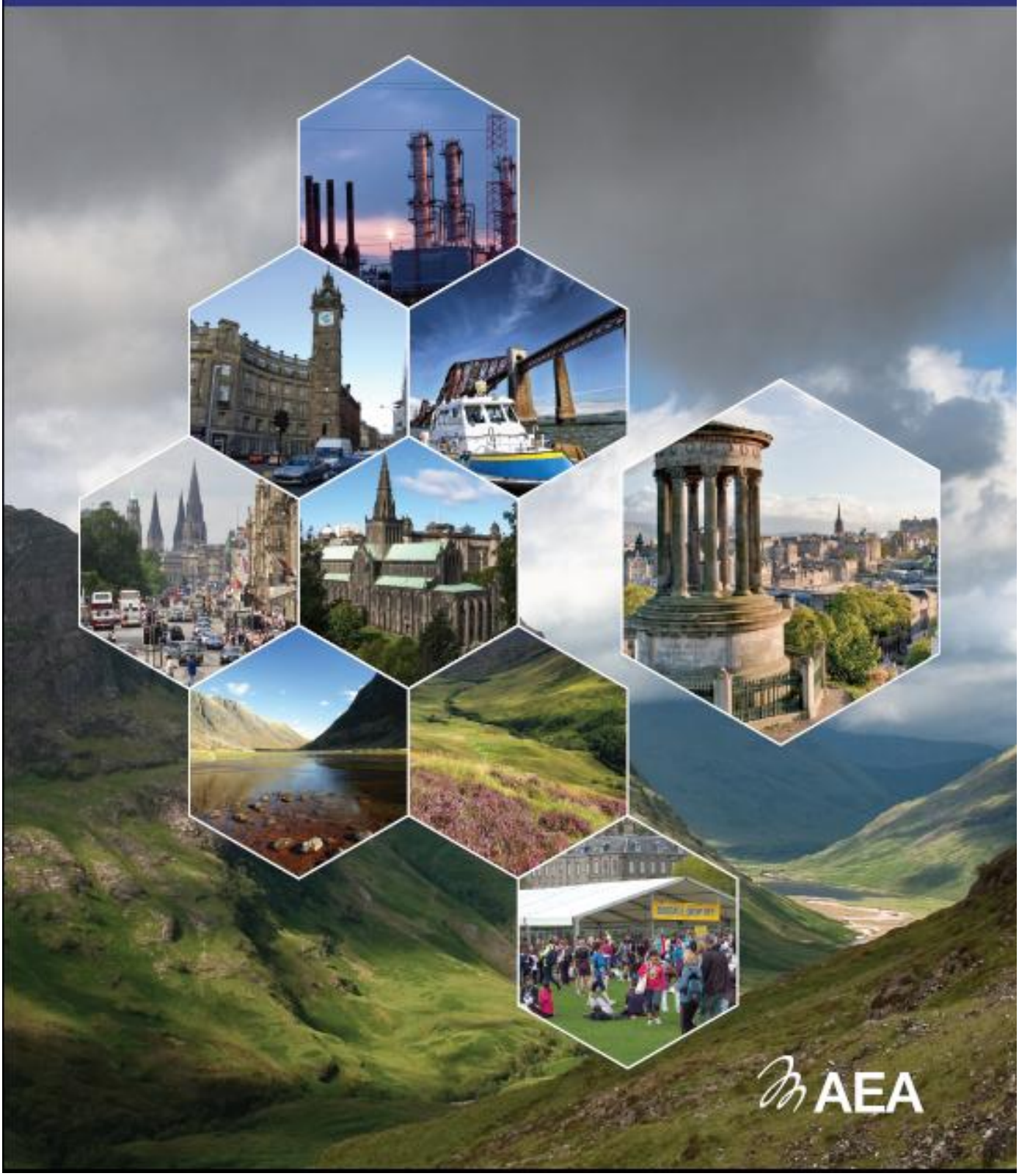
Scottish Air Quality Database Annual Report 2010



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Executive summary

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 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 provision of Openair data analysis tools, the addition of new monitoring sites to the database, and the development of the Air Pollution Detectives Children's pages and the Scottish Air Quality Discussion Forum.

The database and website were launched on the 2nd of April 2007 at http://www.scottishairquality.co.uk/, and have continued to expand and develop ever since. Further enhancements are planned throughout the duration of the project, including the delivery of a Know and Respond Air Quality SMS and Voicemail Alert service, and improved functionality of the database to make it even more useful to all users.

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 2010 the Scottish Air Quality Database contained data for a total of 83 automatic monitoring sites, with 4 new sites being incorporated over the year. This followed on from the net increase of 17 sites added to the database during 2009.

A summary of ratified data for 2010 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 2010 a total of 25 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 2010 is not yet available and data for 2009 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 has been used. Air quality trends have been examined on the basis of individual monitoring sites, and subsets of long-running sites, rather than the composite data set. For concentrations of NO_x at urban background sites, as expected, the precise nature of the trends was site specific. Review of the data from the Glasgow City Chambers monitoring site, which has been in place for over 20 years, indicated a generally downwards trend in NO_x concentrations. However, review of other 'established' monitoring sites in Scotland indicated that average NO_x concentrations have remained relatively stable from 2004 until around 2007, since when they have begun to rise again. Similarly, concentrations of NO_2 at urban background sites have been shown to be site specific, but collectively concentrations have remained relatively flat since 2004.

Annual mean NO_x concentrations available from traffic-related urban sites (kerbside and roadside) indicate very limited variations in the concentrations recorded at most locations since 2004, but with some sites recording an increase in concentrations in 2010. For annual mean NO_2 concentrations

recorded at these traffic related urban sites, it is considered that there is no clear overall trend, but that sites do show site-specific variations.

Monitoring of PM_{10} is undertaken at comparatively fewer sites across Scotland, with most sites only having been established post-2005. Overall the data from these sites appear to indicate a slight downward trend between 2005 and 2008, but with an upturn in the most recent two years.

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 national 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 measure air quality 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. Experience across the rest of the UK indicated that a comprehensive centralised resource providing air quality information for Scotland would serve to improve the quality of research and data analysis required to support and evaluate Scottish air quality policies. Hence, in 2006, The Scottish Government contracted AEA 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:

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

Following this pilot study AEA were commissioned to undertake the next stage which was to further develop and extend the SAQD and website incorporating all stakeholder comments and to bring selected Local Authority sites in line with the national QA/QC requirements.

The reports relating to the first three years of the project, 2007, 2008 and 2009 are available on the website (www.scottishairquality.co.uk).

This is the fourth annual report of this project and summarises the progress made during 2010 in the on-going project tasks and also highlights the considerable new work undertaken during 2010. New activities in the project include:

- Improvements to the database and website design and functionality
- Linking to the SEPA Pollution Release Inventory via the website
- Air quality mapping, source apportionment and forward year projection factors from Scottish data
- The Air Pollution Detectives – Children's web pages
- The Scottish Air Quality Discussion Forum

Chapter 2 provides information on significant enhancements to the website during 2010. These include the development of a functional link to the Openair data analysis software, the 'Air Pollution Detectives' children's pages, and the Scottish Air Quality discussion forum. A further development to provide SMS text/ Voicemail alerts of forecast moderate to high pollution has been developed and will be launched during 2011.

The overall number of sites in the database has increased by 4 sites with the number of sites with data available for all or part of 2010 now being 83. The corresponding QA/QC programmes (**Chapter 5**) have expanded to encompass these additional sites. As in 2009, 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**. This now includes data for $PM_{2.5}$ at seven monitoring sites in Scotland. In addition, this section has been expanded to include data on many additional pollutants monitored within Scotland as part of UK National Networks.

[1] Willis P. (2006). Pilot study for a Scottish air quality database – Final report. AEAT/ENV/R/2338/Issue 1
http://www.scottishairquality.co.uk/documents/reports/177070326_Pilot_Study_for_a_Scottish_Air_Quality_Database__Final.pdf

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 during 2010 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 2010 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 national air quality website, 'Air Quality Scotland' at www.scottishairquality.co.uk has been created to provide a 'one stop shop' resource for information covering all aspects of air pollution in Scotland.

The site is funded by the Scottish Government. It was designed from the outset to be:

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

Recent development work in 2010/11 has focussed on both enhancing the security of the database and adding additional pages and functionalities. New developments include publishing a set of Openair data analysis tools, a discussion forum and pages targeted at raising awareness of air quality and climate change in school children.

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

Since its launch, usage of the website has been monitored through the on-line tracking tool "awstats", the statistics can be accessed by clicking the following link - http://www.scottishairquality.co.uk/cgi-bin/awstats.pl. The software tool provides in-depth analysis of the time, date, location and access route of all those coming 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 2010.

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.

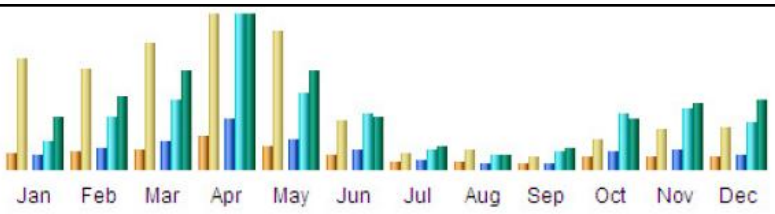
Assuming that hits statistics are genuine, it can therefore be seen that the largest numbers of unique visitors to site were recorded during the months of January to June 2010. The number of visitors per month during this period varied between around 1000 and 2400, whilst a significantly lower number of visitors to the site were recorded during the months of July, August and September. Whilst the reasons for the distinct trends in activity are not clear, the enhanced interest in the website during April and May corresponded with the eruption of the Icelandic volcano Eyjafallajokull and the resulting 'ash cloud' that impacted air travel across the UK. Other possible reasons for increased usage of the website during the first half of 2010 include:

- The annual cycle of local authority review and assessment activity in the spring each year.
- 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. Usage of the website is showing a reasonable level of activity similar in magnitude to usage statistics for the comparable air quality websites for Wales and Northern Ireland. The "Air Quality Wales" website showed a very similar annual profile of monthly usage to "Air Quality in Scotland" in 2010.

Key users of the website include Local Authorities, the Scottish Government, SEPA, universities, health professionals, consultants and the general public.

Figure 2-1 Air Quality Scotland Website Hits 2010



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan	1153	8075	28798	53330	1.21 GB
Feb	1280	7280	40600	98685	1.71 GB
Mar	1376	9131	52848	131416	2.29 GB
Apr	2438	11240	96584	290776	3.59 GB
May	1702	10054	55880	144054	2.29 GB
Jun	1020	3563	36096	103708	1.22 GB
Jul	506	1229	16786	37811	556.63 MB
Aug	580	1384	11682	25852	330.28 MB
Sep	459	953	12910	32963	516.64 MB
Oct	905	2148	32756	104432	1.18 GB
Nov	962	2881	36081	116209	1.52 GB
Dec	919	3063	28694	88865	1.61 GB
Total	13300	61001	449715	1228101	17.99 GB

2.2 Website Maintenance

On a daily basis the web pages are fully checked by the AEA web team, both manually and using a number of automated software systems, in order to ensure that the website is fully functional.

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

- Updates to the national AURN sites are made as required (e.g. If new particulate monitoring instruments come on-line or other sites/instruments are changed.)
- New local authority monitoring sites are added to the database once agreement is reached with the operators.
- Site photos are added as soon as AEA carry out our QA/QC visits, or they are provided by the local authority.
- Ratified data (or any improved provisional data) load automatically to the website from 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.

2.3 Website Upgrades During 2010

A number of enhancements to the website were carried out in 2010, at the request of Scottish Government and the website users, in order to improve the appearance and functionality of the pages.

2.3.1 Linking Openair data analysis tools to the Scottish Air Quality Database

The suite of Openair tools for air pollution data analysis was developed by the Environmental Research Group at King's College London and the University of Leeds under a National Environmental Research Council knowledge exchange project. Openair provides free, open-source innovative data analysis tools and powerful graphing capabilities. The tools and supporting documentation are available from the Openair website. During 2010 a section of the Scottish Air Quality Website has been developed to directly link the SAQD to a subset of the complete functionality of Openair, focussing on the tools that do not require meteorological data in order to run (meteorological data are not routinely provided to the SAQD at most monitoring locations).

In addition to providing online tools to analyse and review automatic data from the Scottish air quality monitoring network, the user can also easily download data from the database in a format suitable for importing into the other Openair tools that are available from the Openair website.

Figure 2-2 Introduction to Openair on the Scottish Air Quality Website

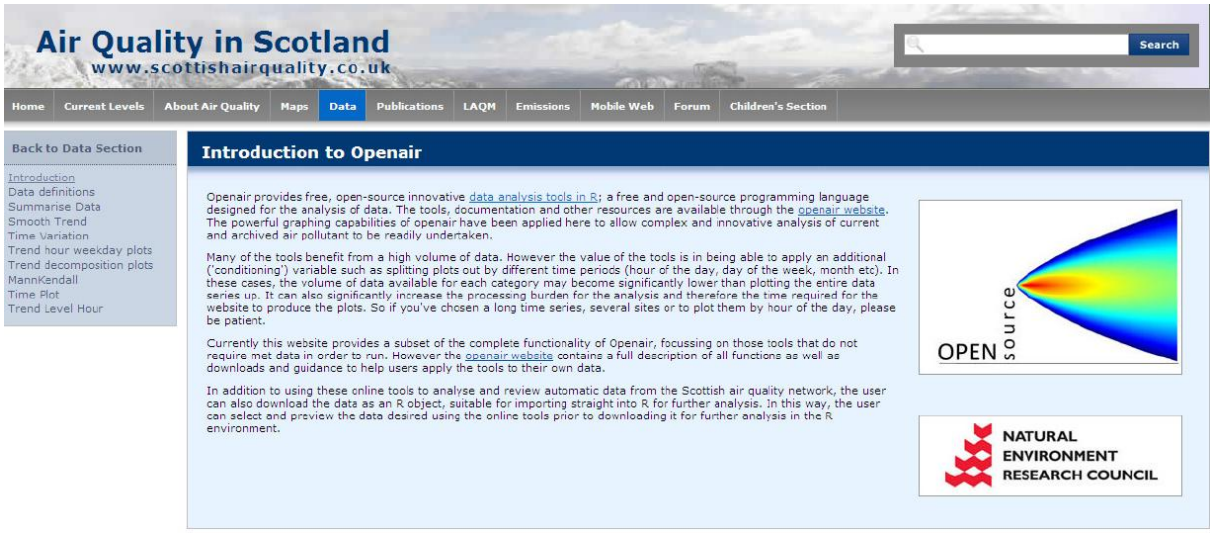
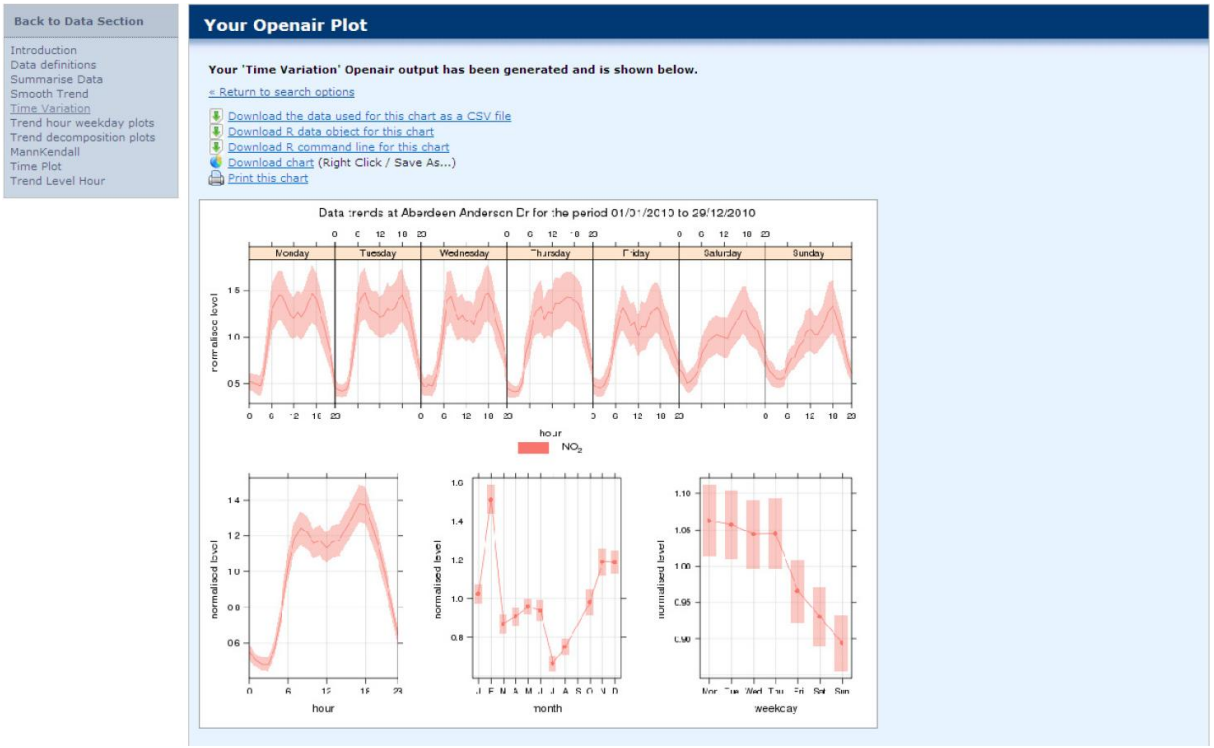


Figure 2-3 Example Openair Plots on the Scottish Air Quality Website



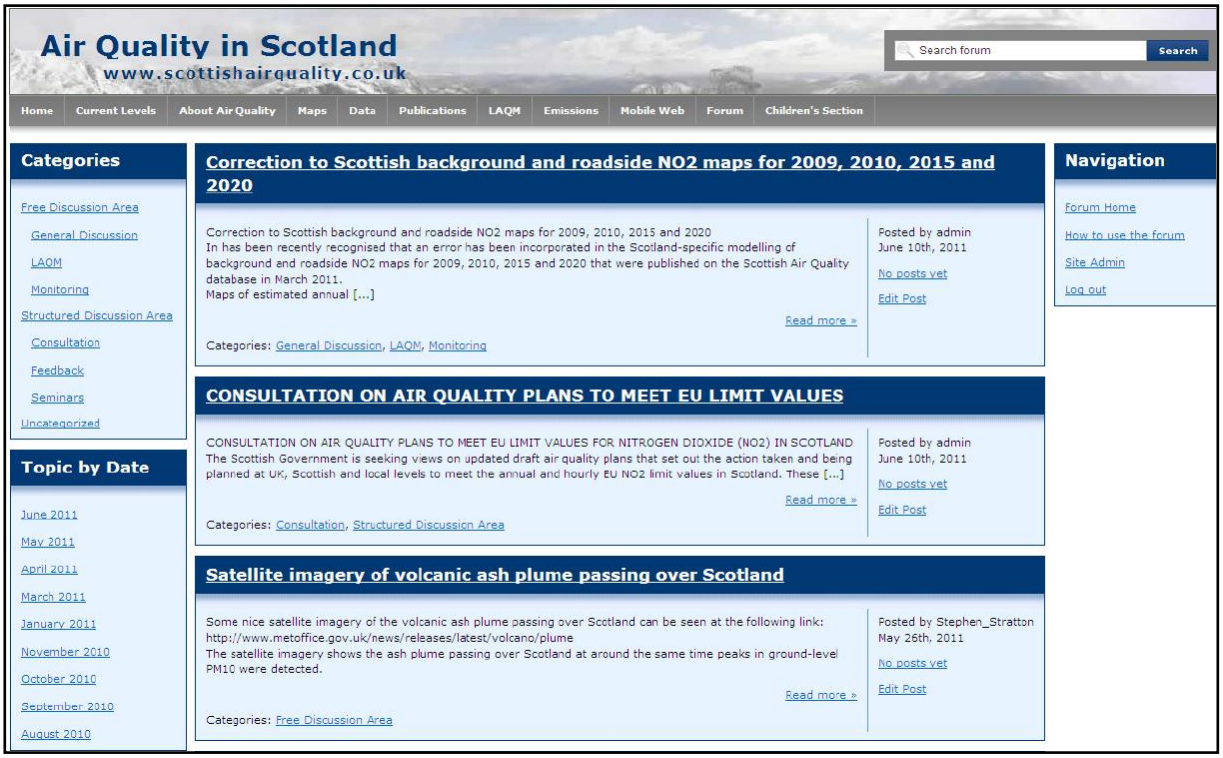
2.3.2 Scottish Air Quality Discussion Forum

In October 2010, the Scottish Government launched the Scottish Air Quality Discussion Forum as part of the Scottish Air Quality Database and Website.

The forum was developed to increase awareness of air quality in Scotland and to facilitate discussion in relation to newly released guidance, articles, studies, conferences and seminars. It is targeted at individuals and organisations with an interest in environmental protection, health, spatial planning and transport planning in Scotland. The forum is updated periodically by the site administrator when relevant new material is identified. However, the main intention of the forum is to encourage discussion between members and it is hoped that members of the forum will contribute to this process and upload appropriate comments and links whenever these arise.

In the first few months following its launch, the forum had attracted approximately 100 members, including representatives from the Scottish Government, local authorities from across the UK, health professionals, consultants, academics and members of the public. A number of items have been posted on the forum since its launch 2010, including the release of new guidance documents and tools, upcoming conferences and seminars, and air quality action plan consultations.

Figure 2-4 Main Page of the Scottish Air Quality Discussion Forum



2.3.3 The Air Pollution Detectives Children's Pages

During 2010, the Scottish Government in partnership with Glow, Scotland's online education community and AEA developed the 'Air Pollution Detectives' children's pages http://www.scottishairquality.co.uk/children as part of the Scottish Air Quality website. The development has been designed to be a fun introduction to air pollution and climate change issues and is targeted at the 8-11 year old age range, but is open to all. The pages were developed with input and feedback from school children and include fun graphics, audio, a quiz and worksheets.

Figure 2-5 Front page of the "Air Pollution Detectives" Children's Web Pages

Users are led through the website by the Air Pollution Detectives 'Maggie' and 'Rabbie' with the help of 'Professor Scott'. The pages have been designed with a crime scene theme with 'voice-overs' provided to help particularly young users (or those who find reading difficult) to access the site. The pages aim to encourage independent thinking from the users, in-line with current educational objectives within Scotland. Users are also encouraged to think about the issues beyond the web pages with appropriate links to other environmental protection websites and organisations.

Figure 2-6 An Introduction to the Air Pollution Suspects

2.3.4 Know and Respond-Scotland Air Quality Alerts

The Know and Respond-Scotland Air Quality Alert Service has been in development since 2009 and constitutes an SMS, email and Voicemail text alert service which will be launched shortly for the public and scientific community. It will enable people to 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 in Scotland. Alerts will be based on the well-established UK AQ Forecasting service operated by AEA on behalf of the Scottish Government.

During 2010 the content of the alerts messages have been agreed with the Scottish Government and Health Protection Scotland, and the Voicemails have been recorded. 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. An example of one of the messages that will be sent out via the system is given below:

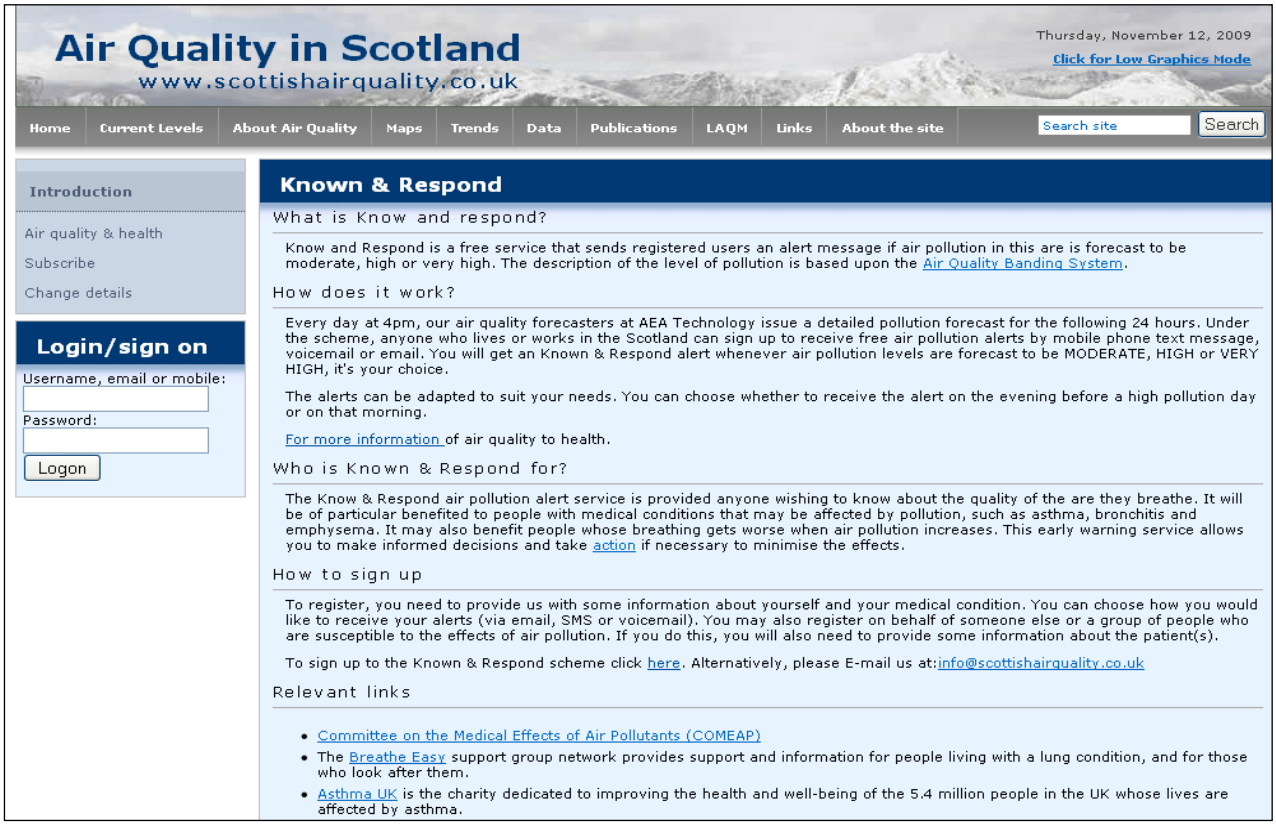
The air pollution forecast for the Glasgow Urban Area is 'Very High'

If you have a pre-existing heart or lung condition your symptoms may worsen as a result of exposure to the air pollution. If this happens and you suffer from a lung disorder, you may need to change your treatment in the usual way to increase its effectiveness, or reduce the time you spend outdoors. If these steps don't help, consult your doctor or ring NHS 24 on 08454 242424.

If you suffer from a heart condition and you notice a change in your symptoms, do not try to change your treatment yourself, but seek medical advice as you normally would or ring NHS 24 on 08454 242424.

Following the development of the information dissemination and sign-up systems during 2009 and 2010, the focus in 2011 is on testing and publicising the launch of the system. Figure 2-7 below shows the sign up page which has been prepared for the service.

Figure 2-7 Know and Respond-Scotland draft 'Sign-Up' page



It is planned that in order to reduce the risks associated with data protection, the system will only hold the subscribers' contact details, not any confidential health-related information.

2.4 Website Developments Planned for 2011

For 2011 a number of further possible website developments are currently under consideration or in early stages of development. These include options to enhance both the statistical power of the database and the graphical user interface. The specification and implementation of these options will be discussed and agreed with Scottish Government and the website stakeholders over the course of 2011.

3 Annual Air Quality Seminar and Newsletter

3.1 Scottish Air Quality Seminar

As part of the Scottish Air Quality Database project, AEA organise, on behalf of Scottish Government, an annual air quality seminar. The latest Scottish Government Annual Air Quality Seminar was held in Stirling on Wednesday 30 March 2011. The event was attended by over fifty air quality experts representing local authorities, the Scottish Government, SEPA and consultancy. 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, the Scottish mapping study and developments on the website including Openair and the Know and Respond System were presented by AEA. In addition, further presentations were given by Dr Jackie Hyland (NHS Fife), Professor Duncan Laxen (Air Quality Consultants), Cheryl Borthwick (ICT/GLOW Development Officer Edinburgh) and Dr Tim Murrells (AEA) on the health effects of air pollution, SNIFFER's $PM_{2.5}$ study, the Air Pollution Detectives and NO_x/ NO_2 emissions respectively.

The agenda for the day is shown in Figure 3-1. 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[2]) is also produced as part of this project. The newsletter for 2010 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@aeat.co.uk, postal address given at the start of this report). Electronic copies in pdf format are available for download at http://www.scottishairquality.co.uk/documents/reports2/309110404_AQ_scot_14_lowres.pdf.

[2] Air Pollution in Scotland 2010
http://www.scottishairquality.co.uk/documents/reports2/309110404_AQ_scot_14_lowres.pdf

Figure 3-1 Agenda for the Scottish Air Quality Seminar on 30 March 2011

The Scottish Government

AEA

SCOTTISH AIR QUALITY DATABASE AND WEBSITE ANNUAL SEMINAR

Wednesday 30 March 2011

The Municipal Chambers, Stirling Council, Stirling, FK8 2ET

09:15	Registration and Coffee	
09:45	Welcome and Introduction	Geeta Puri, SG
10:00	General Updates to the Database and Website – including brief QA / QC	Stuart Sneddon, AEA
10:20	Health Impacts of Air Quality – linking to the Know and Respond Service	Jackie Hyland, NHS Fife
10:55	Know and Respond Service (including AQ forecasting)	Paul Willis, AEA
11:25	Coffee Break	
11:40	Children's Website	Cheryl Borthwick, ICT/GLOW co-ordinator Edinburgh and Stuart Sneddon, AEA
12:10	Openair Data Analysis Tools on the Scottish Air Quality Database	Paul Willis, AEA
12:35	Lunch	
13:35	Scottish Air Quality Mapping – a devolved model	Justin Lingard, AEA
14:10	SNIFFER $PM_{2.5}$ Study	Professor Duncan Laxen, Air Quality Consultants
14:45	Coffee Break	
15:00	Trends in NO_x and NO_2 Emissions and Ambient Measurements in the UK	Tim Murrells, AEA
15:35	Questions	
15:50	Closing Comments	Geeta Puri, SG

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

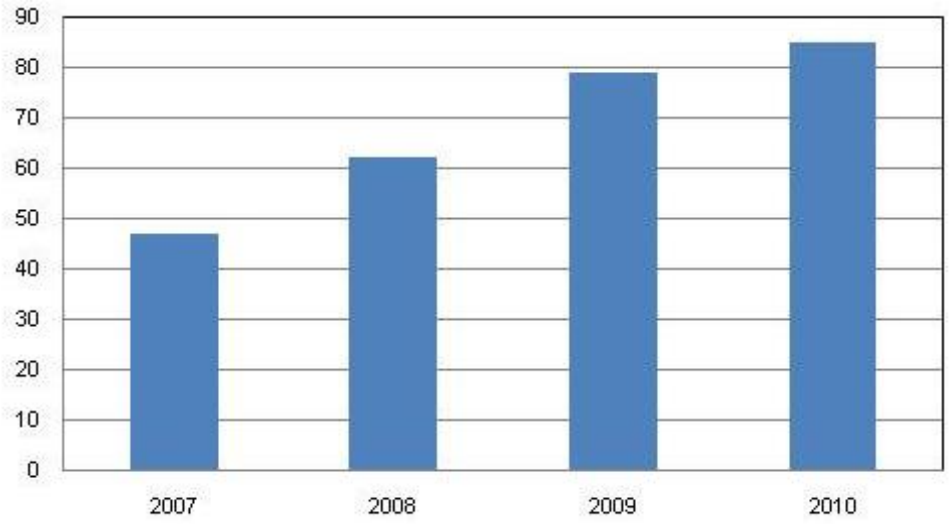
Respondents should be aware that the delegate list for this event is held on a computer. Under the terms of the Data Protection Act, anyone on the mailing list has the right to object to his/her name and address being so held.

4 Data Availability in 2010

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

At the end of 2010 the Scottish Air Quality Database contained data for a total of 85 automatic monitoring sites. In total, 8 new sites were incorporated into the database during 2010, one of which was a relocation (South Ayrshire Maybole, previously South Ayrshire Tarbolton). A second site was moved from the SAQD network and affiliated into the national network (Dumbarton Roadside, previously West Dunbartonshire Glasgow Road). As a result, the number of live sites in the database increased by 6 from 79 sites in 2009. Figure 4-1 shows how the SAQD has grown from 47 sites in 2007 to 85 sites in 2010.

Figure 4-1 Number of Monitoring Sites included in the Scottish Air Quality Database 2007 – 2010



Seventeen sites which are included in the SAQD are also part of the UK's national network (the Automatic Urban and Rural Network, or AURN). For these sites, historic 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 which are not part of the AURN, data are only available from when the station joined the database project. In many cases the stations commenced operation much earlier, and the earlier data may be available from the relevant Local Authority on request.

Data availability for 2010, in terms of site, pollutants and months available, is summarised in Table 4-1. The full 12-figure OS grid reference and the site location classification are also provided for each site.

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 2010

Site Name	Type	East	North	Pollutants	Network	Start date[#]	Data in 2010
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	June – 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	322050	656250	13BD BENZ O_3 PM_{10} $PM_{2.5}$ TOL XYL	AURN	2006	Jan – Dec
Auchencorth Moss PM_{10} $PM_{2.5}$	RURAL	322050	656250	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	Sep – 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	SAQD	2006	Jan – Dec
Dundee Mains Loan	URBAN BACKGROUND	340972	731893	PM_{10}	SAQD	2006	Jan – Dec
Dundee Seagate	KERBSIDE	340487	730446	NO_2	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 – Dec
East Dunbartonshire Bearsden	ROADSIDE	254269	672067	NO_2 PM_{10}	SAQD	2005	Jan – Dec
East Dunbartonshire Bishopbriggs	ROADSIDE	260995	670130	NO_2 PM_{10}	SAQD	2003	Jan – Dec
East Dunbartonshire Kirkintilloch	ROADSIDE	265700	673500	NO_2 PM_{10}	SAQD	2007	Jan - Dec
East 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 Roseburn	ROADSIDE	322900	673260	NO_2 PM_{10}	SAQD	2006	Sept - Dec
Edinburgh Salamander St	ROADSIDE	327621	676342	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Edinburgh St John's Road	KERBSIDE	320100	672890	NO_2	SAQD	2007	Jan – Dec
Edinburgh St Leonards	URBAN BACKGROUND	326250	673132	CO NO_2 O_3 PM_{10} $PM_{2.5}$ SO_2	AURN	2003	Jan – Dec
Eskdalemuir	RURAL	323500	602800	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 PM_{10} 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	SAQD	2007	Jan – Dec
Fife Rosyth	ROADSIDE	311752	683515	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Fort William	SUBURBAN	210849	774421	NO_2 O_3	AURN	2006	Jan – Dec
Glasgow Abercromby Street	ROADSIDE	260420	664175	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Anderston	URBAN BACKGROUND	257925	665487	CO NO_2 PM_{10} SO_2	SAQD	2005	Jan – Dec
Glasgow 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 Byres Road	ROADSIDE	256553	665487	CO NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Centre	URBAN	258902	665028	CO NO_2 O_3 PM_{10}	AURN	1996	Jan – Dec

Site Name	Type	East	North	Pollutants	Network	Start date#	Data in 2010
	CENTRE			$PM_{2.5}$ SO_2			
Glasgow City Chambers	URBAN BACKGROUND	259528	665308	NO_2	AURN	1987	Jan – Dec
Glasgow Kerbside	KERBSIDE	258708	665200	13BD 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 PM_{10}	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 – Dec
Midlothian Dalkeith	ROADSIDE	331159	667298	NO_2 PM10 SO_2	SAQD	2008	Jan – Dec
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	Apr – Dec
N Lanarkshire Harthill West	URBAN BACKGROUND	287480	663810	CO NO_2 PM_{10} SO_2	SAQD	2009	Jan - May
N Lanarkshire Moodiesburn	ROADSIDE	269929	670386	NO_2 PM_{10}	SAQD	2008	Jan - Dec
N Lanarkshire Motherwell	ROADSIDE	275460	656785	PM_{10}	SAQD	2007	June - Dec
N Lanarkshire Shawhead Coatbridge	ROADSIDE	273411	662997	NO_2 PM_{10}	SAQD	2009	Feb - 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	Jul – 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	Oct – 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	Apr - 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	Apr – Dec
South Ayrshire Tarbolton	ROADSIDE	243096	626948	NO_2 PM_{10}	SAQD	2009	Jan – Mar
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	Apr – 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 - Aug
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	NO2 PM10	SAQD	2010	Feb – Dec

* Sites added to database in 2010
+ Sites closed during 2010
# 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 the Database During 2010

The following sites were temporarily closed for relocation or road/building works:

- Paisley Central Road was closed during bus station refurbishment (Oct-09 to Jul-10).
- North Ayrshire Tarbolton closed (24/03/10) and was moved to North Ayrshire Maybole (08/04/10).
- North Lanarkshire Croy closed during a monitoring hut swap.
- South Lanarkshire Glespin was closed for monitoring cabinet upgrade (08/09/10).

The following sites were incorporated into the database during 2010:

• East Ayrshire Kilmarnock John Finnie St	NO_2, PM_{10}	from 21/01/10
• Inverclyde Greenock Dunlop St	NO_2, PM_{10}	from 09/04/10
• Paisley St James St	PM_{10}	from 19/08/10
• Perth Crieff	NO_2, PM_{10}	from 01/04/10
• South Lanarkshire Glespin	PM_{10}	from 01/01/10
• South Lanarkshire Raith Interchange	NO_2, PM_{10}	from 08/04/10

The following site is to be incorporated into the database, but this has not yet happened due to ongoing power supply issues:

- East Dunbartonshire Milngavie.

The following sites closed during 2010:

- N Lanarkshire Harthill West for CO, NO_2, PM_{10}, SO_2 on 24/05/10

The following other changes were made during 2010:

- West Dunbartonshire Glasgow Road became affiliated to the national AURN on 01/09/10 and changed its site name to Dumbarton Roadside.

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 (EN12341). It has long been recognized 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

[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 [Online] Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF (Accessed on 22/07/11]*

[4] *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007. CM 7169 [Online] Available at http://www.defra.gov.uk/publications/2011/03/28/air-quality-strategy-vol2-pb12670/ [Accessed on 22/07/11]*

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. 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) has 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 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.

However, additional refinement of the VCM model has been undertaken and hourly meteorological data for all parameters has been sourced and hence, VCM correction of the 2009 and 2010 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 factor 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 applied to 2010 TEOM PM_{10} data in the SAQD:

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

[5] *UK Equivalence Programme for Monitoring of Particulate Matter. David Harrison Bureau Veritas UK Ltd. June 2006 (BV/AQ/AD202209/DH/2396) [Online]Available at http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf [Accessed on 22/07/11]*

Hourly average temperatures from Edinburgh Airport and pressure measurements from Edinburgh Gogarbank meteorological monitoring stations were used in the model. These sites were selected as a good representation of the weather in the central belt of Scotland and are also located approximately 150 km from Aberdeen, which is within the specified 260 km limit.

Hourly averaged purge measurements from all Scottish FDMS monitoring sites within the Scottish Government network (SAQD) and the 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 4 FDMS sites were used for correcting Aberdeen TEOM data and 26 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.

Table 4-2 FDMS Monitoring Sites used in VCM Correcting TEOM Data from Aberdeen and Central Scotland Monitoring Sites

TEOM Locations	FDMS Sites used in VCM correction	Monitoring Network
Aberdeen	Aberdeen PM_{10}	AURN
	Aberdeen $PM_{2.5}$	AURN
	Angus Forfar	SAQD
	Fife Cupar	SAQD
Central Scotland	Angus Forfar	SAQD
	Auchencorth Moss PM_{10}	AURN
	Auchencorth Moss $PM_{2.5}$	AURN
	East Dunbartonshire Kirkintilloch	SAQD
	East Renfrewshire Sheddens	SAQD
	Edinburgh St Leonards PM_{10}	AURN
	Edinburgh St Leonards $PM_{2.5}$	AURN
	Fife Cupar	SAQD
	Fife Rosyth	SAQD
	Glasgow Abercromby Street	SAQD
	Glasgow Broomhill	SAQD
	Glasgow Centre PM_{10}	AURN
	Glasgow Centre $PM_{2.5}$	AURN
	Glasgow Kerbside PM_{10}	AURN
	Glasgow Kerbside $PM_{2.5}$	AURN
	Glasgow Nithsdale Road	SAQD
	Grangemouth PM_{10}	AURN
	Grangemouth $PM_{2.5}$	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

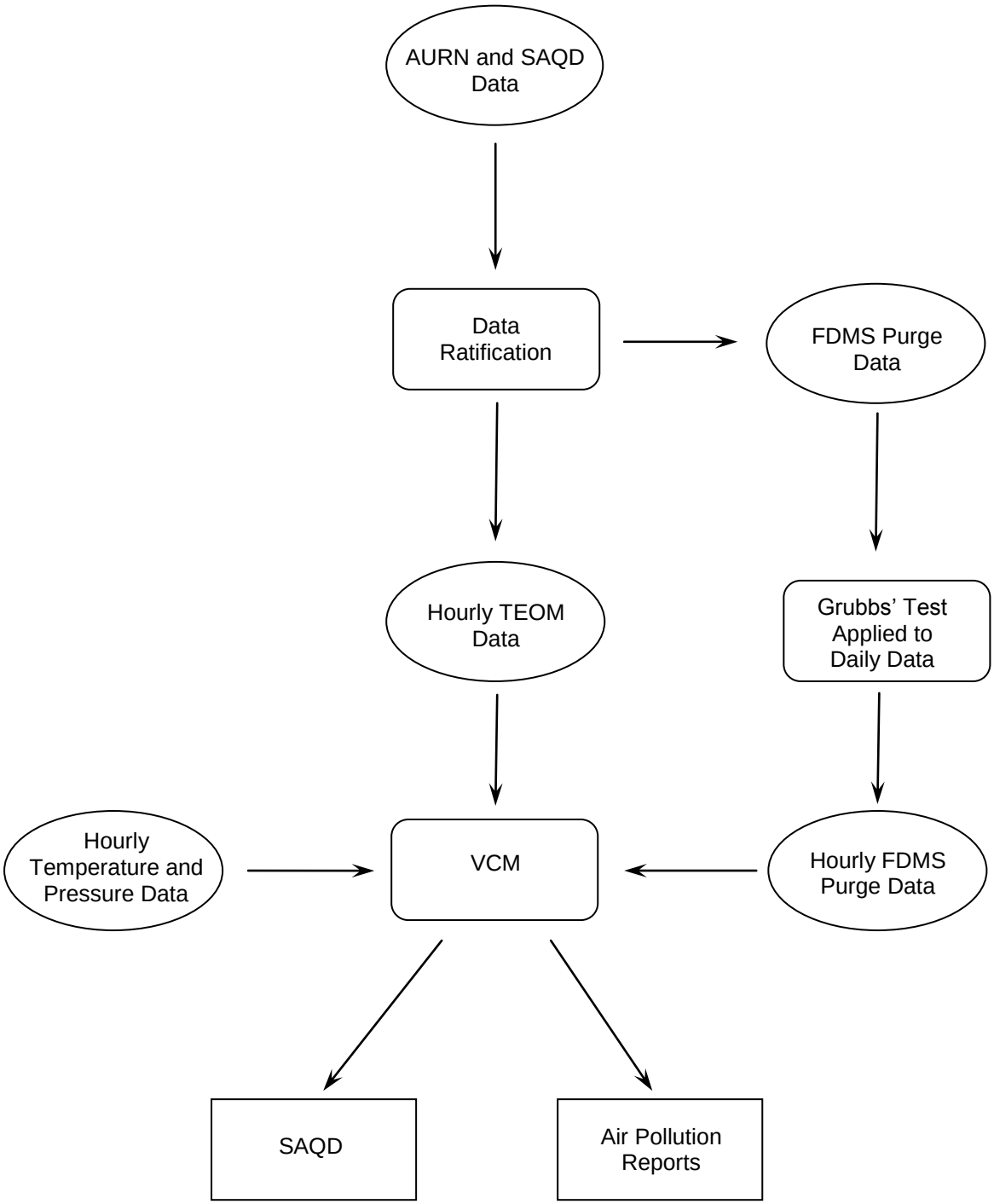
The corrected data for 2010 and calculated summary statistics have been provided to the local authorities. If a PM_{10} analyser was upgraded to an FDMS from a TEOM during 2010, the statistics quoted are calculated using the combination of VCM corrected data and FDMS data. The SAQD now provides all ratified TEOM data for 2010 (and 2009) as VCM corrected via an additional selection option in the data download pages.

A flow chart showing the overall process employed for VCM correction of 2010 SAQD TEOM data is shown in Figure 4-2 Process used for applying the VCM to SAQD TEOM Data.

[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 [Accessed on 22/07/11]*

It is not possible to correct historical data using the VCM as insufficient FDMS measurements are available prior to 2008.

Figure 4-2 Process used for applying the VCM to 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 were monitored within other national networks during 2010:

- UK Automatic Hydrocarbon – 2 sites
- UK Non-Automatic – 2 sites
- PAH – 4 sites
- Heavy Metals – 4 sites
- Acid Deposition – 11 sites
- Ammonia and Nitric Acid – 28 sites
- Particle Numbers and Black Carbon – 2 sites
- TOMPs – 1 site
- Auchencorth Moss EMEP Supersite.

Details of these sites are presented in Appendix 1. It has not yet 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-AQS 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). 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.

5 QA/QC of the Scottish Database

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

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

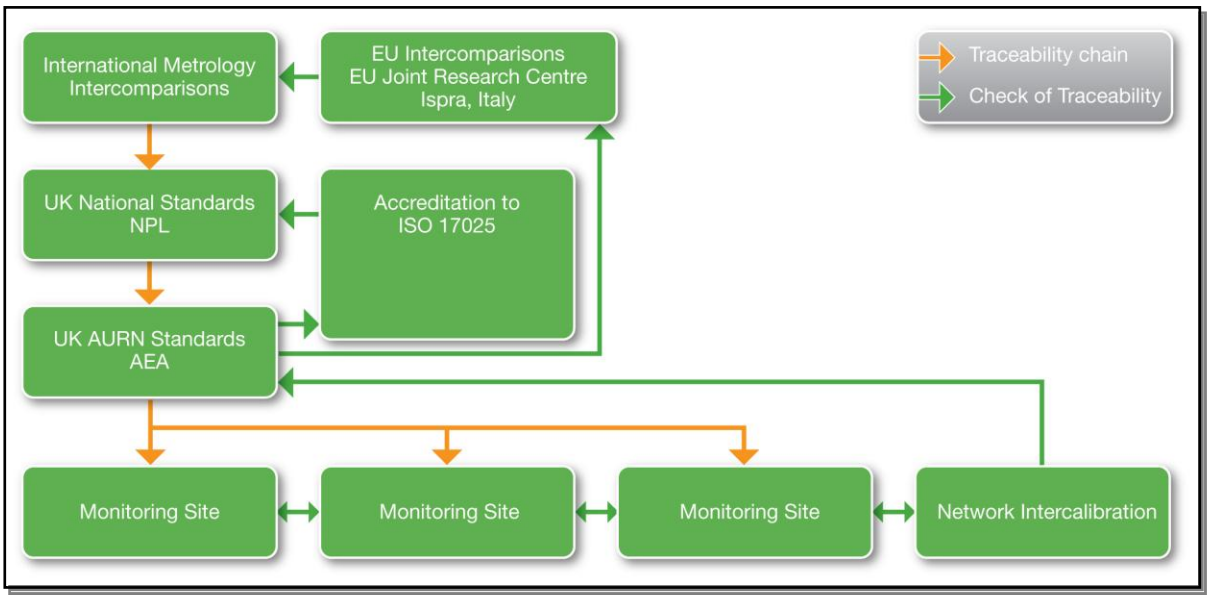
5.1 On-site analyser and calibrations gas audits

The automatic air quality monitoring stations located throughout Scotland employ a wide variety of different analyser types and site infrastructure. Inter-calibration 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 (Figure 5-1). This process ensures that all monitoring stations in Scotland are traceable to reference gas standards held at AEA. These in turn are traceable to UK national reference standard gases held by the National Physical Laboratory who, in turn regularly inter-compare these standards internationally. AEA also participate in EU level inter-comparisons at the EU Joint Research Centre at Ispra, Italy. Hence, there is an unbroken traceability chain from each monitoring site in Scotland to internationally agreed gas calibration standards. This check also identifies any unstable gas cylinders which may need to be recertified or discarded.

Figure 5-1 Traceability chain for the SAQD monitoring stations



The aims and objectives of the audit and inter-calibration 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 process applied to the data from the Scottish Local Authority monitoring stations. This is the same data management process, 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 SAQD and Website as provisional results. These operations are carried out automatically by computer systems, with all output manually checked by data management experts.

The provisional data are freely available to all users on a day-to-day basis. This gives the Local Authority the opportunity to easily view both their own data and data from other stations throughout Scotland. This will assist in dealing with day-to-day requests for information on specific data or the overall pollution situation either locally or throughout Scotland. In particular the automatic data summary bulletin, available by email from the website, and the plotting package incorporated into this, will be useful to authorities to rapidly evaluate their data against that from other stations.

5.3 Data Ratification

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

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

The policy on data rejection opted by 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 automatically to the SAQD as they become available 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 2010

5.4.1 Site Inter-calibrations and Audits

As discussed above, site inter-calibrations and audit visits are undertaken at 6-monthly intervals. However, where a site joins the database part way through a year then it is possible that only one audit will be conducted during the year.

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 2009/10	Number of Monitoring Sites Summer 2010
FDMS* pump vacuum <21”Hg	3	3
TEOM** and TEOM FDMS k_0 out by > 2.5%	9	2
Particulate Analyser*** flow out by >10%	14	7
NO_x analyser converter <97% efficiency	3	2
NO cylinder out by >10%	10	5
SO_2 cylinder out by >10%	2	1

* 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 inter-calibration exercises. As can be seen from the 2010 figures, fewer faults were identified at the summer audits than at the winter audits. This gives us confidence that faults identified and reported earlier in 2010 were fixed in time for the summer audit programme.

In many cases, the results from the audit and inter-calibration 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 shows the full list of inter-calibrations and audits undertaken on air quality sites in the Scottish Database during 2010.

Table 5-2 Air Quality Site Inter-calibration and Audits Conducted During 2010

	Jan - Jun 2010	Jul – Dec 2010		Jan - Jun 2010	Jul – Dec 2010
Aberdeen	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen King Street	✓	✓	Glasgow Centre	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow City Chambers	✓	✓
Aberdeen Union St	✓	✓	Glasgow Kerbside	✓	✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Nithsdale Road	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Alloa	✓	✓	Grangemouth	✓	✓
Angus Forfar	✓	✓	Grangemouth Moray	✓	✓
Auchencorth Moss	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	Inverclyde Greenock Dunlop St	✓	✓
Bush Estate	✓	✓	Inverness	✓	✓
Dumbarton Roadside			Lerwick	✓	✓
Dumfries	✓	✓	Lerwick Staney Hill	✓	✓
Dundee Broughty Ferry Road	✓	✓	Midlothian Dalkeith	✓	✓
Dundee Lochee Road	✓	✓	Midlothian Pathhead	✓	✓
Dundee Mains Loan	✓	✓	N Lanarkshire Chapelhall	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Dundee Union Street	✓	✓	N Lanarkshire Croy	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Harthill West	✓	
East Ayrshire Kilmarnock John Finnie St	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Ayrshire New Cumnock	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	North Ayrshire Irvine High St	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	Paisley Central Road	✓	✓
East Lothian Musselburgh N High St	✓	✓	Paisley Glasgow Airport	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley Gordon Street	✓	✓
Edinburgh Gorgie Road	✓	✓	Paisley St James St		✓
Edinburgh Queen Street	✓	✓	Peebles	✓	✓
Edinburgh Roseburn	✓	✓	Perth Atholl Street	✓	✓
Edinburgh Salamander St	✓	✓	Perth Crieff	✓	✓
Edinburgh St John's Road	✓	✓	Perth High Street	✓	✓
Edinburgh St Leonards	✓	✓	South Ayrshire Ayr High St	✓	✓
Eskdalemuir	✓	✓	South Ayrshire Maybole	✓	✓
Falkirk Grangemouth MC	✓	✓	South Ayrshire Tarbolton	✓	
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 Rosyth	✓	✓	West Dunbartonshire Glasgow Road	✓	✓
Fort William	✓	✓	West Lothian Broxburn	✓	✓
Glasgow Abercromby Street	✓	✓	West Lothian Linlithgow High Street	✓	✓
Glasgow Anderston	✓	✓	West Lothian Whitburn	✓	✓
Glasgow Battlefield Road	✓	✓			

5.4.2 Data ratification

Data ratification is undertaken on 6-month data blocks at 6-monthly intervals. Hence, as with the inter-calibrations and audits, if the site joins the database part way through a year then data can only be ratified from the date of the site joining the database.

All ratified data for 2010 have now been uploaded to the Scottish Air Quality website. Table 5-3 summarises the ratification undertaken during 2010.

Table 5-3 Data Ratification undertaken during 2010

	Jan - Jun 2010	Jul – Dec 2010		Jan - Jun 2010	Jul – Dec 2010
Aberdeen	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen King Street	✓	✓	Glasgow Centre	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow City Chambers	✓	✓
Aberdeen Union St	✓	✓	Glasgow Kerbside	✓	✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Nithsdale Road	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Alloa	✓	✓	Grangemouth	✓	✓
Angus Forfar	✓	✓	Grangemouth Moray	✓	✓
Auchencorth Moss	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Auchencorth Moss PM_{10} $PM_{2.5}$	✓	✓	Inverclyde Greenock Dunlop St	✓	✓
Bush Estate	✓	✓	Inverness	✓	✓
Dumbarton Roadside		✓	Lerwick	✓	✓
Dumfries	✓	✓	Lerwick Staney Hill	✓	✓
Dundee Broughty Ferry Road	✓	✓	Midlothian Dalkeith	✓	✓
Dundee Lochee Road	✓	✓	Midlothian Pathhead	✓	✓
Dundee Mains Loan	✓	✓	N Lanarkshire Chapelhall	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Dundee Union Street	✓	✓	N Lanarkshire Croy	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Harthill West	✓	
East Ayrshire Kilmarnock John Finnie St	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Ayrshire New Cumnock	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	North Ayrshire Irvine High St	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	Paisley Central Road	✓	✓
East Lothian Musselburgh N High St	✓	✓	Paisley Glasgow Airport	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley Gordon Street	✓	✓
Edinburgh Gorgie Road	✓	✓	Paisley St James St		✓
Edinburgh Queen Street	✓	✓	Peebles	✓	✓
Edinburgh Roseburn	✓	✓	Perth Atholl Street	✓	✓
Edinburgh Salamander St	✓	✓	Perth Crieff	✓	✓
Edinburgh St John's Road	✓	✓	Perth High Street	✓	✓
Edinburgh St Leonards	✓	✓	South Ayrshire Ayr High St	✓	✓
Eskdalemuir	✓	✓	South Ayrshire Maybole	✓	✓
Falkirk Grangemouth MC	✓	✓	South Ayrshire Tarbolton	✓	
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 Rosyth	✓	✓	West Dunbartonshire Glasgow Road	✓	✓
Fort William	✓	✓	West Lothian Broxburn	✓	✓
Glasgow Abercromby Street	✓	✓	West Lothian Linlithgow High Street	✓	✓
Glasgow Anderston	✓	✓	West Lothian Whitburn	✓	✓
Glasgow Battlefield Road	✓	✓			

6 Air Pollution in Scotland 2010

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 2010.

- 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. Polycyclic Aromatic Hydrocarbons (PAH)
    4. Toxic Organic Micropollutants (TOMPS)
    5. Metals (Urban network)
    6. Metals (Rural and deposition network)
    7. Black Carbon and Particle Counts
    8. United Kingdom Eutrophying & Acidifying Pollutants Network
        - The Precipitation Network
        - NO_2 Rural Diffusion Tube Network
        - Acid Gases and Aerosol Network (AGANET)
        - National Ammonia Monitoring Network

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

Table 6-1 to show the 2010 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 exceedance and estimate its extent. Where the exceedance 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 2010 Newsletter, is given under each table.

Table 6-1 shows nitrogen dioxide data for the 73 sites utilising automatic monitoring in 2010, 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 60 sites with more than 75% data capture, 21 of these (19 kerbside or roadside and 2 urban sites, both in Glasgow) exceeded the AQS Objective for the NO_2 annual mean (40 µg m^{-3}). At 8 sites, the AQS Objective of not more than 18 exceedances of 200 µg m^{-3} for the hourly mean was also exceeded.

6.1.1 Nitrogen Dioxide

Table 6-1 Ratified data annual average concentration and data capture for NO_2 in 2010 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2010 ($\mu g\ m^{-3}$)	No. hours > 200 $\mu g\ m^{-3}$	Data capture NO_2 2010 (%)
Aberdeen Anderson Dr	Roadside	27	0	89
Aberdeen Errol Place	Urban Background	22	0	72
Aberdeen King Street	Roadside	29	0	99
Aberdeen Market Street 2	Roadside	44	0	78
Aberdeen Union Street Roadside	Roadside	59	17	79
Aberdeen Wellington Road	Roadside	52	1	95
Bush Estate	Rural	8.7	0	98
Dumbarton Roadside	Roadside	32	0	33
Dumfries	Roadside	40	3	99
Dundee Lochee Road	Kerbside	55	67	95
Dundee Seagate	Kerbside	51	0	80
Dundee Union Street	Kerbside	40	0	91
Dundee Whitehall Street	Kerbside	36	0	89
East Ayrshire Kilmarnock John Finnie St	Roadside	43	16	89
East Ayrshire New Cumnock	Urban Background	11	0	100
East Dunbartonshire Bearsden	Roadside	47	37	100
East Dunbartonshire Bishopbriggs	Roadside	33	0	91
East Dunbartonshire Kirkintilloch	Roadside	45	4	94
East Lothian Musselburgh N High St	Roadside	29	0	73
Edinburgh Gorgie Road	Roadside	41	0	76
Edinburgh Queen Street	Roadside	37	0	98
Edinburgh Roseburn	Roadside	30	1	98
Edinburgh Salamander St	Roadside	30	0	97
Edinburgh St John's Road	Kerbside	71	60	94
Edinburgh St Leonards	Urban Background	31	0	98
Eskdalemuir	Rural	3	0	98
Falkirk Grangemouth MC	Urban Background	23	0	94
Falkirk Haggs	Roadside	46	15	98
Falkirk Hope St	Roadside	28	0	98
Falkirk Park St	Roadside	33	0	100
Falkirk West Bridge Street	Roadside	42	0	96
Fife Cupar	Roadside	33	0	97
Fife Dunfermline	Roadside	32	0	99
Fife Rosyth	Roadside	33	0	98
Fort William	Suburban	13	0	92
Glasgow Anderston	Urban Background	35	16	82
Glasgow Battlefield Road	Roadside	29	0	90
Glasgow Byres Road	Roadside	47	14	92
Glasgow Centre	Urban Centre	44	56	98
Glasgow City Chambers	Urban Background	49	10	97
Glasgow Kerbside	Kerbside	84	97	97
Glasgow Waulkmillglen Reservoir	Rural	16	0	99

Site Name	Type	Annual Average NO_2 2010 ($\mu g\ m^{-3}$)	No. hours > 200 $\mu g\ m^{-3}$	Data capture NO_2 2010 (%)
Grangemouth	Urban Industrial	19	0	90
Grangemouth Moray	Urban Background	24	0	99
Inverclyde Greenock Dunlop St	Roadside	16	0	69
Inverness	Roadside	24	0	89
Lerwick Staney Hill	Urban Background	13	0	44
Midlothian Dalkeith	Roadside	25	0	98
N Lanarkshire Chapelhall	Roadside	28	6	85
N Lanarkshire Coatbridge Whifflet	Urban Background	27	0	51
N Lanarkshire Croy	Roadside	30	0	57
N Lanarkshire Harthill West	Urban Background	25	0	39
N Lanarkshire Moodiesburn	Roadside	43	0	99
N Lanarkshire Shawhead Coatbridge	Roadside	41	0	97
North Ayrshire Irvine High St	Kerbside	32	1	49
Paisley Central Road	Kerbside	57	43	50
Paisley Glasgow Airport	Airport	28	9	99
Paisley Gordon Street	Roadside	42	47	93
Peebles	Suburban	9	0	99
Perth Atholl Street	Roadside	56	10	99
Perth Crieff	Roadside	28	0	72
Perth High Street	Roadside	30	0	98
South Ayrshire Ayr High St	Roadside	24	0	97
South Ayrshire Maybole	Roadside	11	0	68
South Ayrshire Tarbolton	Roadside	19	0	23
South Lanarkshire East Kilbride	Roadside	37	27	97
South Lanarkshire Raith Interchange	Roadside	49	38	70
Stirling Craig's Roundabout	Roadside	38	0	93
West Dunbartonshire Clydebank	Roadside	26	0	93
West Dunbartonshire Glasgow Road	Roadside	24	0	65
West Lothian Broxburn	Roadside	46	0	100
West Lothian Linlithgow High Street	Roadside	26	0	86
West Lothian Whitburn	Urban Background	17	0	79

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

Two sites equaled the annual average objective, but did not exceed. Of the sites with less that 75% data capture, Paisley Central Road and South Lanarkshire Raith Interchange exceeded both the NO_2 annual average and hourly average objectives with data capture rates of 50% and 70% respectively.

The highest annual average concentrations were measured at Glasgow Kerbside, Edinburgh St John's Road and Aberdeen Union St with measured concentrations of 84 $\mu g\ m^{-3}$, 71 $\mu g\ m^{-3}$ and 59 $\mu g\ m^{-3}$ respectively. All three sites sit close to extremely busy roads.

6.1.2 Particulate Matter – PM_{10}

Table 6-2 Ratified data annual average concentration and data capture for PM_{10} in 2010 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2010 ($\mu g\ m^{-3}$ gravimetric equivalent)*	No. days > 50$\mu g\ m^{-3}$	Data capture PM_{10} 2010 (%)
Aberdeen Anderson Dr	Roadside	TEOM (VCM)	14	0	88
Aberdeen Errol Place	Urban Background	FDMS	13	1	92
Aberdeen King Street	Roadside	BAM (unheated inlet)	18	4	98
Aberdeen Market Street 2	Roadside	BAM (unheated inlet)	20	6	72
Aberdeen Union St	Roadside	TEOM (VCM)	18	0	97
Aberdeen Wellington Road	Roadside	TEOM (VCM)	22	1	96
Alloa	Roadside	TEOM (VCM)	17	1	95
Angus Forfar	Roadside	FDMS	18	4	95
Auchencorth Moss	Rural	Partisol	8	0	96
Auchencorth Moss PM_{10} $PM_{2.5}$	Rural	FDMS	7	0	69
Dundee Broughty Ferr Road	Roadside	TEOM (VCM)	16	0	99
Dundee Mains Loan	Urban Background	TEOM (VCM)	13	0	99
Dundee Union Street	Kerbside	TEOM (VCM)	17	0	91
East Ayrshire Kilmarnock John Finnie St	Roadside	BAM (unheated inlet)	21	0	87
East Ayrshire New Cumnock	Urban Background	BAM (unheated inlet)	9	0	99
East Dunbartonshire Bearsden	Kerbside	BAM (heated inlet)	25	20	96
East Dunbartonshire Bishopbriggs	Roadside	BAM (heated inlet)	19	11	99
East Dunbartonshire Krikintilloch	Roadside	FDMS	26	21	80
East Lothian Musselburgh N High St	Roadside	BAM (unheated inlet)	12	0	78
East Renfrewshire Sheddons	Roadside	FDMS	17	3	86
Edinburgh Queen Street	Roadside	TEOM (VCM)	18	1	96
Edinburgh Roseburn	Roadside	TEOM (VCM)	15	0	99
Edinburgh Salamander St	Roadside	TEOM (VCM)	26	19	97
Edinburgh St Leonards	Urban Background	FDMS	14	0	95
Falkirk Grangemouth MC	Urban Background	TEOM (VCM)	15	0	96
Falkirk Hope St	Roadside	TEOM (VCM)	15	0	96
Falkirk Park St	Roadside	TEOM (VCM)	17	1	99
Falkirk West Bridge St	Roadside	TEOM (VCM)	21	7	86
Fife Cupar	Kerbside	FDMS	19	3	93
Fife Rosyth	Roadside	FDMS	19	0	93
Glasgow Abercromby	Roadside	FDMS	21	9	90
Glasgow Anderston	Urban Background	TEOM (VCM)	16	4	81
Glasgow Battlefield Road	Roadside	TEOM (VCM)	19	1	90
Glasgow Broomhill	Roadside	FDMS	19	9	92
Glasgow Byres Road	Roadside	TEOM (VCM)	23	9	92
Glasgow Centre	Urban Background	FDMS	23	7	26
Glasgow Kerbside	Kerbside	FDMS	29	25	98
Glasgow Nitshdale Raod	Roadside	FDMS	21	10	77
Glasgow Waulkmilglen	Rural	TEOM (VCM)	16	4	81

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2010 ($\mu g\ m^{-3}$ gravimetric equivalent)*	No. days > 50$\mu g\ m^{-3}$	Data capture PM_{10} 2010 (%)
Grangemouth	Urban Industrial	FDMS	14	1	95
Grangemouth Moray Scot Gov	Urban Background	TEOM (VCM)	14	0	99
Invercylde Greenock	Roadside	TEOM (VCM)	15	2	69
Inverness	Roadside	Partisol	14	2	88
Midlothian Dalkeith	Roadside	TEOM (VCM)	16	0	98
Midlothian Pathead	Kerbside	TEOM (VCM)	18	3	91
N Lanarkshire Chapelhall	Roadside	TEOM (VCM)	19	0	68
N Lanarkshire Coatbridge Whifflet	Urban Background	TEOM (VCM)	15	0	87
N Lanarkshire Croy	Roadside	TEOM (VCM)	21	9	51
N Lanarkshire Harthill West	Urban Background	TEOM (VCM)	14	0	39
N Lanarkshire Moodiesburn	Roadside	BAM (unheated inlet)	20	4	83
N Lanarkshire Mothewell	Roadside	TEOM (VCM)	19	3	64
N Lanarkshire Shawhead Coatbridge	Roadside	BAM (unheated inlet)	19	0	93
North Ayrshire Irvine High St	Kerbside	BAM (unheated inlet)	19	0	96
Paisley Gordon St	Roadside	FDMS	21	11	76
Paisley St James Street	Roadside	FDMS	23	8	23
Perth Atholl	Roadside	TEOM (VCM)	24	12	94
Perth Creiff	Roadside	BAM (unheated inlet)	16	0	66
Perth High Street	Roadside	TEOM (VCM)	19	3	98
South Ayrshire Ayr High Street	Roadside	FDMS	16	0	80
South Ayrshire Maybole	Roadside	FDMS	12	1	65
South Ayrshire Tarbolton	Roadside	FDMS	14	0	22
South Lanarkshire East Kilbride	Roadside	FDMS	17	5	97
South Lanarkshire Raith Interchange	Roadside	FDMS	26	5	56
Stirling Craig's Roundabout	Roadside	TEOM (VCM)	17	0	99
West Dunbartonshire Clydebank	Roadside	TEOM (VCM)	18	3	92
West Lothian Broxburn	Kerbside	FDMS	21	4	95
West Lothian Linlithgow High St	Roadside	FDMS	12	0	57
West Lothian Whitburn	Roadside	FDMS	14	0	79

* FDMS 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
TEOM (VCM) data are adjusted using the Volatile Correction Model
Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6-2 shows the 2010 gravimetric equivalent particulate matter PM_{10} data from 67 sites utilising automatic monitoring and the Partisol daily sampler at Inverness and Auchencorth Moss. Of these sites, 14 have less than 75% data capture. As discussed in Section 4.2.2, all TEOM data have been adjusted using the VCM.

Of the 54 sites with more than 75% data capture, 22 sites exceeded the AQS annual average PM_{10} objective of 18 $\mu g\ m^{-3}$ and a further 6 equaled this objective. Of these sites 11 also exceeded the daily objective of 50 $\mu g\ m^{-3}$ not to be exceeded more than 7 times a year. In addition, 1 site exceeded a daily mean of 50 $\mu g\ m^{-3}$ on 7 occasions.

Of the 14 sites with less than 75% data capture, 7 sites exceeded the annual average PM_{10} objective of 18 $\mu g\ m^{-3}$. Of these sites 2 also exceeded the daily objective of 50 $\mu g\ m^{-3}$ not to be exceeded more than 7 times a year. In addition, 1 site exceeded a daily mean of 50 $\mu g\ m^{-3}$ on 7 occasions.

No site exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10} or the daily objective of 35 exceedances of 50 µg 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 6-2 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 sites measured similar annual average PM_{10} concentrations with 7 µg m^{-3} and 8 µg m^{-3} measured by the Partisol and FDMS instruments respectively. A data capture rate of only 69% was achieved with the FDMS instrument. No exceedances of the daily objective were measured by the Partisol or FDMS.

Figure 6.1 shows the 2010 Annual Average PM_{10} and $PM_{2.5}$ concentrations for all SAQD monitoring sites with more than 75% data capture.

Figure 6-1 Annual Average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites

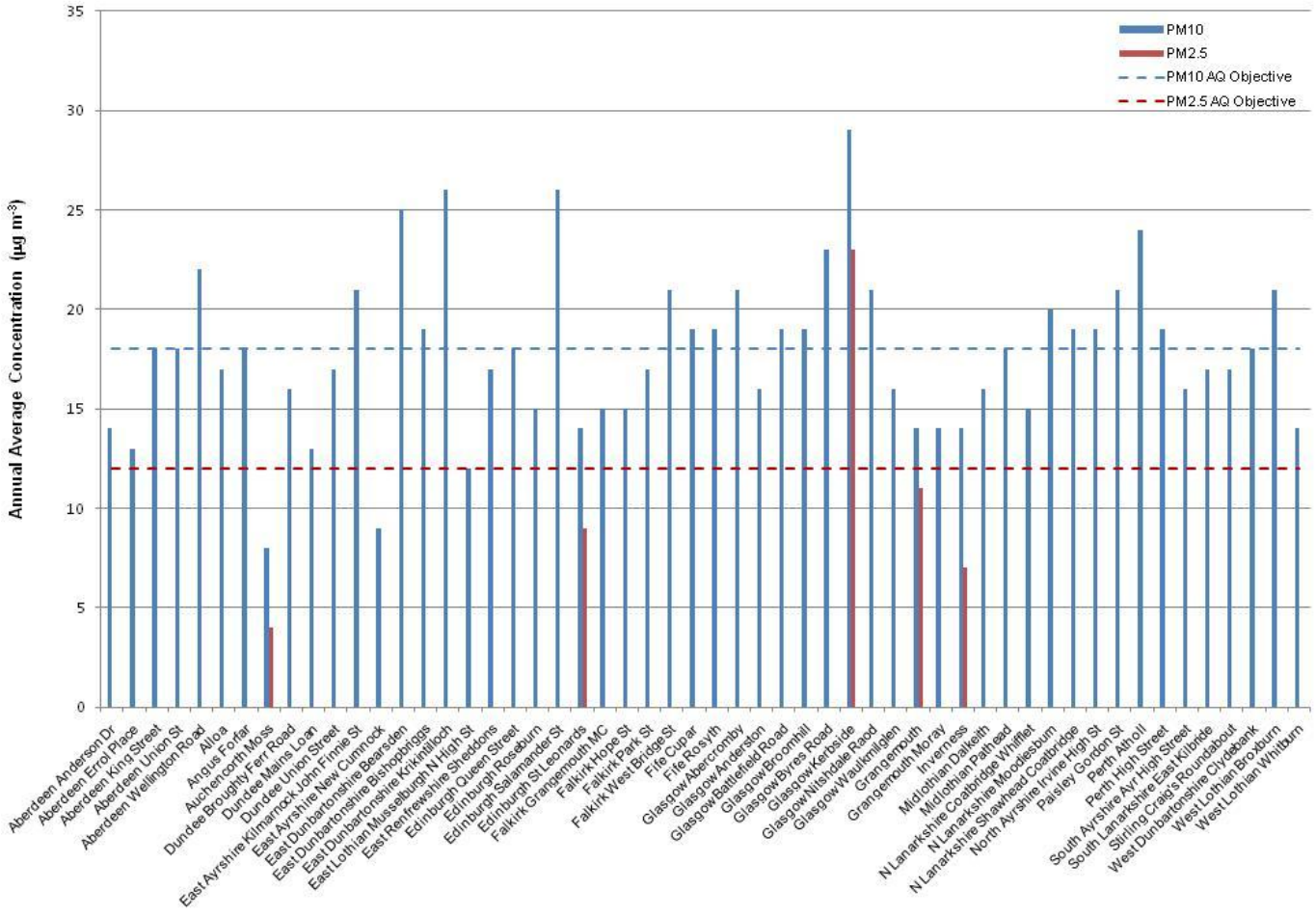


Table 6-3 Ratified data annual average concentration and data capture for $PM_{2.5}$ in 2010 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	$PM_{2.5}$ Analyser Type	Annual Average $PM_{2.5}$ 2010 ($\mu g\ m^{-3}$ gravimetric equivalent)	Data capture $PM_{2.5}$ 2010 (%)
Aberdeen Errol Place	Urban Background	FDMS	7	80
Auchencorth Moss	Rural	Partisol	4	85
Auchencorth Moss PM_{10} $PM_{2.5}$	Rural	FDMS	4	70
Edinburgh St Leonards	Urban Background	FDMS	9	94
Glasgow Centre	Urban Background	FDMS	12	99
Glasgow Kerbside	Kerbside	FDMS	23	96
Grangemouth	Urban Industrial	FDMS	11	94
Inverness	Roadside	Partisol	7	89

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

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 2010.

Only one of these sites had less than 75% data capture – Auchencorth Moss PM_{10} $PM_{2.5}$. At the remaining sites, the Scottish AQS Objective of 12 $\mu g\ m^{-3}$ was exceeded at Glasgow Kerbside and equalled at Glasgow Centre with data capture rates of 96% and 99% respectively.

Over the whole of the UK, the provisional $PM_{2.5}$ Average Exposure Indicator (AEI) for 2010 was 12 $\mu g\ m^{-3}$, which when averaged with the AEI for 2009 of 13 $\mu g\ m^{-3}$ is 12.5 $\mu g\ m^{-3}$. This is borderline between a required reduction of 10% or 15% by 2020 according to the requirements of the EU Directive. The final AEI will to be calculated as an average over 2009, 2010 and 2011.

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 4 $\mu g\ m^{-3}$ measured by both instruments.

The $PM_{2.5}/PM_{10}$ ratios found in Scotland for 2010 are shown in Table 6-4 $PM_{2.5}/PM_{10}$ ratios for 2010 annual average concentrations. These ratios are similar to those found in 2009. The highest $PM_{2.5}/PM_{10}$ ratios were calculated at Glasgow Kerbside and Grangemouth, both having a ratio of 0.79.

Table 6-4 $PM_{2.5}/PM_{10}$ ratios for 2010 annual average concentrations

Site Name	Annual Average PM_{10} 2010 ($\mu g\ m^{-3}$ gravimetric equivalent)	Annual Average $PM_{2.5}$ 2010 ($\mu g\ m^{-3}$ gravimetric equivalent)	Ratio 2010
Aberdeen Errol Place	13	7	0.54
Auchencorth Moss PM_{10} $PM_{2.5}$	7	4	0.57
Auchencorth Moss (Partisol)	8	4	0.50
Edinburgh St Leonards	14	9	0.64
Glasgow Centre	23	12	0.52
Glasgow Kerbside	29	23	0.79
Grangemouth	14	11	0.79
Inverness (Partisol)	14	7	0.50

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

6.1.3 Carbon Monoxide

Table 6-5 shows that carbon monoxide was monitored using automatic techniques at 5 sites in 2010 – one less than in 2009. The site at N. Lanarkshire Harthill West only operated for part of the year. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

Table 6-5 Ratified data annual average concentration and data capture for CO in 2010 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2010 ($mg\ m^{-3}$)	Max. Running 8hr Mean CO 2010 ($mg\ m^{-3}$)	Data capture CO 2010 (%)
Edinburgh St Leonards	Urban Background	0.2	0.8	99
Glasgow Anderston	Urban Background	0.2	2.4	82
Glasgow Byres Road	Roadside	0.4	4.6	93
Glasgow Centre	Urban Centre	0.3	2.4	99
N Lanarkshire Harthill West	Urban Background	0.1	0.3	39

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

6.1.4 Sulphur Dioxide

Table 6-6 shows sulphur dioxide data from the 14 sites utilising automatic monitoring for 2010. Sites at N. Lanarkshire Croy and N. Lanarkshire Harthill West 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 2010. All except two sites, Grangemouth and Grangemouth Moray Scot Gov, met the requirements of the Air Quality Strategy for 15-minute mean. At these sites there were 45 exceedances of the Air Quality Strategy 15min Objective at Grangemouth and 62 exceedances measured at Grangemouth Moray Scot Gov whereas only 35 such instances are permitted.

Table 6-6 Ratified data annual average concentration and data capture for SO2 in 2010 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Avg. SO_2 2010 ($\mu g\ m^{-3}$)	No. Exceed 15min SO_2 2010 ($\mu g\ m^{-3}$)	No. Exceed 1hr SO_2 2010 ($\mu g\ m^{-3}$)	NO. Exceed 24hr SO_2 2010 ($\mu g\ m^{-3}$)	Data capture SO_2 2010 (%)
Dundee Broughty Ferry Road	Roadside	7	0	0	0	97
Edinburgh St Leonards	Urban Background	4	0	0	0	92
Falkirk Grangemouth MC	Urban Background	7	12	0	0	99
Falkirk Hope St	Roadside	5	5	0	0	86
Falkirk Park St	Roadside	6	3	0	0	97
Glasgow Anderston	Urban Background	4	0	0	0	81
Glasgow Centre	Urban Centre	4	0	0	0	99
Grangemouth	Urban Industrial	12	45	2	0	95
Grangemouth Moray Scot Gov	Urban Background	12	62	2	0	98
Lerwick Staney Hill	Urban Background	4	0	0	0	60
Midlothian Dalkeith	Roadside	2	0	0	0	96
Midlothian Pathhead	Kerbside	9	0	0	0	96
N Lanarkshire Croy	Roadside	3	2	0	0	56
N Lanarkshire Harthill West	Urban Background	2	0	0	0	39

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

6.1.5 Ozone

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. Table 6.7 shows ozone data from 11 automatic monitoring sites measuring this pollutant in 2010. In 2010, 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 Peebles.

Table 6-7 Ratified O_3 data (2010) for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average O_3 2010 ($\mu g\ m^{-3}$)	No of days with running 8-hr mean >100 ug m^{-3}	Data capture O_3 2010 (%)
Aberdeen Errol Place	Urban Background	44	0	90
Auchencorth Moss	Rural	56	3	99
Bush Estate	Rural	57	1	99
Edinburgh St Leonards	Urban Background	33	0	96
Eskdalemuir	Rural	55	2	99
Fort William	Suburban	47	4	99
Glasgow Centre	Urban Centre	27	0	99
Glasgow Waulkmillglen Reservoir	Rural	49	3	99
Lerwick	Rural	65	1	99
Peebles	Suburban	51	12	98
Strath Vaich	Remote	61	4	99

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

6.2 Hydrocarbons

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 2009. Where other pollutants are also monitored in these networks, these pollutants are listed, but the data are not provided in this report.

6.2.1 PAH Monitoring Network[7]

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

PAH monitoring of the compound benzo[a]pyrene is undertaken to provide data in compliance with the EU Air Quality Directive (Directive 2004/107/EC) and 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 the filter. At two sites, deposition samplers are also used to determine deposited PAH material.

The PAH monitoring sites in Scotland are shown in Table 6-8. 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 a former aluminium works and the site at Auchencorth Moss is a rural EMEP site as discussed in the automatic hydrocarbon section.

Table 6-8 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	322050,656250

Annual average concentrations for Benzo(a)pyrene (B(a)P) for 2009 and 2010 are shown in Table 6-9. This table shows that the Air Quality Objective for B(a)P of 0.25 ng m^{-3} annual average was exceeded at Kinlochleven 2 in 2009. However, the EU Directive target value of 1 ng m^{-3} annual average was not exceeded at any monitoring site in Scotland. For 2010, only data for between January to September are currently available. Using these data it can been seen that the Air Quality Objective for B(a)P of 0.25 ng m^{-3} annual average has not been exceeded during the first 9 months of 2010.

[7] Conolly C. et al Final Contract Report for the UK PAH Monitoring and Analysis Network (2004-2010) [online]
Available at http://uk-air.defra.gov.uk/reports/cat05/1103040911_AEA_PAH_Network_Report_2010_Final_v3.1.pdf [Accessed on 27/05/11]

Table 6-9 Annual Average Benzo(a)Pyrene concentrations for 2009 - 2010 at 4 sites in Scotland

Site	2009 Annual Mean B(a)P Concentration (ng m^{-3})	2010 Annual Mean B(a)P Concentration (ng m^{-3})
Auchencorth Moss A	0.040	0.040
Edinburgh St Leonards	0.131	0.112
Glasgow Centre	0.189	0.198
Kinlochleven 2	0.300	0.179

Shaded sites indicate data only available for part year

6.2.2 Benzene

Non- Automatic Hydrocarbon Network[8]

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. This network provides benzene data for compliance with the EU air quality Directive. Two of these sites are located in Scotland, at Grangemouth and Glasgow Kerbside. These benzene monitoring sites are co-located with AURN sites.

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 2009 and 2010 are provided in Table 6-10. Non-automatic monitoring of benzene started at Glasgow Kerbside on 1st September 2010. 2010 data are provisional at the time of preparing this report.

Table 6-10 Annual Mean Benzene Concentrations, 2009 and 2010

Site Name	Annual Mean benzene for 2009 (µg m^{-3})	Annual Mean benzene for 2010 - Provisional (µg m^{-3})
Glasgow Kerbside	-	1.1
Grangemouth	1.33	1.4

Shaded sites indicate data only available for part year

Automatic Hydrocarbon Monitoring

Table 6-11 gives the site details for the two automatic hydrocarbon monitoring stations in Scotland - Glasgow Kerbside and Auchencorth Moss. Benzene and a limited range of other hydrocarbon species are measured at the Glasgow Kerbside Site. 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 two European Monitoring and Evaluation Programme (EMEP) level II sites (EMEP "supersites") in the UK. The other EMEP supersite is located at Harwell in Oxfordshire. A much wider range of hydrocarbon species is monitored at Auchencorth Moss. However, the rural nature of this site means that often the concentrations are below the detection limit and hence, the data capture is low. Data for the full range of hydrocarbon species monitored at Glasgow Kerbside and Auchencorth Moss can be downloaded from www.scottishairquality.co.uk .

[8] 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]

Table 6-11 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*	322000,656200
Glasgow Kerbside	KERBSIDE	Benzene and 1,3-butadiene	258708,665200

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

Table 6-12 shows that the EU limit value for benzene of 5 μg m^{-3} was not exceeded at any site in Scotland and that the Scottish Air Quality Objective of 3.25 μg m^{-3} for the annual running mean concentration is unlikely to be exceeded.

Table 6-12 Annual Average Benzene concentration at UK Automatic Hydrocarbon Network sites, 2009 and 2010

Site	2009 Benzene Annual mean concentration (μg m^{-3})	2009 Benzene Maximum running annual concentration (μg m^{-3})	2009 % Data Capture	2010 Benzene Annual mean concentration (μg m^{-3})	2009 Benzene Maximum running annual concentration (μg m^{-3})	2010 % Data Capture
Auchencorth Moss	n/a (low data capture)	n/a (low data capture)	48%	0.31	0.31	77%
Glasgow Kerbside	0.99	1.13	90%	1.03	1.03	96%

6.2.3 1,3-Butadiene

1,3-butadiene is also measured by the UK Automatic Hydrocarbon Network at the same sites as for benzene. (Measurement of 1,3-butadiene within the Non-Automatic Hydrocarbon Network stopped in 2007).

Table 6-13 shows that the Air Quality Objective for 1,3-butadiene of 2.25μgm^{-3} is unlikely to be exceeded in Scotland. There is no EU Directive limit value for 1,3-butadiene.

Table 6-13 Annual Average 1,3-butadiene concentrations at Automatic Hydrocarbon Network sites, 2009 and 2010

Site	2009 1,3-butadiene Annual mean concentration (μg m^{-3})	2009 1,3-butadiene Maximum running annual concentration (μg m^{-3})	2009 % Data capture	2010 1,3-butadiene Annual mean concentration (μg m^{-3})	2010 1,3-butadiene Maximum running annual concentration (μg m^{-3})	2010 % Data Capture
Auchencorth Moss	n/a (low data capture)	n/a (low data capture)	56%	n/a (low data capture)	n/a (low data capture)	28%
Glasgow Kerbside	0.09	0.16	92%	0.08	0.09	96%

6.3 Metals

Lead and a wide range of other metals are monitored in two UK networks – the UK Heavy Metals Monitoring Network (mainly urban sites) and the National Monitoring Network for Heavy Metals (mostly rural sites). The urban network determines airborne particulate concentrations of 13 metals, including the metals lead, nickel, arsenic, cadmium and mercury which are covered by the EU Directive (Directives 2008/50/EC for lead and Directive 2004/107/EC for other metals). The rural network determines the concentration of more than 20 metals both as airborne particulate matter and

as deposited material in rainwater samples. Results for all metals monitored in the UK Heavy Metals Monitoring Network and for a selection of metals monitored in the National Monitoring Network for Heavy Metals are available from www.uk-air.defra.gov.uk.

6.3.1 Urban Metals[9]

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

Table 6-14 gives details of the monitoring sites in Scotland and Table 6.15 provides a summary of the results for the measurement of lead and other metals for 2009.

Table 6-14 Metals Monitoring Network Sites in Scotland 2009

Site	Site type and grid ref	Address	Metals measured
Eskdalemuir	Rural 323500,602800	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 Centre	Urban Background 275764,656282	Civic centre, Motherwell	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn

Table 6-15 Annual mean metal concentrations 2009 (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})
Eskdalemuir	1.4	0.14	0.13	0.03	0.009	1.56
Motherwell Centre	3.9	0.45	0.35	0.07	0.006	2.62

* mercury in particulate phase
\+ total gaseous mercury

6.3.2 Rural Metals[10]

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 two sites in Scotland are provided in Table 6.16 and data for the measurement of lead are provided in Table 6.17.

[9] Brown R et al "Annual Report for 2009 on the UK Heavy Metals Monitoring Network" [online. Available at http:\\uk-air.defra.gov.uk/reports/cat13/1003311043_NPL_Report_AS49_-_Defra_UK_Heavy_Metals_Network_Annual_Report_2009.pdf [Accessed on 01/06/11].
[10] Fowler D. et al "UK Heavy Metals Monitoring Network" [online]. Available at http://nora.nerc.ac.uk/3323/1/FowlerN003323CR.pdf [Accessed on 01/07/11].

Table 6-16 Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322000,656200
Banchory	Rural site, NE Scotland	NO676985

Table 6-17 Annual Mean metal concentrations 2009 (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	1.46	0.28	0.17	0.02	1.11
Banchory	1.79	0.26	0.27	0.03	1.02

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 Scottish Air Quality Objectives for lead (500 ng m^{-3} for 2004 and 250 ng m^{-3} for 2008) were not exceeded at any site in Scotland.

6.4 Discussion of Additional Pollutants Monitored and other Methods of Monitoring

This section discusses other air pollution measurements made in Scotland. Detailed results are not provided here, 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. Polycyclic aromatic hydrocarbons (PAH)
4. Toxic Organic Micropollutants (TOMPS)
5. Metals (Urban network)
6. Metals (Rural and deposition network)
7. Black Carbon and Particle Numbers
8. United Kingdom Eutrophying & Acidifying Pollutants Network, comprising
    - The Precipitation Network
    - NO_2 rural diffusion tube Network
    - Acid Gases and Aerosol Network (AGANET)
    - National Ammonia Monitoring Network

6.4.1 NO_2 Diffusion Tube Results

Many Local Authorities supplement their automatic monitoring with indicative measurements made using diffusion tubes. 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 currently off-line following changes in contractual arrangements, but will be available from http://laqm.defra.gov.uk/diffusion-tubes/data-entry.html when re-started. 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 2009 (the most recent full year available in the Scottish Database) are summarised in Table 6-18.

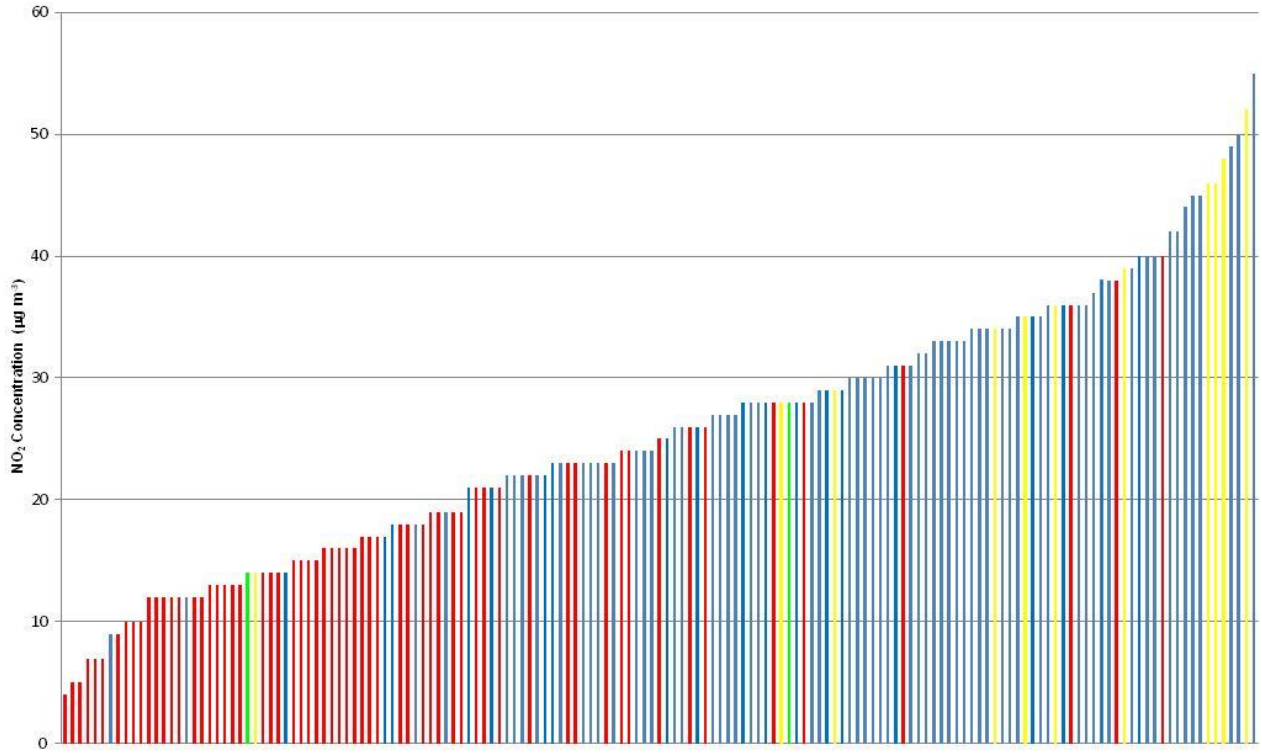
Table 6-18 Number of monitoring sites with valid annual mean for 2009

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	1	3	0	5
Edinburgh	1	0	2	0	3
Falkirk	2	0	2	0	4
Fife	1	0	2	11	14
Highland	2	0	2	0	4
Midlothian	2	1	1	0	4
North Ayrshire	2	0	2	0	4
North Lanarkshire	20	0	17	0	37
Scottish Borders	5	0	7	0	12
South Ayrshire	2	0	2	0	4
South Lanarkshire	4	0	3	0	7
Stirling	2	0	2	0	4
West Dunbartonshire	3	0	4	0	7
West Lothian	1	0	3	0	4
Total:	62	2	82	11	157

A clear limitation in undertaking analysis of these data is that all the diffusion tube data provided are **not bias adjusted**. Bias adjustment of diffusion tube data is required as the tubes may over, or underestimate concentrations and Authorities will have calculated a local bias adjustment 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 has not been carried out. However, an overview of all the data is provided in Figure 6-2 to give an indication of NO_2 concentrations throughout Scotland.

Figure 6-2 Summary of NO_2 diffusion tube results for Scotland 2009



A further limitation on undertaking spatial analysis of these data is that many of the grid references supplied for the location of the monitoring sites have insufficient precision. To assist with this problem, AEA has added an additional site location tool to the Members Area of the Scottish air quality website to allow authorities to position their diffusion tube sites directly on a detailed Google map. The grid references are then automatically uploaded into the database. This system worked extremely well in obtaining more exact locations for the automatic monitoring locations, and we encourage authorities to use the new tool to locate all their diffusion tube sites accurately.

6.4.2 Non- Methane Volatile Organic Compounds (NMVOC)

As discussed in Section 6.2, 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.

6.4.3 Polycyclic Aromatic Hydrocarbons (PAH)

As discussed in Section 6.2, 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

6.4.4 Toxic Organic Micropollutants

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

environment. The TOMPs network provides data on concentrations of these species in the air throughout the UK.

There were six sites in the TOMPs network during 2010 – one of which was in Scotland, at Auchencorth Moss, a remote background site 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/.

6.4.5 Metals (Urban network)

As discussed in Section 6.3 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)).

6.4.6 Metals (Rural and deposition network)

As discussed in Section 6.3 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).

6.4.7 United Kingdom Eutrophying & Acidifying Pollutants Network[11] (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. Final data for this network for 2010 are not yet available at the time of preparing this report. Data for 2009 are provided in the annual report[12].

The UKEAP has 4 component networks:

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

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

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.

[11] For information on this network see http://www.uk-pollutantdeposition.ceh.ac.uk/ukeap [Accessed on 01/07/11]
[12] Conolly C. et al UK Eutrophying and Acidifying Atmospheric Pollutants (UKEAP) Annual Report 2010 [online]
Available at http://uk-air.defra.gov.uk/reports/cat13/1105130856_UKEAP_report_2010_Final.pdf [Accessed on 01/07/11]

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

NO_2 Network (NO_2-Net)

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

Triplicate nitrogen dioxide diffusion tube measurements are run at three AURN sites with co-located automatic instruments (Yarner Wood, Harwell and Eskdalemuir).

Nitrogen dioxide is measured with diffusion tube samplers at 9 sites in Scotland. The annual average concentrations measured in 2009 are provided in Table 6-19.

Table 6-19 NO_2 annual average concentration 2009 at rural monitoring sites

Site	NO_2 ($\mu g\ m^{-3}$)	Data Capture (%)
Loch Dee	3.7	58
Eskdalemuir	3.5	94
Whiteadder	6.1	86
Balquhidder 2	3.0	95
Polloch	1.8	100
Glensaugh	3.8	94
Allt a' Mharcaidh	3.4	90
Strathvaich Dam	1.3	100
Forsinain 2	3.3	49

Shaded sites indicate <75% data capture.

Acid Gas and Aerosol Network (AGANET)

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

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

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

National Ammonia Monitoring Network (NAMN)

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

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

7 Air Quality Trends for Scotland

In this section of the report, evidence of how air quality in Scotland has changed in recent years is summarised. 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). It is usually considered that at least five consecutive years' data are required from a monitoring site, in order to assess long-term trends.

Automatic monitoring of oxides of nitrogen and of ozone has been routinely carried out in Scotland since 1987, and PM_{10} since the early 1990s. However, until 2000 there were relatively few automatic monitoring sites: the number of air quality monitoring site 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 the analysis of trends is based on all available data, discontinuities may be introduced because of the changes in the number of sites (and their distribution). Therefore, this year, investigation of trends has been based on subsets of long-running sites. This should lead to a more robust assessment.

7.1 Oxides of Nitrogen and Nitrogen Dioxide

Within Scotland (and elsewhere across the UK) the largest number of AQMA's 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.

7.1.1 NO_x and NO_2 Trends at Urban Background Sites

Figure 7-1 presents the annual mean variation in measured NO_x concentrations at long-running urban background monitoring stations since automatic measurements began in Scotland in 1987. Only sites that have been in operation for at least five years are shown, and the minimum annual data capture is 75%. Prior to 2000, the only two long-running sites in this category (Glasgow City Chambers and Edinburgh 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, an average NO_x concentration has been calculated, based on data from a subset of four long-running sites (Aberdeen, Edinburgh St Leonards, Glasgow City Chambers and Grangemouth). This is shown in the graph by the pink line. The data indicate that average NO_x concentrations remained relatively stable from 2004 until around 2007, since when they have begun to rise again. 2010 appears to have been a high year for NO_x. Glasgow Centre is not included in this average, despite being a long-running site. This is because the results for the past two years are thought to have been affected by diesel emissions associated with an annual Christmas Market near the site. This is thought to account for the increase in recent years' annual means reported at this site.

Figure 7-2 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 gradual decline in NO_2. Concentrations of NO_2 at this site have decreased much more gradually than concentrations of NO_x. The mean for the four long-running sites (Aberdeen, Edinburgh St Leonards, Glasgow City Chambers and Grangemouth) indicates that urban background NO_2 concentrations have remained relatively stable since 2004. All urban background sites in Scotland recorded annual mean NO_2 concentrations well below the AQS Objective of 40 μgm^{-3} in 2010, with the exception of Glasgow City Chambers and Glasgow Centre. (The latter is thought to be directly affected by diesel emissions, see above).

Figure 7-1 Time Series of Annual Mean NOx Concentration at Urban Background sites in Scotland: 1987 - 2010.

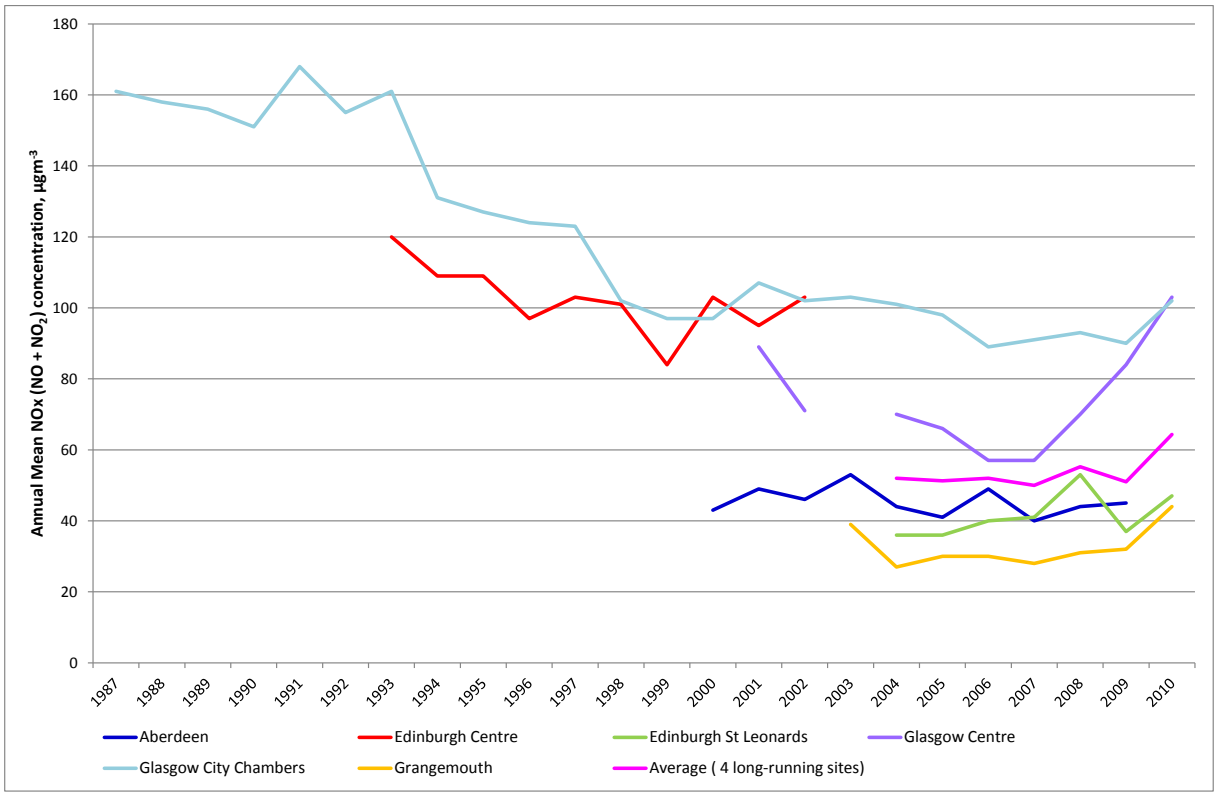
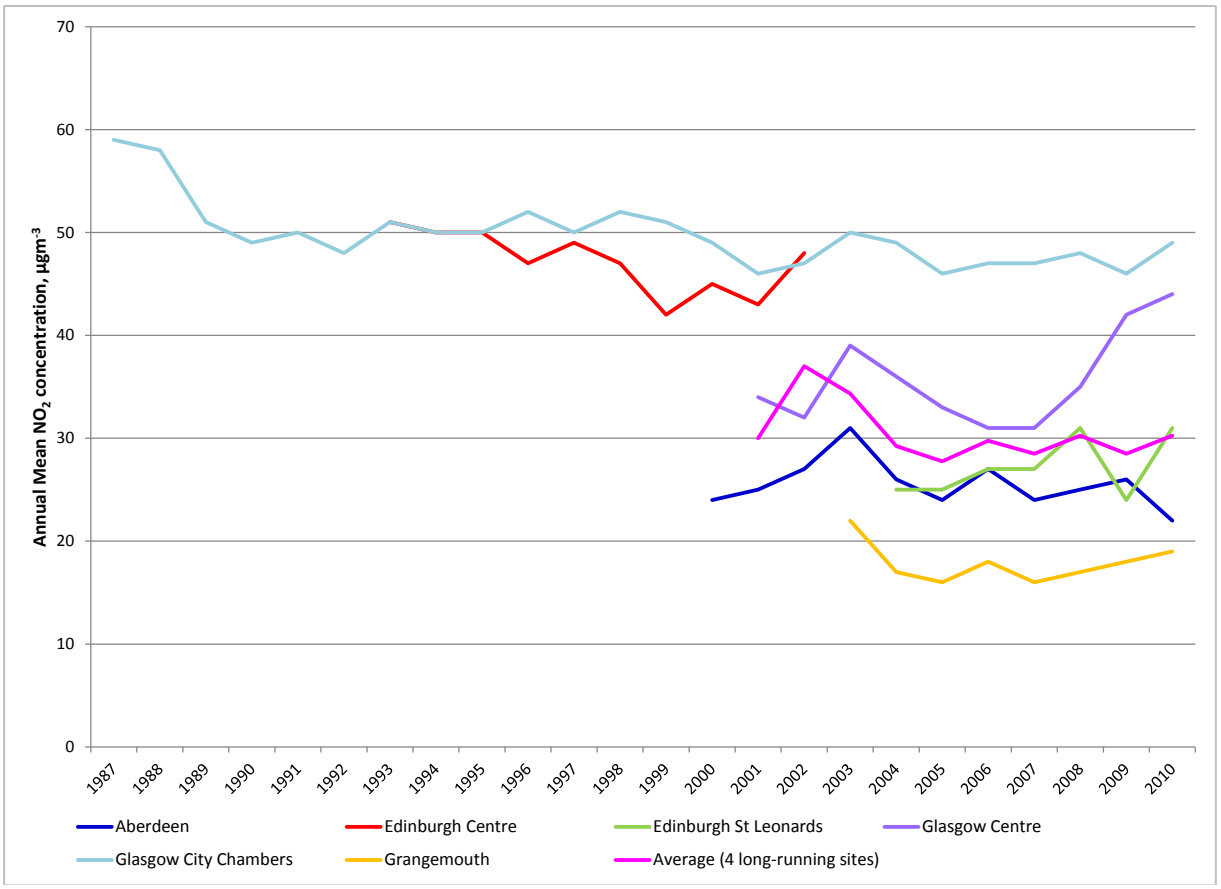


Figure 7-2 Time Series of Annual Mean NO_2 Concentration at Urban Background sites in Scotland: 1987 - 2010.



7.1.2 NO_x and NO_2 Trends at Traffic-related Urban Sites

Figure 7-3 shows annual mean NO_x concentration at traffic-related urban sites, since the first such site in Scotland (Glasgow Kerbside) began operation in 1997. Only sites with at least five years' data are included here, and the minimum annual data capture is 75%. Also shown is the average for five long-running sites (Dumfries, East Dumbarton Bishopbriggs, Glasgow Kerbside, Inverness and Perth High Street), from 2004 onwards (this being the earliest point at which there were at least four traffic-related monitoring sites). There are no clear trends in this statistic: annual mean concentrations of total NO_x appear stable in recent years. However, as for urban background sites, 2010 appears to have been a high year for NO_x.

Figure 7-4 shows the corresponding trends for NO_2 at traffic-related urban monitoring sites, including the average for the same five long-running sites (Dumfries, East Dumbarton Bishopbriggs, Glasgow Kerbside, Inverness and Perth High Street), since 2004. Again, there are no clear trends: in particular, the average for the five long-running sites has remained stable in the period 2004-2010, with a slight increase in 2010. The *average* annual mean NO_2 concentration for these five long-running sites has remained consistently below the AQS Objective of 40 μgm^{-3}. However, this is not the case for the annual means for the individual sites (for example Dumfries and Perth Atholl Street), several of which have been consistently well above 40 μgm^{-3} over the period considered. 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 7-3 Time Series of Annual Mean NOx Concentration at Traffic Urban sites in Scotland: 1997 - 2010.

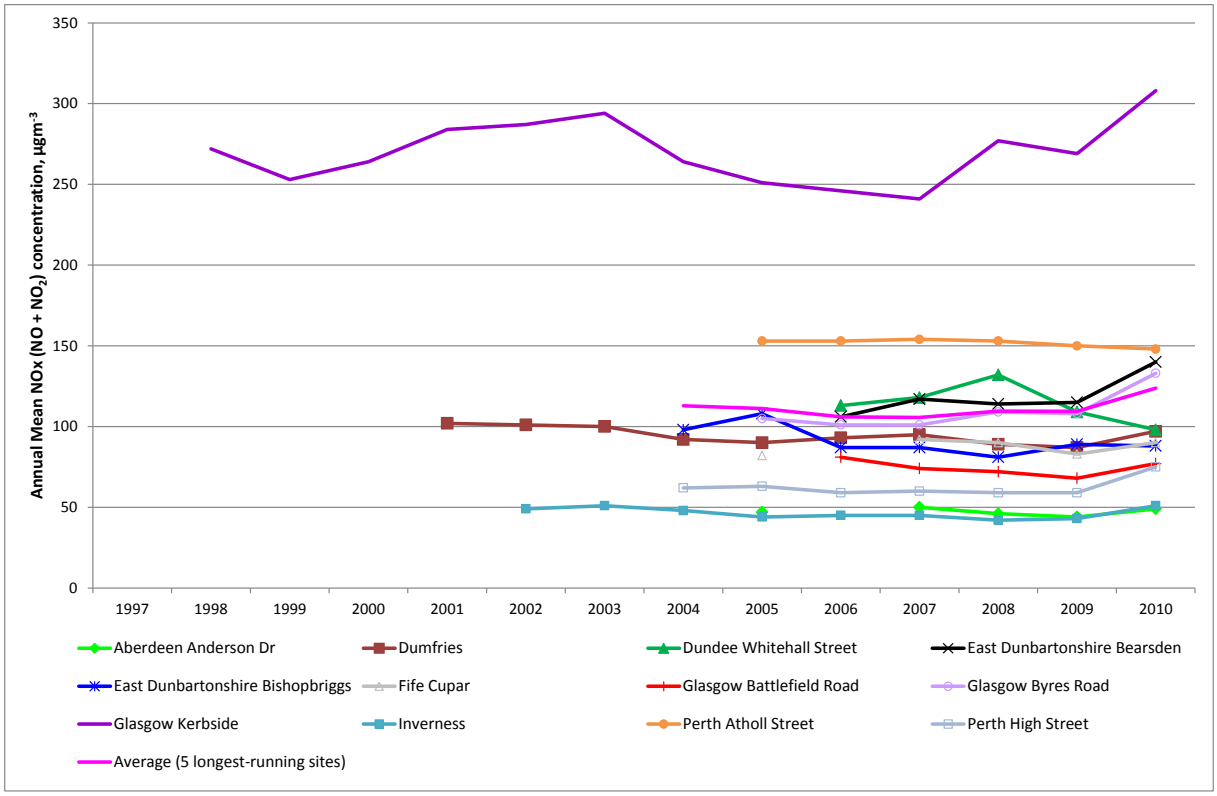
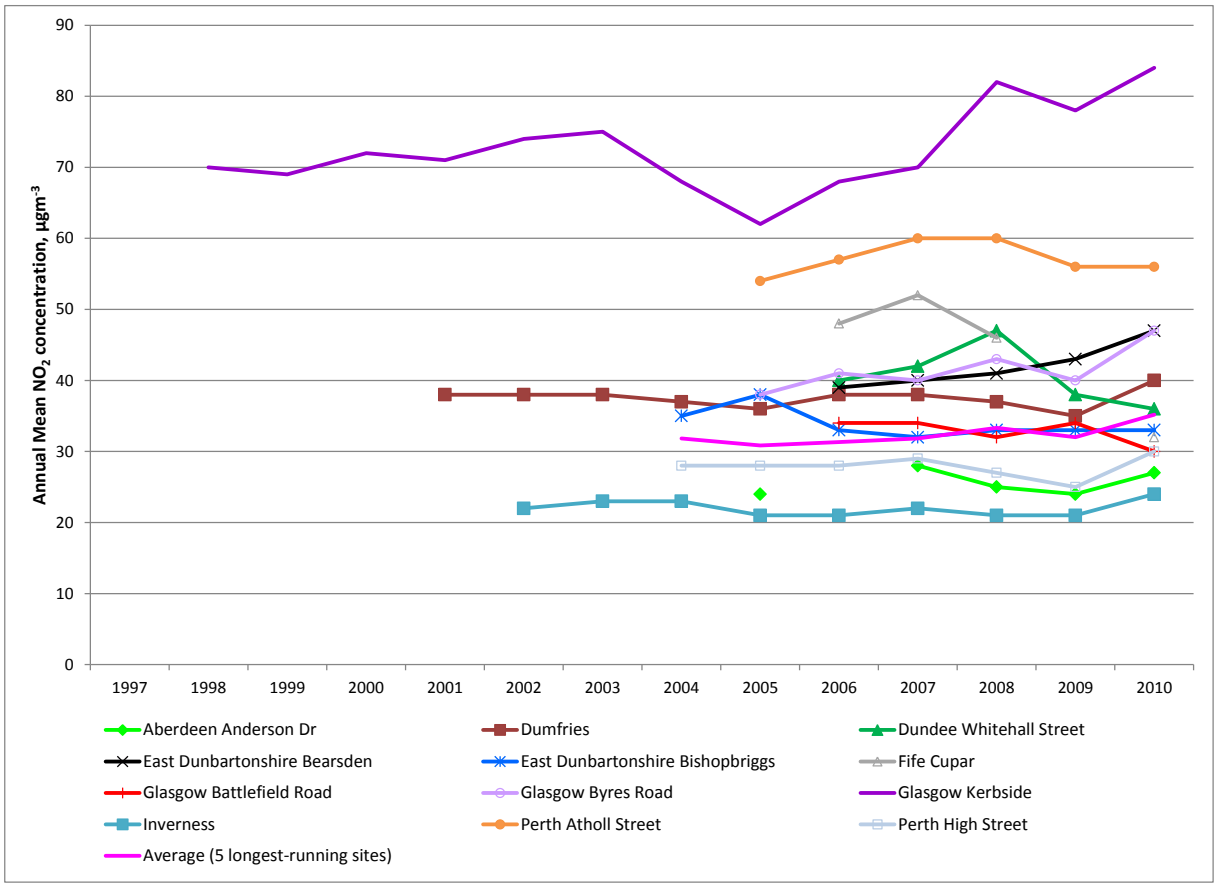


Figure 7-4 Time Series of Annual Mean NO_2 Concentration at Traffic Urban sites in Scotland: 1997 - 2010.



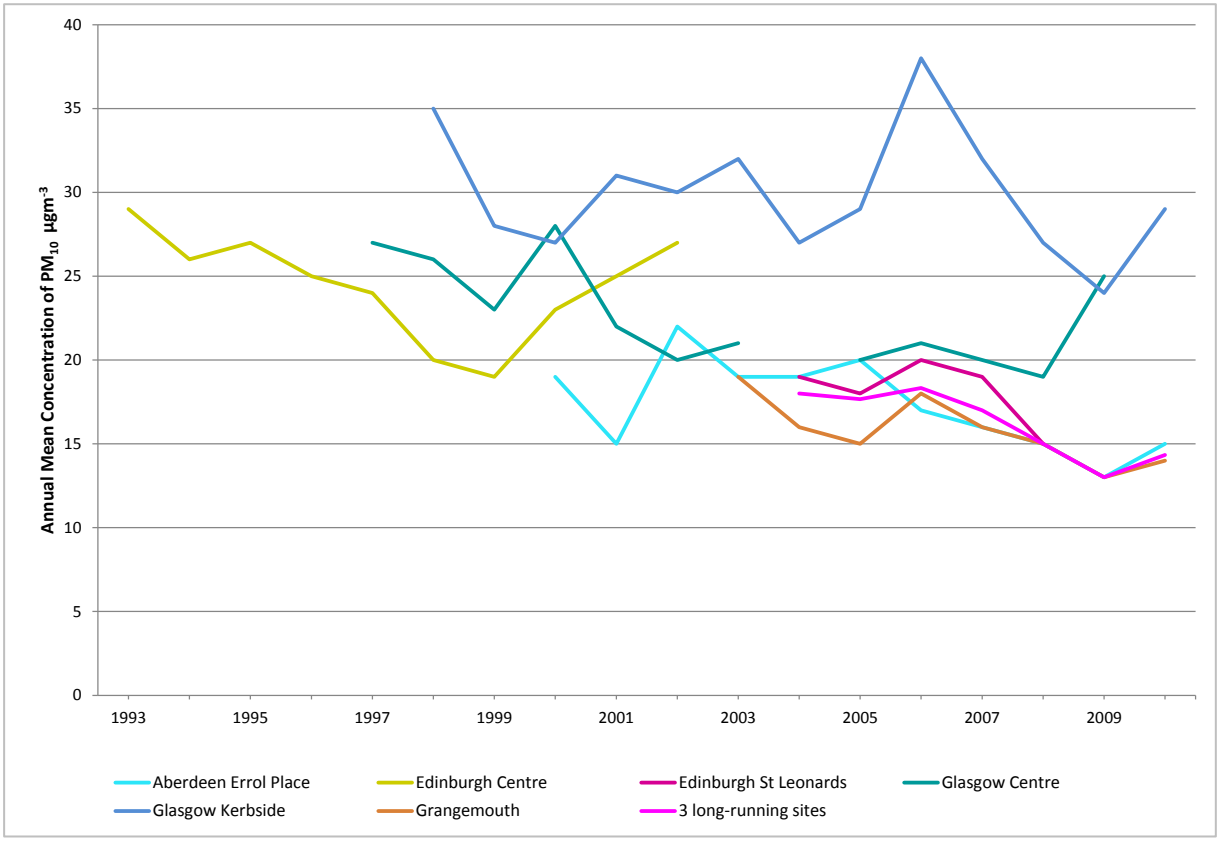
7.2 Particulate Matter

A time series of annual mean PM_{10} concentrations at long-running Scottish sites in shown in Figure 7-5. 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.

In previous years, the policy has been to assess trends on the basis of data from all sites, but with the warning that changes in the size and composition of the network may affect the robustness of the conclusions. This year, the trend investigation has been based on long-running sites only (i.e. those with at least five years of data). Figure 7-5 indicates that several of the long-running sites have shown a decrease in annual mean PM_{10} concentration. There appears to be a slight downward trend at Glasgow Kerbside, although this site shows considerable fluctuation from year to year, with a particularly high year in 2007. From 2004, the average is shown for three long-running urban background sites with relevant exposure (Aberdeen, Edinburgh St Leonards and Grangemouth). Again, Glasgow Centre has been excluded because it is believed to be directly influenced by nearby diesel emissions during the winter months. The mean for these sites appears to show a decrease since 2004.

Figure 7-5 Time Series of Annual Mean PM_{10} Concentration at Long-Running Scottish Sites, 1993 – 2010

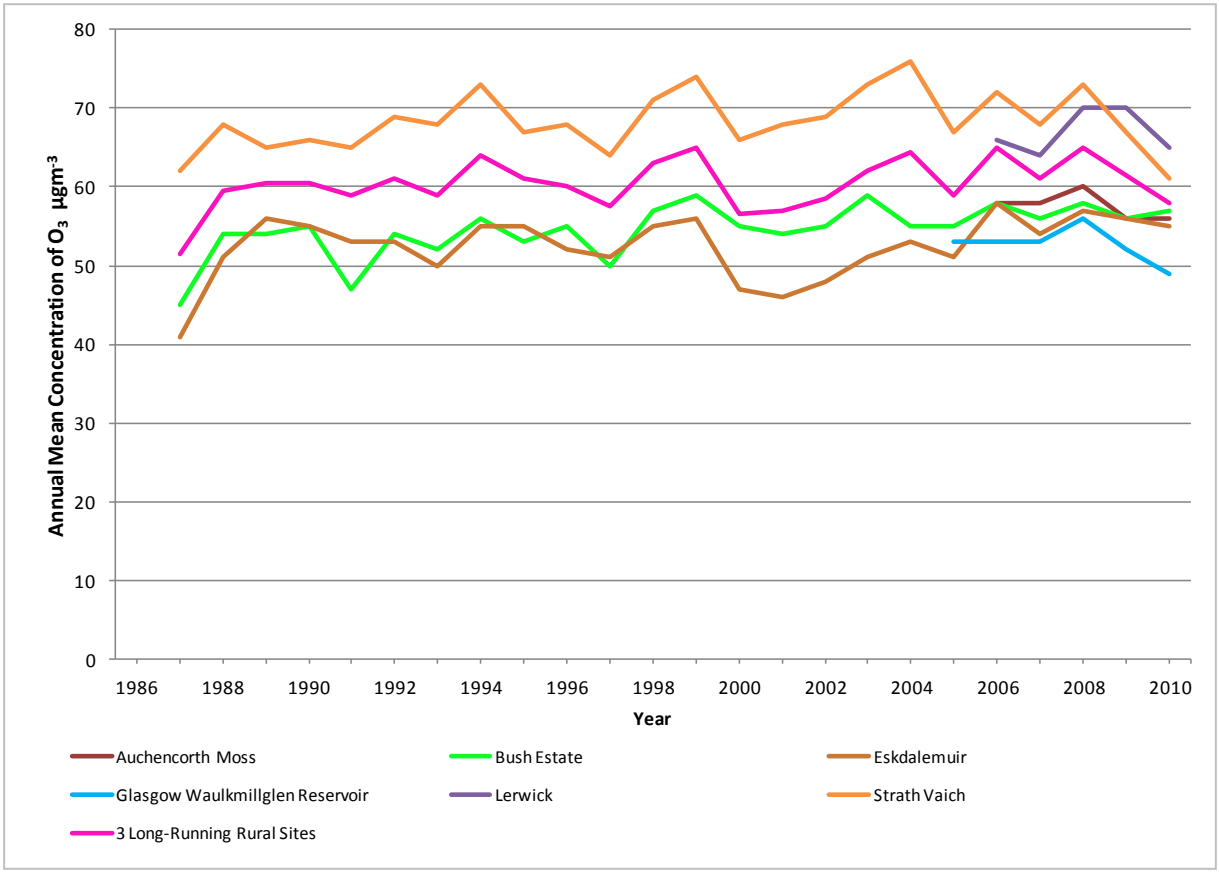


7.3 Ozone

7.3.1 Rural Ozone

Figure 7-6 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 graph is the fluctuation, from year to year, due to variation in meteorological conditions.

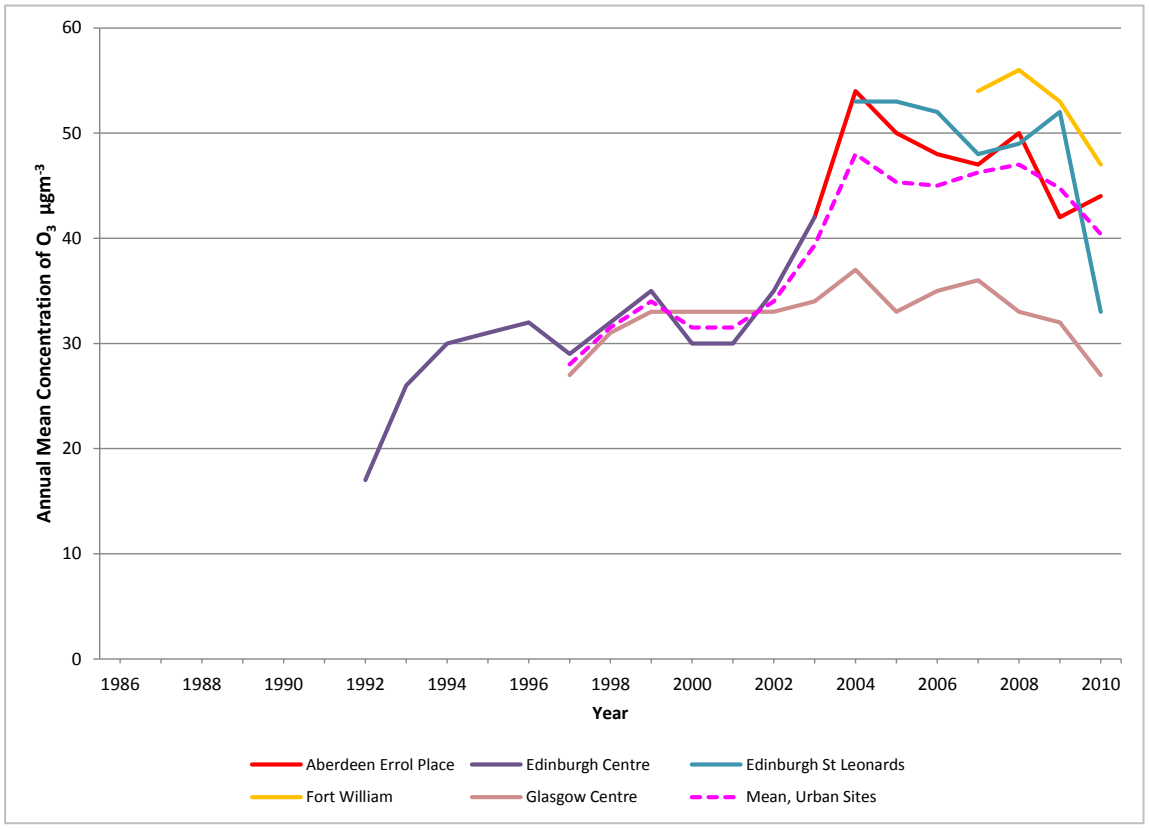
Figure 7-6 Annual Mean O_3 Concentrations at Long-Running Scottish Rural Sites, 1987 – 2010



7.3.2 Urban Background Ozone

Previous reports in this series have also reported trends in ozone concentration at urban background sites. Based on the mean ozone concentration from a number of long-running urban background sites, they have reported a substantial increase in recent years. Figure 7-7 shows annual mean ozone concentrations at all urban background ozone monitoring sites with at least four years of data. The mean is also shown, by the dotted pink line. Based on the mean of all long-running urban background sites, previous reports in this series have reported a substantial increase in urban background concentrations in recent years. However, when the data from individual sites are shown separately, it appears that the apparent upward step-change around 2002-2004 is 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. Both 2009 and 2010 appear to have been relatively low years for ozone.

Figure 7-7 Annual Mean O_3 Concentrations at Long-Running Scottish Urban Background Sites, 1987 – 2010 (note discontinuity due to changes in sites).



8 Air Quality Mapping for Scotland

As part of the Scottish Air Quality Database project, AEA provide mapped concentrations of pollutants on a 1 x 1 km square grid basis. These pollution maps combine measurement data 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 which is used for producing air pollution maps for the whole of the UK.

There are now sufficient monitoring sites in the SAQD for mapping to be undertaken for NO_2 and PM_{10} for Scotland using only the Scottish data. Hence the PCM methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2009 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 pollutant data used in the mapping work presented here uses appropriately scaled PM_{10} monitoring data (FDMS, Partisol and VCM corrected TEOM data) and automatic monitoring data for NO_X and NO_2 in 2009, in conjunction with Scottish meteorology data (from RAF Leuchars) to create the Scotland-specific model.

In 2009 AEA undertook a short study[13] 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 can be downloaded from http://www.scottishairquality.co.uk/maps.php?n_action=data.

8.1 Air Quality Maps for Scotland 2009

The details of the methodology and full results of the mapping study are provided in a separate report[14]. In this report, we summarise the main findings of this work.

8.1.1 NO_2 maps for 2009

The 2009 annual mean NO_2 concentrations for Scotland were modelled for background and roadside locations. Figure 8-1 and Figure 8-2 present maps of the modelled 2009 annual mean background NO_2 concentrations and the modelled 2009 annual mean roadside NO_2 concentrations for Scotland, respectively.

[13] 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

[14] Lingard, J.J.N (2011). Scottish Air Quality Maps. Pollutant modelling for 2009 and projected concentrations for 2010, 2015 and 2020: annual mean NO_X, NO_2, and PM_{10}. AEAT/ENV/R3156 Issue 1. To be published.

Figure 8-1 Background NO_2 map for 2009, µg m^{-3} (Scotland-specific model).

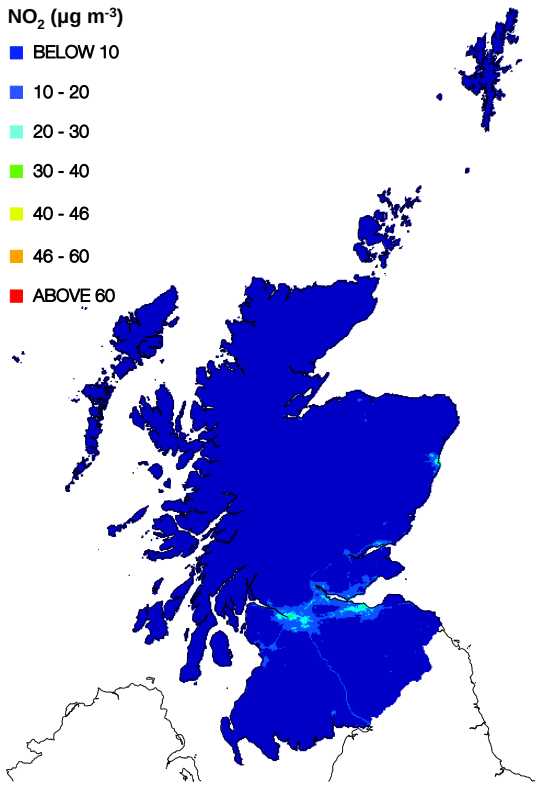
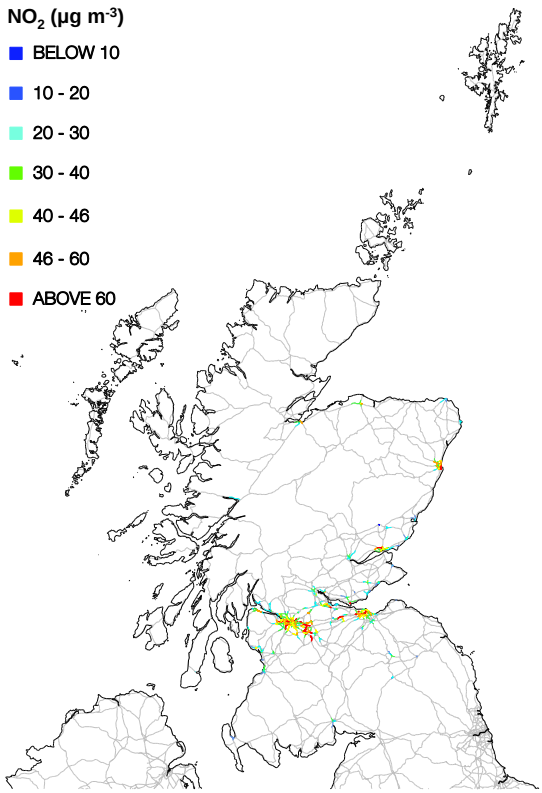


Figure 8-2 Roadside NO_2 map for 2009, µg m^{-3} (Scotland-specific model).



8.1.2 PM_{10} maps for 2009

2009 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 broadly 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 2009 annual mean PM_{10} concentrations for Scotland for background and roadside locations are shown in Figures 8-3 and 8-4, respectively.

Figure 8-3 Background PM_{10} map for 2009, µg m^{-3} (Scotland-specific model).

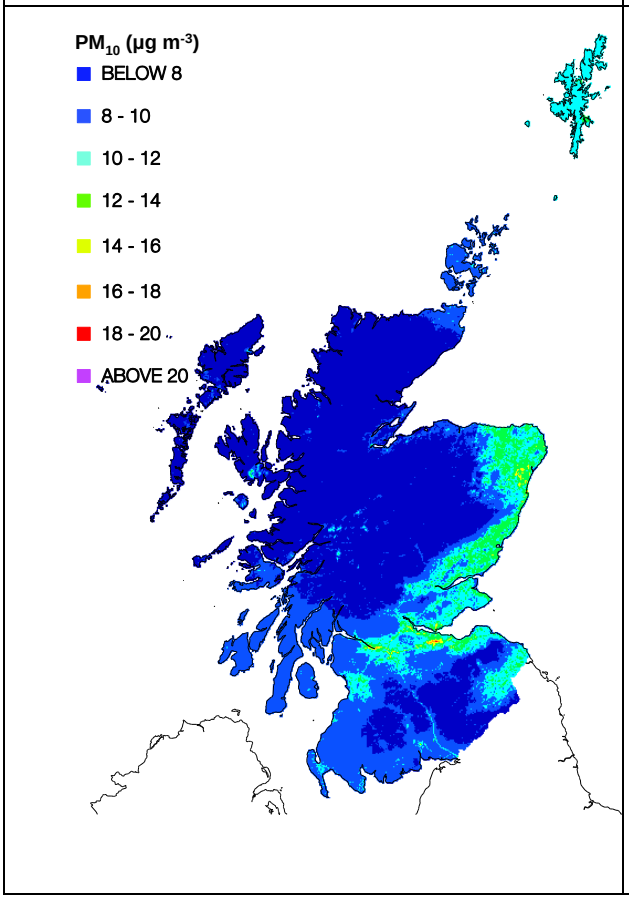
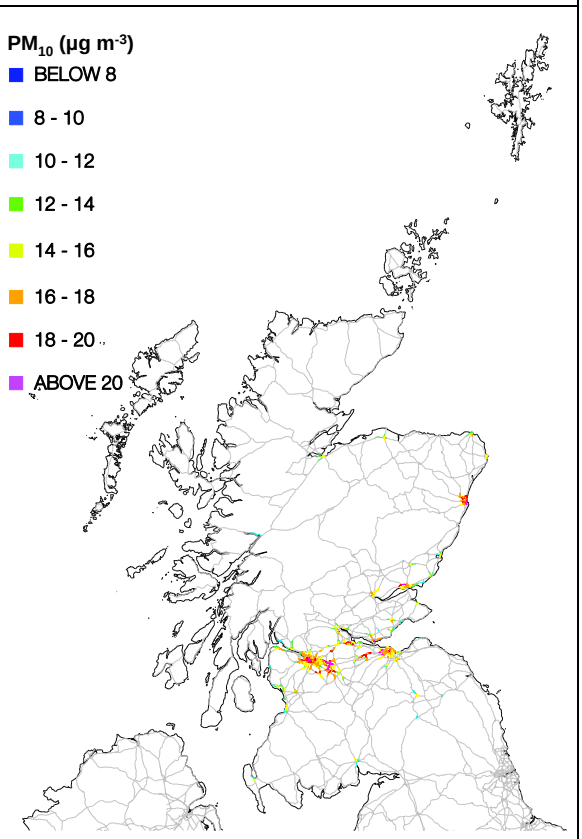


Figure 8-4 Roadside PM_{10} map for 2009, µg m^3 (Scotland-specific model).



8.1.3 NO_2 Scotland-specific pollutant projections for 2010, 2015 and 2020

Projected annual mean concentrations of NO_X and NO_2 for 2010, 2015 and 2020, from a base year of 2009, are presented for the purpose of forward projection assessment. The projected background annual mean concentrations were produced using the UK methodology, but as with the modelled Scottish annual mean NO_2 concentrations for 2009, these were prepared using Scotland-specific data.

Figure 8-5, Figure 8-6 and Figure 8-7 provide background maps of projected annual mean NO_2 concentrations for 2010, 2015 and 2020 based on the 2009 Scotland-specific model. The projected background maps for NO_2 show a progressive decrease in the background annual mean concentration between 2009 and 2020 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 8-5 Background NO_2 map for 2010, µg m^{-3} (Scotland-specific model).

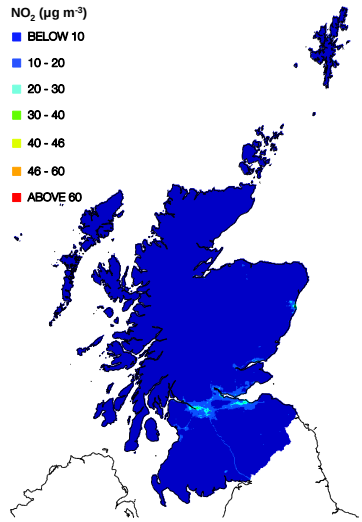


Figure 8-6 Background NO_2 map for 2015, µg m^{-3} (Scotland-specific model).

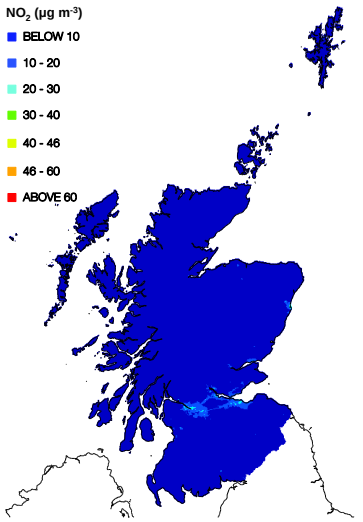
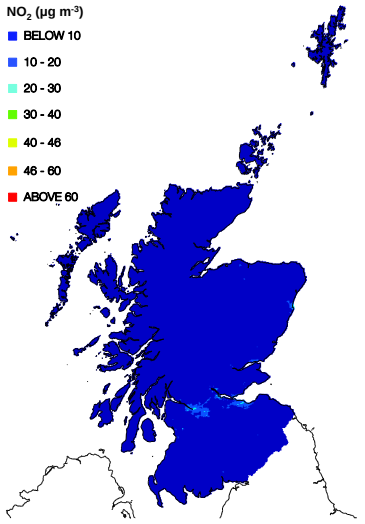


Figure 8-7 Background NO_2 map for 2020, µg m^{-3} (Scotland-specific model).



8.1.4 PM_{10} Scotland-specific pollutant projections for 2010, 2015 and 2020

As for NO_2, projected annual mean PM_{10} concentrations for 2010, 2015 and 2020, from a base year of 2009, are presented for the purpose of forward projection assessment. The projected background annual mean concentrations were produced using the UK methodology, but as with the modelled Scottish annual mean concentrations for 2009, these were prepared using Scotland-specific data.

Figure 8-8 Background PM_{10} map for 2010, µg m^{-3} (Scotland-specific model).

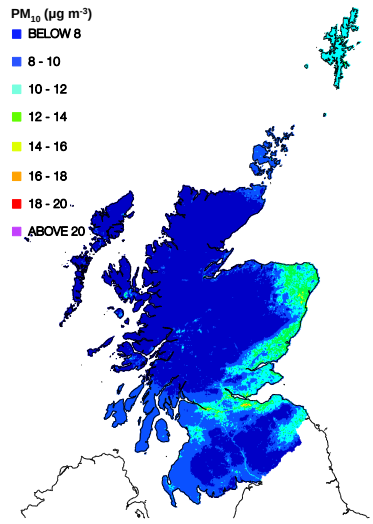


Figure 8-9 Background PM_{10} map for 2015, µg m^{-3} (Scotland-specific model).

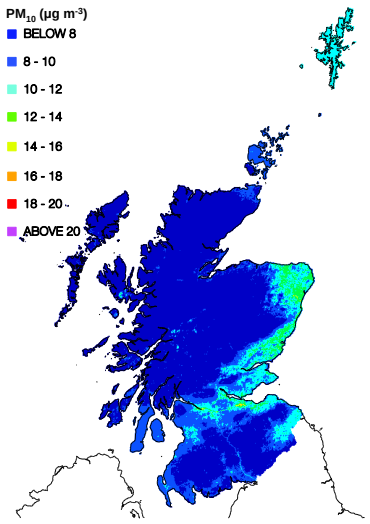


Figure 8-10 Background PM_{10} map for 2020, µg m^{-3} (Scotland-specific model).

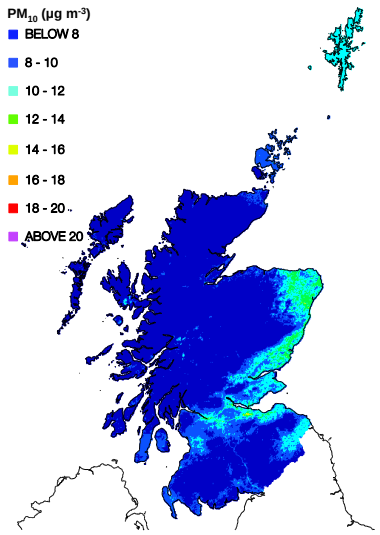


Figure 8-8, Figure 8-9 and Figure 8-10 provide background maps of projected annual mean PM_{10} concentrations for 2010, 2015 and 2020 based on the 2009 Scotland-specific model. As for NO_2, the projected background maps show a progressive decrease in the background annual mean PM_{10} concentration to below 8 µg m^{-3} between 2009 and 2020 for the majority of Scotland which is expected

due to the predicted reduction in primary PM_{10} emissions, and consequentially secondary PM_{10} formation, over the next 11 years. High (10-14 μg m^{-3}) PM_{10} concentrations were projected to persist for 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).

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[15]. 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, 1990-2008

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.

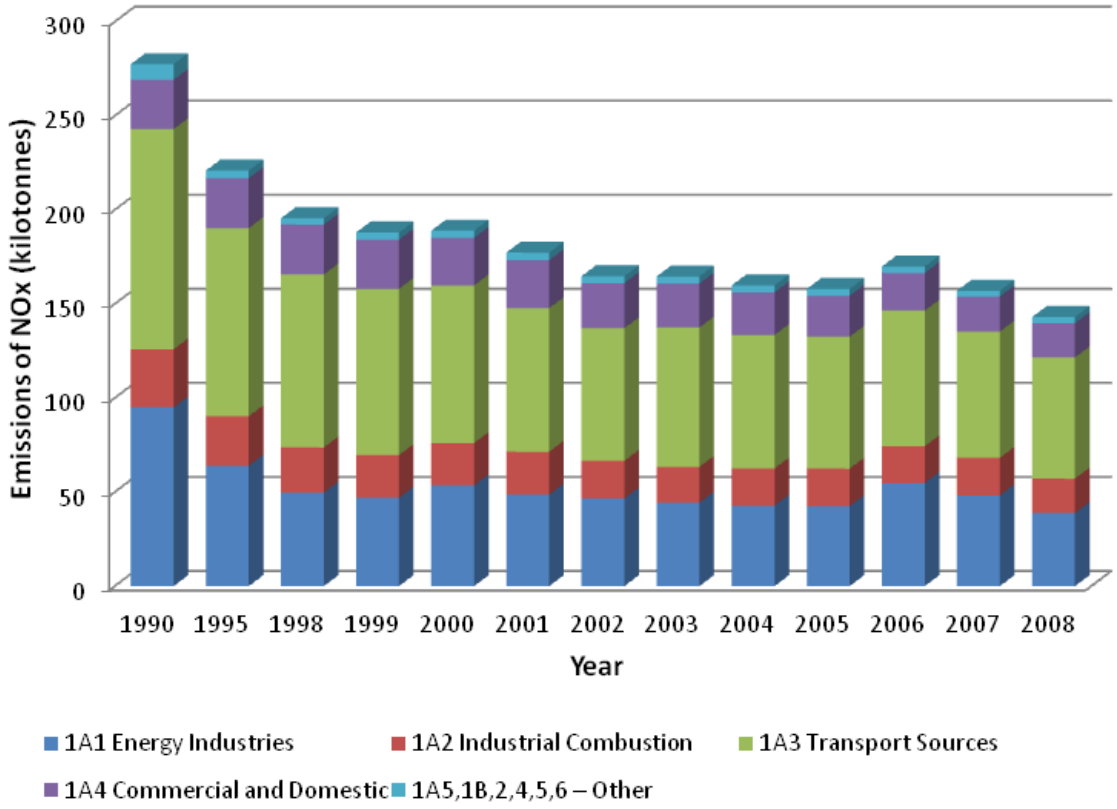
Table 9-1 Scotland emissions of NOx by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% of 2008 Total
1A1 - Energy Industries	95	64	50	47	54	49	47	44	43	43	55	48	39	27
1A2 - Industrial Combustion	31	26	24	23	23	23	20	19	20	20	19	20	18	13
1A3 - Transport Sources	117	100	92	88	84	76	71	74	71	70	72	67	64	45
1A4 - Commercial and Domestic	26	26	26	26	25	25	24	23	23	22	20	19	18	13
1A5,1B,2,4,5,6 – Other	8	4	3	4	4	4	4	4	4	4	3	3	3	2
Total	277	221	196	188	189	177	165	165	160	158	170	157	143	100

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008

[15] Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008
http://uk-air.defra.gov.uk/reports/cat07/1010130853_DA_AQI_2008_main_text_Issue_1.pdf

Figure 9-1 Time series of Scotland NO_x emissions 1990-2008



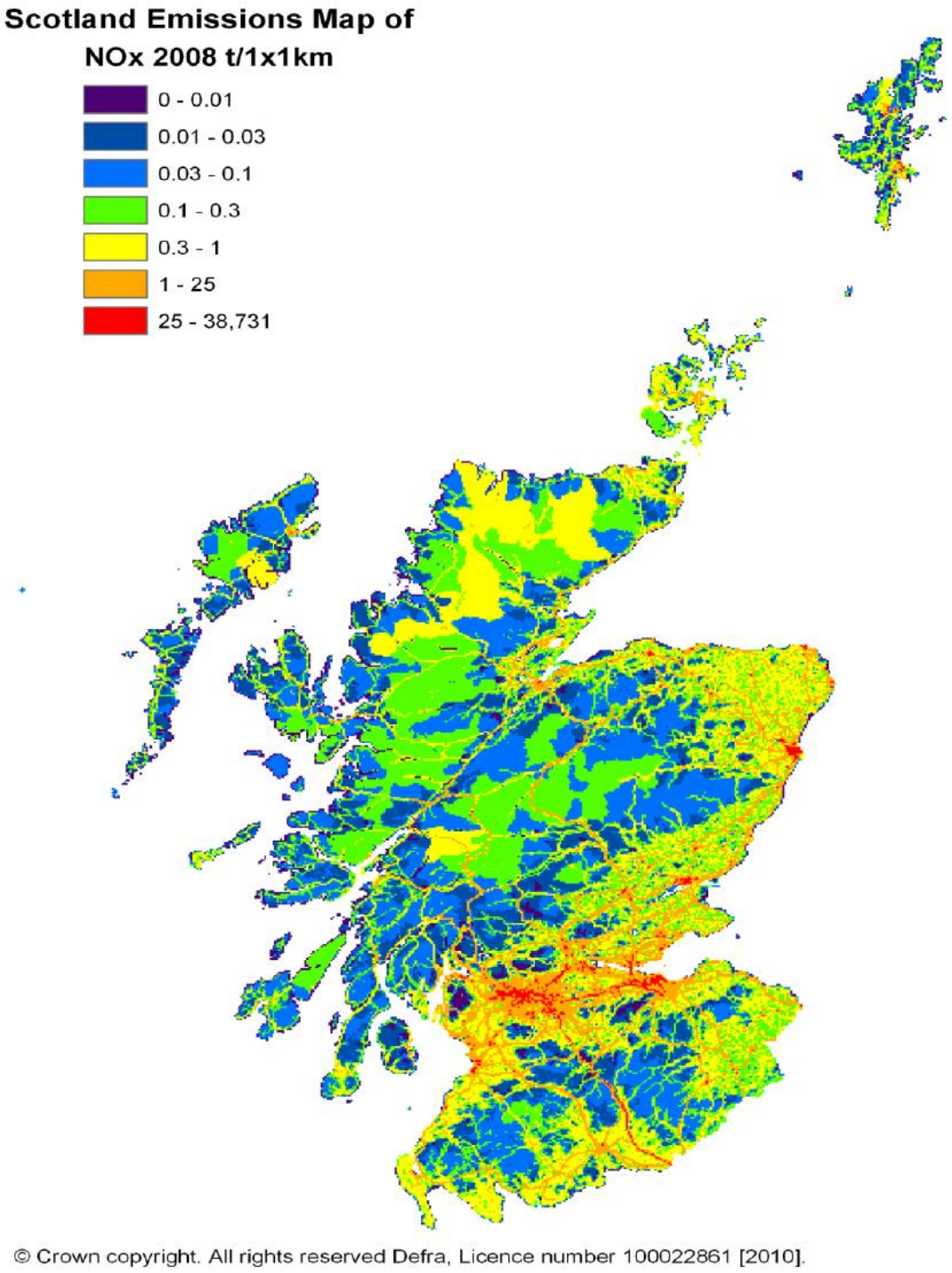
Scotland‟s NO_x emissions are shown to have declined by 48% since 1990 and currently account for 10% of the UK total. Power generation (NFR sector code 1A1a) is a very significant source of NO_x emissions, accounting for 23% of the Scotland total in 2008; although emissions from this source have reduced by 62% since 1990. *(Note that in the figure above, the sector 1A1 includes power generation, petroleum refining and other energy industries such as collieries and gas processing.)*

Recent trends in electricity generation have dominated the overall trends the inventory. In Scotland, coal-fired generation increased to a peak in 2006 (17,488 GWh), and have since declined by over 33% between 2006 and 2008 (to 11,692 GWh). Between 2007 and 2008, coal-fired generation declined by 15%, whilst gas-fired generation increased by 7.3% to 9,594 GWh. However, due in part to the use of over-fire air abatement on the coal-fired plant, overall emissions of NOx from the sector declined by 21% in just that one year.

A further 28% of NO_x emissions in Scotland arise from road transport sources (1A3bi-iv: down by 58% since 1990), 13% stem from industrial combustion (1A2: down 41% since 1990) and 6% is from residential combustion sources (1A4bi: down 2% since 1990). Increases in emissions are only apparent in relatively minor source sectors such as domestic and international aviation landing and take-off (LTO) (1A3ai(i): up by 172% since 1990 and 1A3aii(i): up by 43% since 1990 in 2008). Combined, these sources account for less than 1% of the emissions in Scotland in 2008.

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

Figure 9-2 Map of NOx Emissions in Scotland, 2008



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008

9.1.2 Scotland PM_{10} Inventory by NFR Sector, 1990-2008

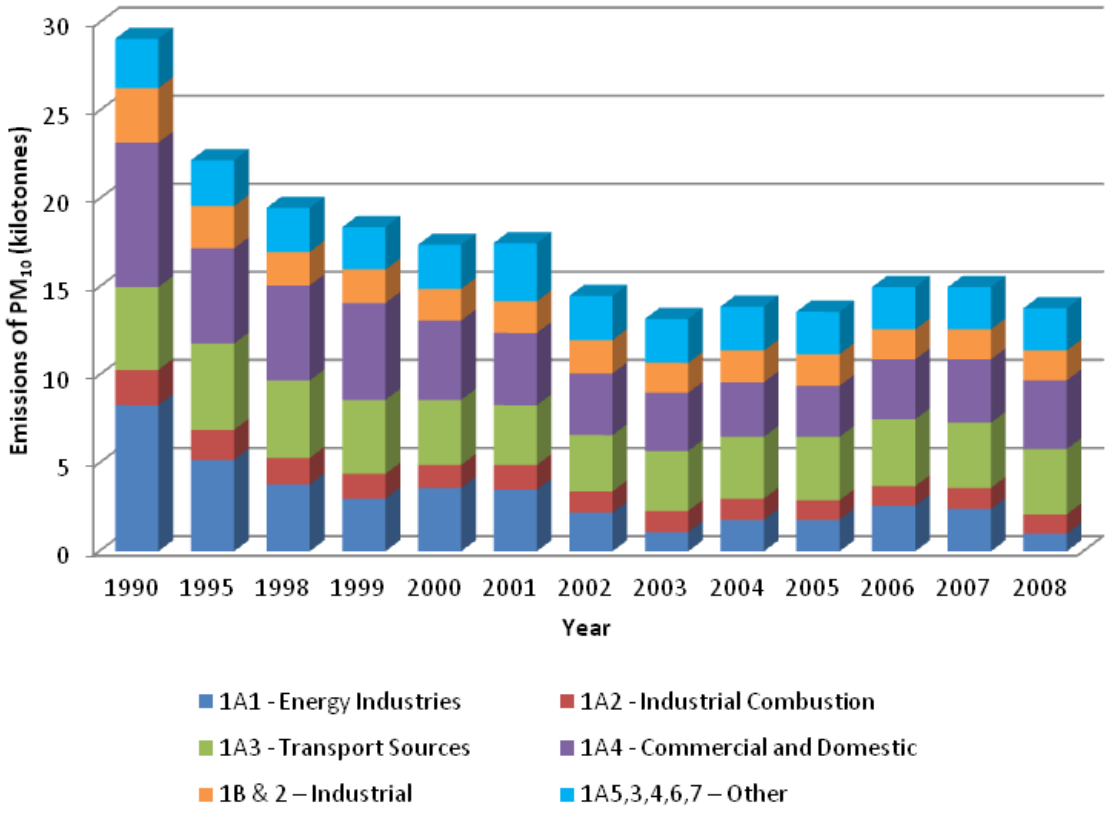
The table and graph below give a summary of the PM_{10} emissions in Scotland by broad NFR sector categories. The detailed data are available in report and website cited in the introduction to this Chapter.

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

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% of 2008 Total
1A1 - Energy Industries	8.3	5.2	3.8	3.0	3.6	3.5	2.2	1.1	1.8	1.8	2.6	2.4	1.0	7
1A2 - Industrial Combustion	2.0	1.7	1.5	1.4	1.3	1.4	1.2	1.2	1.2	1.1	1.1	1.2	1.1	8
1A3 - Transport Sources	4.7	4.9	4.4	4.2	3.7	3.4	3.2	3.4	3.5	3.6	3.8	3.7	3.7	27
1A4 - Commercial and Domestic	8.2	5.4	5.4	5.5	4.5	4.1	3.5	3.3	3.1	2.9	3.4	3.6	3.9	28
1B & 2 – Industrial	3.1	2.4	1.9	1.9	1.8	1.8	1.9	1.7	1.8	1.8	1.7	1.7	1.7	13
1A5,3,4,6,7 – Other	2.8	2.6	2.5	2.4	2.5	3.3	2.5	2.5	2.5	2.4	2.4	2.4	2.4	18
Total	29.0	22.2	19.5	18.4	17.5	17.5	14.5	13.3	14.1	13.6	15.1	14.9	13.7	100

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008

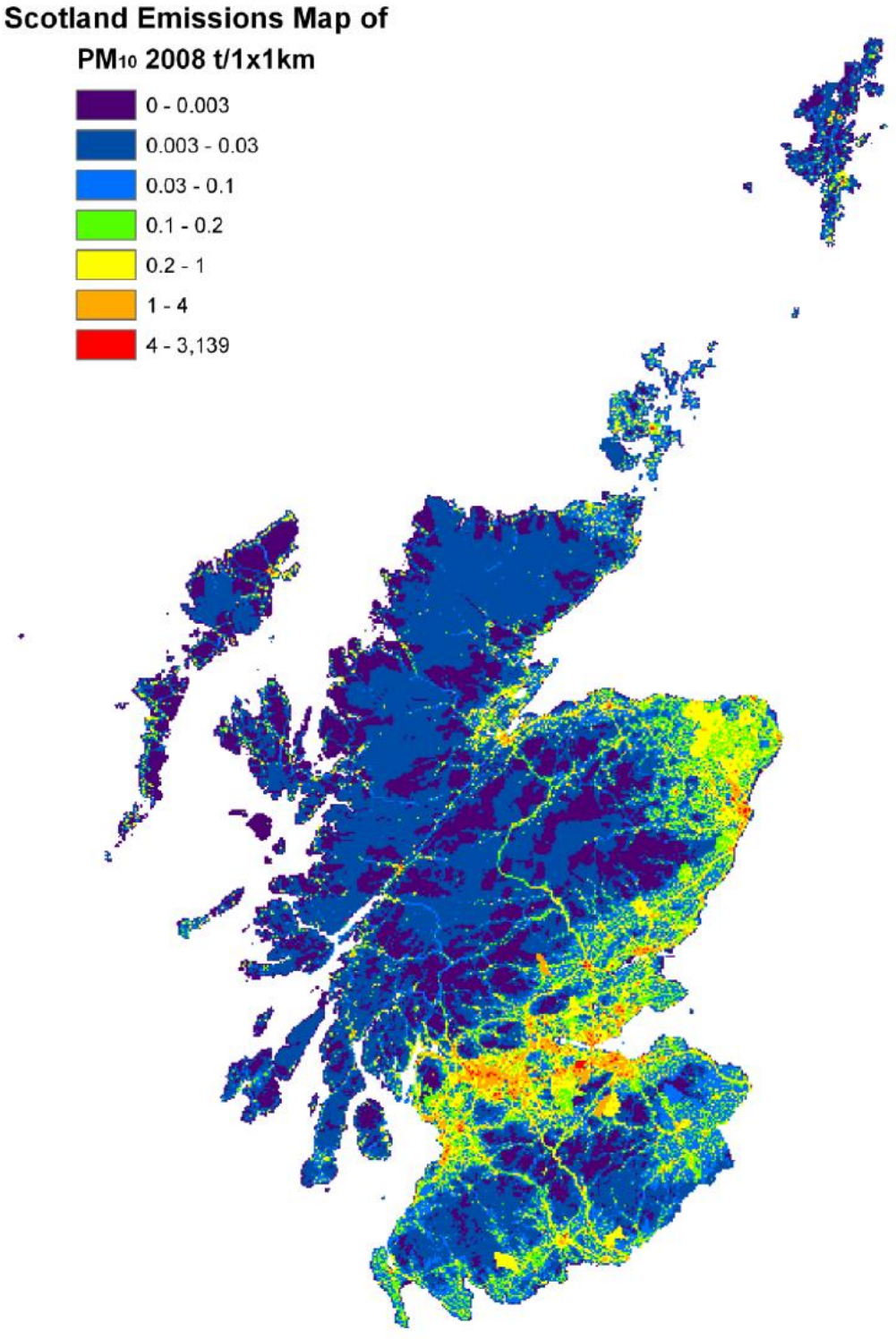
Figure 9-3 Time series of Scotland's PM_{10} emissions 1990-2008



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008

Scotland‟s PM_{10} emissions have declined by 53% since 1990 and account for 10% of the UK total. 27% of PM_{10} emissions in Scotland come from transport (1A3) sources (down by 23% since 1990), whilst 28% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 53% since 1990). Emissions from power generation (1A1a) were 25% of the Scotland total emission in 1990, but have been reduced to 6% of the Scotland total in 2008. Figure 9-4 shows a map of Scotland's emissions.

Figure 9-4 Map of PM_{10} Emissions in Scotland, 2008



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2008

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 2009 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
Scottish Power Generation Ltd, Longannet Power Station	23,500	19,400	19,087	22,731	14,876	14,086	15,170
Scottish Power Generation Ltd, Cockenzie Power Station	10,700	12,100	11,400	20,294	22,054	13,016	8,575
INEOS Manufacturing Scotland Ltd (Refinery),Grangemouth	5,250	3,269	3,349	3,467	3,048	4,102	3,567
Scottish & Southern Energy Plc, Lerwick Power Station	2,650	1,530	1,946	1,644	1,676	1,767	1,658
Scottish and Southern Energy, Peterhead Power Station	1,990	1,980	2,130	2,750	2,110	2,110	1,400
Ardagh Glass Ltd, Irvine	962	638	475	742	994	928	995
ExxonMobil Chemical Ltd, Mossmorran	1,500	1,840	1,594	1,651	798	864	809
Tullis Russell Papermakers Ltd, Glenrothes	448	598	611	723	592	815	757
Lafarge Cement UK, Dunbar Works	1,110	1,695	1,270	1,221	1,459	1,434	724
Shell UK Ltd, St Fergus Gas Plant	102	992	1,010	923	899	751	675

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 2009.

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
Scottish Power Generation Ltd, Longannet Power Station	1,140	700	662	943	555	313	459
Scottish Power Generation Ltd, Cockenzie Power Station	637	738	697	1,258	1,324	331	258
INEOS Manufacturing Scotland (Refinery) Ltd, Grangemouth	212	202	191	195	200	100	104
The Caledonian Cheese Company Ltd. Wigtown	No data	No data	BRT	BRT	74	105	103
Tullis Russell Papermakers Ltd., Glenrothes Fife	72	65	65	31	44	57	51
Scottish and Southern Energy, Peterhead Power Station	No data	20	67	64	68	79	50
The Cheese Company Limited. The Cheese Company Priestdykes Lockerbie	No data	BRT	BRT	95	98	82	48
VION Agriculture Limited. Cambusview Poultry Unit, Alloa	No data	No data	No data	No data	29	32	34
VION Agriculture Limited. Clapperton Poultry Complex, W.Lothian	No data	No data	No data	No data	24	34	33
Scottish & Southern Energy Plc, Lerwick Power Station	No data	50	25	21	23	31	30

Note: BRT = Below Reporting Threshold

10 Conclusions

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 2010, the database and website have been expanded and developed considerably- a number of new features including the 'Air Pollution Detectives', Openair, and the Scottish Air Quality discussion forum 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 83 automatic monitoring sites throughout Scotland are available in the database for all or part of 2010. This is an increase of 4 sites over 2009. 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 2010 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. A new approach to trend analysis has been adopted this year, and the findings suggest various trends for some pollutants, but that 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 second successive year, 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 2010 and further enhancements of the method have been targeted for future years as more data becomes available.

As requested by Scottish Government, links have been established with the SEPA Pollution Release inventory for Scotland (SPRI). Links to the SPRI are now available from the Scottish air quality website and in this report we have included a summary of both the National Atmospheric Emissions Inventory data for Scotland and the SPRI data.

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 2010

Table A1.1. AURN Measurement Sites in Scotland 2010

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)	322050,656250
Bush Estate	RURAL	NO NO_2 NO_X O_3	324500,663500
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	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[3]	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 SO_2 and PM_{10} at this site are part of the Scottish Government Network

Table A1.2. Automatic Hydrocarbon Network Sites in Scotland 2010

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322050, 656250
Glasgow Kerbside$^{\alpha}$	KERBSIDE	Benzene and 1,3-butadiene	258708, 665200

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.
$^{\alpha}$Automatic Monitoring of hydrocarbons was stopped at this site on 31/12/10.

Table A1.3. Non-Automatic Hydrocarbon Network Sites in Scotland 2010

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 A1.4. PAH Monitoring Sites in Scotland 2009

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	322050,656250

Table A1.5. Heavy Metals Monitoring Network Sites in Scotland 2009

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 A1.6. Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322050,656250
Banchory	Rural site, NE Scotland	367650,798550

Table A1.7. Rural Metal Deposition Monitoring sites in Scotland 2009

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	322050,656250	✓	✓		✓	✓

United Kingdom Eutrophying & Acidifying Network (UKEAP)

Table A1.8 The Precipitation Network (PrecipNet) Sites in Scotland 2010

Site Name	Grid Ref	Species included
Forsinain 2	290600, 948600	H^+, SO_4^{2-},ns- SO_4^{2-}, NO_3^-, NH_4^+, Na^+, Mg^{2+}, Ca^{2+}, Cl^-, Rain
Strathvaich Dam	234787,875022	
Allt a'Mhacaidh	287600, 805200	
Glensaugh	366329,780027	
Lochnagar	325200 785900	
Polloch	179200, 768900	
Balquidder	254500, 720700	
Loch Chon	242900, 708400	
Whiteadder	366400, 663300	
Auchencorth Moss	322188,656202	
Eskdalemuir	323588,602997	
Loch Dee	246800, 577900	

Table A1.9 Acid Gas and Aerosol Network (AGANet) and Ammonia Network (NAMN) Sites in Scotland 2010

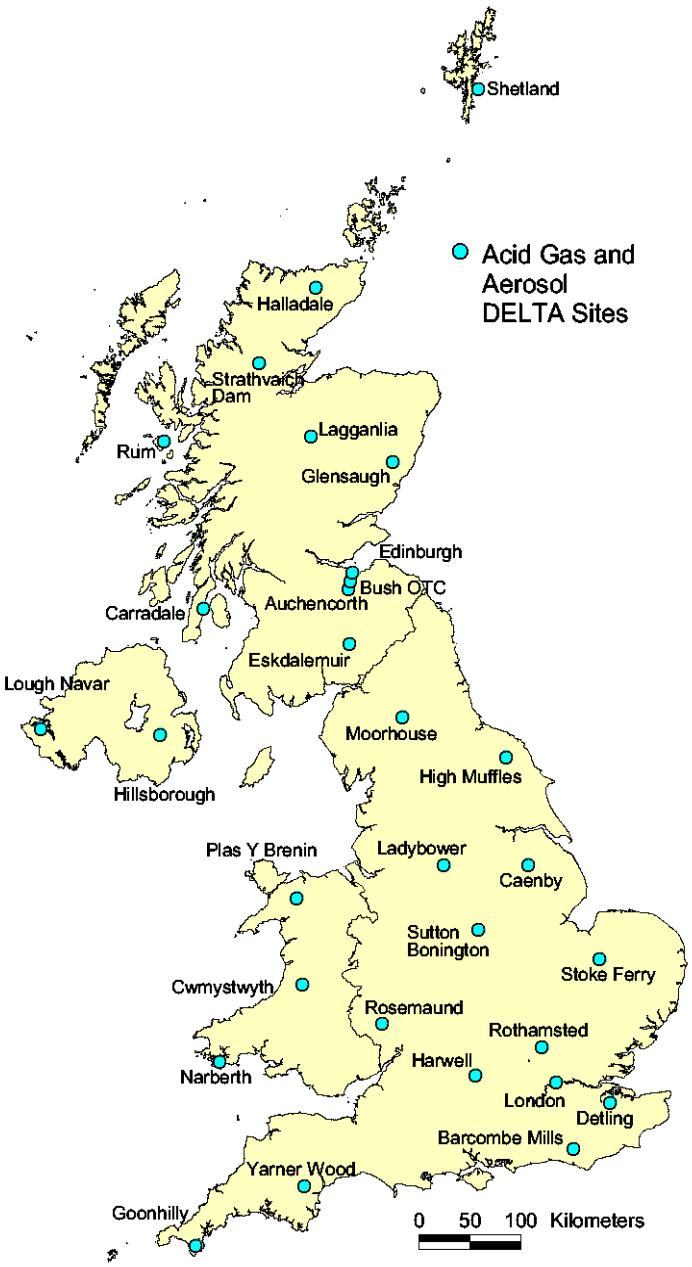
Name	Grid Ref	Ammonia	Nitric Acid
Shetland	445449,113965	✓	✓
Halladale	290285,948838	✓	✓
Inverpolly B	218776,908733	✓	
Strathvaich Dam	234787,875022	✓	✓
Ellon Ythan	394500,830400	✓	
Oldmeldrum	383297,827323	✓	
Pitmedden	388300,827800	✓	
Lagganlia	285684,803720	✓	✓
Allt a Mharcaidh	289184,804320	✓	
Rum	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 Green Cabin (formely 2)	324789,663804	✓	
Bush OTC (formely 1)	324671,663524	✓	✓
Auchencorth Moss	322188,656202	✓	
Carradale	179870,637801	✓	
Auchincruive B	238478,622899	✓	
Auchincruive 3	237977,623399	✓	
Sourhope	386796,621798	✓	
Eskdalemuir	323588,602997	✓	✓

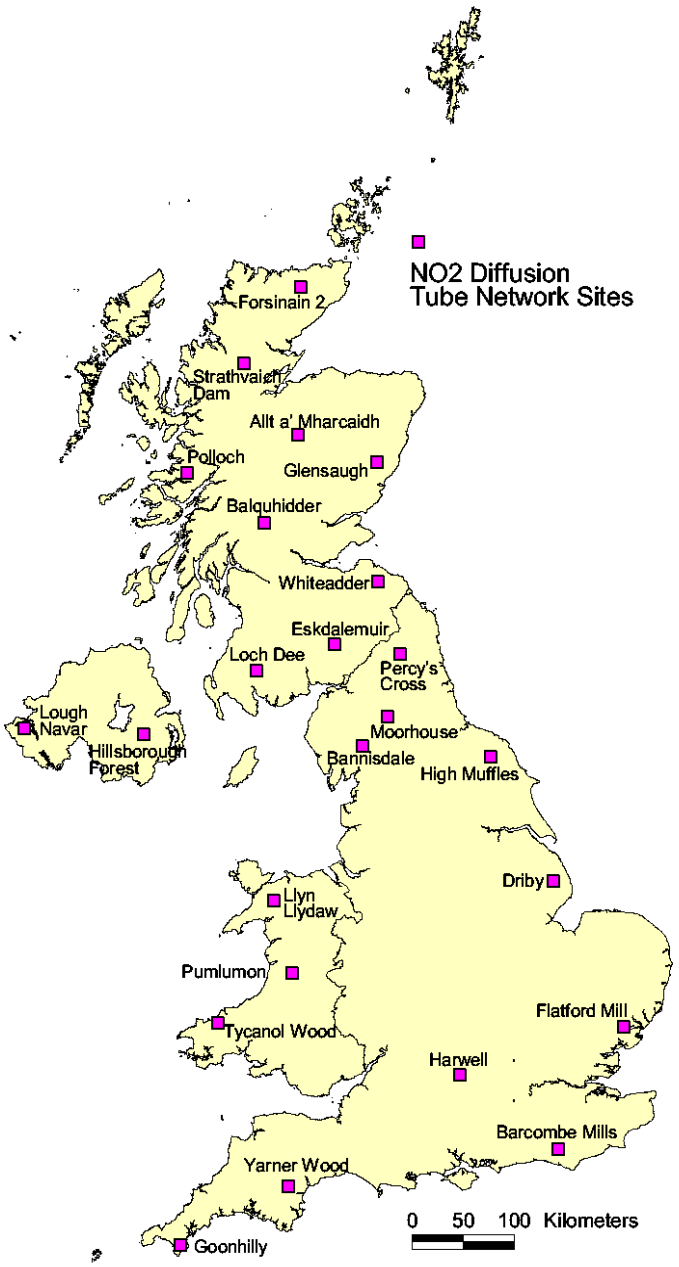
Measurement			NO_2	NH_3 Network (NAMN) DELTA NH_3	NH_3 Network (NAMN) DELTA NH_4^+	NH_X Network (NAMN) ALPHA NH_3	Acid Gas/Aerosol Network (AGAN) DELTA	6-Fig Grid Ref
Frequency: Site	Daily wet-only	Fortnightly Bulk	4-weekly	Monthly	Monthly	Monthly	Monthly	
Auchencorth Moss	✓			✓	✓	✓✓✓	✓	322100 656200
Eskdalemuir		✓	✓✓✓	✓	✓		✓	323500 603000
Bannisdale		✓	✓					351500 504300
Lough Navar		✓	✓	✓	✓		✓	17616 520883
Loch Dee		✓	✓					246800 577900
Whiteadder		✓	✓					366400 663300
Balquhidder		✓	✓					254500 720700
Polloch		✓	✓					179200 768900
Glensaugh		✓	✓	✓	✓	✓✓✓	✓	360200 796700
Allt a' Mharcaidh		✓	✓			✓✓✓		287600 805200
Strathvaich Dam		✓	✓	✓	✓		✓	234700 875000
Forsinain 2 / Halladale [1]		✓	✓	✓	✓		✓	290600 948600
Loch Chon		✓						242900 708400
Lochnagar		✓						325200 785900
Bush OTC				✓	✓	✓✓✓	✓	
Shetland				✓	✓		✓	
Lagganlia				✓	✓		✓	
Rum				✓	✓		✓	
Edinburgh St Leonards				✓	✓		✓	
Carradale				✓	✓		✓	
Bush Green Cabin						✓✓✓		
Inverpolly				✓		✓✓✓		
Ellon Ythan				✓				
Sourhope				✓		✓✓✓		
Auchincruive				✓				
Coleraine				✓				

Measurement			NO_2	NH_3 Network (NAMN) DELTA NH_3	NH_3 Network (NAMN) DELTA NH_4^+	NH_X Network (NAMN) ALPHA NH_3	Acid Gas/Aerosol Network (AGAN) DELTA	6-Fig Grid Ref
Frequency: Site	Daily wet-only	Fortnightly Bulk	4-weekly	Monthly	Monthly	Monthly	Monthly	
Rannoch						✓✓✓		
Tummel						✓✓✓		
Loch Awe						✓✓✓		
Glenshee Hotel [23]				✓				
Oldmeldrum						✓✓✓		

✓✓✓ Triplicate measurements made with passive diffusion samplers (NO2 or NH3)

[1] Forsinain 2 – the co-located Nitric Acid monitoring site is called Halladale


Shetland
Acid Gas and Aerosol DELTA Sites
Halladale
Strathvaich Dam
Lagganlia
Rum
Glensaugh
Edinburgh
Bush OTC
Auchencorth
Carradale
Eskdalemuir
Lough Navar
Moorhouse
High Muffles
Hillsborough
Plas Y Brenin
Ladybower
Caenby
Sutton Bonington
Stoke Ferry
Cwmystwyth
Rosemaund
Rothamsted
Harwell
Narberth
London
Detling
Barcombe Mills
Yarner Wood
Goonhilly
0 50 100 Kilometers


NO2 Diffusion Tube Network Sites
Forsinain 2
Strathvaich Dam
Allt a' Mharcaidh
Polloch
Glensaugh
Balquhidder
Whiteadder
Eskdalemuir
Loch Dee
Percy's Cross
Lough Navar
Hillsborough Forest
Moorhouse
Bannisdale
High Muffles
Driby
Llyn Llydaw
Pumlumon
Flatford Mill
Tycanol Wood
Harwell
Barcombe Mills
Yarner Wood
Goonhilly
0 50 100 Kilometers


Wet Deposition Sites
Forsinain 2
Strathvaich Dam
Allt a' Mharcaidh
Glensaugh
Lochnagar
Polloch
Balquhidder
Loch Chon
Whiteadder
Eskdalemuir
Loch Dee
Beags Burn
Percy's Cross
Lough Navar
Scoat Tarn
Moorhouse
Hillsborough Forest
Bannisdale
High Muffles
Thornganby
River Etherow
Driby
Llyn Llydaw
Llyn Llagi
Wardlow Hay Cop
Bottesford
Preston Montford
Pumlumon
Stoke Ferry
Ystradffin
Tycanol Wood
Flatford Mill
Crai Reservoir
Rothamsted
Harwell
Barcombe Mills
Yarner Wood
0 50 100 Kilometers
Goonhilly

)8

Appendix 2
Inter-calibration, Audit and Data Ratification Procedures

A2.1 Intercalibration and Audit procedures

The audit and intercalibration procedures adopted by 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 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 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

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 (PM10) 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.

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 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 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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