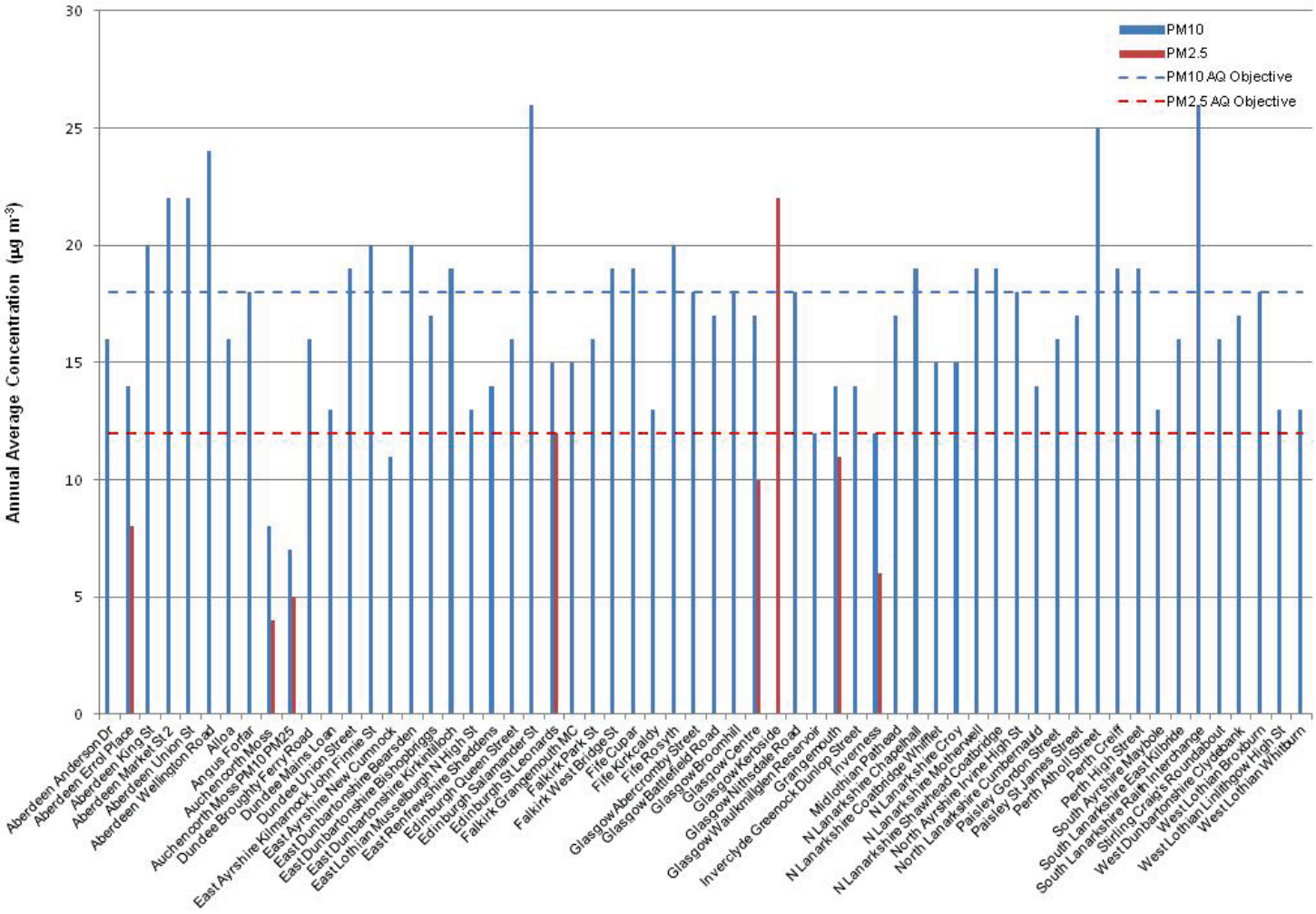
Of the 14 sites with less than 75% data capture, 6 sites exceeded the Annual Average PM_{10} Objective of 18 $\mu g\ m^{-3}$. Of these sites 1, Glasgow Burgher Street, also exceeded the Daily Objective of 50 $\mu g\ m^{-3}$ not to be exceeded more than 7 times a year.

No site exceeded the UK AQS Objective of 40μgm^{-3} for the annual mean PM_{10} or the daily objective of 35 exceedences of 50 $\mu g\ m^{-3}$.

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 and Auchencorth Moss PM_{10} $PM_{2.5}$ for measurements using Partisols and FDMS respectively. As can be seen both methods measured similar annual average concentrations with 8 $\mu g\ m^{-3}$ and 7 $\mu g\ m^{-3}$ measured at the Partisol and FDMS sites respectively. No exceedences of the daily objective were measured at the two sites.

Figure 6-1-1 shows the 2011 Annual Average PM_{10} and $PM_{2.5}$ concentrations for all SAQD monitoring sites with more than 75% data capture.

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 2011



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 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	$PM_{2.5}$ Analyser Type	Annual Average $PM_{2.5}$ 2011 (µg m^{-3} gravimetric equivalent)	Data capture $PM_{2.5}$ 2011 (%)
Aberdeen Errol Place	Urban Background	FDMS	8	91
Auchencorth Moss	Rural	Partisol	4	99
Auchencorth Moss PM_{10} $PM_{2.5}$	Rural	FDMS	5	98
Edinburgh St Leonards	Urban Background	FDMS	12	98
Glasgow Centre	Urban Background	FDMS	10	94
Glasgow Kerbside	Kerbside	FDMS	22	90
Grangemouth	Urban Industrial	FDMS	11	92
Inverness	Roadside	Partisol	6	91

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 seven sites in Scotland are therefore available for all or part of 2011.

All $PM_{2.5}$ sites achieved a data capture rate of greater than 90%. The Scottish AQS Objective of 12 µg m^{-3} was exceeded at Glasgow Kerbside and equalled at Edinburgh St Leonards with data capture rates of 90% and 98% respectively. Figure 6-1-1 shows the 2011 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 $PM_{2.5}$ (and PM_{10}). The results from the Partisol sampler and FDMS analyser are similar with annual average concentrations of 5 µg m^{-3} and 4 µg m^{-3} measured respectively.

The $PM_{2.5}/PM_{10}$ ratios calculated for each site for the years 2009, 2010 and 2011 are shown in Table 6-1-4. The highest $PM_{2.5}/PM_{10}$ ratios during 2011 for sites with greater than 75% data capture was calculated at Edinburgh St Leonards and Grangemouth with calculated ratios of 0.80 and 0.79 respectively. The data capture rate for PM_{10} at Glasgow Kerbside was 43% and therefore the ratio of 1.22 is not an accurate representation of $PM_{2.5}$ and PM_{10} ratio at this site.

Table 6.1.4 $PM_{2.5}/PM_{10}$ ratios for 2011 annual average concentrations

Site Name	Annual Average PM_{10} 2011 (µg m^{-3} gravimetric equivalent)	Annual Average $PM_{2.5}$ 2011 (µg m^{-3} gravimetric equivalent)	Ratio 2011	Ratio 2010	Ratio 2009
Aberdeen Errol Place	14	8	0.57	0.54	0.47
Auchencorth Moss (Partisol)	7	5	0.71	0.50	0.64
Auchencorth Moss PM_{10} $PM_{2.5}$	8	4	0.50	0.57	0.51
Edinburgh St Leonards	15	12	0.80	0.64	0.50
Glasgow Centre	17	10	0.59	0.52	0.46
Glasgow Kerbside	18	22	1.22	0.79	0.81
Grangemouth	14	11	0.79	0.79	0.68
Inverness (Partisol)	12	6	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 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2011 (mg m^{-3})	Max. Running 8hr Mean CO 2011 (mg m^{-3})	Data capture CO 2011 (%)
Edinburgh St Leonards	Urban Background	0.2	0.8	96
Glasgow Anderston	Urban Background	0.1	1.1	91
Glasgow Byres Road	Roadside	0.3	1.7	42
Glasgow Centre	Urban Centre	0.2	1.1	98
N Lanarkshire Croy	Urban Background	0.2	2.0	95

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 5 sites during 2011. 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 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average SO_2 2011 ($\mu g\ m^{-3}$)	No. Exceed 15min SO_2 2011 ($\mu g\ m^{-3}$)	No. Exceed 1hr SO_2 2011 ($\mu g\ m^{-3}$)	NO. Exceed 24hr SO_2 2011 ($\mu g\ m^{-3}$)	Data capture SO_2 2011 (%)
Dundee Broughty Ferry Road	Roadside	6	0	0	0	83
Edinburgh St Leonards	Urban Background	3	0	0	0	98
Falkirk Grangemouth MC	Urban Background	5	6	0	0	98
Falkirk Hope St	Roadside	2	0	0	0	98
Falkirk Park St	Roadside	3	0	0	0	95
Glasgow Anderston	Urban Background	3	0	0	0	91
Glasgow Centre	Urban Centre	2	0	0	0	98
Grangemouth	Urban Industrial	7	36	2	0	97
Grangemouth Moray	Urban Background	13	72	1	2	97
Lerwick Staney Hill	Urban Background	2	0	0	0	28
Midlothian Dalkeith	Roadside	2	0	0	0	50
Midlothian Pathhead	Kerbside	6	0	0	0	94
N Lanarkshire Croy	Roadside	1	17	0	0	87
N Lanarkshire Cumbernauld	Urban Background	3	0	0	0	92

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

Table 6-1-6 shows sulphur dioxide data from the 14 sites utilising automatic monitoring for 2011. Sites at Midlothian Dalkeith and Lerwick Staney Hill were only operated for part of the year. All sites in Scotland met the requirements of the Air Quality Strategy for 1-hour and 24-hour mean SO_2 in 2011. All except two sites, Grangemouth (36 exceedences) and Grangemouth Moray (72 exceedences), met the requirements of the Air Quality Strategy for 15-minute mean, where 35 exceedences are permitted.

6.1.6 Ozone

Table 6-1-7 Ratified data annual average concentration and data capture for O_3 in 2011 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average O_3 2011 ($\mu g\ m^{-3}$)	No of days with running 8-hr mean >100 ug m^{-3}	Data capture O_3 2011 (%)
Aberdeen Errol Place	Urban Background	42	4	96
Auchencorth Moss	Rural	56	6	99
Bush Estate	Rural	59	12	99
Edinburgh St Leonards	Urban Background	40	0	99
Eskdalemuir	Rural	53	10	93
Fort William	Suburban	54	7	98
Glasgow Centre	Urban Centre	34	2	98
Glasgow Waulkmillglen Reservoir	Rural	54	9	95
Lerwick	Rural	69	13	99
Peebles	Suburban	54	10	97

Site Name	Type	Annual Average O_3 2011 ($\mu g\ m^{-3}$)	No of days with running 8-hr mean >100 ug m^{-3}	Data capture O_3 2011 (%)
Strath Vaich	Remote	64	14	97

Highlighted figures (in yellow) indicate exceedence of Scottish Air Quality Objectives

Table 6-1-7 shows ozone data from 11 sites utilising automatic monitoring for 2011. 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 2011, the air quality objective of not more than 10 days with a maximum 8hr running mean greater than 100 $\mu g\ m^{-3}$ was exceeded at Bush Estate, Lerwick and Strath Vaich. Exactly 10 days with a maximum 8hr running mean greater than 100 $\mu g\ m^{-3}$ were measured at Eskdalemuir and Peebles. All sites achieved a data capture rate of greater than 90%.

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 2010. 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[9]

The UK Monitoring and Analysis Network monitors some 39 Polyaromatic 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 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.

[9] 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 27/05/11]

Table 6-2-1. PAH Monitoring Sites in Scotland

Site	Address	Grid Reference
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow	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 2010 and 2011 are shown in Table 6-2-2. This table shows that the Air Quality Objective for B(a)P of 0.25 ng m^{-3} annual average was exceeded at Glasgow Centre and Kinlochleven 2 in 2010, and at Kinlochleven 2 in 2011. 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 2010 - 2011 at 4 sites in Scotland

Site	2010 Annual Mean B(a)P Concentration (ng m^{-3})	2011 Annual Mean B(a)P Concentration (ng m^{-3})
Auchencorth Moss A	0.034	0.022
Edinburgh St Leonards	0.130	0.099
Glasgow Centre	0.251	0.196
Kinlochleven 2	0.272	0.284

6.2.2 Benzene

Non- automatic hydrocarbon monitoring[10]

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 2010 and 2011 are provided in Table 6-2-3. Non-automatic monitoring of benzene started at Glasgow Kerbside on 1st September 2010. The data for 2011 are provisional from 13/10/1201 and 01/01/2011 for Glasgow Kerbside and Grangemouth respectively.

Table 6-2-3 Annual Mean Benzene Concentrations at Grangemouth in 2010 and 2011

Site Name	Annual Mean benzene for 2010 (µg m^{-3})	Annual Mean benzene for 2011 – Provisional (µg m^{-3})
Glasgow Kerbside	1.07	0.90
Grangemouth	1.42	1.34

Shaded sites indicate data only available for part year

[10] Butterfield D. et al UK Non-Automatic Hydrocarbon Network: Annual Report for 2009 [online]
Available at http:\\uk-air.defra.gov.uk/reports/cat13/1006040944_NPL_Report_AS_50.pdf%20 [Accessed on 27/05/11]

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.scottischairquality.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 Glasgow Kerbside and Auchencorth Moss sites in the UK Automatic Hydrocarbon Network, for 2011

Site	2011 Benzene Annual mean concentration ($\mu g\ m^{-3}$)	2011 Benzene Maximum running annual concentration ($\mu g\ m^{-3}$)	2011 % Data Capture
Auchencorth Moss	0.21	0.31	54

Table 6-2-3 and 6-2-5 indicate that it is unlikely that the EU limit value for benzene of 5 $\mu g\ m^{-3}$ was exceeded at Auchencorth Moss and that the Scottish Objective of 3.25 $\mu g\ m^{-3}$ for the annual running mean concentration is also unlikely to be exceeded. Please note that the data capture for 2011 is 54% and therefore these statistics are for indication only.

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 Glasgow Kerbside and Auchencorth Moss sites in the UK Automatic Hydrocarbon Network, for 2011

Site	2011 1,3-butadiene Annual mean concentration ($\mu g\ m^{-3}$)	2011 1,3-butadiene Maximum running annual concentration ($\mu g\ m^{-3}$)	2011 % Data capture
Auchencorth Moss	0.02	0.03	38

Table 6-2-6 indicates that it is unlikely that the Air Quality Objective for 1,3-butadiene of 2.25$\mu g m^{-3}$ has been exceeded in Scotland in 2011. There is no EU target or limit value covering 1,3-butadiene. Please note that the data capture for 2011 is 38% and therefore these statistics are for indication only.

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 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[11]

Monitoring of metals in urban areas is undertaken to determine compliance with the EU Directive 2004/107/EC 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 2010 and 2011.

Table 6-2-7 Heavy Metals Monitoring Network Sites in Scotland 2010

Site	Site type and grid ref	Address	Metals measured
Eskdalemuir	Rural 323552,603018	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
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 2010 - 2011 (ng m^{-3}) (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})	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Eskdalemuir	1.3	1.16	0.15	0.39	0.14	0.10	0.02	0.02	0.004	0.006	1.69	1.50
Motherwell South	16.8	2.22	0.32	0.37	0.76	0.22	0.24	0.05	0.009	0.006	2.94	1.53

* mercury in particulate phase
\+ total gaseous mercury

Rural Heavy Metals[12]

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 2 sites in Scotland are provided in Table 6-2-9 and data for the measurement of lead in 2010 are provided in Table 6-2-10 *(2011 data were not available at the time of writing this report)*.

[11] Brown R et al Annual Report for 2010 on the UK Heavy Metals Monitoring Network
http://uk-air.defra.gov.uk/reports/cat13/1106300827_Defra_UK_Heavy_Metals_Network_Annual_Report_2010_FINAL2.pdf
[12] Fowler D. Et al UK Heavy Metal Monitoring Network
http://nora.nerc.ac.uk/3323/1/FowlerN003323CR.pdf

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	NO676985

Table 6-2-10 Annual Mean metal concentrations 2010 (ng m^{-3}) (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 Concentration (ng m^{-3})
Auchencorth Moss	2.576	0.523	0.052	0.294	0.644
Banchory	2.925	0.548	0.311	0.066	2.422

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 both the UK air quality website (http://uk-air.defra.gov.uk/) and the Scottish air quality website (www.scottishairquality.co.uk)

The NO_2 diffusion tube data, for 2010, available in the Scottish Database are summarised in Table 6-3-1 *(2011 data were incomplete at the time of writing this report)*.

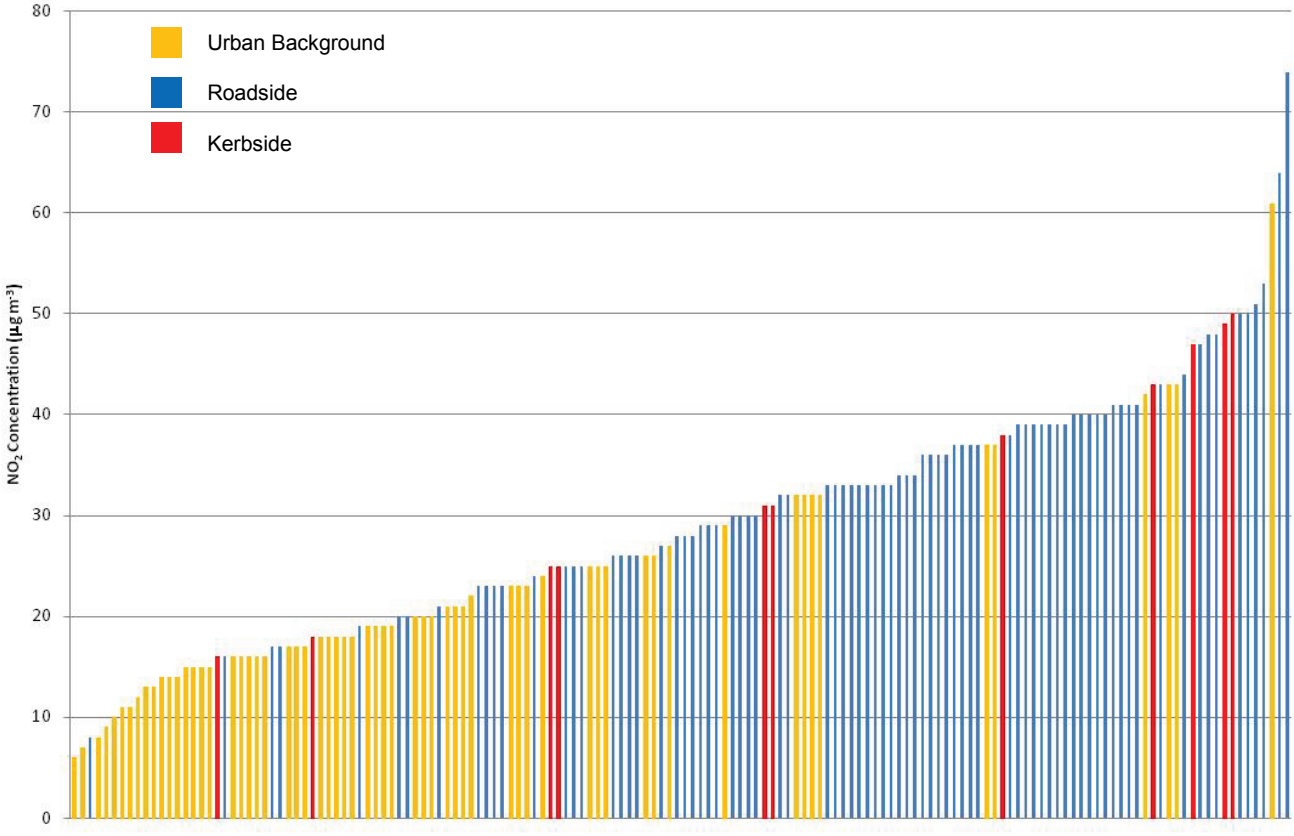
Table 6-3-1 Number of monitoring sites with valid annual mean for 2010 by local authority and site type

Local Authority	UB	INT	RS	KS	Total
Aberdeenshire	6	0	8	0	14
Clackmannanshire	2	0	2	0	4
Dundee	2	0	2	0	4
East Dunbartonshire	4	0	18	0	22
East Renfrewshire	1	0	2	0	3
Edinburgh	2	0	2	0	4
Falkirk	2	0	2	0	4
Fife	2	0	4	12	18
Highland	0	0	0	0	0
Midlothian	2	0	2	0	4
North Ayrshire	2	0	2	0	4
North Lanarkshire	19	0	15	0	34
Scottish Borders	5	0	6	0	11
South Ayrshire	1	0	2	1	4
South Lanarkshire	4	0	3	0	7
Stirling	2	0	2	0	4
West Dunbartonshire	4	0	4	0	8
West Lothian	2	0	2	0	4
Total:	62	0	79	13	154

A clear limitation in undertaking analysis of these data is that all the diffusion tube data provided are **not bias corrected**. Bias correction of diffusion tube data is required as the tubes may over, or underestimate concentrations and Authorities will have calculated a local bias correction factor, or used an appropriate national factor, prior to using the diffusion tube data in their LAQM review and assessment reports.

Hence, to avoid confusion, detailed analysis of these data will not be undertaken. However, an overview of all the data is provided in Figure 6-3-1 to give an indication of NO_2 concentrations throughout Scotland.

Figure 6-3-1 Summary of NO_2 diffusion tube results for Scotland 2010
Note – These data are NOT bias corrected



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

6.3.2 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

6.3.3 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 2010; 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.

A selection of statistics for Auchencorth Moss can be downloaded in spreadsheet format from http://uk-air.defra.gov.uk/

6.3.4 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)).

6.3.5 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 two sites in Scotland, Auchencorth Moss and Banchory, 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).

6.3.6 United Kingdom Eutrophying & Acidifying Pollutants Network[13] (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 UK wide scale, however with differing spatial and temporal resolution which reflects the spatial and temporal heterogeneiety of the atmospheric pollutant concerned.

Data from the UKEAP Network can be downloaded from http://pollutantdeposition.defra.gov.uk/ukeap.

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 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).

Nitrogen dioxide is measured with diffusion tube samplers at 9 sites in Scotland. The annual average concentrations measured in 2010 are provided in Table 6-3-1 (*2011 data were not available at the time of writing this report)*.

[13] For information on this network see http://www.uk-pollutantdeposition.ceh.ac.uk/ukeap

Table 6-3-1 NO_2 annual average concentrations 2010 at rural monitoring sites

Site	NO_2 (ug m^{-3})	Data Capture (%)
Allt a'Mharcaidh	2.7	83
Balquhidder 2	3.0	100
Eskdalemuir	4.6	100
Forsinain 2	6.5	100
Glensaugh	3.1	100
Loch Dee	2.9	100
Polloch	1.4	100
Strathvaich Dam	1.1	100
Whiteadder	5.9	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 NH_3 and NH_4^+ (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 provides mapped concentrations of pollutants on a 1 x 1 km square grid basis. These pollution maps combine measurement data (from Scotland's network of air quality monitoring stations) with the spatially disaggregated emissions information from the National Atmospheric Emissions Inventory (NAEI), to 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.

There are now sufficient monitoring sites in the SAQD for mapping to be undertaken for NO_2 and PM_{10} throughout Scotland, using only the Scottish data. Hence the PCM methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2010 (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 pollution data used in the maps presented here consists of appropriately scaled PM_{10} monitoring data (FDMS, Partisol and VCM-corrected TEOM data) and automatic monitoring data for NO_X and NO_2 in 2010. This is combined with Scottish meteorology data (from RAF Leuchars) to create the Scotland-specific model.

In 2009 RICARDO-AEA undertook a short study[14] 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 2010

The details of the methodology and full results of the mapping study are provided in a separate report[15]. In this report, we summarise the main findings of this work.

7.1.1 NO_2 maps for 2010

The 2010 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.

[14] 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

[15] Lingard, J.J.N (2011). Scottish Air Quality Maps. Pollutant modelling for 2010 and projected concentrations for 2015, 2020 and 2030: annual mean NO_X, NO_2, and PM_{10}. AEAT/ENV/R3156 Issue 1.

Figure 7-1 Background NO_2 map for 2010, µg m^{-3} (Scotland-specific model).

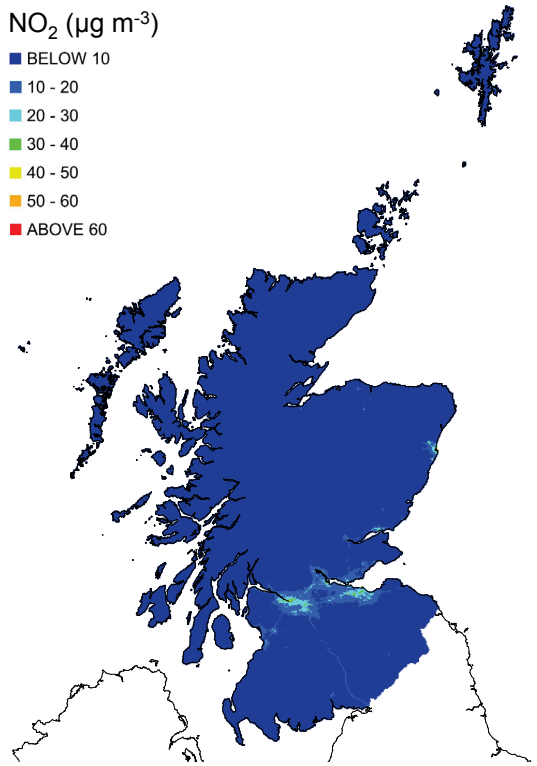
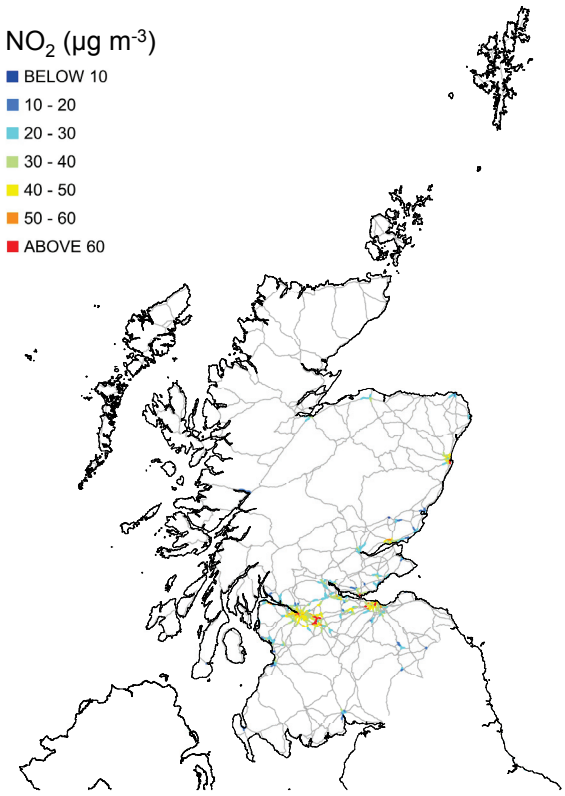


Figure 7-2 Roadside NO_2 map for 2010, µg m^{-3} (Scotland-specific model).



7.1.2 PM_{10} maps for 2010

2010 annual mean PM_{10} concentrations for Scotland were modeled for background and roadside locations. The modeling 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 (e.g., sulphate, nitrate, ammonium-based particles, SIA)
- 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 modeled 2010 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 2010, µg m^{-3} (Scotland-specific model).

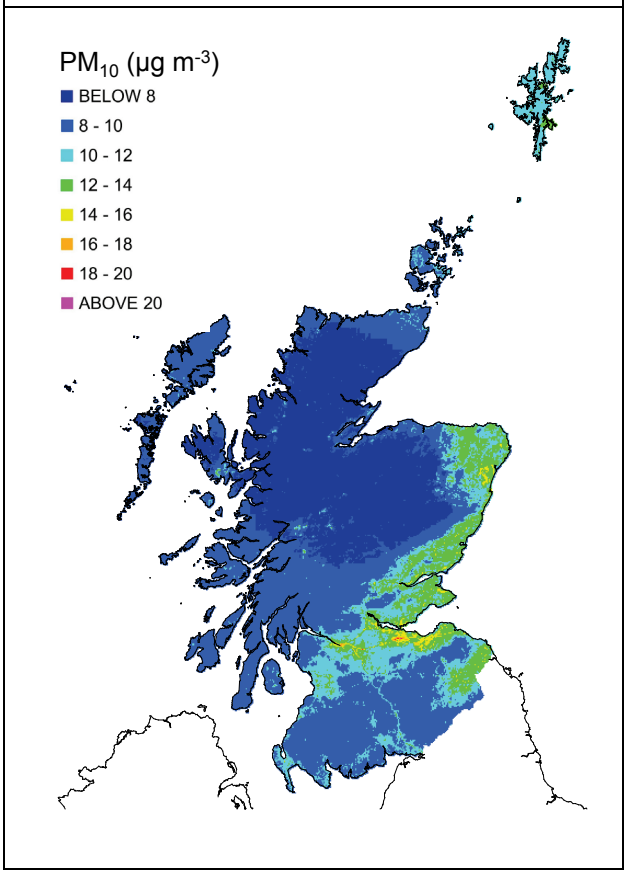
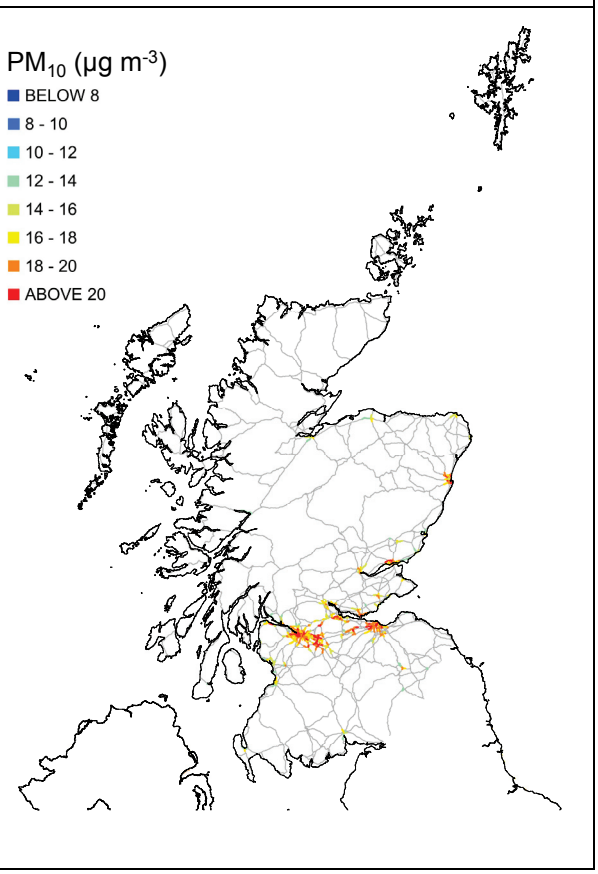


Figure 7-4 Roadside PM_{10} map for 2010, µg m^{3} (Scotland-specific model).



7.1.3 NO_2 Scotland-specific pollutant projections for 2015 to 2030

For the purpose of forward projection assessment, maps have been produced showing projected annual mean concentrations of NO_X and NO_2 for future years. These indicate how background concentrations of this pollutant might be expected to change in the future. This series of maps now covers five year intervals from 2010 up to 2030. The latest versions of these have been produced according to the UK methodology, using Scotland-specific data. The base year used was 2009.

Figure 7-5, Figure 7-6 Figure 7-7 and Figure 7-8 show the projected background annual mean NO_2 concentrations for 2015, 2020, 2025 and 2030. These maps predict a progressive decrease in the background annual mean concentration between 2010 and 2030; by 2030 it is predicted that, away from roadsides or other specific sources, annual mean concentrations greater than 20 µg 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 (see main report of the mapping work, reference 20, for more details).

Figure 7-5 Background NO_2 map for 2015, µg m^{-3} (Scotland-specific model).

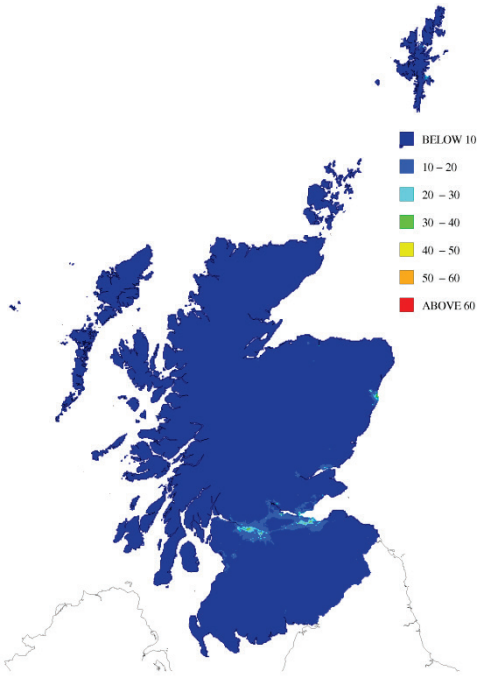


Figure 7-6 Background NO_2 map for 2020, µg m^{-3} (Scotland-specific model).

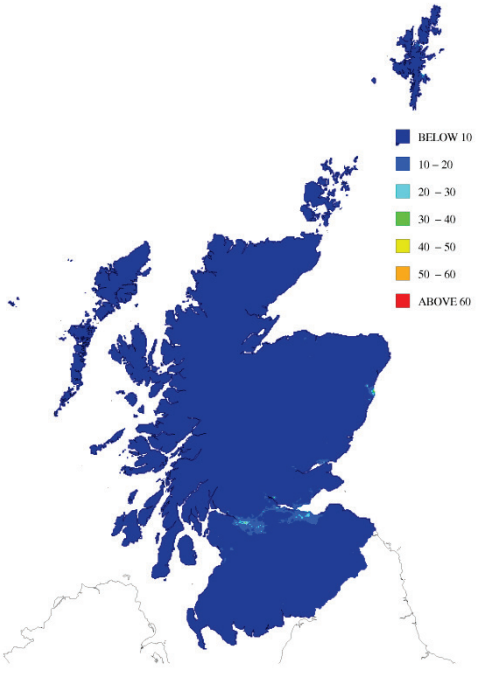


Figure 7-7 Background NO_2 map for 2025, µg m^{-3} (Scotland-specific model).

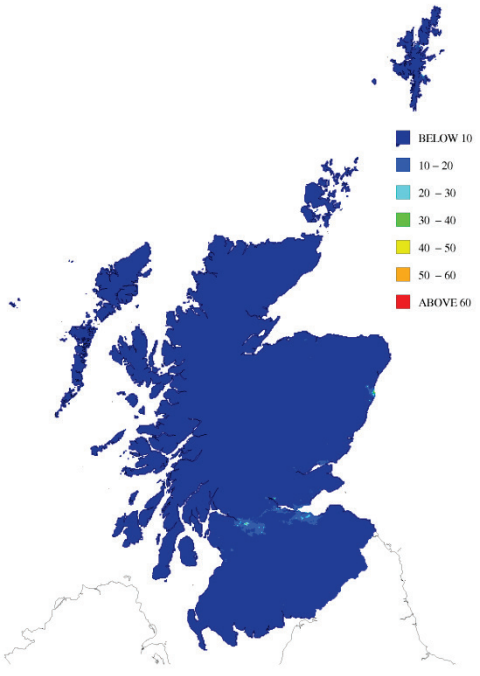
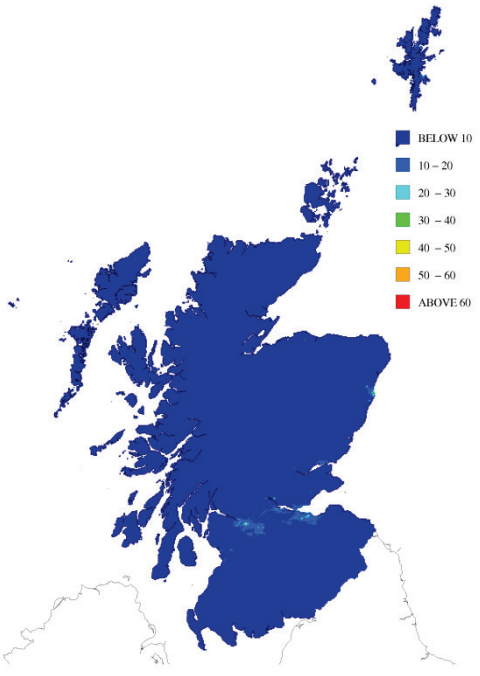


Figure 7-8 Background NO_2 map for 2030, µg m^{-3} (Scotland-specific model).



7.1.4 PM_{10} Scotland-specific pollutant projections for 2015 to 2030

Maps of projected annual mean concentrations have also been produced for PM_{10}. These also cover years 2010, 2015, 2020, 2025 and 2030, from a base year of 2009, and were also produced according to the UK methodology, using Scotland-specific data.

Figure 8-9, Figure 8-10, Figure 8-11 and Figure 8-12 show the background maps of projected annual mean PM_{10} concentration for 2015, 2020, 2025 and 2030. Like NO_2, annual mean background concentrations of PM_{10} are predicted to decrease between 2010 and 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 $\mu g\ m^{-3}$, shaded light blue and green on the maps) are predicted to persist along the eastern coast of Scotland. This is believed to be due to enhancements in the annual mean background PM_{10} concentrations due to contributions from wind-blown soil dusts.

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 (see main report of the mapping work, reference 20, for more details).

Figure 7-9 Background PM_{10} map for 2015, µg m^{-3} (Scotland-specific model).

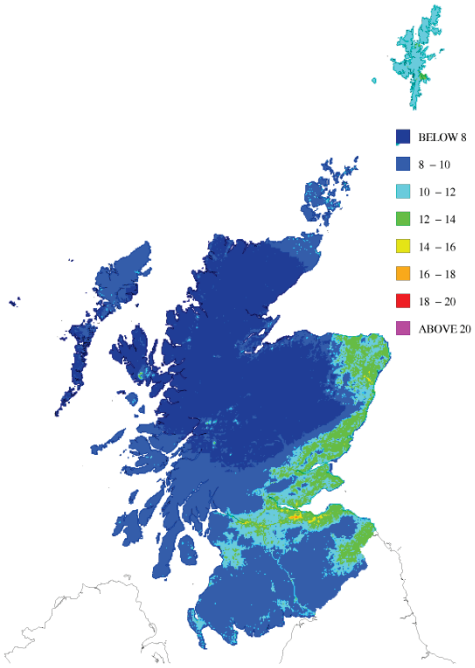


Figure 7-10 Background PM_{10} map for 2020, µg m^{-3} (Scotland-specific model).

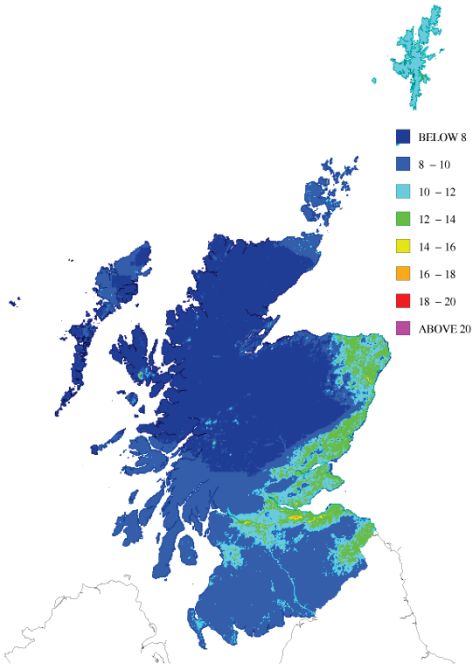


Figure 7-11 Background PM_{10} map for 2025, µg m^{-3} (Scotland-specific model).

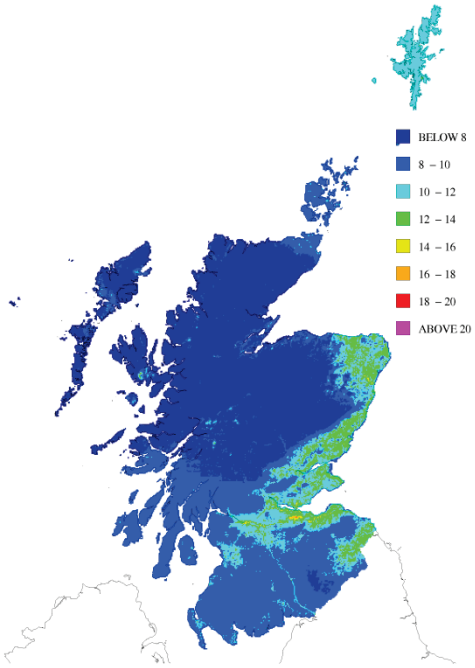
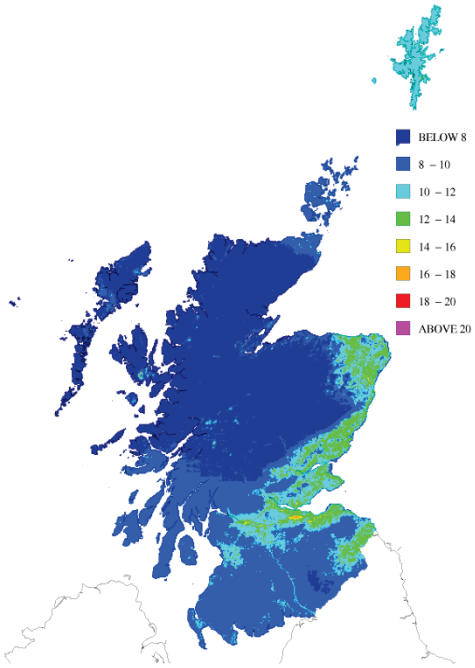


Figure 7-12 Background PM_{10} map for 2030, µg m^{-3} (Scotland-specific model).



8 Air Quality Trends for Scotland

This section of the report summarises how air quality in Scotland has changed in recent years. The section 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 early 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 2007. 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 due to the changes in the number of sites (and their distribution). Therefore, this year (as in 2010), 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, so all the sites included here have been in operation since at least 2007.

8.1 Oxides of Nitrogen and Nitrogen Dioxide

In Scotland (as elsewhere in the UK) the largest number of AQMAs are currently declared based on exceedances of the annual mean NO_2 objective of 40 μgm^{-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. Changes in NO_2 over time cannot be considered without also taking into account the variations in total NO_x concentrations, since a large proportion of NO_2 is formed from the oxidation of NO emitted from sources such as vehicle tailpipes or industrial chimneys. At roadside locations direct emissions of NO_2 are also important; the effect of these is discussed in more detail later in this section.

8.1.1 NO_x and NO_2 at Urban Background Sites

Figure 8-1 illustrates the variation in measured annual mean NO_x concentrations at long-running urban background monitoring stations since automatic measurements began in Scotland in 1987. The chart shows data from the following long-running sites:

- Glasgow City Chambers – from 1987 until 2010 (its last full year of operation)
- Glasgow Centre from 1997, but excluding 2009 and 2010 because the results for those two years are thought to have been affected by emissions from a diesel generator associated with an annual Christmas Market near the site. (In 2011, the generator was sited elsewhere, for this reason).
- Edinburgh Centre, in operation from 1993 to 2002 (its first and last full years of operation)
- The mean NO_x concentration as measured by a subset of three long-running sites in operation since 2004; Aberdeen, Edinburgh St Leonards and Grangemouth
- The mean NO_x concentration from five long-running sites in operation since 2007: Aberdeen, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth.

Only sites that have been in operation for at least five years are included, and the minimum annual data capture is 70% (except Fort William in 2011, which has been included with a data capture of 64%).

Prior to 2000, the three long-running sites in this category (Glasgow City Chambers, Edinburgh Centre and Glasgow Centre) indicate a long-term improvement in NO_x concentrations. Since then, data from other sites appear to indicate a flattening-off of this downward trend.

From 2004 onwards, the average NO_x concentration based on data from the three long-running sites (Aberdeen, Edinburgh St Leonards and Grangemouth) is shown in the chart by the green line. This indicates that average NO_x concentrations have been relatively stable from 2004, although possibly increasing around 2007. 2011 appears to have been a lower year for NO_x, after a high year in 2010. A similar pattern is shown by the subset of four sites in operation since 2007.

Figure 8-1. Time Series of Annual Mean NOx Concentration at Urban Background sites in Scotland: 1987 - 2011

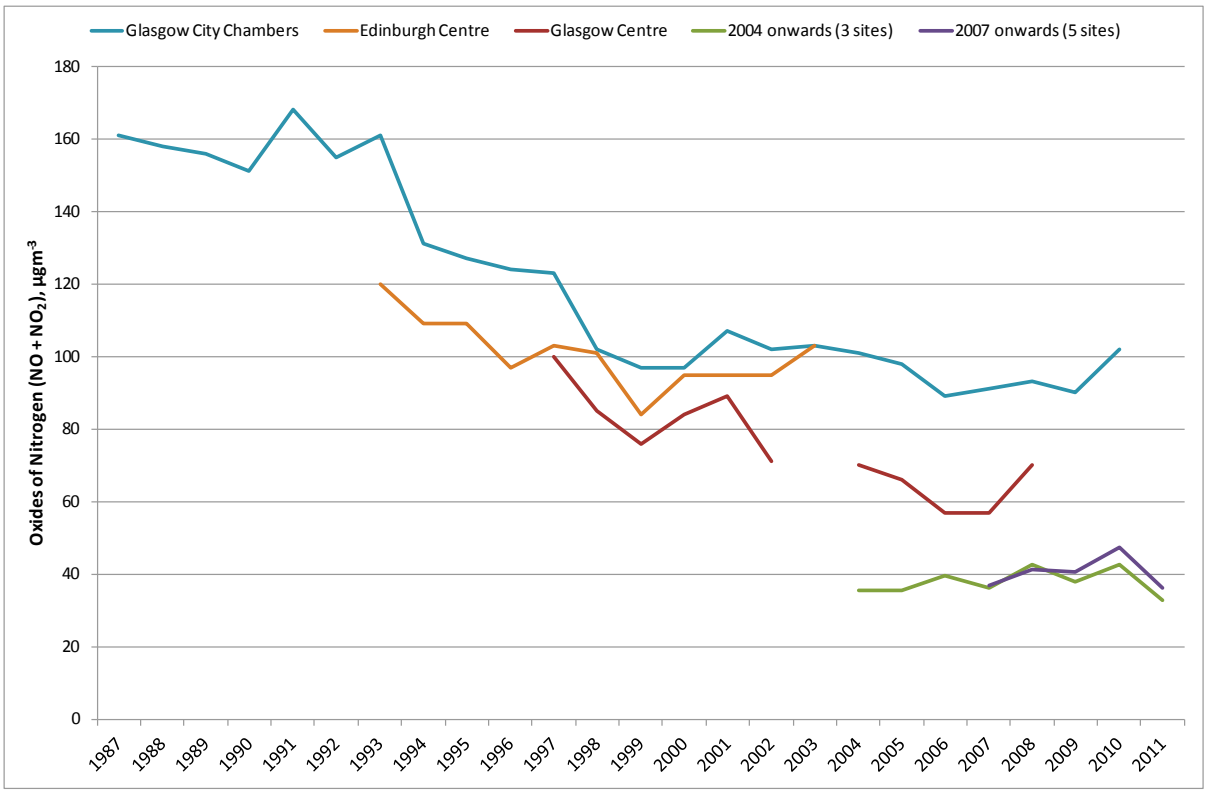
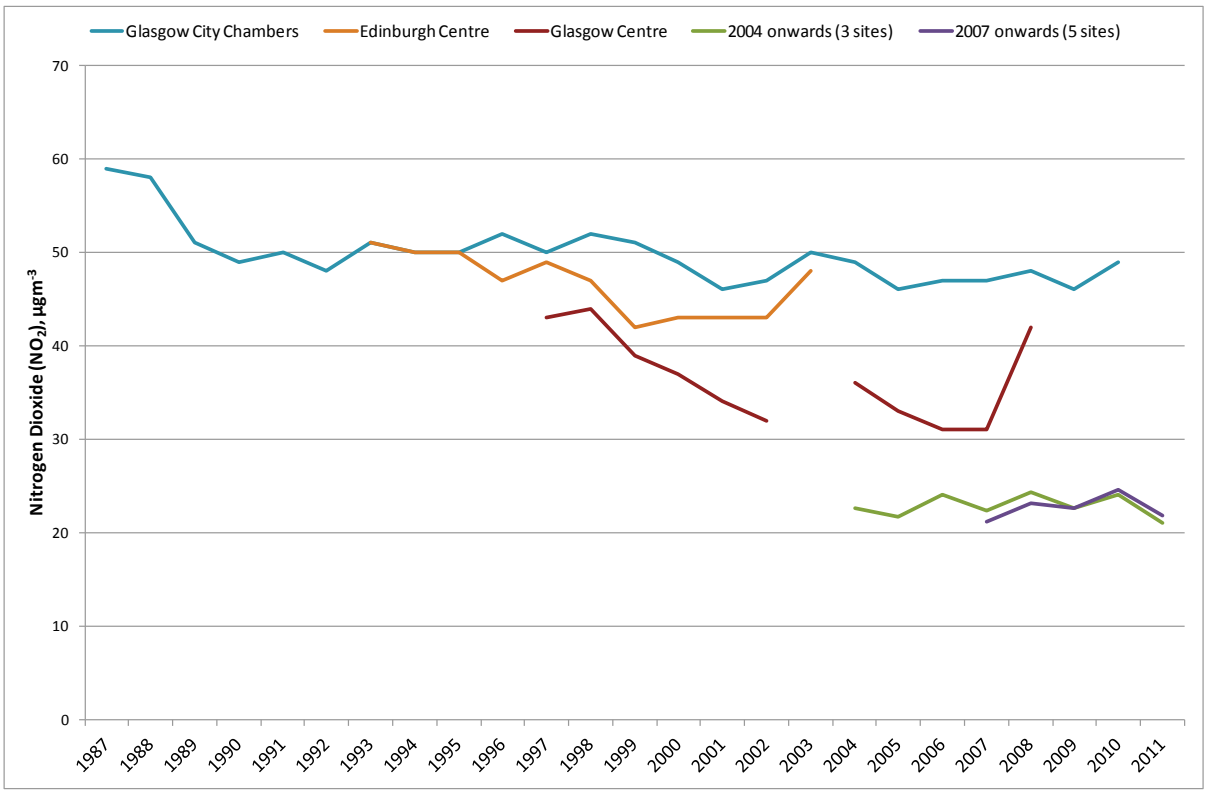


Figure 8-2 shows how annual mean concentrations of NO_2 have changed, at the same set of long-running urban background monitoring sites. Glasgow City Chambers (which has been operating for over 20 years) shows a general decline in NO_2, but the decrease is much more gradual than concentrations of NO_x. Similarly, Edinburgh Centre (between 1993 and 2002) and Glasgow Centre (1997 to 2008) show a less clear downward trend for NO_2 than for NOx. The mean for the three long-running sites in operation since 2004 (Aberdeen, Edinburgh St Leonards and Grangemouth) indicates that urban background NO_2 concentrations have remained relatively stable over the past eight years. The mean for the five sites in operation since 2007 (Aberdeen, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth) shows a similar pattern, with no clear upward or downward trend.

All urban background sites in Scotland recorded annual mean NO_2 concentrations well below the AQS Objective of 40 μgm^{-3} in 2011, with the exception of Glasgow City Chambers (which closed in March 2011 and was only in operation for 20% of the year). At Glasgow Centre the annual mean for 2011 was 34 μgm^{-3}, indicating that the elevated concentrations measured in 2009 and 2010 were due to the proximity of the diesel generator used during the Christmas market (which was located elsewhere in 2011).

Figure 8-2. Time Series of Annual Mean NO_2 Concentration at Urban Background sites in Scotland: 1987 - 2011



8.1.2 NO_x and NO_2 at Traffic-related Urban Sites

Figure 8-3 shows annual mean NO_x concentration at traffic-related urban sites, since the first such site in Scotland (Glasgow Kerbside) began operation in 1997. The chart shows the annual mean for the following sites and groups of sites:

- Glasgow Kerbside, the longest-running site, from 1997 onwards.
- A subset of three long-running sites (Dumfries, Inverness and Glasgow Kerbside), all of which have been in operation since 2002 or earlier. The average annual mean NOx concentration is shown.
- A subset of 10 long-running sites in operation since 2005 or earlier (Aberdeen Anderson Drive, Aberdeen Union Street, Dumfries, East Dumbartonshire Bishopbriggs, Edinburgh Gorgie Road, Glasgow Byres Road, Glasgow Kerbside, Inverness, Perth Atholl Street and Perth High Street).
- A subset of 23 sites in operation for the past five years (i.e. since 2007 or earlier). These are the above ten sites plus Dundee Lochee Road, Dundee Seagate, Dundee Union Street, Dundee Whitehall Street, East Dunbartonshire Bearsden, East Dunbartonshire Kirkintilloch, Edinburgh Queen Street, Edinburgh Roseburn, Edinburgh St John's, Falkirk Hope Street, Falkirk Park Street, Glasgow Battlefield Road, West Dunbartonshire Clydebank.

Only sites with at least five years' data are included here. The minimum annual data capture for inclusion is 70%, with the exception of Aberdeen Anderson Drive in 2006 (data capture 59%), and East Dunbartonshire Bishopbriggs in 2011 (data capture 65%). These have been included for completeness as they have good data capture in all other years.

There are no clear trends apparent in Figure 8-3: annual mean concentrations of total NO_x at traffic-related sites appear stable in recent years. 2011 appears to have been a slightly lower year for NO_x, after a higher year in 2010.

Figure 8-3 Time Series of Annual Mean NOx Concentration at Traffic Urban sites in Scotland: 1997 - 2011

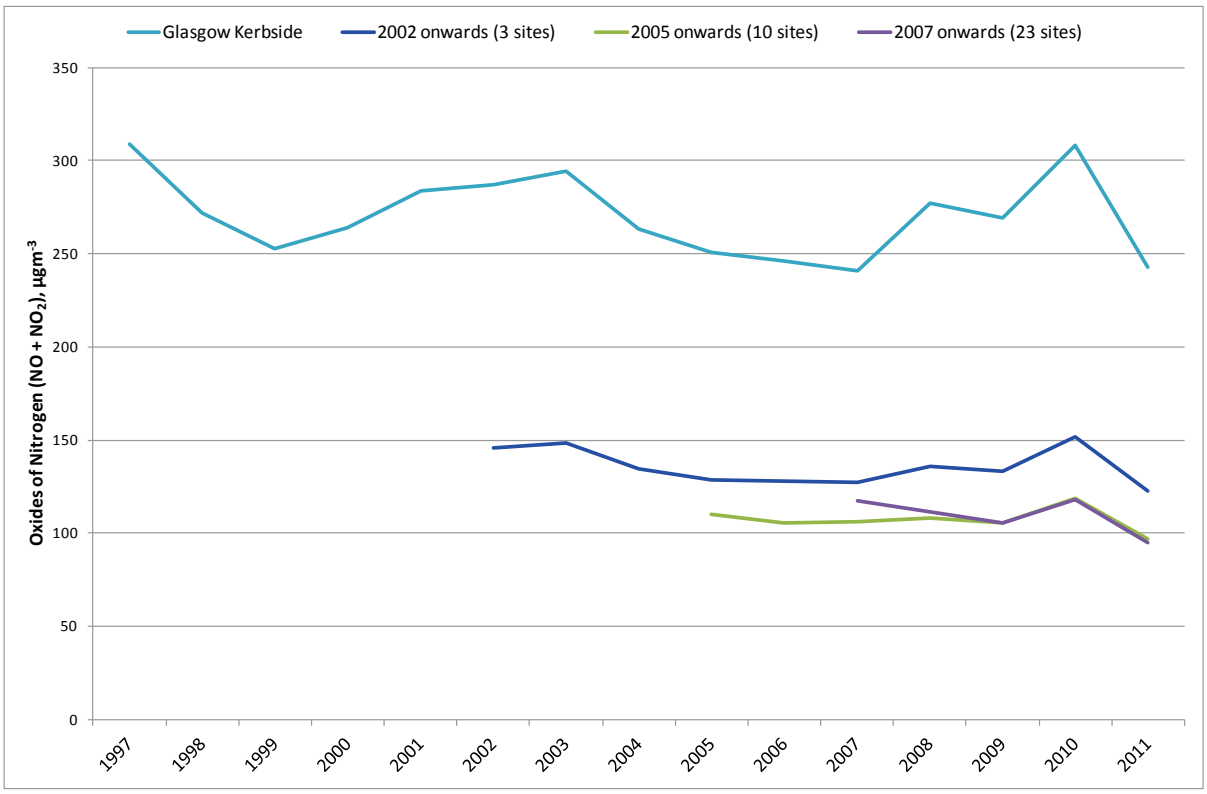
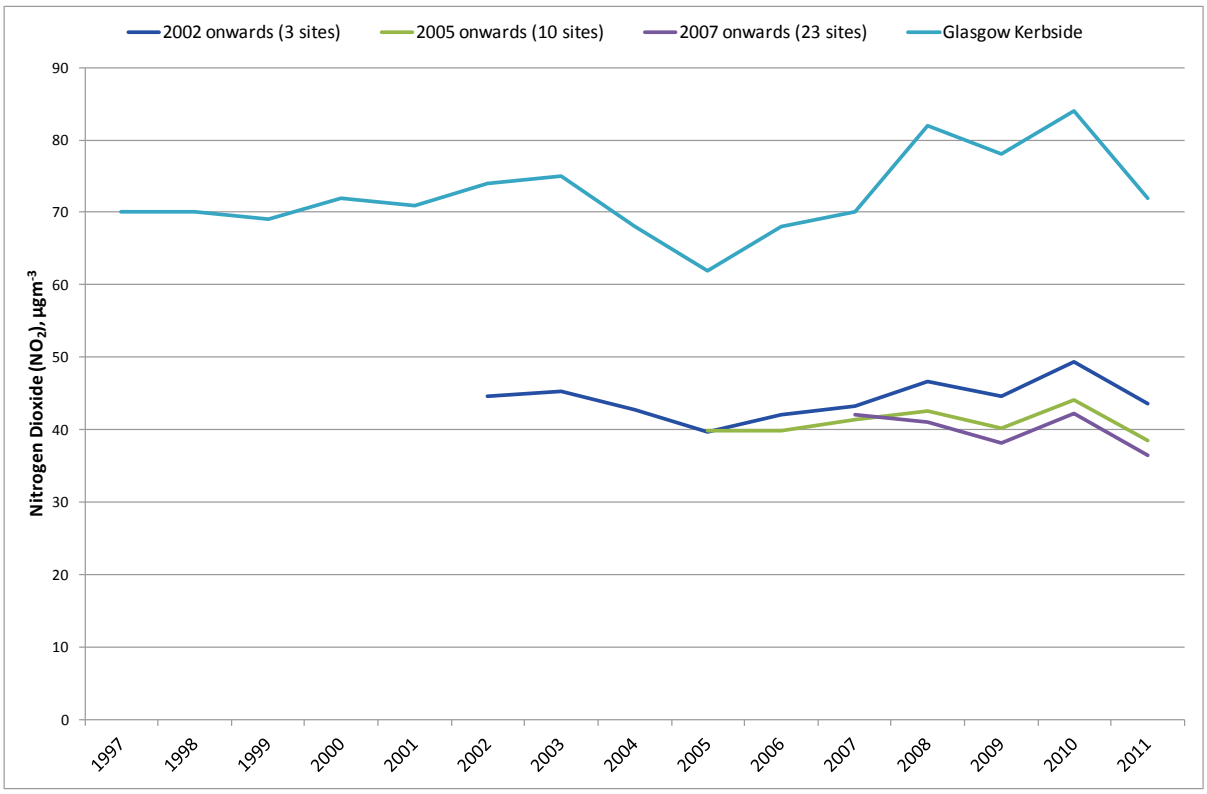


Figure 8-4 shows the corresponding time series chart for NO_2 at traffic-related urban monitoring sites. This shows the annual mean NO_2 concentration at Glasgow Kerbside, as well as the same subsets of long running sites (i.e. three that have operated since 2002 or earlier, ten sites that have operated since 2004 or earlier and 23 that have operated since 2007 or earlier).

Again, there are no clear trends: in particular, the average for the three long-running sites in operation since 2002 has remained stable over the past ten years, dropping in 2011 after a slight increase in 2010. The *average* annual mean NO_2 concentration for these three long-running sites has been consistently above the AQS Objective of 40 μgm^{-3}. The same applies to the average NO_2 concentrations for the sites in operation from 2005 onwards and 2007 onwards. Data from the whole monitoring network shows that the AQS Objective for annual mean NO_2 is not consistently met at traffic urban locations in Scotland.

Figure 8-4 Time Series of Annual Mean NO_2 Concentration at Traffic Urban sites in Scotland: 1997 - 2011



8.2 Particulate Matter

This pollutant is of great interest because:

- Scotland has adopted a more stringent annual mean PM_{10} objective (18 μgm^{-3}) than the objective of 40 μgm^{-3} adopted in the rest of the UK, for 2010.
- Scientists do not believe that there is actually a safe level of this pollutant in terms of human health effects.

8.2.1 PM_{10} at Urban Background Sites

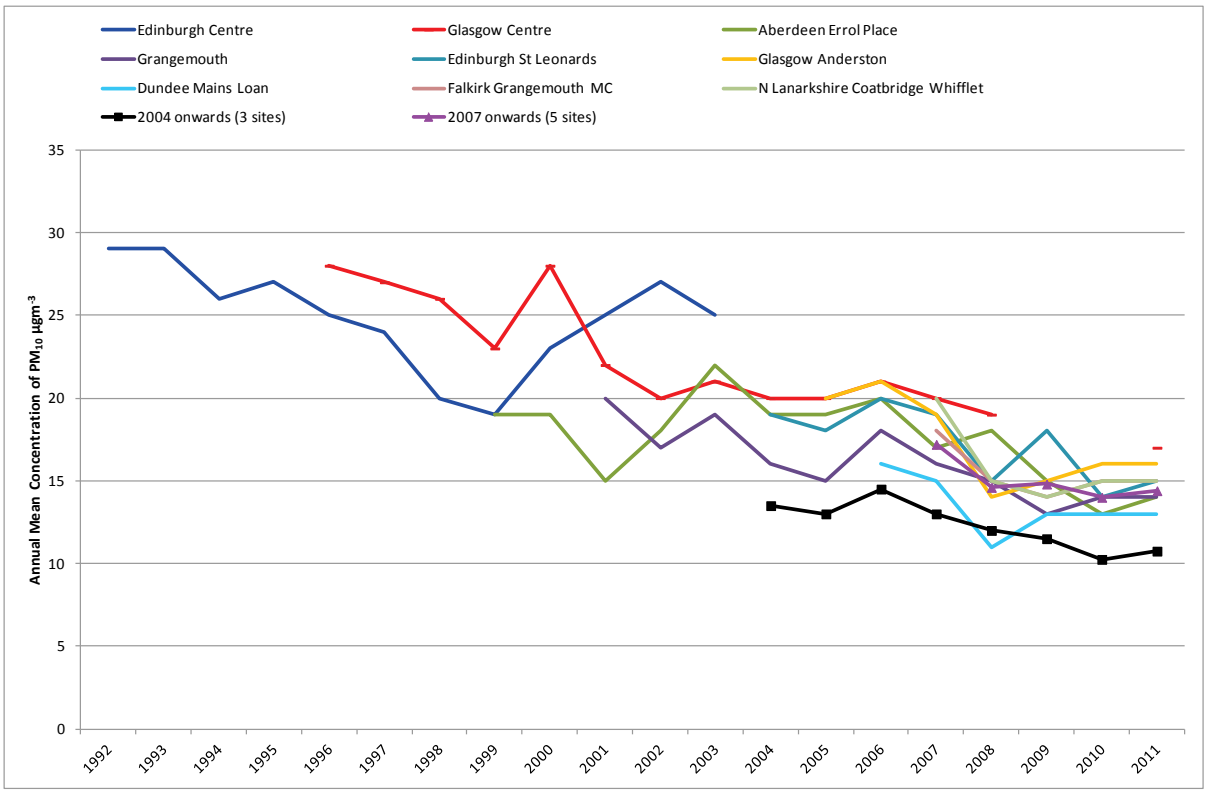
A time series chart of annual mean PM_{10} concentrations at long-running Scottish urban background sites is shown in Figure 8-5. This includes data from the following sites:

- Eight sites in operation for at least five years: Edinburgh Centre, Glasgow Centre (excluding 2009 and 2010 when the site was thought to be affected by nearby diesel emissions), Aberdeen (Errol Place), Grangemouth, Edinburgh St Leonards, Glasgow Anderston, Dundee Mains Loan, Falkirk Grangemouth MC, and North Lanarkshire Coatbridge Whifflet.
- The mean for a subset of three sites in operation since 2004 or earlier (Aberdeen Errol Place, Edinburgh St Leonards and Grangemouth).
- The mean for a subset of five sites in operation since 2007 or earlier – the above three sites plus Glasgow Anderston and Dundee Mains Loan.

Minimum data capture for inclusion in this chart is 50%. Figure 8-5 indicates a general decrease in annual mean PM_{10} concentration since the early 1990s, though individual sites show considerable fluctuation year on year. The average of the three sites in operation since 2004 indicates a decrease between 2006 and 2010 (although 2011 appears to have been a slightly higher year). This is also reflected in the mean of the five sites in operation since 2007.

The average PM_{10} concentration for all urban background sites in 2011 was 15 μgm^{-3}: this is well within the Scottish AQS Objective of 18 μgm^{-3}. All the individual sites met this objective.

Figure 8-5 Time Series of Annual Mean PM_{10} Concentration at Long-Running Scottish Urban Background Sites, 1992 – 2011



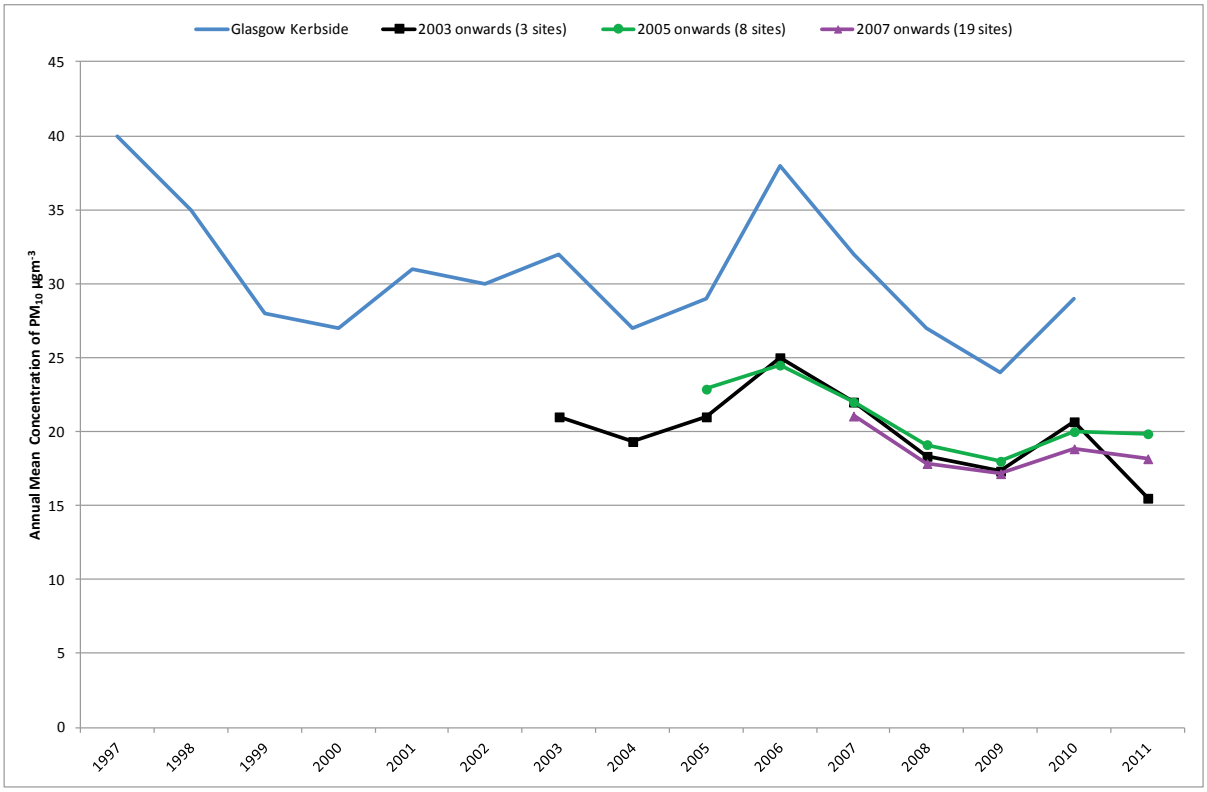
8.2.2 PM_{10} at Traffic-Related Urban Sites

A similar time series chart of PM_{10} concentrations at long-running Scottish traffic-related urban sites is shown in Figure 8-6. This shows the following sites:

- The long-running Glasgow Kerbside site (upto 2010, as data capture in 2011 was low),
- A subset of three sites (Glasgow Kerbside, Inverness and Perth High Street) in operation since 2003 or earlier.
- A subset of eight sites in operation since 2005 or earlier (the above three plus Perth Atholl Street, Aberdeen Anderson Drive, Aberdeen Union Street, East Dunbartonshire Bishopbriggs and Glasgow Byres Road)
- A subset of nineteen sites in operation since at least 2007 (i.e. with five years' data: the above eight plus East Dunbartonshire Bearsden, Fife Cupar, Glasgow Battlefield Road, Alloa, Dundee Broughty Ferry, Dundee Union Street, Edinburgh Roseburn, Angus Forfar, Edinburgh Queen Street, South Ayrshire Ayr High Street, West Dunbartonshire Clydebank).

Minimum annual data capture for inclusion is 50%. Although Figure 8-6 shows some indication of a general decrease since the early 2000s, this is less pronounced than in the case of the urban background sites. Also, there is still clearly substantial fluctuation from year to year. The average PM_{10} concentration for all traffic-related sites in 2011 was 17 μgm^{-3}: this is just within the Scottish AQS Objective of 18 μgm^{-3}. However, not all of the sites met the objective, as discussed in Section 6.

Figure 8-6 Series of Annual Mean PM_{10} Concentration at Long-Running Traffic-Related Scottish Sites, 1992 – 2011



Note: Many of Scotland's monitoring sites use the Tapered Element Oscillating Microbalance (TEOM) to monitor PM_{10}. For the reasons discussed in Section 4, TEOM data from 2009 onwards have been corrected for possible evaporation of the volatile component (due to the high operating temperature of the TEOM) using the King's College Volatile Correction Model (VCM), which can be found at http://www.volatile-correction-model.info/ . For earlier years (up to and including 2008) the convention used was to apply a factor of 1.3 to the data. The data presented here have been adjusted in this way.

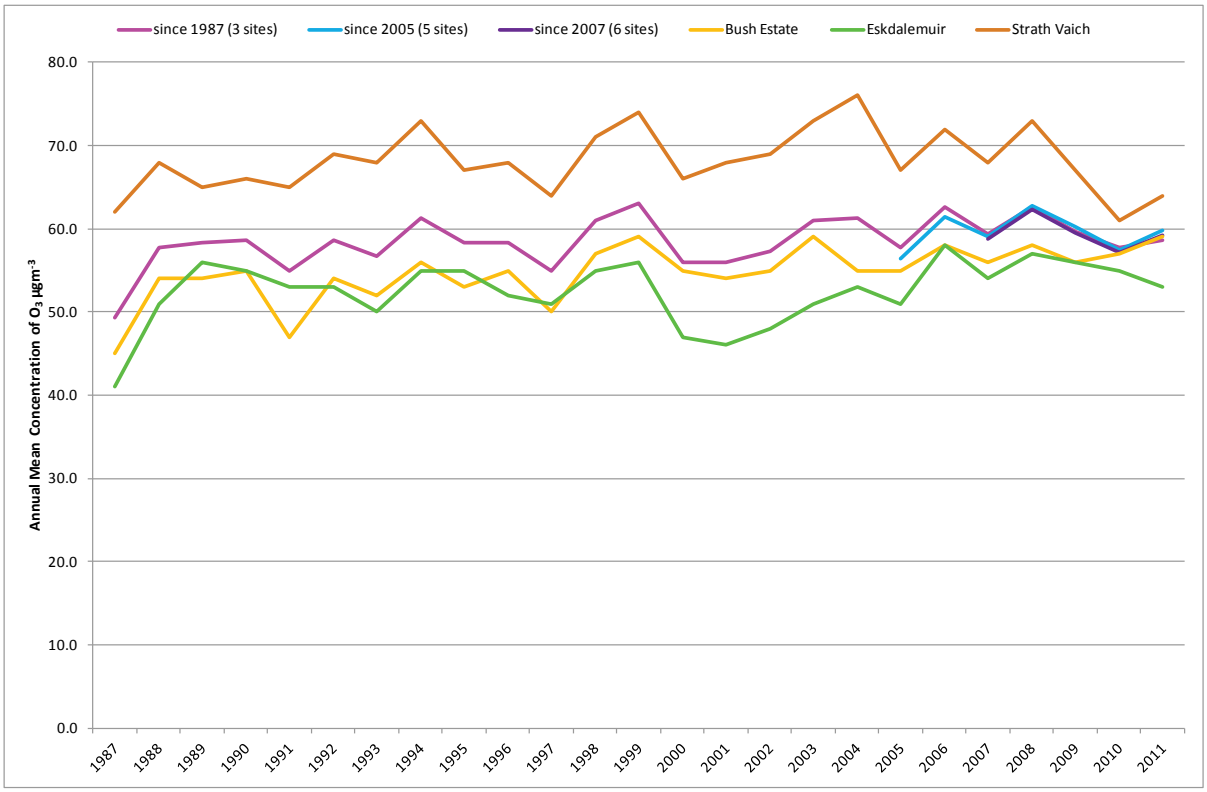
8.3 Ozone

8.3.1 Rural Ozone

Figure 8-7 shows average annual ozone (O_3) concentrations at rural monitoring sites across Scotland. Three rural sites have been in operation since 1987: they are Bush Estate, Eskdalemuir and Strath Vaich. The mean of these three long-running sites is shown by the pink line. This indicates a slight upward trend in annual mean rural ozone concentrations over the past two decades. However, the main feature of this chart is the fluctuation, from year to year, due to variation in meteorological conditions.

Also shown is the mean for the five sites in operation since 2005 (the above three, plus Auchencorth Moss and Glasgow Waulkmillglen Reservoir) and the six sites operating since 2007 (the above five sites plus Lerwick). These show a similar pattern.

Figure 8-7 Annual Mean O_3 Concentrations at Long-Running Scottish Rural Sites, 1987 – 2011



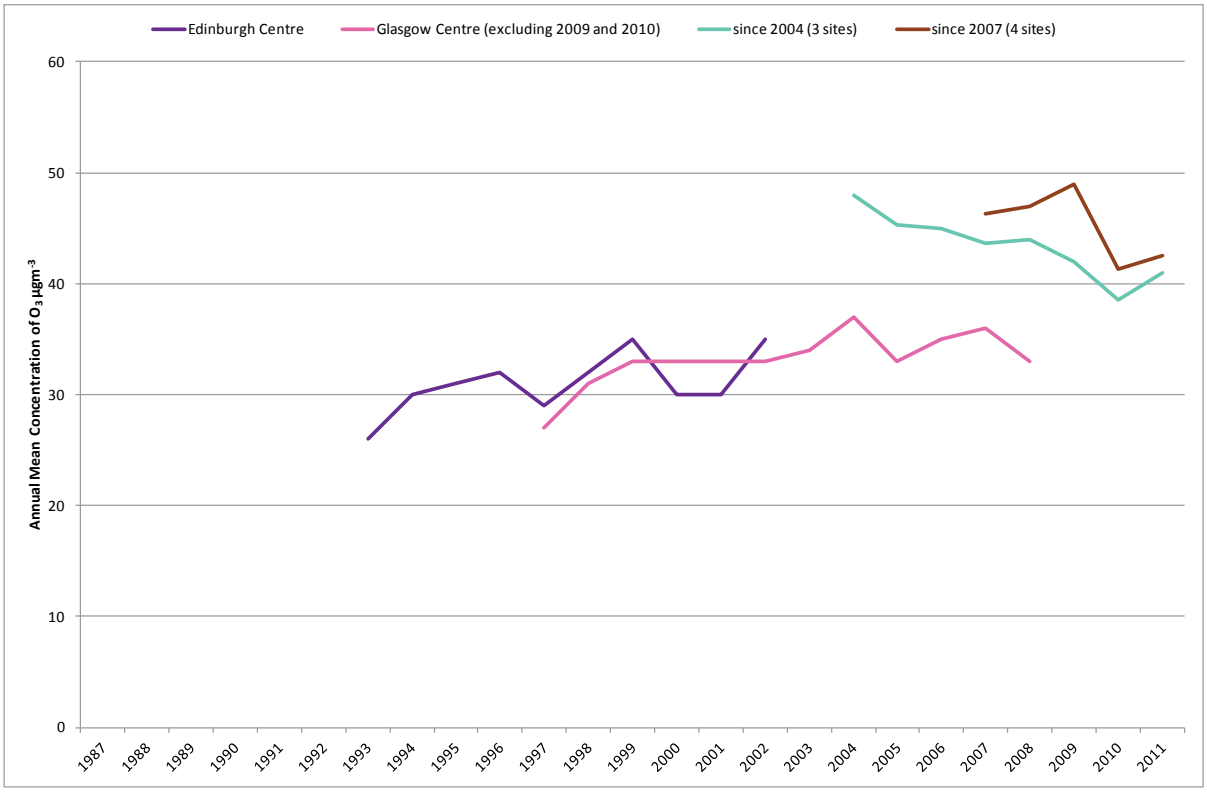
8.3.2 Urban Background Ozone

Figure 8-8 shows annual mean ozone concentrations at Scottish urban background monitoring sites. This shows data from the following sites:

- Edinburgh Centre, up to 2002 (its last full year of operation)
- Glasgow Centre (excluding 2009 and 2010, when the site was affected by nearby diesel emissions, which would have lowered ozone concentrations around the site)
- Three sites in operation since 2004 or earlier (Glasgow Centre, Edinburgh St Leonards and Aberdeen)
- Four sites in operation since 2007 or earlier (the above three plus Fort William).

In the case of urban background sites, there are no clear trends, partly due to the changes in the number of sites. Previous reports in this series (up to 2009) have reported a substantial increase in recent years, based on the mean of all long-running urban background sites, However, when the data from individual sites are shown separately, it becomes clear that the reported apparent increase around 2002-2004 was due at least in part to discontinuities in the set of sites available – the closure of Edinburgh Centre and its replacement by Edinburgh St Leonards, also the inclusion of Aberdeen Errol Place and Fort William. This highlights the importance of taking into consideration changes in the composition of the network, when assessing trends over time.

Figure 8-8 Annual Mean O_3 Concentrations at Long-Running Scottish Urban Background Sites, 1987 – 2011



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 dissagregated into the UK constituent countries[16]. 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, 1990-2009

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.

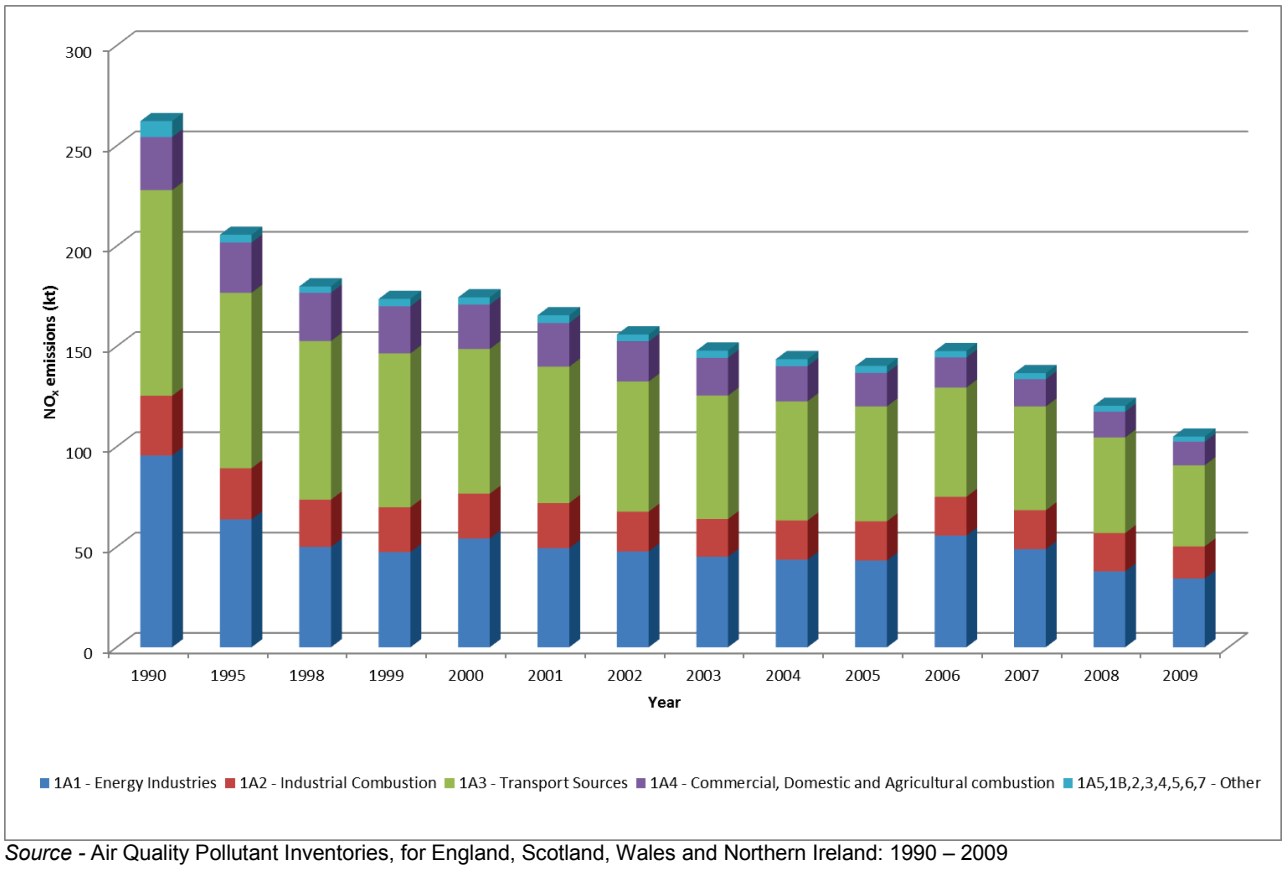
Table 9-1 Scotland emissions of NOx by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2009 (%)
1A1 - Energy Industries	95.6	63.7	50.1	47.5	54.3	49.4	47.8	45.1	43.6	43.3	55.7	48.9	37.8	34.3	33%
1A2 - Industrial Combustion	29.7	25.5	23.5	22.4	22.3	22.5	19.8	18.8	19.6	19.5	19.4	19.4	19.1	16.0	15%
1A3 - Transport Sources	103	87.5	79.1	76.7	72.1	68.0	64.9	61.5	59.4	57.3	54.5	51.7	47.7	40.5	39%
1A4 -Commercial, Domestic and Agricultural	26.5	25.1	24.1	23.5	22.1	21.8	20.0	18.9	17.5	16.7	15.0	13.6	12.9	11.8	11%
1A5,1B,2,4,5,6 - Other	8.0	3.8	3.1	3.7	3.6	3.8	3.5	3.5	3.5	3.4	3.2	3.0	2.9	2.5	2%
Total	**262**	**206**	**180**	**174**	**174**	**166**	**156**	**148**	**144**	**140**	**148**	**137**	**120**	**105**	**100%**

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

[16] Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009
http://uk-air.defra.gov.uk/reports/cat07/1110121007_DA_AQI_2009_Finalr.pdf

Figure 9-1 Time series of Scotland NO_x emissions 1990-2009



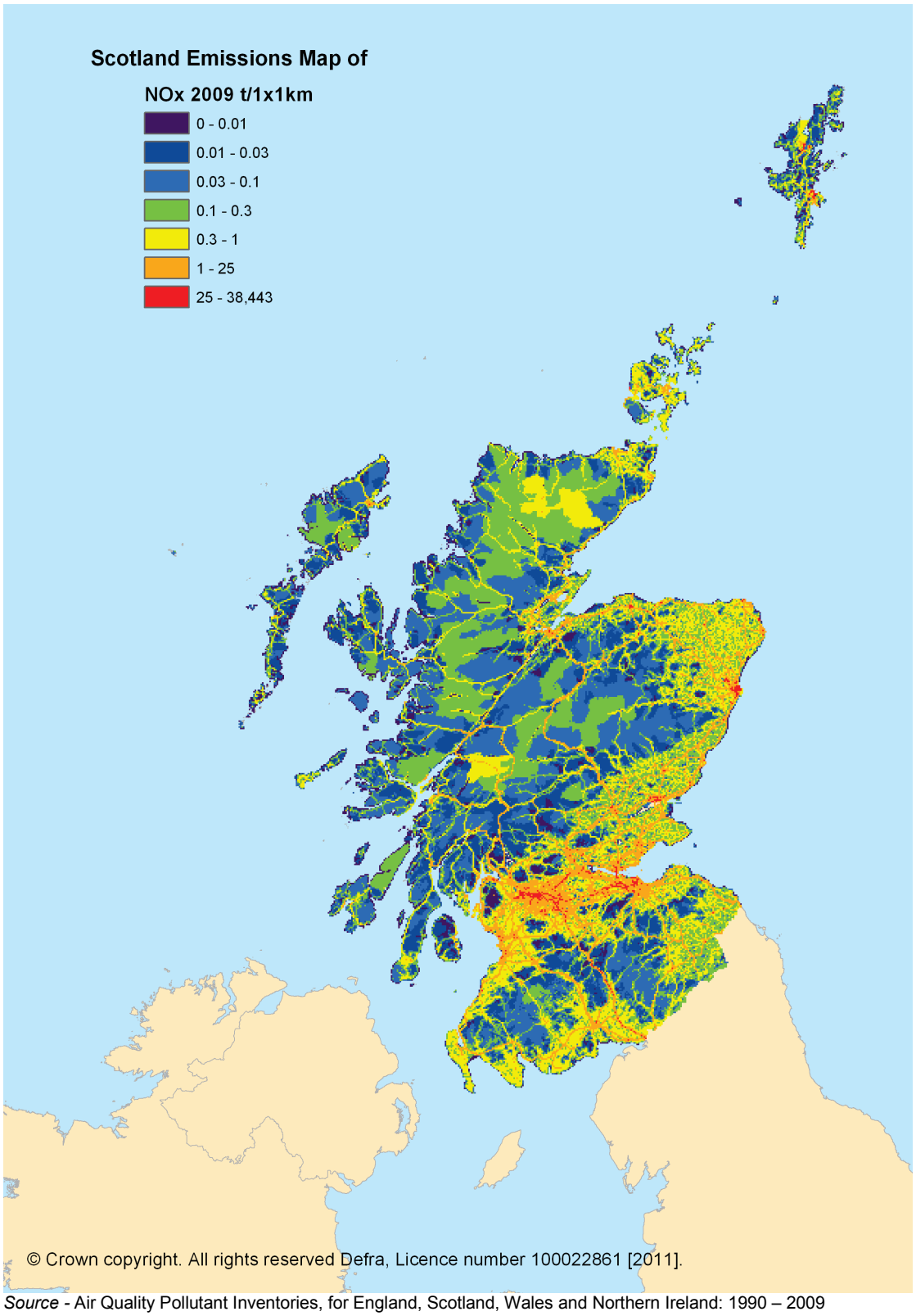
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

Scotland's NO_x emissions have declined by 60% 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 27% of the Scotland total in 2009; although emissions from this source have reduced by 68% 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 in the inventory. In Scotland, coal-fired generation increased to a peak in 2006 (17,488 GWh), and have since declined by 32% between 2006 and 2009 (to 11,896 GWh). Between 2008 and 2009, coal-fired generation has increase slightly by 1.7%, whilst gas-fired generation has decreased by 20.6% to 7,615 GWh. A further 30% of NO_x emissions in Scotland arise from road transport sources (1A3bi-iv: down by 66% since 1990), 15% stem from industrial combustion (1A2: down 46% since 1990) and 6% is from agricultural mobile machinery (1A4cii, down 57% 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 151% since 1990 and 1A3aii(i): up by 16% since 1990 in 2009). Emissions from rail have also increased by 74% 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 rises in passenger train km and freight train km during this time.

Figure 9-2 shows a map of Scotland's NOx emissions.

Figure 9-2 Map of NOx Emissions in Scotland, 2009



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

9.1.2 Scotland PM_{10} Inventory by NFR Sector, 1990-2009

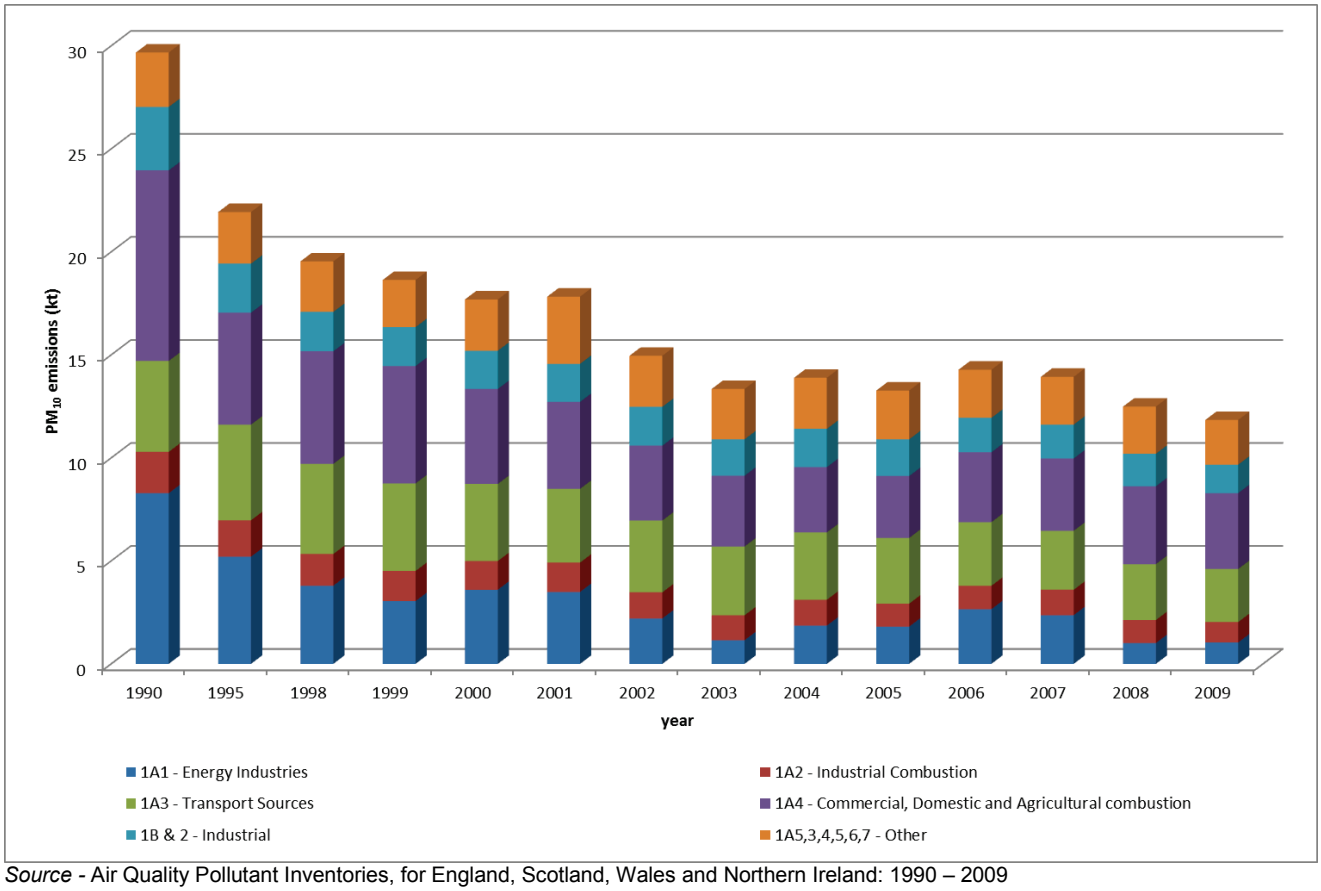
The table and graph below give a summary of the PM_{10} emissions in Scotland by broad NFR sector categories. The detailed data are available in the report and website cited in the introduction to this Chapter.

Table 9-2 Scotland's emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2009 (%)
1A1 - Energy Industries	8.3	5.2	3.8	3.0	3.6	3.5	2.2	1.1	1.9	1.8	2.7	2.4	1.0	1.0	9%
1A2 - Industrial Combustion	2.0	1.8	1.5	1.5	1.4	1.4	1.3	1.2	1.3	1.1	1.1	1.2	1.1	1.0	8%
1A3 - Transport Sources	4.4	4.6	4.4	4.2	3.7	3.6	3.5	3.3	3.3	3.2	3.1	2.9	2.7	2.6	22%
1A4 - Commercial, Domestic and Agricultural	9.3	5.4	5.5	5.7	4.6	4.2	3.6	3.4	3.2	3.0	3.4	3.5	3.8	3.7	31%
1B & 2 - Industrial	3.1	2.4	1.9	1.9	1.9	1.8	1.9	1.8	1.9	1.8	1.7	1.6	1.6	1.4	12%
1A5,3,4,6,7 - Other	2.6	2.5	2.4	2.3	2.5	3.3	2.5	2.4	2.5	2.4	2.3	2.3	2.3	2.2	18%
Total	**29.7**	**21.9**	**19.5**	**18.6**	**17.7**	**17.8**	**15.0**	**13.3**	**13.9**	**13.3**	**14.3**	**13.9**	**12.5**	**11.8**	**100 %**

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

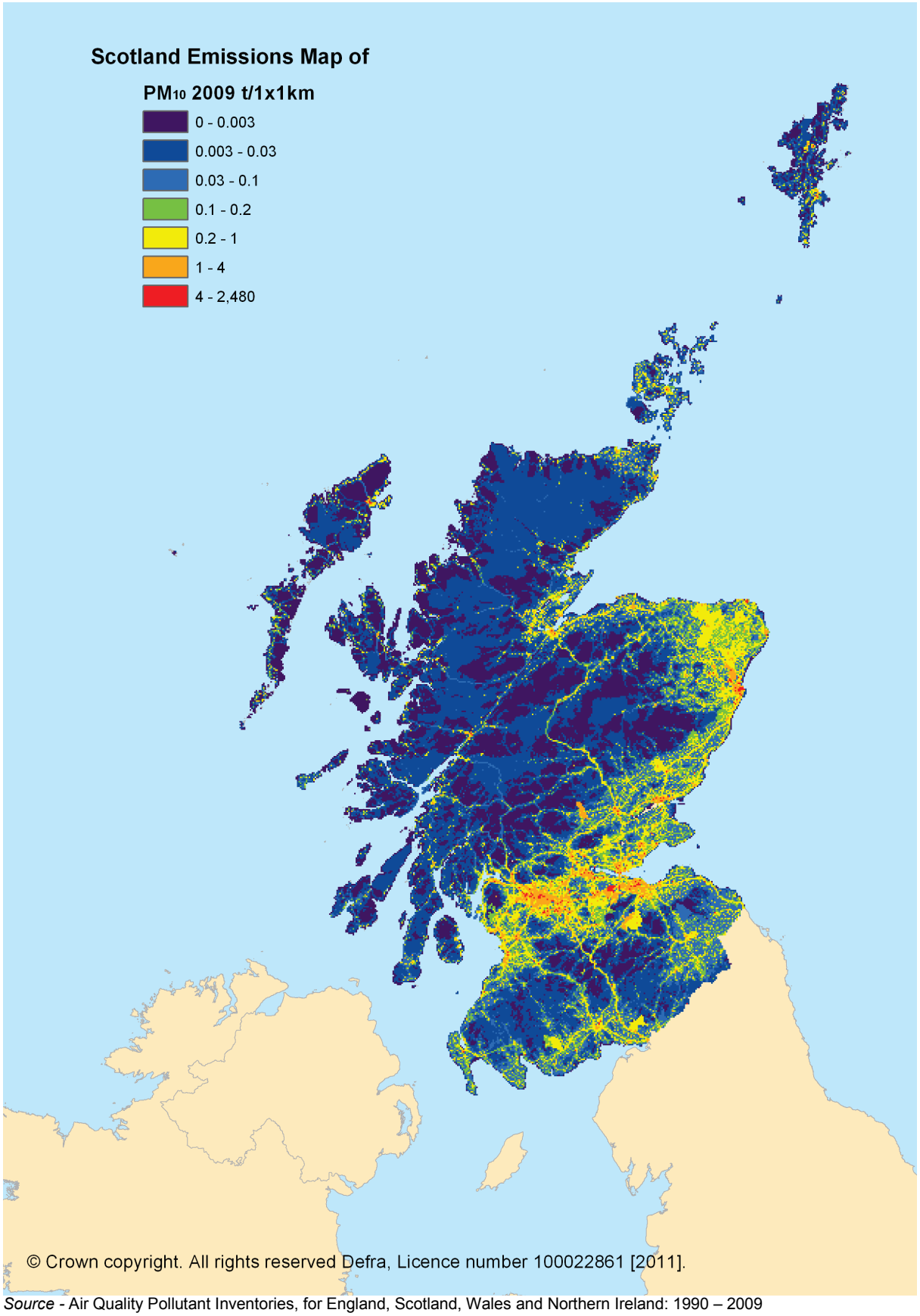
Figure 9-3 Time series of Scotland's PM_{10} emissions 1990-2009



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

Scotland's PM_{10} emissions have declined by 60% since 1990 and account for 10% of the UK total. 22% of PM_{10} emissions in Scotland come from transport (1A3) sources (down by 42% since 1990), whilst 31% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 60% since 1990). Emissions from power generation (1A1a) were 25% of the Scotland total emissions in 1990, but have been reduced to 8% of the Scotland total in 2009. Figure 9-4 shows a map of Scotland's emissions.

Figure 9-4 Map of PM_{10} Emissions in Scotland, 2009



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2009

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 NO_x in Scotland

The majority of Scotland's industrial NO_x emissions are generated in east central Scotland, where the largest emitters of NO_x are the Longannet and Cockenzie power stations near Edinburgh. The annual mass emissions from the 10 largest industrial sources of NO_x in Scotland (based on 2010 SPRI data) are presented below in Table 9-3.

Table 9-3 Largest industrial sources of NO_x emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007	2008	2009	2010
Scottish Power Generation Ltd, Longannet Power Station	23,500	19,400	19,087	22,731	14,876	14,086	15,170	15,246
Scottish Power Generation Ltd, Cockenzie Power Station	10,700	12,100	11,400	20,294	22,054	13,016	8,575	10,718
INEOS Manufacturing Scotland Ltd (Refinery),Grangemouth	5,250	3,269	3,349	3,467	3,048	4,102	3,567	3,572
Scottish & Southern Energy Plc, Lerwick Power Station	2,650	1,530	1,946	1,644	1,676	1,767	1,658	1,832
ExxonMobil Chemical Ltd, Mossmorran	1,500	1,840	1,594	1,651	798	864	809	1,060
Scottish and Southern Energy, Peterhead Power Station	1,990	1,980	2,130	2,750	2,110	2,110	1,400	981
Ardagh Glass Ltd, Irvine	962	638	475	742	994	928	995	978
O - I Manufacturing UK Ltd, Clackmannanshire	807	784	777	821	793	684	595	694
Shell UK Ltd, St Fergus Gas Plant	102	992	1,010	923	899	751	675	646
Tullis Russell Papermakers Ltd, Glenrothes	448	598	611	723	592	815	757	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 2010.

Table 9-4 Largest industrial sources of PM_{10} (and smaller PM) emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007	2008	2009	2010
Scottish Power Generation Ltd. Longannet Power Station	1,140	700	662	943	555	313	459	587
Scottish Power Plc. Cockenzie Power Station	637	738	697	1,258	1,324	331	258	450
Aggregate Industries UK Limited. Glensanda Quarry Operations	No data	No data	No data	No data	BRT	BRT	BRT	180
INEOS Manufacturing Scotland (Refinery) Limited, Grangemouth	212	202	191	195	200	100	104	108
The Caledonian Cheese Company Ltd. Wigtown	No data	No data	BRT	BRT	74	105	103	72
The Cheese Company Limited. Lockerbie	No data	BRT	BRT	95	98	82	48	69
SSE Generation Limited, Lerwick Power Station	No data	50	25	21	23	31	30	66
SSE Generation Limited. Peterhead Power Station	No data	20	67	64	68	79	50	38
Tullis Russell Papermakers Ltd. Glenrothes Fife	72	65	65	31	44	57	51	36
Lafarge Cement UK Limited. E.Lothian	No data	No data	No data	No data	122	37	28	33

Note: BRT = Below Reporting Threshold

10 Conclusions

RICARDO-AEA is continuing to develop an Air Quality Database and Website for Scotland on behalf of The Scottish Government. The web site and database are available at www.scottishairquality.co.uk.

During 2011, the database and website have been expanded and developed considerably - a number of new features including the Know and Respond-Scotland Air Quality Alert Service have been added to the site. Comments and suggestions from stakeholders received during the annual seminar and at other times have also been incorporated.

Air pollution data for 86 automatic monitoring sites throughout Scotland are available in the database for all or part of 2011. 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 all traceable to UK national calibration standards for the various pollutants.

A summary of ratified data for 2011 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. 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. 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.

The data in the database have been utilised to provide information on nationwide pollution episodes and on trends in air quality over many years. The findings suggest various trends for some pollutants, but in general, concentrations and trends are often specific to individual sites. Analysis of trends in ozone concentrations indicate year on year fluctuations in ozone concentrations associated with variations in meteorological conditions.

For the third year in a row, Scotland-specific monitoring data have been used to produce pollution climate maps for both oxides of nitrogen and PM_{10}. In addition, source apportionment and annual projection factors, based on Scottish data, have been produced to accompany these maps. The methodology used to produce the maps has been developed during 2011 and further enhancements of the method have been targeted for future years as more data becomes available.

In conclusion, it is anticipated that the Scottish Air Quality Database and Website will continue to develop and remain an invaluable national resource of air quality data for The Scottish Government, Local Authorities, health professionals and environmental practitioners. We also hope that the database and website will increasingly become a valuable education resource for schools and an information service for the general public.

Appendices

CONTENTS

Appendix 1
National Monitoring Network Sites in Scotland 2011

Table A1.1. AURN Measurement Sites in Scotland 2011

Site Name	Site Type	Species Measured	Grid Reference
Aberdeen	URBAN BACKGROUND	NO NO_2 NO_X O_3 PM_{10}	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 PM_{10}	240234,675193
Dumfries	ROADSIDE	CO 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 Centre	URBAN CENTRE	CO NO NO_2 NO_X O_3 PM_{10} $PM_{2.5}$ SO_2	258902,665028
Glasgow City Chambers[3]	URBAN BACKGROUND	NO NO_2 NO_X	259528,665308
Glasgow Kerbside	KERBSIDE	NO NO_2 NO_X PM_{10}	258708,665200
Grangemouth	URBAN INDUSTRIAL	NO NO_2 NO_X PM_{10} SO_2	293840,681032
Grangemouth Moray[4]	URBAN BACKGROUND	NO NO_2 NO_X PM_{10}	296436,681344
Inverness	ROADSIDE	PM_{10}(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 closed on 16/03/2011
4 SO_2 and PM_{10} at this site are part of the Scottish Government Network

Table A1.2. Automatic Hydrocarbon Network Sites in Scotland 2011

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 2011

Site Name	Site Type	Species Measured	Grid Reference
Glasgow Kerbside[α]	KERBSIDE	Benzene	258708, 665200
Grangemouth	URBAN INDUSTRIAL	Benzene	293840,681032

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

[α]Non–Automatic Monitoring of Benzene started at this site on 01/09/10.

Table A1.3. PAH Monitoring Sites in Scotland 2011

Site	Address	Grid Reference
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow	St Enoch Square Glasgow G2 8BX	258902, 665028
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 2011

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

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 2011

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 2011

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 2011

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 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.

The RICARDO-AEA HIS data ratification software automatically produces a data ratification report for the selected monitoring stations giving the following information:

- Station, pollutants measured and start date
- Latest annual QC audit results for the station
- Results of initial electronic data screening
- LSO calibration dates and any comments

- List of all gaps in the data
- Any other issues relating to the station.

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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