Scottish Air Quality Database Annual Report 2007

A report to the Scotttish Government

AEA

The Scottish Government

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Executive Summary

AEA Energy & Environment has been commissioned by The Scottish Government to undertake a 3-year project to develop an Air Quality Database and Website for Scotland. This work follows from the Pilot Project undertaken in 2006 and incorporates feedback received from a wide range of stakeholders during the pilot.

This report presents the activities undertaken during the first full year of the project – April 2007 – April 2008.

The database and website were launched on 2 April 2007. Continuous expansion and improvements to the website have been undertaken since the launch and these will continue throughout the duration of the project. Air pollution data for 47 automatic monitoring sites throughout Scotland are available in the database for all or part of 2007.

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 2007 is provided. Where exceedences 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.

The automatic PM_{10} and $PM_{2.5}$ data from the database have been used to examine an episode of particle pollution which was observed throughout Scotland during the period 24 March to 2 April 2007. This episode was mainly due to particles transported in the atmosphere from agricultural and forest fires in Russia.

The data from 2006 (less monitoring sites than available for 2007) have been used to improve and better calibrate the air pollution background and roadside concentration maps for Scotland. Data for 2007 will be used in the next update of these maps.

Also, data within the database covering many years have been used to examine trends in air pollution throughout Scotland. Inevitably, the data from earlier years are based on only a few monitoring sites. However, as the number of monitoring sites within the database increases over time, then the reliability of the trend data will improve.

The Scottish Air Quality website is available at www.scottishairquality.co.uk

Contents

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 Assembly Government and the Department of the Environment in Northern Ireland. In addition a large number of Local Authorities 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 was collected by a wide range of organisations for a number of purposes and was 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 database 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 database and website incorporating all stakeholder comments and to bring selected Local Authority sites in line with the national QA/QC requirements. This report summarises the progress made during 2007 in the following project tasks:

- Improvements to the database and to website functionality
- Harmonised QA/QC of Local Authority monitoring site data
- Overview of air quality in Scotland in 2007
- Air Quality mapping in Scotland
- Air Quality trends for Scotland.

As the database builds in size and scope, it will become an invaluable resource for air quality data in Scotland.

2 Database and Website

During the 2006 pilot study the Air Quality in Scotland website was developed by AEA on behalf of Scottish Government, here we describe how this has progressed to a fully functional public access website during 2007.

2.1 WEBSITE LAUNCH

The development of the pilot study website and database focussed around a number of stakeholder meetings, seminars and a questionnaire to consult on the content and functionality of the system.

The pilot study was found to be extremely successful with much positive feedback from Local Authorities, SEPA, health and statistics professionals and other bodies. On this basis The Scottish Government decided in January 2007 to commission a fully populated and publicly available Air Quality in Scotland website.

A number of the stakeholder recommendations were implemented during the pilot study phase, whilst others remained to be addressed in order to develop the pilot study into a fully live system. A period of further development therefore ensued with the Air Quality Scotland website being launched publicly on Monday 2 April 2007. A screenshot of the website home page is illustrated in Figure 2.1 below.

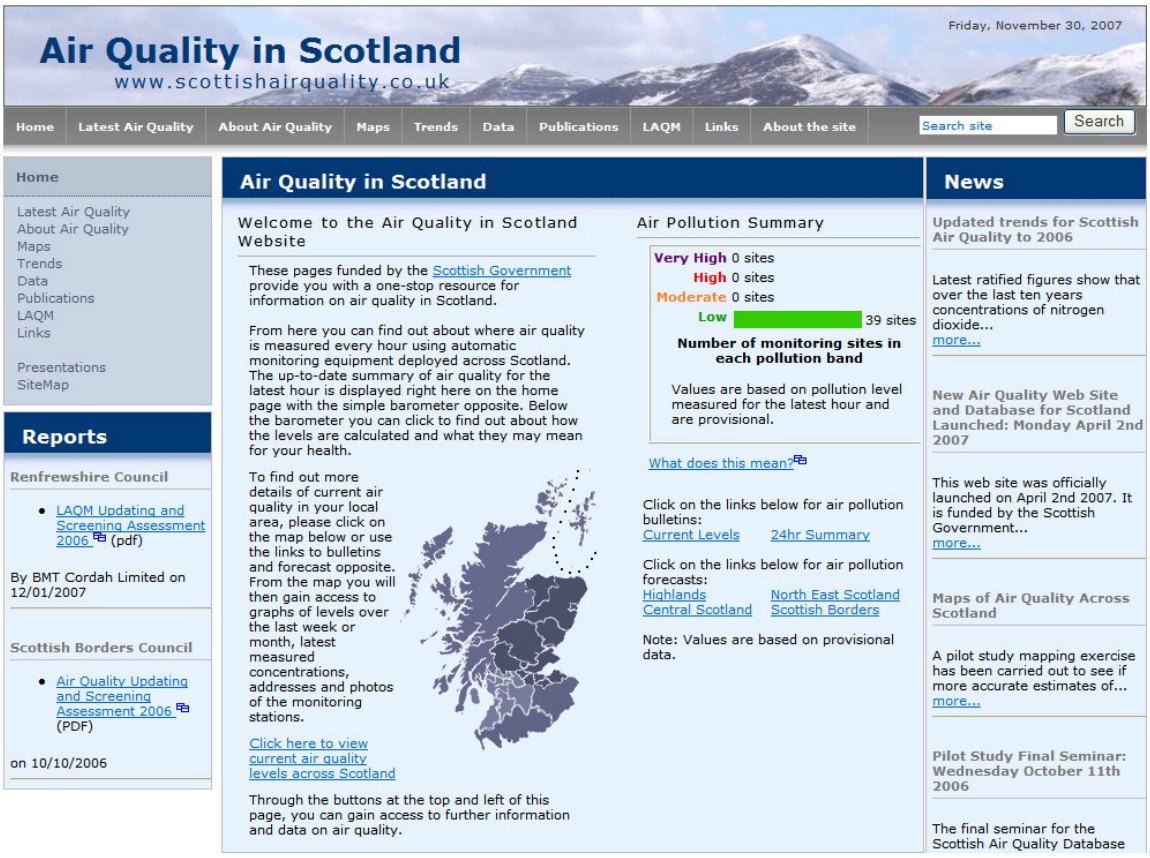
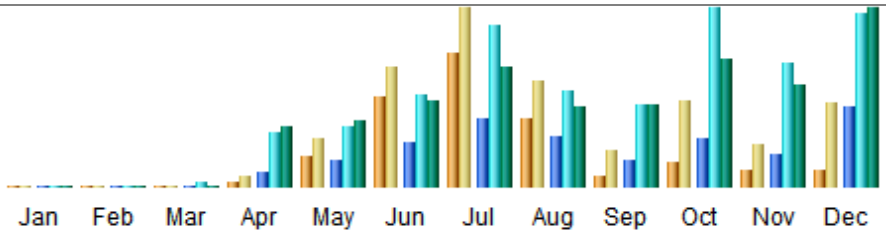


Figure 2.1 Air Quality in Scotland website home page.

2.2 USAGE STATISTICS

Since its launch, usage of the website has been monitored through an 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 2.2 below illustrates how the number of hits varied during 2007.



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	6	9	126	799	3.59 MB
Apr	137	328	2191	8407	207.02 MB
May	920	1450	4038	9303	233.86 MB
Jun	2705	3556	6866	14408	300.75 MB
Jul	3992	5306	10628	25068	413.63 MB
Aug	2034	3127	7802	14804	280.26 MB
Sep	309	1073	4154	12732	287.49 MB
Oct	761	2573	7603	27608	442.03 MB
Nov	514	1289	5122	19055	354.75 MB
Dec	490	2488	12311	26957	619.67 MB
Total	11868	21199	60841	159141	3.07 GB

Figure 2.2 Air Quality Scotland Website Hits 2007.

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.

Figure 2.2 shows that the largest numbers of unique visitors to site were recorded in June, July and August 2007. We believe that this corresponds to some of the early publicity about the launch of the site (in Air Quality Management and Air Quality Bulletin journals for instance), which will hopefully have encouraged a number of users to come and take a look at the site for the first time.

Since this initial burst of activity, the statistics show that the number of visitors has fallen to a steady level of around 500 per month, although the number of pages opened and total hits continue to show higher levels. We believe that this indicates the website is now being used by a core group who are more active in using the full functionality of the pages.

2.3 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 with no broken links.

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

- Updates to the national AURN sites are made as required (e.g. If new particulate monitoring instruments come on-line or other sites/instruments are changed.)
- New local authority monitoring sites are added to the database once agreement is reached with the operators
- Site photos are added as soon as AEA carry out our QA/QC visits, or they are provided by the local authority
- Ratified data (or any improved provisional data) load automatically to the website from AEA's data management software on a daily basis
- Statistics are automatically recalculated every night:
    - Daily, Monthly & Annual Means etc.
    - All exceedence statistics
- The LAQM pages are automatically 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.

We are pleased to report that thanks to the ongoing checks and maintenance the web pages were available for 100% of the time during 2007 with no breakdowns or downtime reported.

2.4 WEBSITE UPGRADES DURING 2007

A number of enhancements to the website were carried out in 2007, at the request of Scottish Government and the website users, in order to improve the appearance and functionality of the pages.

2.4.1 Improvement to the Latest Data Display

Upon launch of the website the "Latest Air Quality" headline summary for Scotland was presented by taking the worst-case of all the automatic monitoring stations across Scotland. It soon became clear however that a number of near-road or industrial monitoring locations could provide locally recorded levels of High or Very High pollution which were not representative of the overall situation across Scotland.

A number of different options were therefore tested in order to consider whether the headline summary could be an "Average" of all the latest automatic monitoring results, or some other measure of the n^{th} highest reading in order to present an accurate picture without discounting the genuinely high localised levels in some areas.

In the end it was concluded that any attempt to amalgamate all the monitoring results into a single headline summary could be misunderstood or poorly interpreted by some users. The solution was therefore to simply use graphical means to present all the monitoring results and then leave it to the user to conclude whether any High measurements were localised or represented a widespread pollution event across the whole of Scotland. This decision could of course be supported by the Scottish air quality forecasts which attempt to predict the widespread pollution situation and not individual local events.

Figure 2.3 below illustrates the map and histogram which is now used to present the latest, hourly updated data summary. In this case it can be clearly seen that although one monitoring station is recording High pollution, and another two are Moderate, the overwhelming situation recorded by the other thirty-nine sites is of a Low pollution situation.

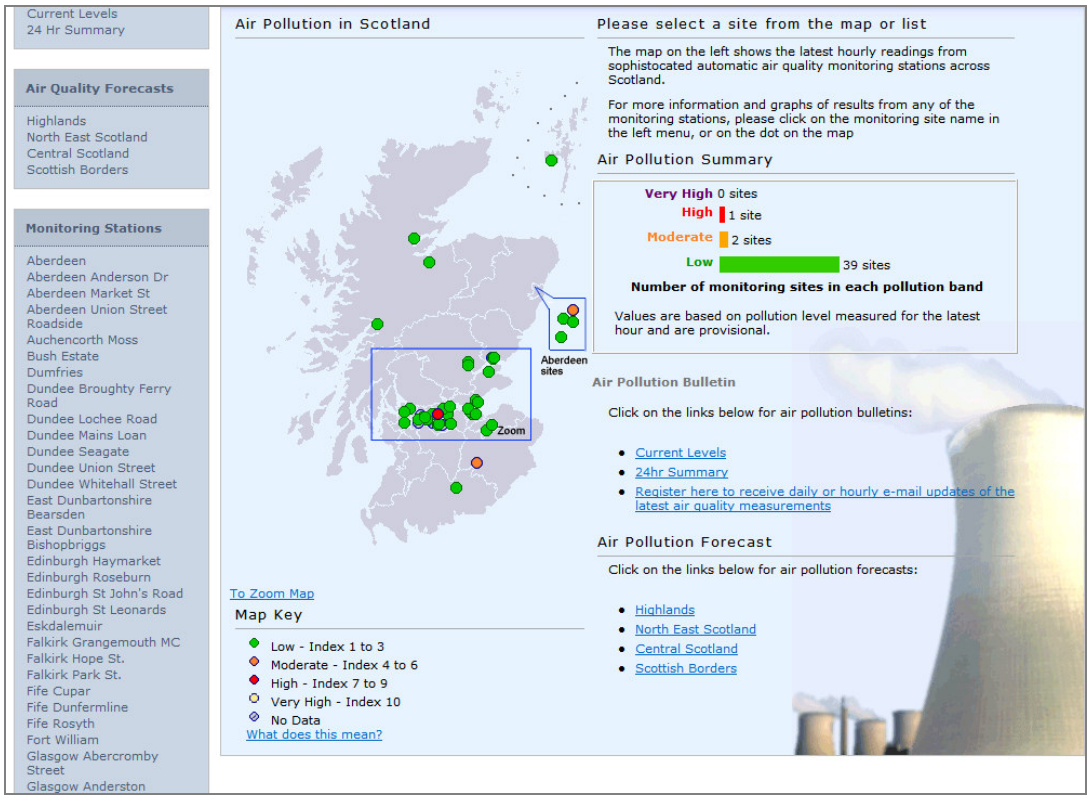


Figure 2.3 Air Pollution in Scotland latest data summary.

2.4.2 Air Quality Bulletins by e-mail

This enhancement to the website functionality was added by popular request of the users, so that they could be easily alerted of any pollution events which were either of their local, regional or national interest.

Users can register for this service on the web site at http://www.scottishairquality.co.uk/bulletin_reg.php where they are able to choose from a range of different options to receive the information:

- A specified bulletin by e-mail at any required time of the day
  - Latest hour.
  - 24-hour summary.
  - Including forecast.
  - All Scotland or just your local area.
- Choose to receive bulletins all the time, or just if the measurements or forecast are moderate/high.

The flow chart in Figure 2.4 below illustrates the website registration process.

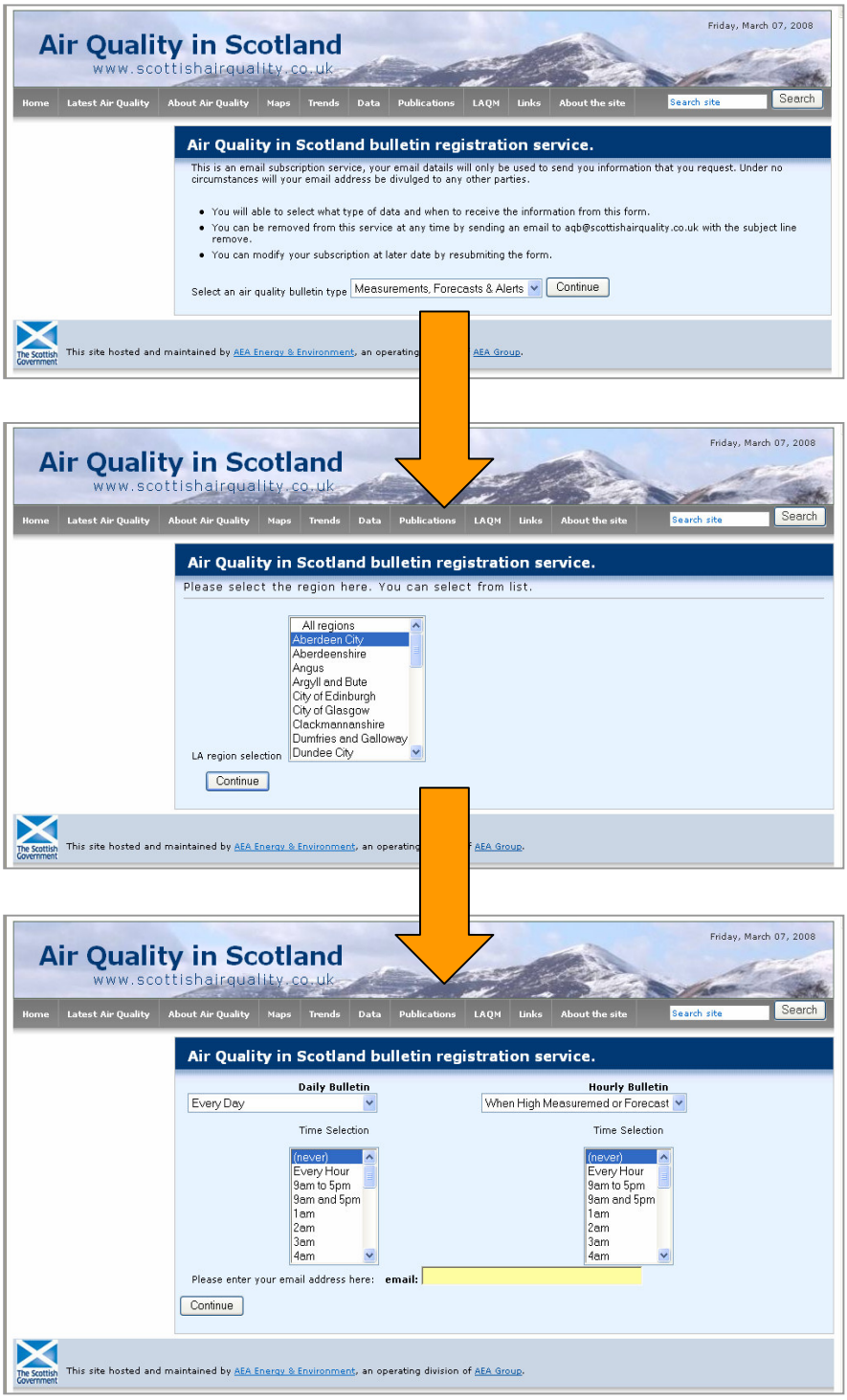


Figure 2.4 Air Pollution e-mail Bulletin registration.

Upon website registration the user automatically receives an e-mail asking them to confirm that they have requested to be added to the bulletin database. This is for security purposes to avoid the possibility of form-filling by automated malicious software. Once confirmed the user begins to receive the requested bulletins in the format illustrated in Figure 2.5 below. The bulletin consists of a tabulated list of latest air pollution measurements together with the option to click on the site name or pollutant to display a timeseries graph of the last weeks' hourly measurements.

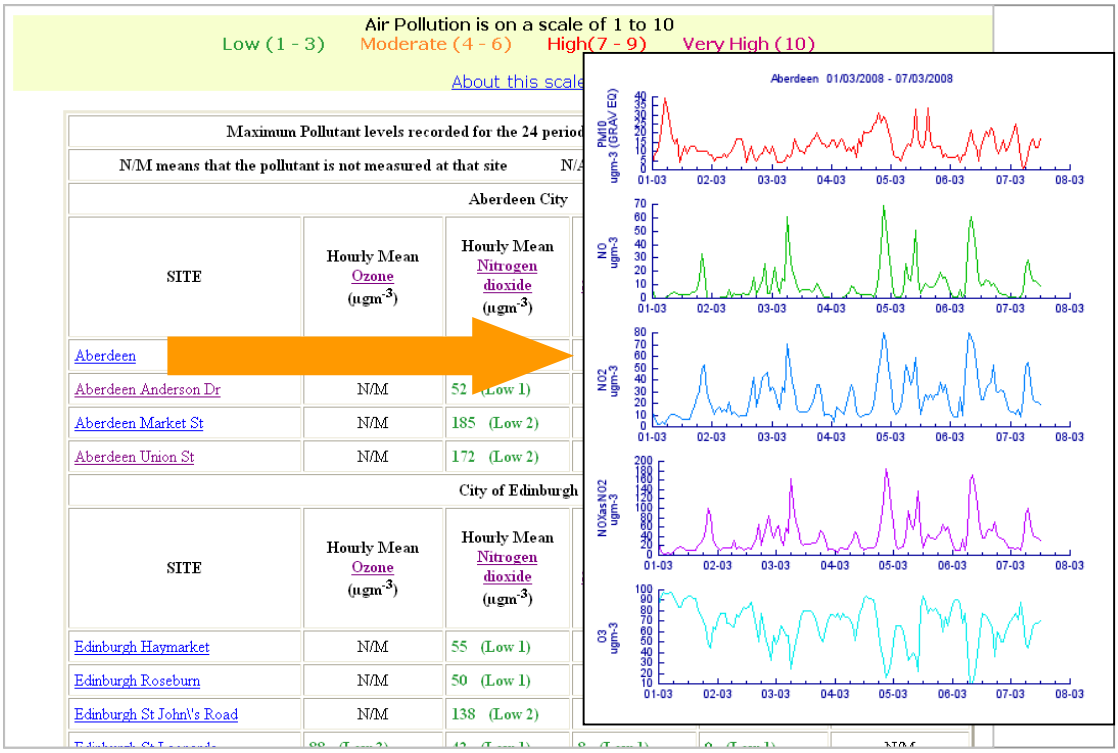


Figure 2.5 Air Pollution Bulletin format (table and graphs).

2.5 FUTURE WEBSITE DEVELOPMENTS

For 2008 a number of further possible website developments are currently under consideration. These include options to enhance both the statistical power of the database and the graphical user interface as follows:

- Additional automated e-mail alerts to cover exceedences of Air Quality Strategy Standards and Objectives, in addition to the existing alerts for High or Very High according to the Air Quality Bandings (as described above)
- Alerts to inform when new reports, news or website developments become available
- The provision of the Scottish Air Quality Database results in near-real time in Google Earth format
- An enhanced interactive mapping function to show the latest automatic monitoring results, through the incorporation of Google Maps functionality into the Air Quality Scotland website.

These options, and their feasibility to implement within the scope of this contract, will be discussed and agreed with Scottish Government and the website stakeholders over the course of 2008.

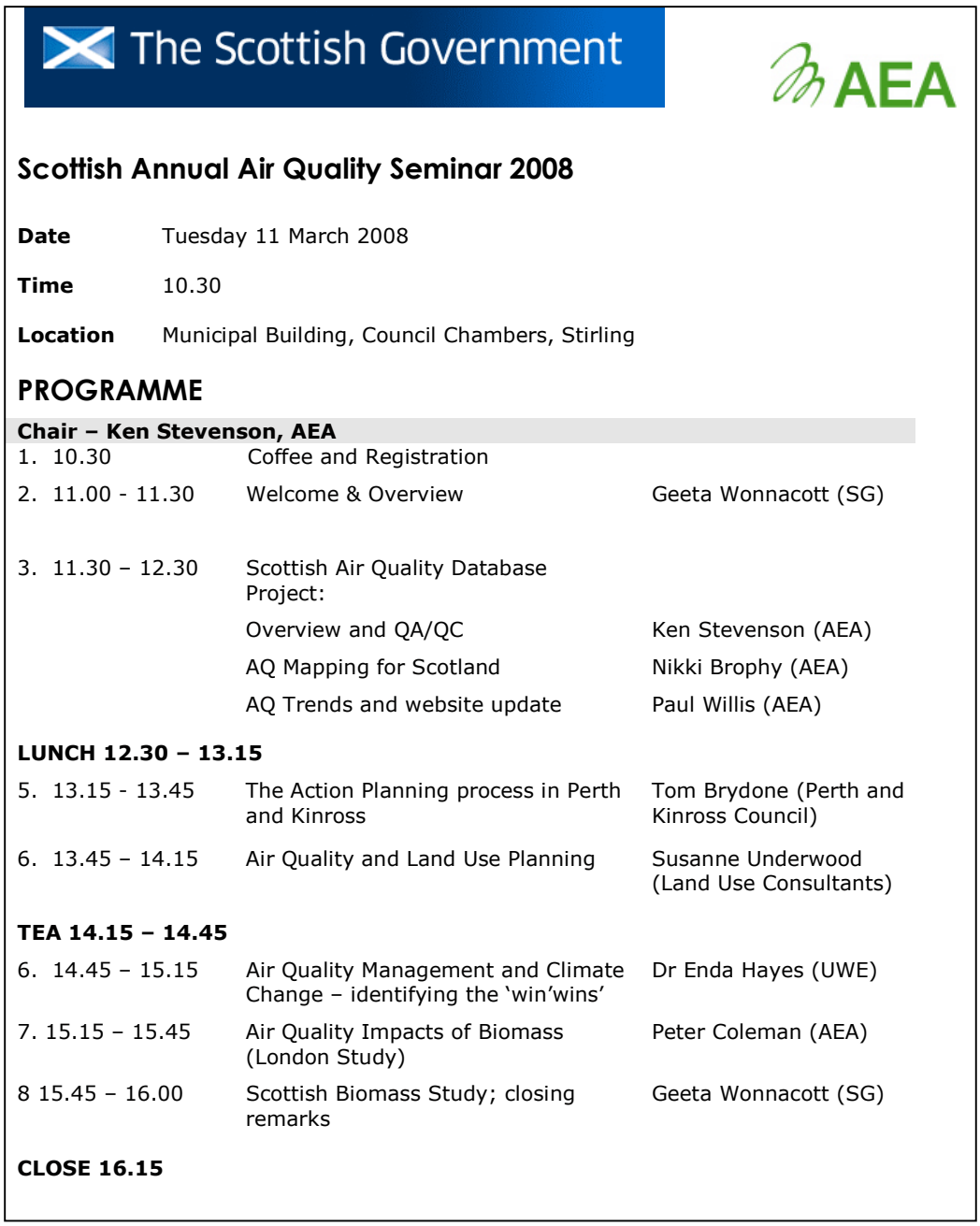
3 Annual Air Quality Seminar and Newsletter

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 Tuesday 11 March 2008. The event was attended by over fifty air quality experts from a range of Local Authorities and other stakeholder groups in Scotland. The objective was to discuss 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 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 brochure "Air Pollution in Scotland" is also produced as part of this project. The brochure for 2007 sets the legislative and policy background to air quality control in Scotland and briefly reviews 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. Hard copies of the brochure are available from Ken Stevenson - ken.stevenson@aeat.co.uk (postal address is given at the start of this report). Electronic copies in pfd format are available at http://www.scottishairquality.co.uk/reports.php?n_action=report2



The Scottish Government

AEA

Scottish Annual Air Quality Seminar 2008

Date Tuesday 11 March 2008

Time 10.30

Location Municipal Building, Council Chambers, Stirling

PROGRAMME

Chair – Ken Stevenson, AEA

1. 10.30	Coffee and Registration	
2. 11.00 - 11.30	Welcome & Overview	Geeta Wonnacott (SG)
3. 11.30 – 12.30	Scottish Air Quality Database Project:	
	Overview and QA/QC	Ken Stevenson (AEA)
	AQ Mapping for Scotland	Nikki Brophy (AEA)
	AQ Trends and website update	Paul Willis (AEA)
LUNCH 12.30 – 13.15		
5. 13.15 - 13.45	The Action Planning process in Perth and Kinross	Tom Brydone (Perth and Kinross Council)
6. 13.45 – 14.15	Air Quality and Land Use Planning	Susanne Underwood (Land Use Consultants)
TEA 14.15 – 14.45		
6. 14.45 – 15.15	Air Quality Management and Climate Change – identifying the 'win'wins'	Dr Enda Hayes (UWE)
7. 15.15 – 15.45	Air Quality Impacts of Biomass (London Study)	Peter Coleman (AEA)
8 15.45 – 16.00	Scottish Biomass Study; closing remarks	Geeta Wonnacott (SG)

CLOSE 16.15

Figure 3.1 Agenda for the Scottish Air Quality Seminar 11 March 2008

4 Data Availability in 2007

4.1 HOURLY DATA FOR NITROGEN DIOXIDE, CARBON MONOXIDE, SULPHUR DIOXIDE, OZONE AND PM10

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

Data availability for 2007, 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 Scottish Air Quality Database Data Availability in 2007

Site Name	Pollutants	Type	East	North	Data in 2007
Aberdeen	CO NO_2 O_3 PM10 SO_2	Urban Background	394416	807408	Jan – Dec
Aberdeen Anderson Dr	NO_2 PM10	Roadside	392506	804186	Jan – Dec
Aberdeen Market St	NO_2 PM10	Roadside	394408	805893	Jan – Dec
Aberdeen Union St	NO_2 PM10	Roadside	393656	805967	Jan – Dec
Auchencorth Moss	O_3 PM10 PM25	Rural	322050	656250	Jan – Dec
Bush Estate	NO_2 O_3	Rural	324500	663500	Jan – Dec
Dumfries	CO NO_2 PM10	Roadside	297012	576278	Jan – Dec
Dundee Broughty Ferry Road	PM10 SO_2	Roadside	341970	730997	Jan – Dec
Dundee Lochee Road	NO_2	Kerbside	338861	730773	Jan – Dec
Dundee Mains Loan	PM10	Urban background	340972	731893	Jan – Dec
Dundee Seagate	NO_2	Kerbside	340487	730446	Jan – Dec
Dundee Union Street	NO_2 PM10	Kerbside	340236	730090	Jan – Dec
Dundee Whitehall Street	NO_2	Kerbside	340279	730155	Jan – Dec
East Dunbartonshire Bearsden	NO_2 PM10	Kerbside	254269	672067	Jan – Dec
East Dunbartonshire Bishopbriggs	NO_2 PM10	Roadside	260995	670130	Jan – Dec
Edinburgh Haymarket	NO_2 PM10	Roadside	323890	673180	Jan – Dec
Edinburgh Roseburn	NO_2 PM10	Roadside	322939	673233	Jan – Dec
Edinburgh St John's Road	NO_2	Kerbside	320100	672890	Jan – Dec
Edinburgh St Leonards	CO NO_2 O_3 PM10 SO_2	Urban background	326200	673200	Jan – Dec
Eskdalemuir	NO_2 O_3	Rural	323500	602800	Jan – Dec
Falkirk Grangemouth MC	NO_2 PM10 SO_2	Urban background	292816	682009	Jan – Dec
Falkirk Hope St	NO_2 PM10 SO_2	Roadside	288688	680218	Jan – Dec
Falkirk Park St	NO_2 PM10 SO_2	Roadside	288892	680070	Jan – Dec
Fife Cupar	NO_2 PM10	kerbside	337401	714572	Jan – Dec

Site Name	Pollutants	Type	East	North	Data in 2007
Fife Dunfermline	NO_2	Roadside	309910	687745	Aug – Dec
Fort William	NO_2 O_3	Suburban	210849	774421	Jan – Dec
Glasgow Anderston	CO NO_2 PM10 SO_2	Urban background	257925	665487	Jan – Dec
Glasgow Battlefield Road	NO_2 PM10	Roadside	258417	661385	Jan – Dec
Glasgow Byres Road	CO NO_2 PM10	Roadside	256553	665487	Jan – Dec
Glasgow Centre	CO NO_2 O_3 PM10 SO_2	Urban centre	258902	665028	Jan – Dec
Glasgow City Chambers	CO NO_2	Urban background	259528	665308	Jan – Dec
Glasgow Kerbside	CO NO_2 PM10	Kerbside	258708	665200	Jan – Dec
Glasgow Waulkmillglen Reservoir	NO_2 O_3 PM10	Rural	252520	658095	Jan – Dec
Grangemouth	CO NO_2 PM10 SO_2	Urban industrial	293840	681032	Jan – Dec
Inverness	CO NO_2 PM10	Roadside	265720	845680	Jan – Dec
Lerwick	O_3	Rural	445337	1139683	Jan – Dec
N Lanarkshire Chapelhall	NO_2 PM10	Roadside	278174	663124	Oct – Dec
N Lanarkshire Coatbridge Ellis St	NO_2	Roadside	273086	665077	Oct – Dec
N Lanarkshire Coatbridge Whifflet	NO_2 PM10	Urban background	273668	663938	Oct – Dec
N Lanarkshire Croy	NO_2 PM10 SO_2	Roadside	272775	675738	Oct – Dec
N Lanarkshire Harthill	CO NO_2 PM10 SO_2	Roadside	288051	663975	Oct – Dec
Paisley Central Road	NO_2	Roadside	248445	664191	Jan – Dec
Perth	NO_2 PM10	Roadside	311688	723625	Jan – Dec
Perth 2	NO_2 PM10	Roadside	311582	723931	Jan – Dec
Strath Vaich	O_3	Remote	234829 234700	874785 875000	Jan – Dec
West Dunbartonshire Clydebank	NO_2 PM10	Roadside	249724	672042	Feb - Dec
West Dunbartonshire Glasgow Road	NO_2	Roadside	240236	675195	May - Dec

At the end of 2007 a total of 47 automatic monitoring sites had been included within the database. In addition, during 2007 two sites were decommissioned namely Fife Kincardine which ended on 11 May 2007 and West Dunbartonshire Balloch which ended on 26 April 2007. As there is therefore only limited data availability for these sites in 2007, they are not included in the table above.

During 2008 we anticipate that another 14 Local Authority sites will be added to the database.

4.2 NATIONAL NETWORK MONITORING FOR OTHER POLLUTANTS IN SCOTLAND

In addition to the 14 UK National Network AURN monitoring sites in Scotland, a number of other pollutants are monitored within other national networks:

- UK Automatic Hydrocarbon Monitoring Networks – 2 sites
- PAH Monitoring Network – 3 sites
- Heavy Metals Monitoring Networks – 3 sites
- Heavy Metals Deposition Network – 3 sites
- Acid Deposition Network – 11 sites
- Ammonia and Nitric Acid Monitoring Network – 26 sites

Details of these sites are presented in Appendix 1. It has not been possible to load all of these data onto the Scottish database just yet, but as the database

develops, these data will be loaded and hence the database will become a consolidation of air quality data from a wide variety of sources and will include these specialist data. Data will then be available from one easily accessible web portal.

4.3 GRAVIMETRIC PM10 AND PM2.5 MONITORING

During 2006 and 2007, The Scottish Government commissioned a programme of additional gravimetric PM10 and PM2.5 monitoring at a number of sites throughout Scotland, as detailed below:

Bush	PM10 and PM2.5
Dumfries	PM2.5 (PM10 in AURN)
Eskdalemuir	PM10 and PM2.5
Fort William	PM10 and PM2.5
Inverness	PM2.5 (PM10 in AURN)

Though the full year of monitoring at these sites has now been completed the data are not yet available. The reason for this is that a filter weighing anomaly appears to have affected the results leading to an over-estimation of the measured concentrations. This same problem has affected gravimetric PM measurements throughout the UK and is currently the subject of detailed investigation. A report of these investigations will be available in the middle of 2008 and it is anticipated that an appropriate correction factor for the data will be calculated and agreed.

When the Scottish Gravimetric data are corrected they will be uploaded to the database. These data will then be utilised to update the PM mapped concentrations throughout Scotland (see Section 7) and provide improved background PM10 and PM2.5 concentration maps.

5 QA/QC of the Database

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

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

5.1 ON-SITE ANALYSER AND CALIBRATIONS GAS AUDITS

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

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

The assessment of the station calibration cylinder concentrations provides an indication that the cylinder concentration has remained stable and therefore suitable for data scaling purposes. This process also ensures that all monitoring stations in Scotland are traceable to reference gas standards held at AEA. These in turn are traceable to UK national reference standard gases held by the National Physical Laboratory who, in turn regularly intercompare these standards internationally. Hence, there is an unbroken traceability chain from each monitoring site in Scotland to internationally agreed gas calibration standards.

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

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

Detailed audit procedures are provided in Appendix 2.

5.2 DATA MANAGEMENT

The following sections describe the data management package applied to the data from the Scottish Local Authority monitoring stations. This is the same data

management package, using the same data ratification procedures, that is applied to the AURN network stations across the UK.

The process includes the following tasks:
- Data acquisition
- Data validation
- Ratification

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

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

The validated data are then updated to the Scottish Air Quality Database – and accessible via the web - as provisional data. These data are therefore available to all users on a day-to-day basis. This gives the Local Authority the opportunity to easily view both their own data and data from other stations throughout Scotland. This will assist in dealing with day-to-day requests for information on specific data or the overall pollution situation either locally or throughout Scotland.

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'.

The aim of data ratification is to make use all of the available information to identify and remove faulty data, ensuring that remaining measurement data meet the accuracy and precision specifications the Scottish Government for Detailed Review and Assessment (LAQM.TG(03)).

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

5.4 QA/QC DURING 2007

5.4.1 Site intercalibrations and audits

As discussed above, site intercalibrations and audit visits are undertaken at 6-monthly intervals. However, where a site joins the database part way through a year then it is possible that only one audit will be conducted during the year. Table 5.1 shows the full list of intercalibrations and audits undertaken on air quality sites in the Scottish Database during 2007.

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 included:

- 2 NOx converter efficiencies were less than 95% (90.8% and 93.5%)
- 1 Ozone monitor was out by more than 10% (13%)
- 2 TEOM Ko were not set correctly, 1 was incorrect by 5.5%, 1 TEOM had the Main flow out by 12% and 1 TEOM failed the leak test
- 4 NO Cylinders had changed by more than 10% (-36.4%, -17.3%, -39%, -19.2%)
- 1 NOx analyzer failed the leak test.

These are all typical faults that are found during audit and intercalibration exercises.

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

Table 5.1 Air Quality Site Intercalibration and Audits Conducted During 2007

	Jan - Jun 2007	Jul – Dec 2007		Jan - Jun 2007	Jul – Dec 2007
Aberdeen	✓	✓	Glasgow Anderston	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Market St	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Centre	✓	✓
Auchencorth Moss	✓	✓	Glasgow City Chambers	✓	✓
Bush Estate	✓	✓	Glasgow Kerbside	✓	✓
Dumfries	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Dundee Broughty Ferry Road	✓	✓	Grangemouth	✓	✓
Dundee Lochee Road	✓	✓	Inverness	✓	✓
Dundee Mains Loan	✓	✓	Lerwick	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Chapelhall		✓
Dundee Union Street	✓	✓	N Lanarkshire Coatbridge Ellis St		✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Coatbridge Whifflet		✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Croy		✓
East Dunbartonshire Bishopbriggs	✓	✓	N Lanarkshire Harthill		✓
Edinburgh Haymarket		✓	Paisley Central Road		
Edinburgh Roseburn		✓	Perth	✓	✓
Edinburgh St John's Road		✓	Perth 2	✓	✓
Edinburgh St Leonards	✓	✓	Strath Vaich	✓	✓
Eskdalemuir	✓	✓	West Dunbartonshire Clydebank	✓	✓
Falkirk Grangemouth MC	✓	✓	West Dunbartonshire Glasgow Road	✓	✓
Falkirk Hope St		✓			
Falkirk Park St		✓			
Fife Cupar	✓	✓			
Fife Dunfermline	✓	✓			
Fort William	✓	✓			

5.4.2 Data ratification

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

Table 5.2 shows the data that have been ratified and are available in the database. For the sites in Edinburgh and the site at Glasgow Road in West Dunbartonshire, additional information is required to complete the ratification and we are liaising with the relevant Local Authorities to obtain the required data.

Table 5.2 Data Ratification Undertaken During 2007

	Jan - Jun 2007	Jul – Dec 2007		Jan - Jun 2007	Jul – Dec 2007
Aberdeen	✓	✓	Glasgow Anderston	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Market St	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Centre	✓	✓
Auchencorth Moss	✓	✓	Glasgow City Chambers	✓	✓
Bush Estate	✓	✓	Glasgow Kerbside	✓	✓
Dumfries	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Dundee Broughty Ferry Road	✓	✓	Grangemouth	✓	✓
Dundee Lochee Road	✓	✓	Inverness	✓	✓
Dundee Mains Loan	✓	✓	Lerwick	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Chapelhall	✓	✓
Dundee Union Street	✓	✓	N Lanarkshire Coatbridge Ellis St	✓	✓
Dundee Whitehall Street	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Croy	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	N Lanarkshire Harthill	✓	✓
Edinburgh Haymarket			Paisley Central Road	✓	✓
Edinburgh Roseburn			Perth	✓	✓
Edinburgh St John's Road			Perth 2	✓	✓
Edinburgh St Leonards	✓	✓	Strath Vaich	✓	✓
Eskdalemuir	✓	✓	West Dunbartonshire Clydebank	✓	✓
Falkirk Grangemouth MC		✓	West Dunbartonshire Glasgow Road	✓	
Falkirk Hope St		✓			
Falkirk Park St		✓			
Fife Cupar	✓	✓			
Fife Dunfermline	✓	✓			
Fort William	✓	✓			

6 Air Pollution in Scotland 2007

6.1 ANNUAL AVERAGE SUMMARY STATISTICS

Tables 6.1 – 6.5 show the 2007 annual average data statistics for NO_2, PM10, CO, SO_2 and O_3 respectively, for the ratified automatic data from monitoring sites included in the Scottish Air Quality Database. These are shown along with the corresponding data capture for the year.

These data will have been used by Local Authorities to assess air quality within their area as part of the Local Air Quality Review and Assessment process. Where any of the Air Quality Objectives for Scotland have been exceeded - at locations where there is relevant exposure of the general public - then the Authority will need to proceed to a Detailed Assessment to confirm the exceedence and estimate its extent. Where the exceedence is confirmed then the Authority will declare an Air Quality Management Area (AQMA). At present, 10 Local Authorities in Scotland have declared AQMAs (see http://www.scottishairquality.co.uk/laqm.php) and a number of other authorities are proceeding through the process of declaration.

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

Nitrogen Dioxide

Table 6.1 Ratified data annual average concentration and data capture for NO_2 in 2007 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2007 (μgm^{-3})	Data capture NO_2 2007 (%)	Comment
Aberdeen	Urban Background	24	95	Jan – Dec
Aberdeen Anderson Dr	Roadside	28	90	Jan – Dec
Aberdeen Market St	Roadside	62	99	Jan – Dec
Aberdeen Union St	Roadside	53	99	Jan – Dec
Bush Estate	Rural	9	91	Jan – Dec
Dumfries	Roadside	38	99	Jan – Dec
Dundee Lochee Road	Kerbside	53	93	Jan – Dec
Dundee Seagate	Kerbside	49	94	Jan – Dec
Dundee Union Street	Kerbside	36	99	Jan – Dec
Dundee Whitehall Street	Kerbside	42	91	Jan – Dec
East Dunbartonshire Bearsden	Kerbside	40	99	Jan – Dec
East Dunbartonshire Bishopbriggs	Roadside	32	99	Jan – Dec
Edinburgh Haymarket	Roadside			Not yet ratified

Site Name	Type	Annual Average NO_2 2007 (μgm^{-3})	Data capture NO_2 2007 (%)	Comment
Edinburgh Roseburn	Roadside			Not yet ratified
Edinburgh St John's Road	Kerbside			Not yet ratified
Edinburgh St Leonards	Urban background	27	97	Jan – Dec
Eskdalemuir	Rural	5	78	Jan – Dec
Falkirk Grangemouth MC	Urban background	(22)	49	July – Dec only
Falkirk Hope St	Roadside	(26)	45	July – Dec only
Falkirk Park St	Roadside	(33)	47	July – Dec only
Fife Cupar	Kerbside	52	98	Jan – Dec
Fife Dunfermline	Roadside	(32)	37	Site starts Aug 07
Fort William	Suburban	9	85	Jan – Dec
Glasgow Anderston	Urban background	30	70	Jan – Dec
Glasgow Battlefield Road	Roadside	34	99	Jan – Dec
Glasgow Byres Road	Roadside	40	99	Jan – Dec
Glasgow Centre	Urban centre	31	92	Jan – Dec
Glasgow City Chambers	Urban background	47	97	Jan – Dec
Glasgow Kerbside	Kerbside	70	92	Jan – Dec
Glasgow Waulkmillglen Reservoir	Rural	10	97	Jan – Dec
Grangemouth	Urban industrial	16	98	Jan – Dec
Inverness	Roadside	22	98	Jan – Dec
N Lanarkshire Chapelhall	Roadside	(41)	25	Oct – Dec only
N Lanarkshire Coatbridge Ellis St	Roadside	(38)	25	Oct – Dec only
N Lanarkshire Coatbridge Whifflet	Urban background	(33)	25	Oct – Dec only
N Lanarkshire Croy	Roadside	(29)	25	Oct – Dec only
N Lanarkshire Harthill	Roadside	(25)	25	Oct – Dec only
Paisley Central Road	Roadside Special	92	99	Jan – Dec
Perth	Roadside	29	96	Jan – Dec
Perth 2	Roadside	60	99	Jan – Dec
West Dunbartonshire Clydebank	Roadside	25	82	Feb - Dec
West Dunbartonshire Glasgow Road	Roadside			Not yet ratified

Table 6.1 shows nitrogen dioxide data from the 43 sites utilising automatic monitoring in 2007, although data for 9 of these are only available for part of the year. Three roadside/kerbside sites (Aberdeen Market Street, Edinburgh St. John's Road (data not yet ratified) and Glasgow Kerbside) exceeded the Air Quality Strategy (AQS) Objective of 200μgm^{-3} for the hourly mean more than the permitted 18 times.

However, nine roadside automatic sites exceeded the AQS Objective for the annual mean (40μgm^{-3}). These were Aberdeen Market Street, Aberdeen Union Street, Dundee Lochee Road, Dundee Seagate, Dundee Whitehall street, Fife Cupar, Glasgow City Chambers, Glasgow Kerbside, and Perth Atholl Street, all of which are close to busy roads.

The site in the covered area at Paisley Central Road also exceeded both the annual average and the hourly NO_2 Objectives.

All of the above named Local Authorities have declared, or are in the process of declaring Air Quality Management Areas for exceedences of the NO_2 objective.

Particulate Matter –PM10

Table 6.2 Ratified data annual average concentration and data capture for PM10 in 2007 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average PM10 2007 (μgm^{-3} gravimetric equivalent)	Data capture PM10 2007 (%)	Comment
Aberdeen	Urban Background	17	99	Jan – Dec
Aberdeen Anderson Dr	Roadside	17	90	Jan – Dec
Aberdeen Market St	Roadside	84	75	Jan – Dec
Aberdeen Union St	Roadside	19	93	Jan – Dec
Auchencorth Moss	Rural	7	97	Jan - Dec
Dundee Broughty Ferry Road	Roadside	18	99	Jan – Dec
Dundee Mains Loan	Urban background	15	99	Jan – Dec
Dundee Union Street	Kerbside	22	90	Jan – Dec
East Dunbartonshire Bearsden	Kerbside	22	85	Jan – Dec
East Dunbartonshire Bishopbriggs	Roadside	22	97	Jan – Dec
Edinburgh Haymarket	Roadside			Not yet ratified
Edinburgh Roseburn	Roadside			Not yet ratified
Edinburgh St John's Road	Kerbside			Not yet ratified
Edinburgh St Leonards	Urban background	19	76	Jan – Dec
Falkirk Grangemouth MC	Urban background	(18)	34	July – Dec only
Falkirk Hope St	Roadside	(18)	42	July – Dec only
Falkirk Park St	Roadside	(20)	49	July – Dec only
Fife Cupar	Kerbside	23	99	Jan – Dec
Glasgow Anderston	Urban background	19	72	Jan – Dec
Glasgow Battlefield Road	Roadside	23	85	Jan – Dec
Glasgow Byres Road	Roadside	25	99	Jan – Dec
Glasgow Centre	Urban centre	20	98	Jan – Dec
Glasgow Kerbside	Kerbside	32	95	Jan – Dec
Glasgow Waulkmillglen Reservoir	Rural	15	79	Jan – Dec
Grangemouth	Urban industrial	16	98	Jan – Dec
N Lanarkshire Chapelhall	Roadside	(31)	21	Oct – Dec only
N Lanarkshire Coatbridge Whifflet	Urban background	(20)	25	Oct – Dec only
N Lanarkshire Croy	Roadside	(23)	24	Oct – Dec only
N Lanarkshire Harthill	Roadside	(19)	25	Oct – Dec only
Perth	Roadside	20	94	Jan – Dec
Perth 2	Roadside	27	88	Jan – Dec
West Dunbartonshire Clydebank	Roadside	17	71	Feb – Dec

Table 6.2 shows particulate matter – PM10 - data from 32 sites utilising automatic monitoring in 2007, although data for 8 of these are only available for part of the year. Data from TEOM analysers have been multiplied by a conversion factor of 1.3 to convert measurements into gravimetric equivalent results. (Although Local authorities in Scotland can choose to use either a factor of 1.14 or 1.3 for their TEOM data, to avoid confusion we only show data with one conversion factor in the database. We have chosen to use the 1.3 factor, at present, so that the Scottish data are consistent with that for the remainder of the UK.) For data from Beta attenuation monitors and TEOM FDMS monitors no conversion factor has been applied. Partisol data have not been presented (see Section 4.3)

Most monitoring stations met the AQS Objective of 40µgm^{-3} (gravimetric equivalent) for the annual mean PM10, although an exceedence was observed at Aberdeen Market Street.

Aberdeen Market Street and Glasgow Kerbside exceeded the AQS Objective of 50µgm^{-3} (gravimetric equivalent) for the 24-hour mean on more than the permitted 35 occasions.

Based on 2007 data, the 18µgm^{-3} annual mean objective for 2010 could be exceeded at many more of Scotland's monitoring sites.

Five Local Authorities in Scotland have declared Air Quality Management Areas for exceedences of the PM10 Air Quality Objective.

Carbon Monoxide

Table 6.3 Ratified data annual average concentration and data capture for CO in 2007 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2007 (mgm^{-3})	Data capture CO 2007 (%)	Comment
Aberdeen	Urban Background	0.3	74	Jan – Dec
Dumfries	Roadside	0.4	70	Jan – Dec
Edinburgh St Leonards	Urban background	0.3	97.4	Jan – Dec
Glasgow Anderston	Urban background	0.2	68	Jan – Dec
Glasgow Byres Road	Roadside	0.3	99	Jan – Dec
Glasgow Centre	Urban centre	0.3	98	Jan – Dec
Glasgow City Chambers	Urban background	0.3	74	Jan – Dec
Glasgow Kerbside	Kerbside	0.4	74	Jan – Dec
Grangemouth	Urban industrial	0.2	73	Jan – Dec
Inverness	Roadside	0.3	74	Jan – Dec
N Lanarkshire Harthill	Roadside	(1.0)	25	Oct – Dec only

Table 6.3 shows carbon monoxide was monitored using automatic techniques at 12 sites in 2007, but one of these has data available for only part of the year. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

No Air Quality Management Areas have been declared for carbon monoxide.

Sulphur Dioxide

Table 6.4 Ratified data annual average concentration and data capture for SO_2 in 2007 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average SO_2 2007 (μgm^{-3})	Data capture SO_2 2007 (%)	Comment
Aberdeen	Urban Background	3	73	Jan – Dec
Dundee Broughty Ferry Road	Roadside	4	99	Jan – Dec
Edinburgh St Leonards	Urban background	3	97	Jan – Dec
Falkirk Grangemouth MC	Urban background	(5)	50	July – Dec only
Falkirk Hope St	Roadside	(4)	41	July – Dec only
Falkirk Park St	Roadside	(4)	29	July – Dec only
N Lanarkshire Croy	Roadside	(3)	25	Oct – Dec only
N Lanarkshire Harthill	Roadside	(2)	25	Oct – Dec only

Table 6.4 shows sulphur dioxide data from the eight sites utilising automatic monitoring for 2007, although 5 of these sites only had data for part of the year. All sites in Scotland met the requirements of the Air Quality Strategy for 15-minute, 1-hour and 24-hour mean SO_2 in 2007. However, one Local Authority has declared an Air Quality Management Area for sulphur dioxide, based on data from previous years.

Ozone

Table 6.5 Ratified data annual average concentration and data capture for O_3 in 2007 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average O_3 2007 (μgm^{-3})	Data capture O_3 2007 (%)	Comment
Aberdeen	Urban Background	47	99	Jan – Dec
Auchencorth Moss	Rural	58	99	Jan – Dec
Bush Estate	Rural	56	99	Jan – Dec
Edinburgh St Leonards	Urban background	48	98	Jan – Dec
Eskdalemuir	Rural	54	99	Jan – Dec
Fort William	Suburban	54	79	Jan – Dec
Glasgow Centre	Urban centre	36	98	Jan – Dec
Glasgow Waulkmillglen Reservoir	Rural	53	98	Jan – Dec
Lerwick	Rural	64	87	Jan – Dec
Strath Vaich	Remote	68	88	Jan – Dec

Table 6.5 shows ozone data from 10 sites utilising automatic monitoring for 2007. Ozone (O_3) is a secondary pollutant formed by reactions involving other pollutant gases, in the presence of sunlight, and over several hours; it may persist for several days and be transported over long distances. This means that Local Authorities have little control over ozone levels in their area. In 2007, the target value for the 8hr running mean Objective was exceeded on more than the permitted ten days at Eskdalemuir and Strath Vaich.

6.2 PM EPISODE, 24 MARCH – 2 APR 2007

During the period 24 March 2007 to 2 April 2007 an episode of particulate matter was observed throughout the UK. This episode has been analysed in a report[2] produced by AEA and the Met Office as part of the Air Quality Forecasting contract for the Scottish Government, Defra and the other DAs. In this section, data available for Scotland within the Scottish Air Quality Database are examined in more detail.

PM10 data for 23 monitoring sites are available. However, data for Aberdeen Market Street has not been used in this analysis as this site is strongly influenced by local effects. Figure 6.1 shows the PM10 data for these sites for the period 24 March – 4 April 2007. The effects of the episode were clearly seen during the period 25 – 28 March. A change of meteorological condition on 29 March brought rain and cleaner air from the Atlantic and clearly interrupted the episode. After this interruption the episode continued for another couple of days. The data show that the episode was widespread across Scotland.

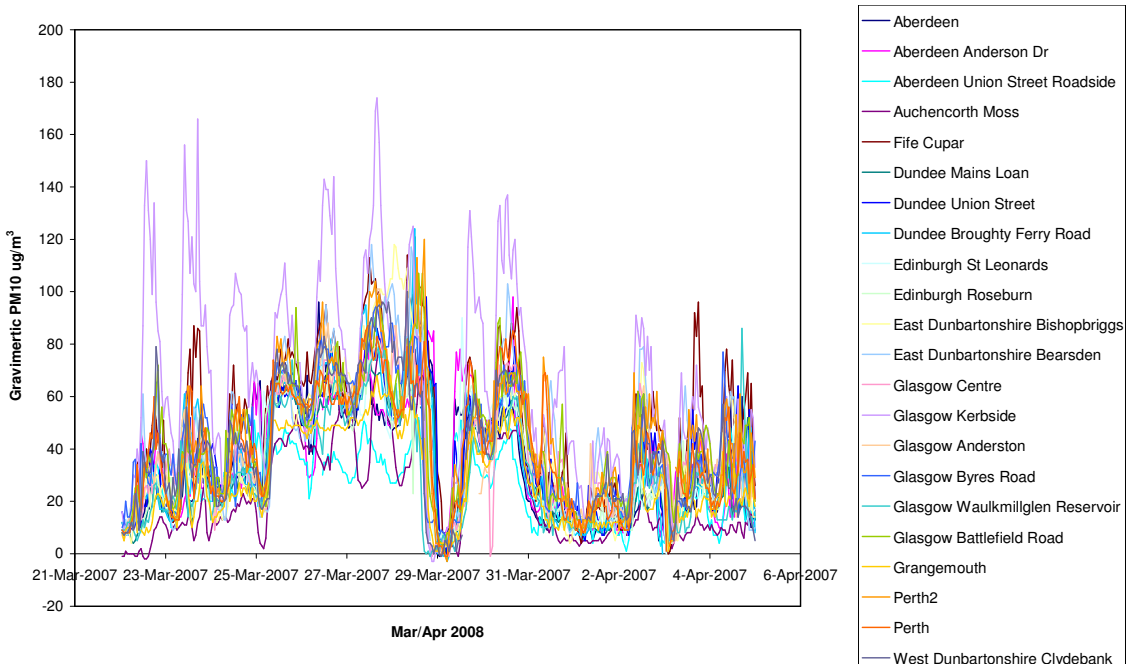


Figure 6.1 PM10 Episode in Scotland 24 March – 2 April 2007

Analysis in the report produced by the Forecasting Team shows that the air masses arriving in the UK had originated from the east during much of the period of the episode. There were two possible origins of the particles during this period – a dust storm in the Sahara desert and forest fires in Ukraine and Russia. The air mass back-trajectory analysis indicated that a significant proportion of the air mass arriving at the UK had come from Eastern Europe and only very small parts from the area of Southern Europe and the Sahara. Hence, the forest fires were the most likely source of the particulate material during the episode, although the Saharan dust may have contributed during the onset of the episode on 25 March. Figure 6.2 shows the typical airstream from Eastern Europe during the episode, Figure 6.3 clearly shows the change in conditions on 29 March with a mixed airsteam from both easterly (air from Europe) and westerly direction (clean air over the Atlantic Ocean).

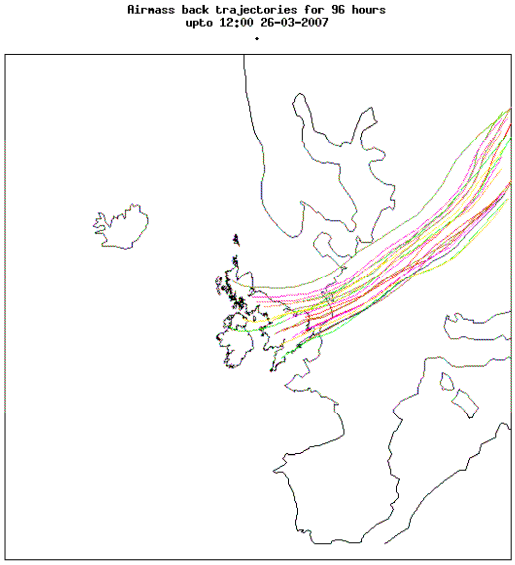


Figure 6.2 Air mass trajectories for 26 March 2007

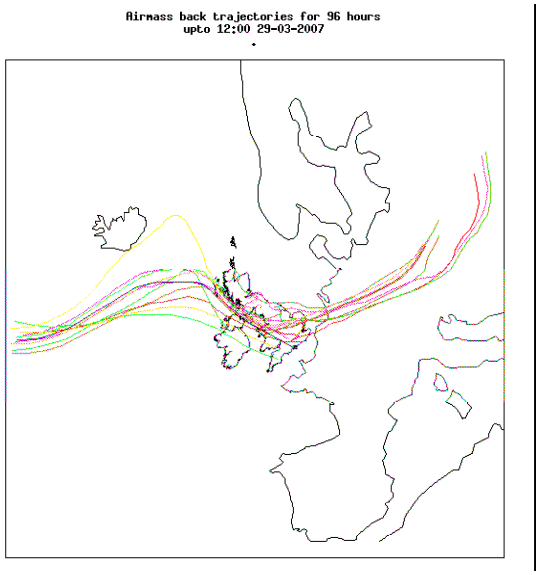


Figure 6.3 Air mass trajectories for 28 March 2007

During the episode period data from one TEOM FDMS analyser are available within the database – the rural site at Auchencorth Moss to the south of Edinburgh.

Figure 6.4 shows the total PM10 and the volatile and non-volatile component during the episode. Although there was a small increase in the volatile component, it is clear that the majority of the episode particulate material is in the non-volatile fraction. It is thought that the increase in the volatile component arises from secondary particulate material transported from Europe to the UK during the working week, with a time delay of approximately one day to reach the UK. The temporary clearance of the particulate laden air on 29 March had a dramatic effect on the concentration of both volatile and non-volatile components.

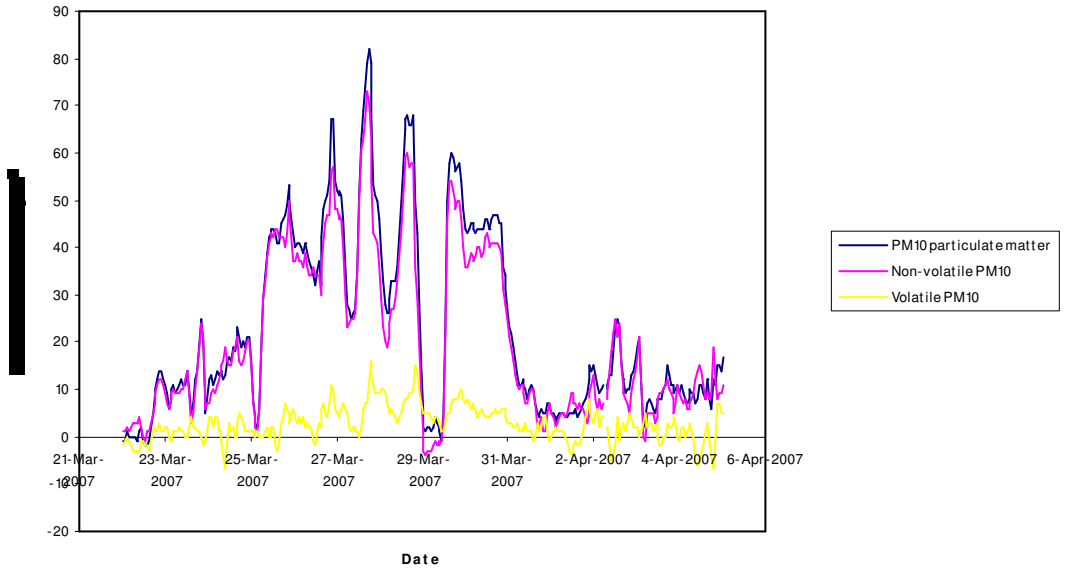


Figure 6.4 Volatile and Non-volatile Components of PM10 at Auchencorth Moss

In addition, both PM10 and PM2.5 are measured at Auchencorth Moss. Figure 6.5 shows the PM10 and PM2.5 concentrations during the episode.

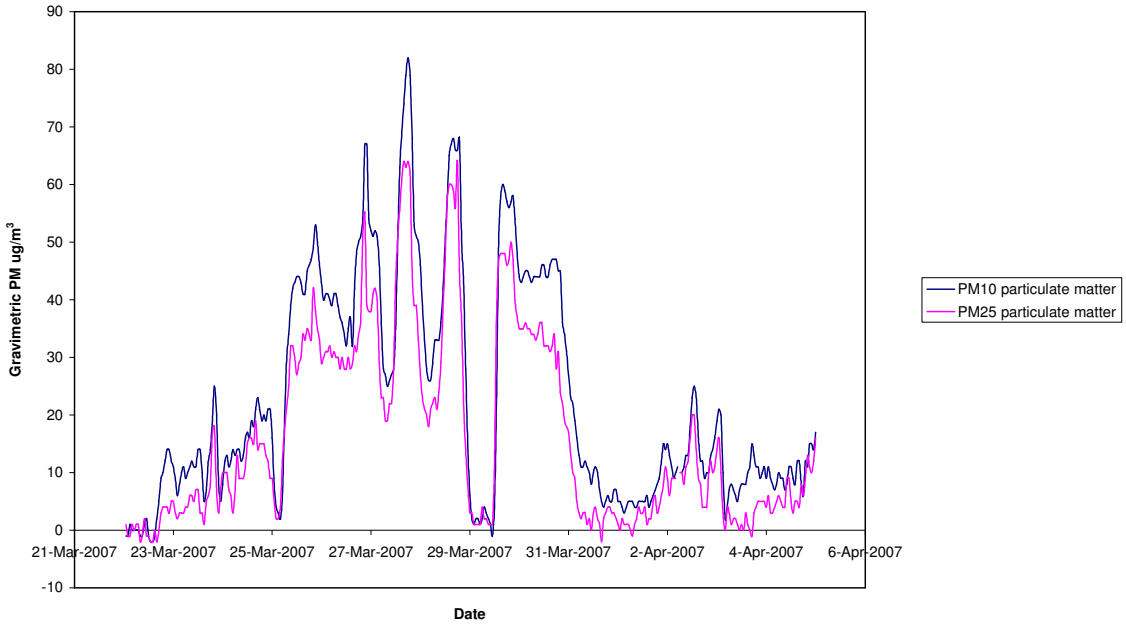


Figure 6.5 PM10 and PM2.5 concentrations at Auchencorth Moss

Figure 6.5 shows that for the majority of the episode, particulate material collected in the PM10 size fraction was composed of particles mainly of the PM2.5 size fraction. A more detailed analysis of the size fractions during the episode is provided in the Episode report.

During 2008, many more TEOM FDMS analysers and PM2.5 particle analysers will join the Scottish Database to allow more detailed analysis of any future episodes.

7 Air Quality Mapping for Scotland

7.1 INTRODUCTION

Each year AEA performs detailed modelling exercises on behalf of Defra and the Devolved Administrations (DAs) to produce up-to-date UK maps and projections for the future in order to supplement data from the national monitoring networks and to satisfy the UK's Daughter Directive reporting requirements. The outputs are maps of background air pollutant concentrations on a 1km x 1 km grid and roadside air pollutant concentrations for urban road links. The models are calibrated using data from the national networks and are verified using independent monitoring data from local authorities and ad-hoc monitoring campaigns that have been quality assured to the same standard as the AURN. The modelling employs a single set of calibration coefficients to represent the whole of the UK.

A pilot mapping project was conducted using the 2004 air quality data with the intention of producing a more Scotland-specific air quality model by incorporating a Scottish meteorological data set (from RAF Leuchars) and a Scotland-specific model calibration. The performance of the Scotland-specific model for 2004 and 2005 suggested that there was little improvement in the model performance resulting from the Scotland-specific changes to the model. Following this work AEA have focused on a verification of maps produced for 2006 for the UK as a whole (which are provided to Defra and the DAs in fulfilment of European obligations) with 2006 monitoring data from the Scottish air quality monitoring sites. This work has been presented in a full report[3] and is summarised here.

7.2 METHODOLOGY

The modelled maps of ambient concentrations are calculated from National Atmospheric Emissions Inventory (NAEI) data using a dispersion modelling approach, which is calibrated using monitored data from the national monitoring networks. These modelled maps are then verified against independent monitoring data held by AEA (typically from ad-hoc monitoring campaigns, airport authorities and Local Authorities). Original UK versions of the 2006 maps and the detailed explanations of the modelling methodology and verification are presented in Kent et al[3]., (2008).

The maps produced by AEA for Defra and the DAs include:

- NO_X annual mean concentration ($\mu g\ m^{-3}$)
- NO_2 annual mean concentration ($\mu g\ m^{-3}$)
- PM_{10} (gravimetric) annual mean concentration ($\mu g\ m^{-3}$)
- SO_2 annual mean concentration ($\mu g\ m^{-3}$)
- SO_2 99.73rd percentile of hourly means ($\mu g\ m^{-3}$)
- SO_2 99.18th percentile of daily means ($\mu g\ m^{-3}$)
- SO_2 99.9th percentile of 15 minute means ($\mu g\ m^{-3}$)
- CO annual average concentration ($mg\ m^{-3}$)

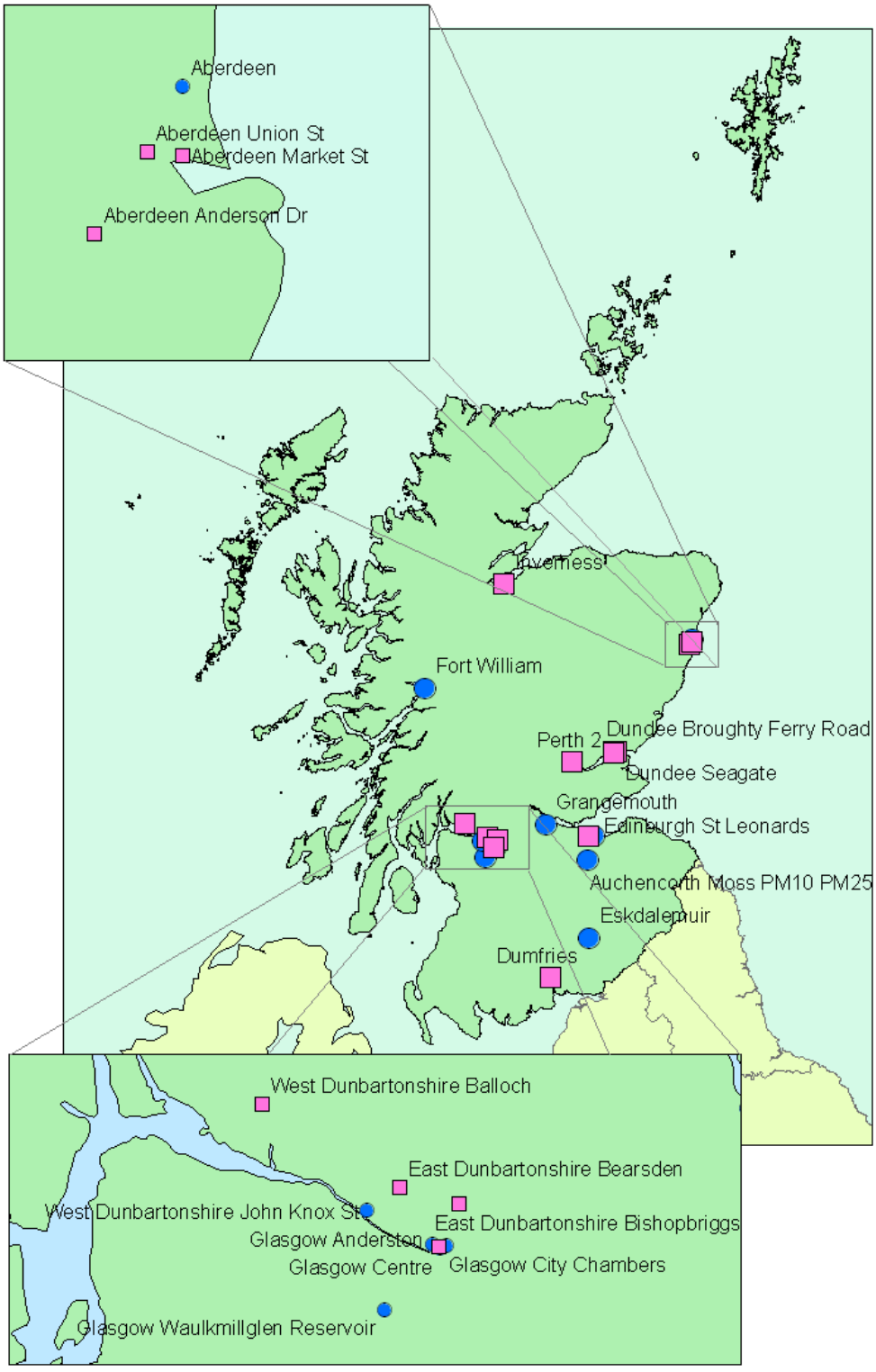
- CO maximum 8 hourly concentration (mg m^{-3})

The locations of each of the Scottish air quality monitoring sites were plotted on the modelled background air pollution maps and the corresponding modelled background concentration for the relevant 1x1 km grid square extracted. A 75% data capture threshold was applied to the monitoring data for this analysis - any site with data capture below this was omitted and sites were also omitted if their automatic monitoring data had not yet been fully ratified. At roadside sites, where available, the corresponding modelled road link was used to ascertain a modelled roadside value rather than the modelled background concentration.

A list of sites used in this analysis is presented in Table 7.1. This specifies those sites that do and do not belong to the Defra Automatic Urban and Rural Network (AURN). The AURN sites in Scotland were included in the calibration of the UK scale models whilst all the sites in Table 7.1 were included in the calibration undertaken for this work. The data from all of the sites listed for 2006 have been fully ratified by AEA. Although the air quality monitoring in Scotland is generally of a high standard and has expanded dramatically in recent years, not all the monitoring is suitable for use in this mapping work. For example, sites with data quality issues, low annual data capture or known local influences that would not be represented in the model, (such as construction works nearby). The locations of all monitoring sites are illustrated in Figure 7.1.

Table 7.1. Scottish monitoring sites used in the model verification process.

Site name	Easting	Northing	Site type	AURN site	NO_x/NO_2	CO	PM_{10} (TEOM)	PM_{10} (grav)	SO_2
Aberdeen	394416	807408	URBAN BACKGROUND	✓	✓	✓	✓		✓
Aberdeen Anderson Dr	392506	804186	ROADSIDE		✓		✓		
Aberdeen Market St	394408	805893	ROADSIDE		✓		✓		
Aberdeen Union St	393656	805967	ROADSIDE		✓		✓		
Auchencorth Moss PM10 PM25	322050	656250	RURAL				✓		
Dumfries	297012	576278	ROADSIDE	✓	✓	✓		✓	
Dundee Broughty Ferry Road	341970	730997	ROADSIDE				✓		✓
Dundee Seagate	340487	730446	KERBSIDE		✓				
Dundee Union Street	340236	730090	KERBSIDE		✓		✓		
East Dunbartonshire Bearsden	254269	672067	ROADSIDE		✓		✓		
East Dunbartonshire Bishopbriggs	260995	670130	ROADSIDE		✓		✓		
Edinburgh Roseburn	322900	673260	ROADSIDE		✓		✓		
Edinburgh St Leonards	326250	673132	URBAN BACKGROUND	✓	✓	✓	✓		✓
Eskdalemuir	323500	602800	RURAL	✓	✓				
Fort William	210849	774421	SUBURBAN	✓	✓				
Glasgow Anderston	257925	665487	URBAN BACKGROUND		✓	✓	✓		✓
Glasgow Centre	258902	665028	URBAN CENTRE	✓	✓	✓	✓		✓
Glasgow City Chambers	259528	665308	URBAN BACKGROUND	✓	✓	✓			
Glasgow Kerbside	258708	665200	KERBSIDE	✓	✓	✓	✓		
Glasgow Waulkmillglen Reservoir	252520	658095	RURAL		✓		✓		
Grangemouth	293840	681032	URBAN INDUSTRIAL	✓	✓	✓	✓		✓
Inverness	265720	845680	ROADSIDE	✓	✓	✓		✓	
Perth 2	311582	723931	ROADSIDE		✓		✓		
West Dunbartonshire Balloch	238590	681550	ROADSIDE		✓				
West Dunbartonshire John Knox St	250540	669390	URBAN BACKGROUND		✓		✓		



blue: background sites **magenta: roadside sites**

Figure 7.1. Locations of the Scottish monitoring sites used in the model verification process.

The modelled information was directly compared with the corresponding monitored metric from each site and plotted in a scatter plot. Lines at ±30% (for NO_x and NO_2) or ±50% (for other pollutants) from the 1:1 correlation line were plotted – these are the data quality objectives (DQOs) specified in the 1st and 2nd Daughter Directives. Where data falls within these DQOs this suggests that the model and the monitored results are comparable.

7.3 RESULTS

For NO_2 the majority of data points fell within the DQOs showing that the measured concentrations compare reasonably well with the modelled values. The model performance, however, was better for background sites than for roadside sites. This may be explained by the uncertainty surrounding the additional steps in the roadside model (which includes the uncertainty of inputs from the background model to calculate a roadside increment). It is also possible that there is some degree of error in the traffic census data such as vehicle flows that are used to calibrate the roadside model.

In the pilot study model verification of PM_{10} was not possible owing to the lack of monitoring sites. However, the additional PM_{10} monitoring sites now included in the Database during 2007 provide enough monitoring data to perform a basic calibration, although still more sites would be preferable. In general these measured concentrations agreed reasonably well with the model results, particularly for background sites which all fall within the DQO range and clustered evenly around the 1:1 line. For roadside sites the model performance was marginally worse with slightly more variation.

The output from the Scottish SO_2 model compared reasonably well with the monitored data considering the complexity of SO_2 modelling. It should be noted, however, that there is considerable uncertainty in modelling SO_2 and the low number of sites in this analysis makes it hard to draw any robust conclusions.

Finally, the comparison between measured and modelled CO concentrations in 2006 has historically been less favourable than the other pollutants, as has been noted in previous reports. However, in 2006 the model performance was reasonable for Scotland.

Examples of the Scottish air quality maps resulting from this pilot study are illustrated in Figure 7.2 and 7.3 below. For the complete set of results please refer to the separate report[4].

Figure 7.2. Estimated 2006 NO_2 annual mean concentrations, µg m^{-3}

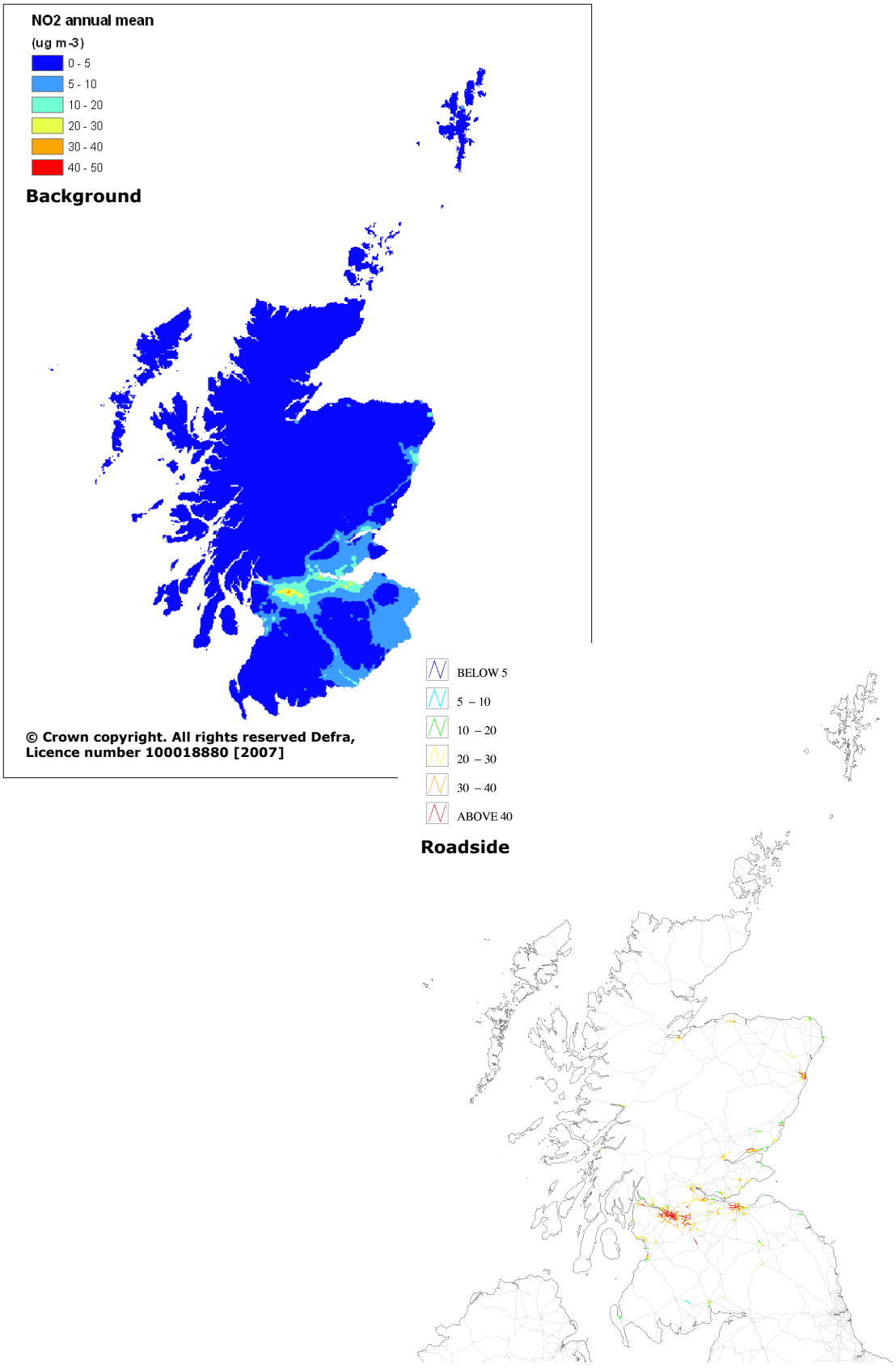
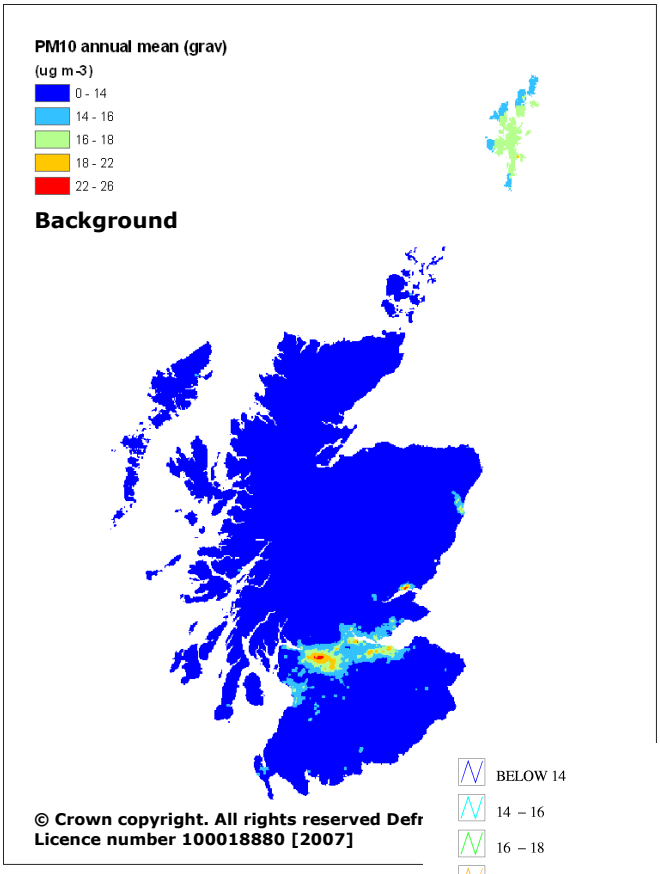


Figure 7.3. Estimated 2006 PM_{10} (gravimetric) annual mean, µg m^{-3}



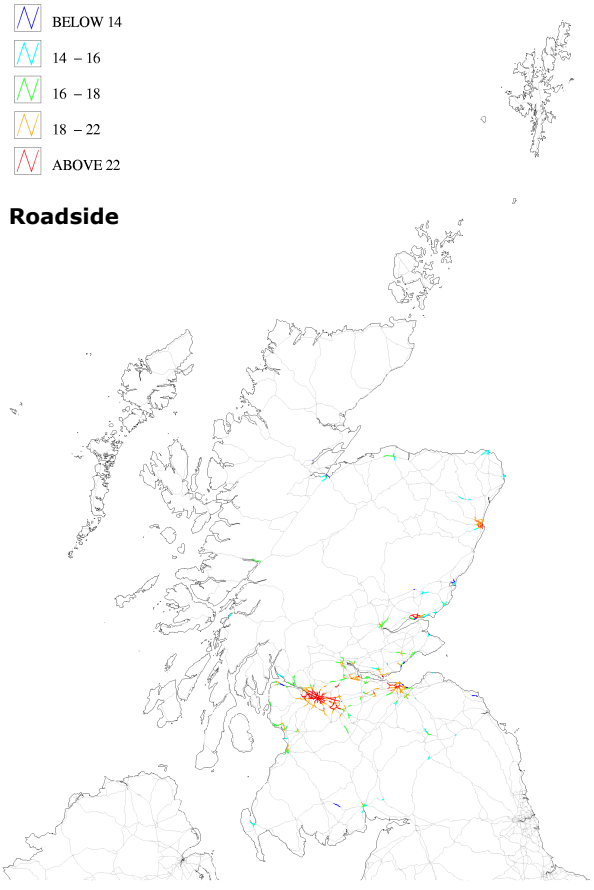


Figure 7.4. Estimated 2006 SO_2 99.9th percentile of 15-minute means, µgm^{-3}

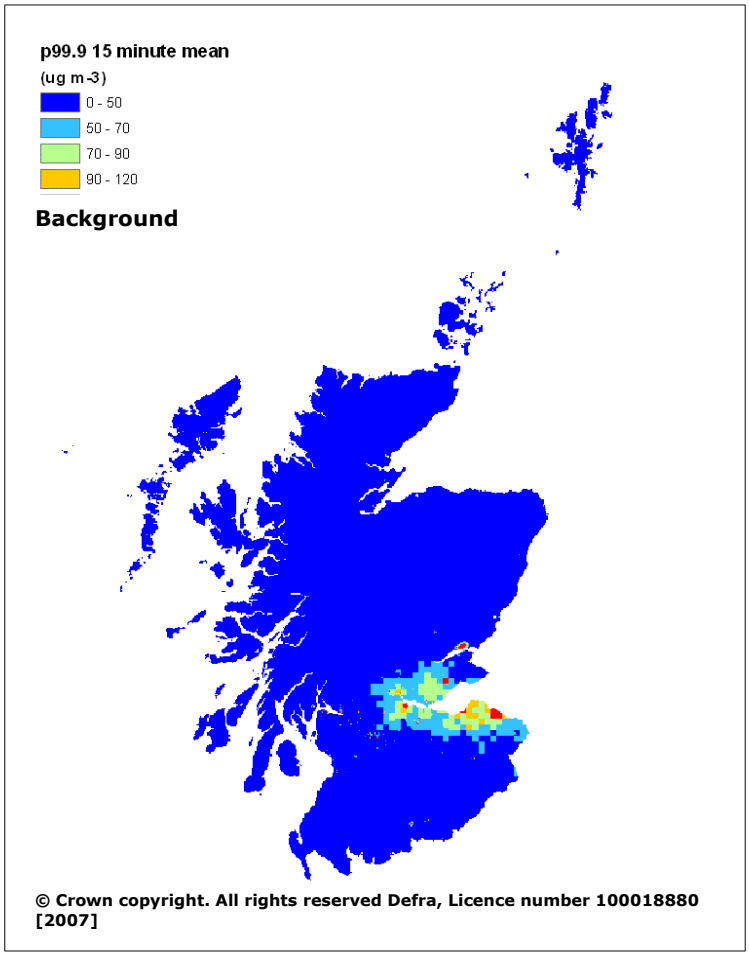


Figure 7.2 shows the estimated concentrations for NO_2 and shows that background concentrations of NO_2 are generally low. The highest concentrations are mainly limited to Glasgow and Edinburgh although other main urban centres and transport routes can also be identified by elevated concentrations. The map showing the roadside concentrations also mirrors the background map.

The gravimetric PM_{10} map shown in Figure 7.3 is interesting as it shows the highest concentrations in the same region of Central Scotland, as seen with NO_2 but also elevated concentration in the Shetland Islands. This is a result of sea salt (chloride) concentrations at the islands.

Figure 7.4 shows the peak (99.9th percentile) 15-minute average concentrations of sulphur dioxide. The main sources of this pollutant are industrial and domestic fuel burning. Peak concentrations are low over the majority of Scotland but there are clear clusters of elevated peak SO_2 concentrations around Grangemouth, Longannet, Cockenzie and Dunbar along the Firth of Forth. There are also small areas of higher concentrations that may indicate small pockets of high domestic coal or oil use. However, it may to some extent be a feature of the emission inventory used in the model, as monitoring data at some of these locations do not show such concentrations as high as these estimate values.

8 Air Quality Trends for Scotland

This section presents an investigation of trends in pollution levels in Scotland over the last 20 years up to 2007. During the pilot study[1] problems were encountered with undertaking the Headline Air Quality Indicator analysis due to the small number of monitoring sites complying with the criteria for inclusion in the analysis. In this report the trends analysis follows the technique used in the pilot study. This used the annual mean concentration across all sites in Scotland and split them into "background" and "roadside/kerbside" locations. The values were then averaged across all the sites in each category for each year to provide annual trend data.

The analysis was focused on the pollutants that have been identified as potential issues with respect to Scotland meeting their Air Quality Strategy Objectives. These are NO_2, PM_{10} and ozone.

8.1 ANNUAL MEAN TRENDS FOR NITROGEN DIOXIDE AND OZONE

Within Scotland, as is the case for the rest of the UK, the largest number of AQMAs are currently declared based on exceedances of the annual NO_2 objective of 40 μg m^{-3}. This is also reflected in the number of sites recording an exceedance of this objective. Investigating how trends in this pollutant have changed over time is therefore a useful tool to determine whether concentrations are improving or deteriorating.

A large proportion of NO_2 is formed from the oxidation of NO following its emissions from motor vehicle exhausts or industrial stacks. It is therefore important to consider trends in NO_x concentrations as well as NO_2 concentrations.

Figure 8.1 and Figure 8.2 present the annual mean trend in measured NOx and NO_2 concentrations at roadside/kerbside and urban background monitoring stations since reliable measurements began in Scotland in 1987.

For background NOx/NO_2 there was only one site (Glasgow City Chambers) available until 1992. From 1993 to 1996 there were two sites, and then from 1997 to 2005 the number of sites available increased from three to eight in total. Even eight sites is a small number for presenting a robust indicator, as is illustrated for 2005 where addition of two high pollution sites in Aberdeen to the database has caused a rise in the trend. For roadside/Kerbside NOx/NO_2 only one site was available until 2001. From here onwards the number of sites gradually increased from two to seven in 2005.

Figure 8.1 shows a smooth and long-term improvement in NOx concentrations which can be attributed to reductions in emissions from combustion sources following the implementation of UK and EU policies. The reduction in NO_2 concentrations over time has been less smooth due primarily to the dependence of NO_2 concentrations on atmospheric ozone chemistry and therefore concentrations are significantly affected by meteorology conditions. It can also be seen that concentrations of NO_2 show evidence of levelling off. It is believed that this may be due to increases in the proportion of NO_2 emitted directly into the atmosphere. This is most likely a result of increases in the proportion of diesel vehicles and the retrofitting of end of tail pipe emission control devices such as catalytic regenerative traps on buses[5]. Figure 8.3 also shows how the period where NO_2 concentrations have levelled off coincide to some degree by increases in O_3 concentrations. The increased availability of ozone can lead to increased conversion of

NO to NO_2 in areas where NO concentrations are elevated, for example at roadside locations.

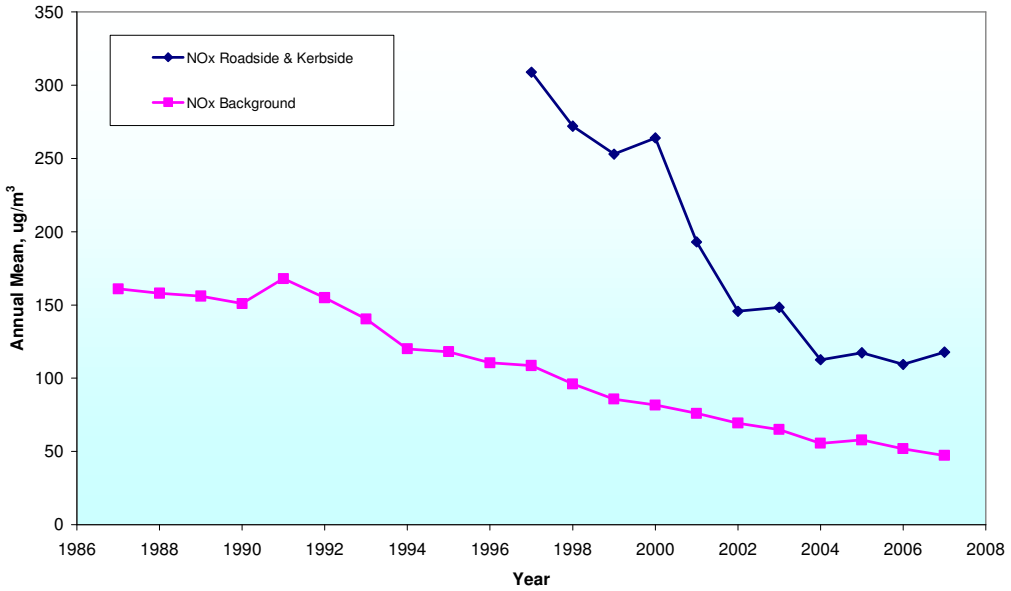


Figure 8.1. Trends in annual mean NOx concentrations at urban background and roadside sites in Scotland.

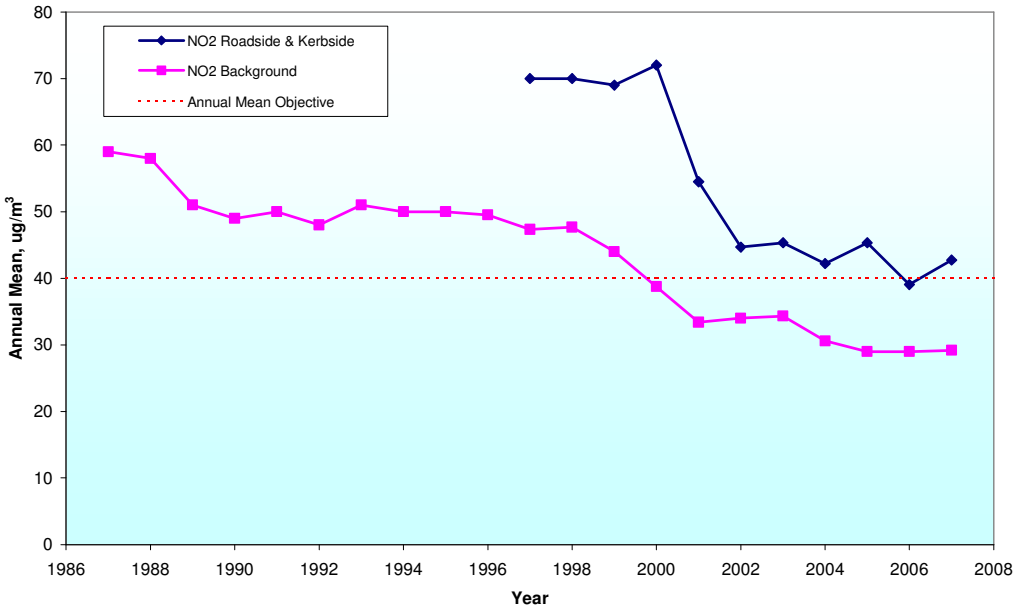


Figure 8.2. Trends in annual mean NO_2 concentrations at urban background and roadside sites in Scotland.

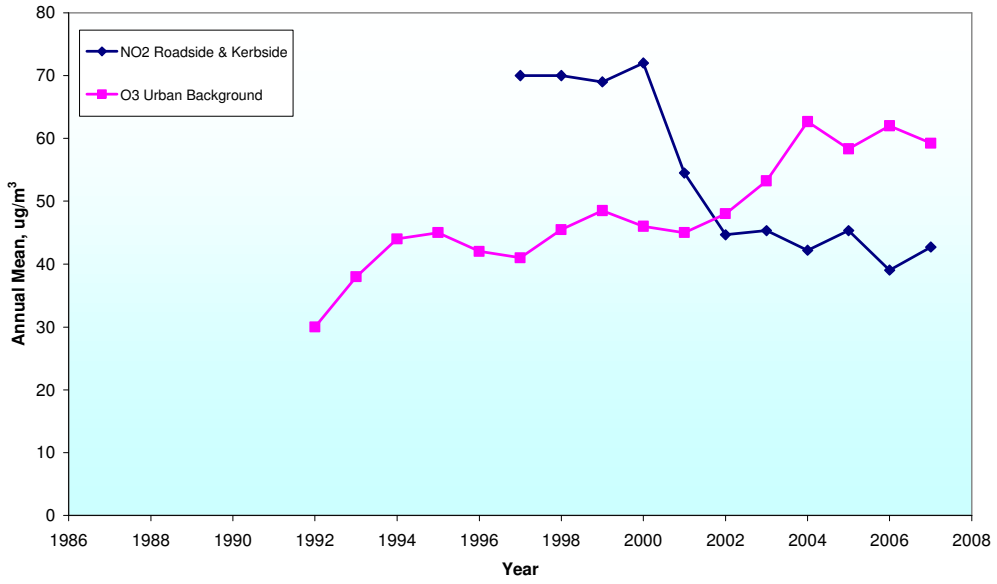


Figure 8.3. Trends in annual mean O_3 background concentrations and NO_2 roadside concentrations in Scotland.

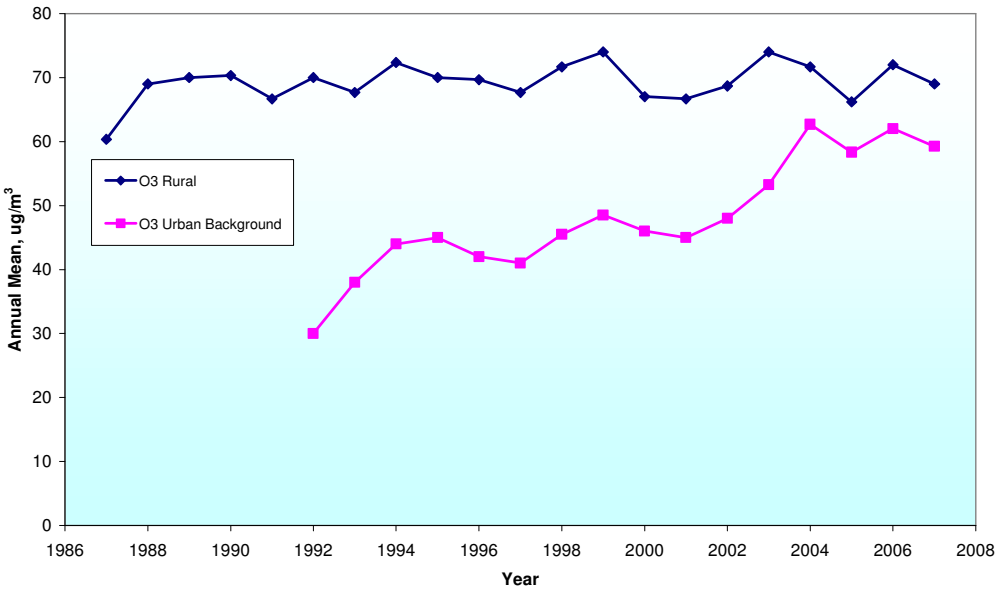


Figure 8.4. Trends in annual mean O_3 concentrations at urban background and rural sites in Scotland.

Figure 8.4 illustrates a small increase in rural ozone concentrations but a dramatic increase at urban background locations. This is as a result of the decrease of NOx concentrations in urban areas.

8.2 ANNUAL MEAN TRENDS FOR PM_{10}

For background PM_{10} the number of sites increased from only one in 1993 to five in 2005. Despite the small number of monitoring stations this trend does appear to be fairly robust with a consistent fall in concentrations across all the stations included in the analysis. Figure 8.5 demonstrates a general reduction in urban background concentration since 1992 but that for the last few years concentrations have stabilised at a level close to the annual mean objective level set by The Scottish Government.

For Roadside/Kerbside PM_{10} the number of sites increased from one only in 1997 to six in 2005. This trend appears to show a steeper downward slope than the background locations until 2005. The increase in 2005 is likely to be caused by the addition of the six new sites which included Aberdeen Market Street. This site experiences significantly higher concentrations than the other sites included within this trend analysis. In general, statistical studies have shown that the trend indicator used here is robust if at least four sites are used, and extremely robust if at least seven sites are used. For Scotland this means that data from 2001 onwards for PM_{10} should be robust although this does not take into account the addition of sites to the analysis.

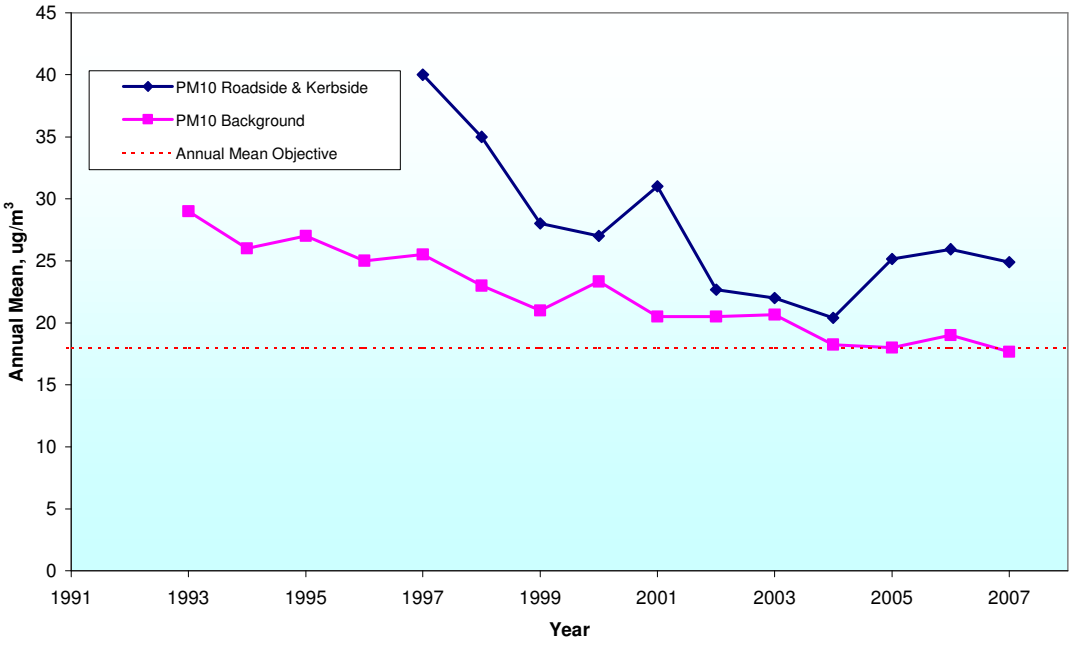


Figure 8.5. Trends in annual mean PM_{10} concentrations at urban background and roadside sites in Scotland.

9 Conclusions

AEA Energy & Environment is developing 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 2007, the database and website have been expanded and developed considerably. Comments and suggestions from stakeholders provided as part of the previous Pilot Project have been incorporated.

Air pollution data for 47 automatic monitoring sites throughout Scotland are available in the database for all or part of 2007 and it is anticipated that a further 14 sites will be incorporated during 2008. By 2010, we anticipate that about 80% of the total number of air quality monitoring stations in Scotland will be incorporated into the Scottish Air Quality Database. In addition, it is envisaged that air quality data from the Scottish Environment Protection Agency (SEPA) will also be incorporated into the database.

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 2007 is provided. Where exceedences 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.

The data have been utilised to provide information on nationwide pollution episodes and on trends in air quality over many years. In general, pollutant concentrations have decreased considerably – but now appear to be levelling off. Urban ozone levels have increased, in line with the reduction in NOx concentrations in urban areas. As the number of monitoring sites in the database increases, then the evaluation of trends will become more robust.

The data in the database have also been used to provide additional calibration of the air quality maps for Scotland. Again, as data in the database increases these will be incorporated in the pollution mapping process.

It is anticipated that the Scottish Air Quality Database and Website will provide a valuable national resource of air quality data for The Scottish Government, Local Authorities, health professionals, EIA and SEA practitioners, academics, the general public and any others interested in air quality in Scotland.

10 References

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

2 Cook et al. UK Air Quality Forecasting – A UK Particulate Episode from 24 March to 2 April 2007. AEAT/ENV/R/2556. January 2008 (http://www.airquality.co.uk/archive/reports/cat12/0802071455_AQF_Partepi0307-final_final.pdf

3 Kent et al (2008). UK air quality modelling for annual reporting 2006 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA Energy & Environment report. AEAT/ENV/R/2502 Issue 1.

4 Brophy N. and Kent A. (2008) Comparison of the modelled national air quality maps with Scottish air quality monitoring data

5 AQEG (2007). Air Quality Expert Group report - Trends in primary nitrogen dioxide in the UK. http://www.defra.gov.uk/environment/airquality/panels/aqeg/publications/index.htm

Appendices

CONTENTS

Appendix 1
National Monitoring Network Sites in Scotland

Table A1.1. AURN Measurement Sites in Scotland

Site Name	Site Type	Species Measured	Grid Reference
Aberdeen	URBAN BACKGROUND	CO NO NO_2 NO_X O_3 PM_{10} SO_2	394416,807408
Auchencorth Moss	RURAL	O_3 PM_{10}(grav) $PM_{2.5}$(grav)	322000,656200
Bush Estate	RURAL	NO NO_2 NO_X O_3	324500,663500
Dumfries	ROADSIDE	CO PM_{10}(grav) NO NO_2 NO_X	297012,576278
Edinburgh St Leonards*	URBAN BACKGROUND	CO NO NO_2 NO_X O_3 PM_{10} SO_2	326200,673100
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} SO_2	258902,665028
Glasgow City Chambers	URBAN BACKGROUND	CO NO NO_2 NO_X	259528,665308
Glasgow Kerbside	KERBSIDE	CO NO NO_2 NO_X PM_{10}	258708,665200
Grangemouth*§	URBAN INDUSTRIAL	CO NO NO_2 NO_X PM_{10} SO_2	293840,681032
Inverness	ROADSIDE	CO PM_{10}(grav) NO NO_2 NO_X	265720,845680
Lerwick	RURAL	O_3	445337,1139683
Strath Vaich	REMOTE	O_3	234700,875000

*Additional measurements of benzene concentrations integrated over a two-week period as part of the Non-automatic Hydrocarbon Monitoring network.

§Additional passive sampling of 1,3-butadiene.

Table A1.2. Automatic Hydrocarbon Network 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 A1.3. PAH Monitoring Sites in Scotland

Site	Address	Grid Reference
Edinburgh	West Richmond Street Gardens	326282,673125
Glasgow	20 Cochrane Street Glasgow G1 1RN	259422,665275
Kinlochleven 2	Electrical Substation Kinlochleven	219305,761905

Table A1.4. Species measured at PAH sampler locations

Acenaphthene,
Acenaphthylene,
Anthanthrene,
Anthracene,
Benzo(a)anthracene,
Benzo(b)fluoranthene,
Benzo(j)fluoranthene,
Benzo(k)fluoranthene,
Benzo(b)naph(2,1-d)thiophene,
Benzo(ghi)perylene,
Benzo(c)phenanthrene,
Benzo(a)pyrene,

Benzo(e)pyrene,
Chrysene,
Cyclopenta(c,d)pyrene,
Dibenzo(ah/ac)anthracenes,
Dibenzo(ae)pyrene,
Dibenzo(ah)pyrene
Dibenzo(ai)pyrene,
Dibenzo(al)pyrene,
Fluoranthene,
Fluorene,
Indeno(123cd)pyrene,
1-Methyl Anthracene,

2-Methyl Anthracene,
9-Methyl Anthracene,
5-Methyl Chrysene,
1-Methyl Phenanthrene,
2-Methyl Phenanthrene,
4,5-Methylene Phenanthrene,
Perylene,
Phenanthrene,
Pyrene,
Retene,

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

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
Glasgow	Urban Background 261337,664435	Glasgow, St Annes, St Annes Primary School, 37 David Street Glasgow G40 2UN	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 Metal Deposition Monitoring sites in Scotland

Site	Location Grid Ref.	Heavy metals			Mercury	
		In Particles	In Rain	In Cloud	In Air	In Rain
Inverpolly	218700,908900		✓			
Banchory	367600,798500	✓	✓		✓	✓
Bowbeat	328300,647300		✓	✓		
Auchencorth Moss	322000,656200	✓	✓		✓	✓

Table A1.7. Acid Deposition Monitoring sites in Scotland

Site Name	Grid Ref	Species included
Glensaugh	366029,779670	pH, SO_4, NO_3, NH_4, Na, Mg, Ca, Cl, K, PO_4, nss-SO_4, H, conductivity
Eskdalemuir	323500,602800	
Strathvaich Dam	234700,875000	
Allt a' Mharcaidh	287500,803500	
Whiteadder	366180,663130	
Loch Dee	246630,578135	
Polloch	179250,768950	
Balquhidder 2	254550,720750	
Loch Chon	242960,708370	
Lochnagar	325400,786120	
Forsinain	290395,948735	

Table A1.8. Ammonia and Nitric Acid Monitoring Sites in Scotland

Name	Grid Ref	Ammonia	Nitric Acid
Shetland	450000,1140000	✓	
Halladale 1	289400,951400	✓	
Inverpolly	218700,908800	✓	
Strathvaich Dam	234800,875000	✓	✓
Ellon Ythan	394500,830400	✓	
Pitmedden	388300,827800	✓	
Lagganlia	885600,203700	✓	
Allt a Mharcaidh	289500,802400	✓	
Rum	140800,799250	✓	
Glensaugh	366400,779900	✓	✓
Gulabin Lodge	311000,770100	✓	
Glenshee Hotel	311100,769900	✓	
Glen Shee	311700,769300	✓	
Tummel	274400,761100	✓	
Rannoch	260300,753300	✓	
Loch Awe	196600,711500	✓	
Edinburgh-Johnston Terrace	325300,673400	✓	
Bush 2	324700,663800	✓	
Bush 1	324500,663500	✓	✓
Auchencorth Moss	322000,656200	✓	
Carradale	179800,537800	✓	
Auchincruive	237900,623400	✓	
Sourhope	386700,621800	✓	
Eskdalemuir	323500,602800	✓	✓
Coalburn	369300,578200	✓	
Dumfries	254600,565800	✓	

Appendix 2
Intercalibration, 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.