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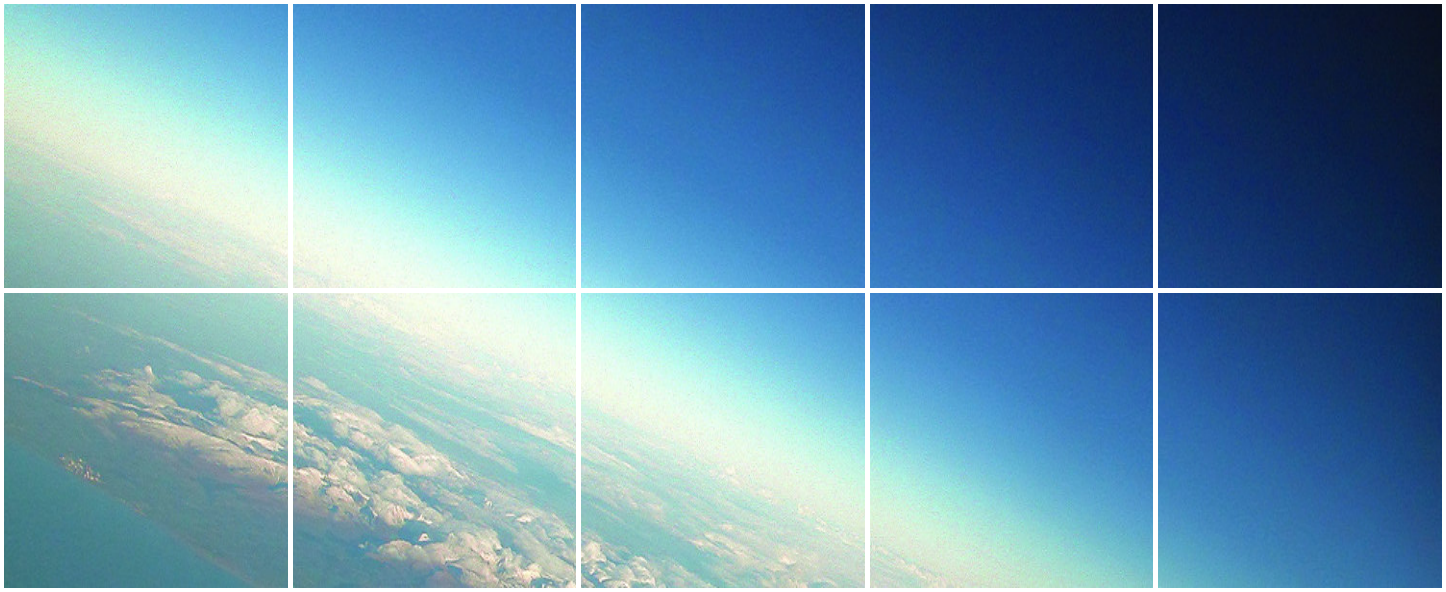

QA/QC Procedures for the UK Automatic Urban and Rural Air Quality Monitoring Network (AURN)

Report to Defra and the Devolved Administrations

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Executive summary

The UK Automatic Urban and Rural Network (AURN) has been established to provide information on air quality concentrations throughout the UK for a range of pollutants. The primary function of the AURN is to provide data in compliance with EU Directives on Air Quality. However, in addition, the data and information from the AURN is required by scientists, policy makers and planners to enable them to make informed decisions on managing and improving air quality for the benefit of health and the natural environment.

Within the UK, the Department for Environment, Food and Rural Affairs (Defra) has a Public Service Agreement (PSA) within its Performance Framework for improving air quality by meeting the Air Quality Strategy targets for eight pollutants. Progress towards this target is determined through a PSA Air Quality Indicator Statistic. For the two most significant problem pollutants in the UK, NO_2 and $PM_{10,}$ data from the AURN are used to calculate the appropriate indicator.

Hence, it is therefore essential that users have confidence in the data and, to that end, the AURN employs robust quality assurance and quality control (QA/QC) procedures to ensure the accuracy and precision of the published pollutant concentrations.

The responsibility for QA/QC of the AURN lies with the network QA/QC Unit - currently AEA Technology plc. However, the operation of the AURN involves many contractors, both locally and nationally and the work of all of these organisations contributes considerably to the overall quality of the data.

This report outlines the EU and UK data quality requirements and describes how these are addressed within the AURN:

- Monitoring site numbers and location
- Measurement methods
- Establishing new monitoring sites
- Data telemetry and validation
- Ongoing QA/QC including network inter-comparisons and data ratification
- Traceability of the measurements to national and international standards.

The calculation of the overall uncertainty of the measurements is then presented and compared with the Data Quality Objectives specified in the appropriate EU Directive.

The report also briefly discusses how data from non-AURN monitoring in the UK and from the extensive UK air quality modelling undertaken within the Pollution Climate Mapping project are merged with the AURN data to provide the overall assessment of air quality in the UK, as required by the EU Directive.

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1 Introduction

1.1 Scope

This report documents quality assurance and quality control procedures employed in the UK Automatic Urban and Rural Network. This section provides a brief explanation of the background to this monitoring network and the operational structure that has been created by Defra and the Devolved Administrations.

The report also presents the European and UK legislation within which the AURN operates, and considers how the AURN meets the quality requirements laid out in the relevant legislation.

This report describes how quality procedures are used during the selection and set up of monitoring sites; evaluation of monitoring equipment, operation of the monitoring equipment; data handling, ratification, review and reporting.

1.2 History and background

Air pollution in the European Union (EU) is believed to cause the premature death of hundreds of thousands of people each year and is estimated to reduce life expectancy by an average of nine months. Throughout the EU, Member States rely on networks of air quality monitoring equipment to measure and assess the concentrations of pollutants that are known to be hazardous to human health. In the UK, air pollution policy development relies heavily on the national air quality monitoring networks to provide scientifically robust data on ambient pollution concentrations. These data are used to establish priorities for policy development and to assess the effectiveness of regulatory action over time.

Pollution in the UK has been recognised as a problem since the 17th century and monitoring networks have been used since the Clean Air Act of 1956. The earliest air quality measurements used relatively simple, manual techniques whereby a sample would often be collected at a site and then returned to a laboratory for analysis. This is, in fact, still a common practice today, due to the relative low cost and high reliability of these types of measurements. However, in the 1970s the UK also introduced automatic analysers to the monitoring networks. These had the benefit of lower labour costs and could provide highly temporal resolution (i.e. hourly) continuous measurements. These continuous measurements became a requirement for regulatory purposes and so, in 1987, an automatic UK urban monitoring network was established to monitor compliance with the emerging EU Directive limit values on air quality. This network subsequently expanded, following commitments by Government to expand urban monitoring in the UK and improve public availability of air quality information. The growth in automatic air quality measurements made in the UK since 1972 is shown in Figures 1.1 and 1.2.

In 1992, the then Department of Environment established an Enhanced Urban Network (EUN). In 1996, this network expanded following an initiative designed to promote the integration of local authority sites into the national network where data quality could be assured. In 1995, all statutory and other urban monitoring was consolidated into one comprehensive programme. Throughout the next five years, over 50 local authority sites were integrated into the resulting network, including 14 of the London Air Quality Monitoring Network sites and the previously separate UK urban and rural automatic networks were combined to form the current Automatic Urban and Rural Network (AURN). The AURN is currently the largest and most comprehensive automatic national monitoring network in the UK. The most important role of the AURN is to provide accurate air quality monitoring data as required to fulfill the UK Government's statutory reporting obligations under the EU Air Quality Directives.

In addition to this, data from the AURN are used by Government, scientists, the medical community, policy makers, planners and air quality researchers in order to directly or indirectly influence behaviour and improve air quality in the UK.

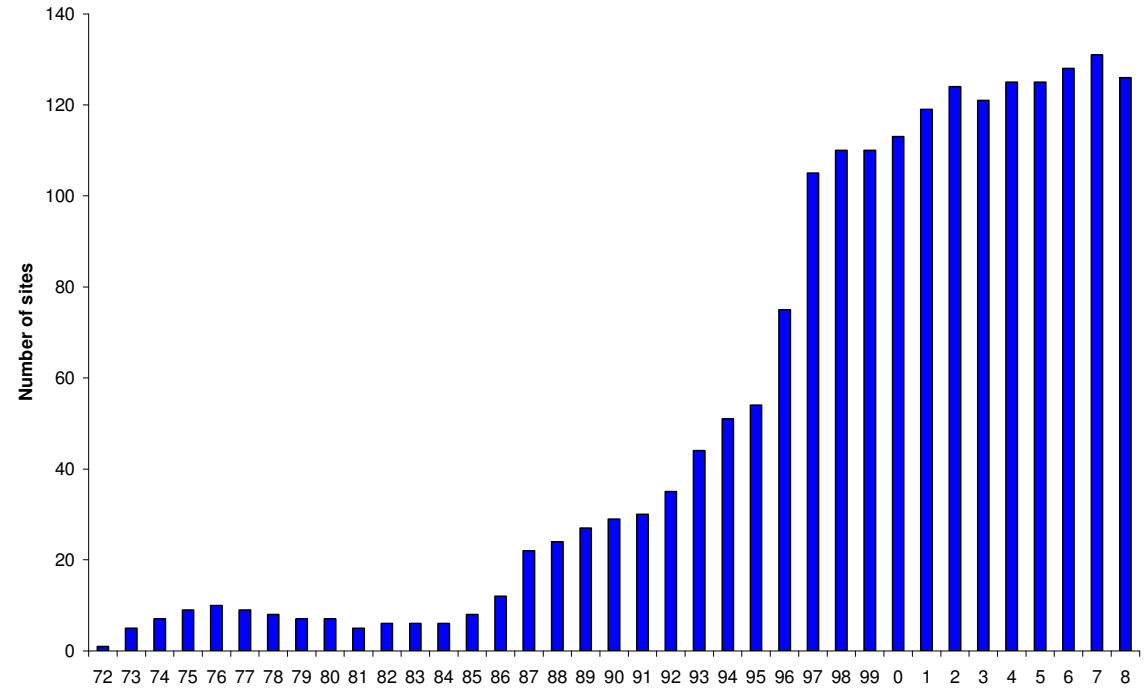

Figure 1.1. The number of automatic measurement stations in the UK

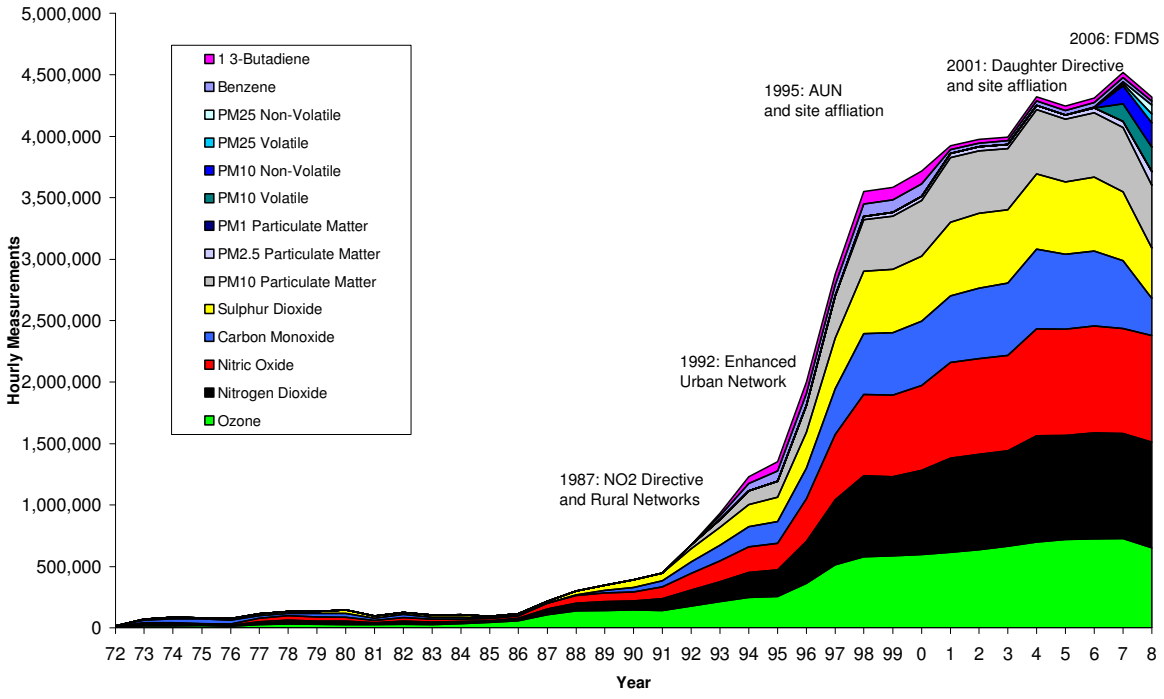

Figure 1.2.The number of hourly measurements made every year for all pollutants in the automatic monitoring networks (O_3, NO_2, CO, SO_2 and PM_{10}) and for other UK Strategy pollutants.

1.3 Network structure

A number of organisations are involved in the day-to-day running of the network. Currently, the role of Central Management and Co-ordination Unit (CMCU) for the AURN is contracted to Bureau Veritas, whilst the Environmental Research Group (ERG) of King's College London has been appointed as Management Unit for the AURN monitoring sites that are also part of the London Air Quality Network (LAQN). AEA undertakes the role of Quality Assurance and Control Unit (QA/QC Unit) for sites within the AURN. The responsibility for operating individual monitoring sites is assigned to local organisations with relevant experience in the field under the direct management (and contract to) CMCU. Calibration gases for the network are supplied by Air Liquide Ltd and are provided with a UKAS certificate of calibration by AEA. The monitoring equipment is serviced and maintained by a number of Equipment Support Units, under contract to the CMCU.

Dissemination of the data from the AURN via the UK Air Quality Archive website (www.airquality.co.uk) and other media such as teletext and freephone services is undertaken by the Air Quality Communications Unit. A summary report of the data is also published annually in the Air Pollution in the UK[1] series of reports.

Figure 1.3 summarises the structure of the AURN and the major interactions between the participating organisations.

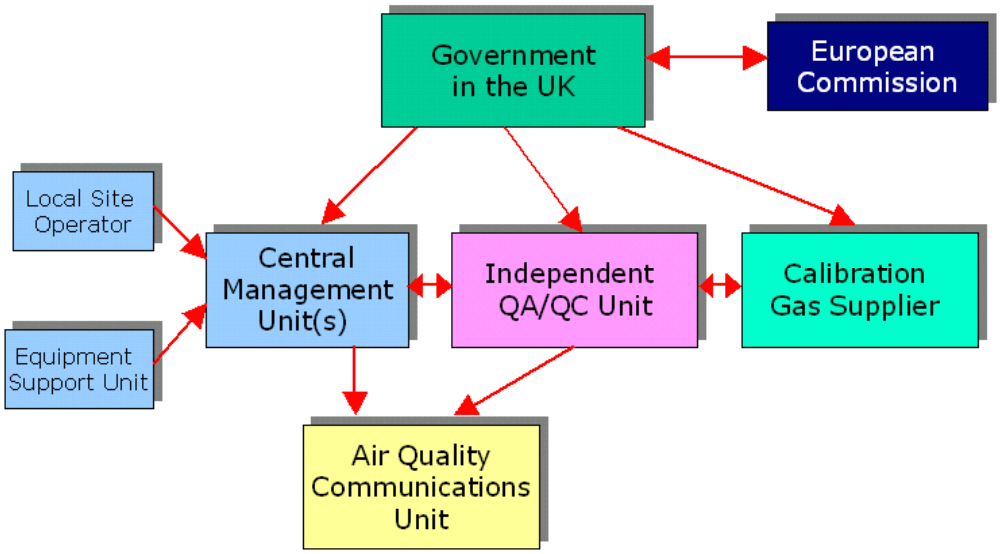

Figure 1.3. Structure of the AURN

Quality control and quality assurance are managed by the QA/QC Unit, whose primary function is to maintain the data quality and ensure that the EU Directive Data Quality Objectives are met. In this way this independent unit is able to coordinate the quality efforts of all other AURN stakeholders and approach all QA/QC issues in a focused and structured way.

1.4 Role of the AURN and QA/QC Unit

The primary objective of the QA/QC Unit is to maintain high quality QA/QC arrangements to ensure that data made available to the public are robust and that data reported to the Commission meet the legal obligations of the Directives. Overall, the AURN monitoring network **aims** to:

- Inform the public about air quality in near-real time
- Check if statutory air quality standards, objectives, target and limit values are met
- Assess effects of air pollution on health and the environment
- Provide information for local air quality review and assessments within the UK Air Quality Strategy
- Inform and support the development of cost-effective planning solutions and identify long-term trends and sources of pollution.

The key objective of the QA/QC Unit, within the network, is to ensure that the AURN data are of high quality and meet the Data Quality Objectives (DQOs) specified in the Directive. The QA/QC interacts closely with the AURN CMCU and Gas Provision contractors to ensure that these network objectives are met.

1.5 Pollutants measured in the AURN

The AURN is one of many national air quality monitoring networks in the UK. The AURN focuses on the measurement of the following pollutants:

- Nitrogen dioxide and oxides of nitrogen (NO_2/NOx)
- Particulate matter (PM_{10} and $PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)
- Ozone (O_3)

Other pollutants covered by EU Air Quality Directives, such as lead, benzene and polycyclic aromatic hydrocarbons are measured in other UK air quality monitoring networks.

As the name would suggest, the AURN consists predominantly of automatic monitoring equipment, however some non-automatic methods are still utilized in the measurement of particulate matter. As discussed in Chapter 5, gaseous pollutants are monitored with the defined EU reference methods. However, particulate matter is monitored at the majority of sites by equipment that has been demonstrated to be equivalent with the specified EU reference method. Hence, utilizing a mixture of measurement methods for particulate matter provides additional QC information and, in particular, the non-automatic methods will be used to check that the equivalence of automatic monitoring methods is maintained in the long-term.

Table 1.1 gives an overview of the pollutants measured within the network.

Table 1.1. AURN Pollutant Overview

Pollutant Overview			
Pollutant	**Sources**	**Site Classifications**	**Methodology**
Nitrogen Dioxide (NO_2)	Road transport and industry	Urban and Rural	Chemiluminescence
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	Urban and Rural	UV absorption
Sulphur Dioxide (SO_2)	Industry and fuel combustion	Urban and Rural	UV fluorescence
Carbon Monoxide (CO)	Road transport	Urban	IR Absorption
Particles (PM_{10}, $PM_{2.5}$)	Road transport, industry, construction, soil and natural sources	Mostly Urban	Gravimetric monitor FDMS[1] TEOM[2] BAM[3]

[1] *Filter Dynamic Measurement System*
[2] *Tapered Element Oscillating Microbalance*
[3] *Beta Attenuation Monitor*

2 EU Requirements

The 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[2] is a revision and replacement of Council Directives published between 1996 and 2002:

- Directive 96/62/EC on Ambient Air Quality Assessment and Management, 'The Framework Directive', which established a framework under which the EU agreed air quality limit values for pollutants specified in a series of 'Daughter Directives'.
- The First Daughter Directive (1999/30/EC), which set limit values for sulphur dioxide (SO_2), oxides of nitrogen, particulate matter as PM_{10}, and lead.
- The Second Daughter Directive (2000/69/EC), which set limit values for carbon monoxide (CO) and benzene.
- The Third Daughter Directive (or EC Ozone Directive, 2002/3/EC), which set target values for protection of human health and vegetation.
- Council Decision 97/101/EC, which established a reciprocal exchange of air quality monitoring information and data, between the Member States.

The aim of the new Directive is to protect human health and ecosystems within the EU through the setting of Limit Values or Target Values to be achieved by specific dates. These values are primarily based on World Health Organisation (WHO) guidelines. The Directive takes into account recent medical and scientific developments. It provides a common approach to the assessment of ambient air quality for Member States, thus improving comparability of data and benchmarking, through the use of standardised measurement techniques and criteria for monitoring sites and reporting.

In Article 1, the Directive states that one of its aims is to assess the ambient air quality of Member States on the basis of common methods and criteria. The AURN QA/QC Unit ensures that these methods and criteria are adhered to in the UK, in order to maximise confidence in the resulting data.

The Directive sets specific Limit Values for the pollutants that must be adhered to by a specific date (see Appendix 1) In addition, there are a number of other specific requirements:

- Data Quality Objectives
- Location of sampling points
- Number of sampling points
- Reference measurement methods
- Requirements for data reporting.

The following sections discuss how these requirements are addressed within the AURN.

2.1 Data Quality Objectives

Data Quality Objectives are provided in Annex i of Directive 2008/50/EC and are summarised below for the pollutants covered by this report.

Table 1.2: Data quality objectives for ambient air quality assessment

	Sulphur dioxide, nitrogen dioxide and oxides of nitrogen and carbon monoxide	**Particulate matter (PM_{10}/$PM_{2,5}$) and lead**	**Ozone and related NO and NO_2**
Fixed measurements [(1)] Uncertainty	15%	25%	15%

[(1)] The uncertainty (expressed at a 95% confidence level) of the assessment methods will be evaluated in accordance with the principles of the CEN Guide to the Expression of Uncertainty in Measurement (ENV 13005-1999), the methodology of ISO 5725:1994 and the guidance provided in the CEN report 'Air Quality – Approach to Uncertainty Estimation for Ambient Air Reference Measurement Methods' (CR 14377:2002E). The percentages for uncertainty in the above table are given for individual measurements averaged over the period considered by the limit value (or target value in the case of ozone), for a 95% confidence interval. The uncertainty for the fixed measurements shall be interpreted as being applicable in the region of the appropriate limit value (or target value in the case of ozone).

An evaluation to show compliance with the data uncertainty requirements of the data quality objectives is provided in Chapter 10.

2.2 Location and number of sampling points

The microscale and macroscale siting requirements for sampling points (measurement stations) are listed in Annex iii of Directive 2008/50/EC.

The minimum number of number sampling points (measurement stations) required is specified in Annex v and ix of Directive 2008/50/EC.

The territory of each Member State is classified into zones and agglomerations. According to the Directive a zone is 'part of the territory of a Member State, as delimited by that Member State for the purposes of air quality assessment and management'. An agglomeration is 'a zone that is a conurbation with a population in excess of 250,000 inhabitants or, where the population is 250 000 inhabitants or less, with a given population density per km^2 to be established by the Member States'. Zones and agglomerations have been established in the UK since 2000, following recommendations by AEA[3] and subsequent approval by Defra and the Devolved Administrations. Details on the current zones and agglomerations can be found in Chapter 4.

Where pollutants in a zone or agglomeration are above the lower assessment threshold (LAT), monitoring is required. Below the LAT, modelling techniques alone may be used. Fixed sampling points in the UK are detailed in Chapter 4. Monitoring results from the AURN are supplemented by modeled data[4] and results supplied by Local Authorities (see Chapter 11).

2.3 Measurement Methods

The EU reference methods of measurement for the various pollutants are specified in Annex vi of Directive 2008/50/EC.

These are the Standard Methods developed by CEN (European Committee for Standardisation) and realised in the UK through published British Standards as follows:

- BS EN14211: 2005 (NOx)
- BS EN14212: 2005 (SO_2)
- BS EN14625: 2005 (O_3)
- BS EN14626: 2005 (CO)
- BS EN12341: 1999 (PM_{10})
- BS EN14907: 2005 ($PM_{2.5}$).

UK air quality monitoring experts work closely with CEN to develop such methods to ensure high quality data. These standards describe in detail how analysers are to be tested, approved for use, calibrated and their ongoing performance determined. These harmonised procedures allow Member States to reliably and consistently quantify the uncertainties associated with their measurements of air pollution. CEN, through the various Working Groups, continue to revise and improve the Standards as new information becomes available.

Many of the QA/QC procedures adopted in the UK arise directly from the requirements of the CEN standard methods and are described in later sections of this report.

3 UK Requirements

3.1 The UK Air Quality Strategy

The Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland[5] was first published in March 1997 in response to the Environment Act 1995. The Strategy has since been reviewed in 2000 and 2007 and has established a strong framework for addressing and dealing with air pollution in the UK.

The UK Air Quality Strategy's primary focus is on protecting the health of the UK population, although it also includes targets for the protection of vegetation and ecosystems. In order to assess the UK's progress against these targets, long term monitoring of air pollutants is required and the quality of the data produced is an important consideration when looking at both absolute concentrations and for the analysis of trends.

The Strategy aims to:

- Map out future ambient air quality policy in the United Kingdom
- Provide best practicable protection to human health by setting health-based objectives for air pollutants
- Contribute to the protection of the natural environment through objectives for the protection of vegetation and ecosystems
- Describe current and future levels of air pollution
- Provide a framework to help identify what we all can do to improve air quality.

The Strategy has established objectives for eight key air pollutants, based on the best available medical and scientific understanding of their effects on health, as well as taking into account relevant developments in Europe and the World Health Organisation. The UK Air Quality Objectives are at least as stringent as the Limit Values of the relevant EU Directives.

The specific objectives set in the latest Air Quality Strategy are provided in Appendix 1.

3.2 Defra Performance Framework – Public Service Agreement

During 2007, the Government published the results of the Comprehensive Spending Review (CSR) 2007. As well as spending settlements for all Departments, this contained a new set of cross-government priorities or Public Service Agreements (PSAs), to replace those which were agreed in the previous Spending Review. These will be key priorities for the Government for the period from April 2008 until March 2011.

Defra are assessing performance internally against defined Departmental Strategic Objectives (DSOs), and reporting regularly to Treasury. Following the creation of a new Department for Energy and Climate Change (DECC), Defra Ministers have now set a new direction for the Department. Defra is leading on one cross-government PSA for the remainder of the CSR period – the Natural Environment PSA:-

- Secure a healthy natural environment for everyone's well being, health and prosperity, now and in the future

The full delivery agreements for the PSA can be found on the HM Treasury website:

Indicators for Defra-led PSA

The Natural Environment PSA will be measured against the following indicators:

- Water - improving water quality as measured by parameters assessed by Environment Agency river water quality monitoring programmes
- Biodiversity - as measured by data on bird populations in England as a proxy for the health of wider biodiversity
- Air quality - improving air quality by meeting the Air Quality Strategy targets for eight air pollutants
- Marine - Clean, healthy, safe, productive and biologically diverse oceans and seas as indicated by proxy measurements of fish stocks, sea pollution and plankton status.
- Land management - the positive and negative impacts of agricultural land management to the natural environment.

The AURN provides the necessary data for the indicator on improving air quality.

A separate paper has been prepared on the evaluation of this indicator from the AURN dataset[6].

3.3 Commitments of the Devolved Administrations

Wales

The Environment Strategy for Wales, presented in full at www.wales.gov.uk, was published in 2006; it sets out the Welsh Assembly Government's long-term strategy for maintaining and improving the environment of Wales. The Strategy defines a series of measurable and time-defined outcomes for improving all aspects of the environment in Wales. In order to achieve these outcomes, WAG will seek to ensure that the necessary processes - from the formulation of
Directives at the European level to the management of specific local issues through LAQM will be fully implemented.

The Strategy aims to bring about a reduction in air pollution leading to an increase in life expectancy by 2020 and ecological protection by 2010. The indicators for these achievements are:

- Trends in number of days when air pollution is moderate or higher in rural zones and urban agglomerations.
- Number of Air Quality Management Areas (AQMAs).
- Levels of emissions from Wales of SO_2, NH_3, fine particulates, ammonia, NOx and Volatile Organic Compounds.
- Area of natural and semi-natural habitat where deposition of a) acid and b) nitrogen compounds exceeds critical loads.

Scotland

The Scottish Government's air quality indicators for Scotland can be viewed in Key Scottish Environment Statistics 2009: http://www.scotland.gov.uk/Publications/2009/08/26112651/0.

Northern Ireland

There are no equivalent indicators for Northern Ireland.

3.4 Local Air Quality Monitoring

At a local level, Local Authorities are required to review and assess air quality in their area under the requirements of Part IV of the Environment Act (1995). This assessment is based partly on results from monitoring stations in the AURN, partly on monitoring stations run independently by Local Authorities and also on local modelling studies. Where Air Quality Objectives are exceeded or expected to be exceeded, Local Authorities need to develop an Air Quality Action Plan with the aim of achieving these objectives by the set date.

The UK has produced significant guidance for Local Authorities regarding their responsibilities and the Review and Assessment process, notably the Local Air Quality Management Policy Guidance (PG09) and Technical Guidance LAQM.TG(09). Corresponding Policy Guidance is also provided by each of

the UK Devolved Administrations. Background maps, correction factors and other tools based on AURN monitoring data are available for use by the Local Authorities from the National Air Quality Archive (www.airquality.co.uk).

4 AURN Monitoring site numbers and locations

4.1 UK zones and agglomerations

As discussed in Section 2.2, the EU Directive sets specific minimum requirements for monitoring site numbers and locations. These are based on an assessment of concentrations with respect to the Lower and Upper Assessment thresholds (Directive Annex ii), population within the zone or agglomeration (Annex v and Annex ix) and whether supplementary information is available from modelling and/or indicative measurements (Article 7).

As discussed in Section 2.2, the UK was divided into zones and agglomerations in 2000, in compliance with earlier EU Directives. The UK has 28 agglomerations with population greater than 250,000. The remainder of the territory of the UK has been split into 15 zones, following existing administrative boundaries (See Figure 4.1).

During 2008, there has been a major restructuring and rationalisation of the AURN to ensure compliance with the new Directive. This is just the latest in a series of expansions and restructuring of monitoring in the UK following changes in EU legislation and UK policy over the years in which the AURN has been required to respond. Notable changes include:

- Additional monitoring of NO_2 has been introduced in order to satisfy the Directive requirements (Annex v) for the mixture of urban background and roadside monitoring of this pollutant.

- In addition, a major increase in $PM_{2.5}$ monitoring has been introduced to satisfy the new requirements for widespread monitoring of this pollutant.

The scale of monitoring of CO and SO_2 has been considerably reduced following the 5-year re-evaluation of the Article 5 assessment undertaken during 2007/8. This assessment showed that concentrations of these pollutants had decreased and were below the LAT in many zones and agglomerations and hence, monitoring was no longer required. However, even in some of these cases monitoring has been retained, over and above the Directive requirements, in order to satisfy the following:

- Good geographic coverage of monitoring throughout the UK
- Provide data for model validation
- Provide data for air pollution forecasting
- Continuity of data at long-running sites.

In the UK, modelling is used as a supplementary assessment methodology and hence the monitoring requirements in Annex v and Annex ix have been reduced by 50%, in compliance with Article 7.

Tables 4.1 – 4.7 list the requirements and current monitoring sites numbers in the AURN to show compliance with the Directive 2008/50/EC. Corresponding tables with the full list of monitoring site names are provided in Appendix 3.

Table 4.4 lists those $PM_{2.5}$ sites that have been specifically designated as the sites required to monitor compliance with the EU Directive Average Exposure Indicator (AEI) requirements for $PM_{2.5}$.

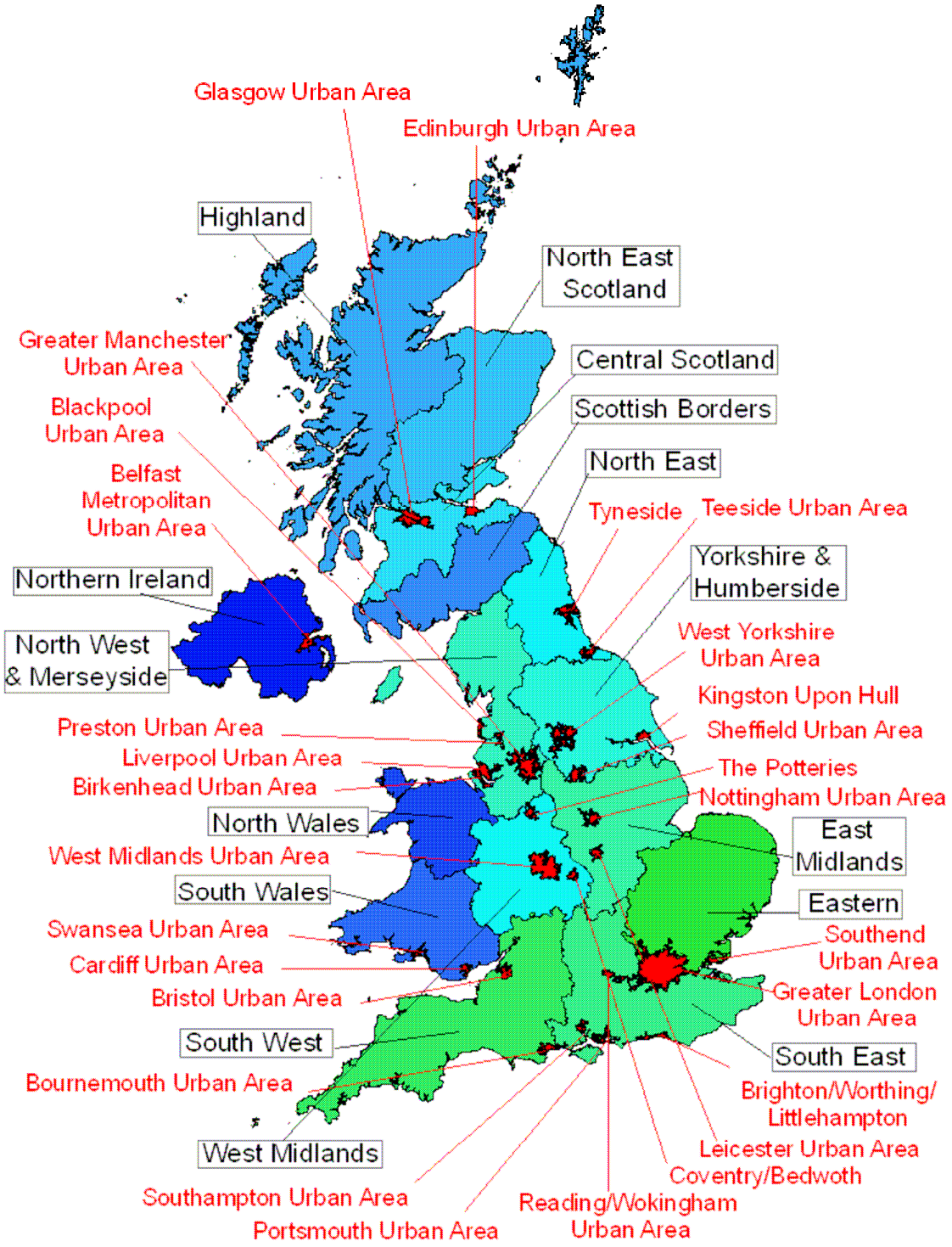

Figure 4.1 Air Quality Assessment zones and agglomerations in the UK. UK agglomeration zones shown in red, non-agglomeration zones in black

4.2 NO_2 monitoring site numbers

Table 4.1 NO_2 monitoring site numbers

Zone/ Agglomeration	Population (2001)	Concentration 1 = <LAT 2 = LAT – UAT 3 = >UAT	No of sites required per Annex V	No of sites required when Article 7 is applied	Total Number of Sites in AURN	Traffic - Urban	Background Urban	Background Rural	Industrial Urban
Greater London Urban Area	8278251	3	10	5	15	6	8	0	1
West Midlands Urban Area	2284093	3	6	3	4	1	3	0	0
Greater Manchester Urban Area	2244931	3	6	3	4	1	2	0	1
West Yorkshire Urban Area	1499465	3	4	2	2	1	1	0	0
Tyneside	879996	3	3	2	2	1	1	0	0
Liverpool Urban Area	816216	3	3	2	2	1	1	0	0
Sheffield Urban Area	640720	3	2	1	2	0	1	0	1
Nottingham Urban Area	666358	3	2	1	1	0	1	0	0
Bristol Urban Area	551066	3	2	1	2	1	1	0	0
Brighton/ Worthing/ Littlehampton	461181	3	2	1	2	1	1	0	0
Leicester Urban Area	441213	3	2	1	1	0	1	0	0
Portsmouth Urban Area	442252	3	2	1	1	0	1	0	0
Teeside Urban Area	365323	3	2	1	2	0	0	0	2
The Potteries	362403	3	2	1	1	0	1	0	0
Bournemouth Urban Area	383713	3	2	1	1	0	1	0	0
Reading/ Workingham Urban Area	369804	3	2	1	1	0	1	0	0
Coventry/ Bedworth	336452	3	2	1	1	0	1	0	0
Kingston Upon Hull	301416	3	2	1	1	0	1	0	0
Southampton Urban Area	304400	3	2	1	1	0	1	0	0
Birkenhead Urban Area	319675	3	2	1	1	0	1	0	0
Southend Urban Area	269415	3	2	1	1	0	1	0	0
Blackpool Urban Area	261088	3	2	1	1	0	1	0	0
Preston Urban Area	264601	3	2	1	1	0	1	0	0
Glasgow Urban Area	1168270	3	4	2	3	1	2	0	0
Edinburgh Urban Area	452194	3	2	1	1	0	1	0	0
Cardiff Urban Area	327706	3	2	1	1	0	1	0	0
Swansea Urban Area	270506	3	2	1	2	1	0	0	1
Belfast Urban Area	580276	3	2	1	1	0	1	0	0
Eastern	5124072	3	9	5	7	3	2	2	0
South West	3980991	3	8	4	6	2	2	2	0
South East	6392004	3	10	5	9	2	4	3	0
East Midlands	3084598	3	7	4	6	2	2	2	0
North West & Merseyside	2826622	3	7	4	5	2	3	0	0
Yorkshire & Humberside	2514947	3	6	3	4	1	1	1	1
West Midlands	2271650	3	6	3	3	1	2	0	0
North East	1269803	3	4	2	2	1	1	0	0
Central Scotland	1813314	3	5	3	4	1	1	1	1
North East Scotland	1001499	3	4	2	2	1	1	0	0
Highlands	380062	1	0	0	2	1	1	0	0
Scottish Borders	254690	3	2	1	3	1	1	1	0
South Wales	1578773	3	5	3	4	1	2	1	0
North Wales	720022	3	2	1	3	1	1	1	0
Northern Ireland	1104991	3	4	2	2	1	1	0	0
TOTAL				**82**	**120**	**36**	**62**	**14**	**8**

Hence, overall the Directive requirement for a minimum number of monitoring sites in each zone and agglomeration is met. There are 38 more monitoring sites than required as the minimum number in the Directive and, 20 of the 43 UK zones and agglomerations have more than the minimum number of sites required.

For each zone and agglomeration where the minimum number of sites is 2 or more, at least one site is a traffic site and one other site is an urban background or urban industrial site – this satisfies the Directive requirement "to include at least one urban background monitoring station and one traffic-orientated station provided this does not increase the number of sampling points". Also, the requirement that "the total number of urban-background stations and the total number of traffic oriented stations shall not differ by more than a factor of 2" is met – in the UK, this ratio is 1.7.

4.3 PM_{10} and $PM_{2.5}$ monitoring site numbers

Table 4.2 PM_{10} and $PM_{2.5}$ monitoring site numbers

Zone/ Agglomeration	Population	Concen-tration 1 <LAT 2 =LAT – UAT 3>UAT	No of sites required per Annex V	No of sites required when Article 7 is applied	Total Number of Sites PM_{10} + $PM_{2.5}$	Total Number of Sites in AURN (PM_{10})	PM_{10}				Total Number of Sites in AURN ($PM_{2.5}$)	$PM_{2.5}$			
							Traffic - Urban	Backgroun d Urban	Backgroun d Rural	Industrial Urban		Traffic - Urban	Backgroun d Urban	Backgroun d Rural	Industrial Urban
Greater London Urban Area	8278251	3	15	8	18	7	4	2	0	1	11	3	7	0	1
West Midlands Urban Area	2284093	3	8	4	5	2	1	1	0	0	3	1	2	0	0
Greater Manchester Urban Area	2244931	3	8	4	5	2	1	0	0	1	3	1	2	0	0
West Yorkshire Urban Area	1499465	3	6	3	4	2	1	1	0	0	2	1	1	0	0
Tyneside	879996	3	4	2	2	1	0	1	0	0	1	0	1	0	0
Liverpool Urban Area	816216	3	4	2	2	1	0	1	0	0	1	0	1	0	0
Sheffield Urban Area	640720	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Nottingham Urban Area	666358	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Bristol Urban Area	551066	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Brighton/ Worthing/ Littlehampton	461181	2	2	1	1	0	0	0	0	0	1	0	1	0	0
Leicester Urban Area	441213	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Portsmouth Urban Area	442252	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Teeside Urban Area	365323	3	3	2	2	1	0	0	0	1	1	0	0	0	1
The Potteries	362403	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Bournemouth Urban Area	383713	2	2	1	2	1	0	1	0	0	1	0	1	0	0
Reading/ Workingham Urban Area	369804	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Coventry/ Bedworth	336452	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Kingston Upon Hull	301416	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Southampton Urban Area	304400	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Birkenhead Urban Area	319675	2	2	1	1	0	0	0	0	0	1	0	1	0	0
Southend Urban Area	269415	2	2	1	1	0	0	0	0	0	1	0	1	0	0
Blackpool Urban Area	261088	2	2	1	1	0	0	0	0	0	1	0	1	0	0
Preston Urban Area	264601	2	2	1	1	0	0	0	0	0	1	0	1	0	0
Glasgow Urban Area	1168270	3	6	3	4	2	1	1	0	0	2	1	1	0	0
Edinburgh Urban Area	452194	2	2	1	2	1	0	1	0	0	1	0	1	0	0
Cardiff Urban Area	327706	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Swansea Urban Area	270506	3	3	2	4	2	1	1	0	0	2	1	0	0	1
Belfast Urban Area	580276	3	3	2	2	1	0	1	0	0	1	0	1	0	0
Eastern	5124072	3	13	7	7	4	2	2	0	0	3	2	1	0	0
South West	3980991	3	11	6	6	3	2	1	0	0	3	2	1	0	0
South East	6392004	3	15	8	12	6	2	2	2	0	6	2	2	2	0
East Midlands	3084598	3	10	5	5	2	1	1	0	0	3	1	2	0	0
North West & Merseyside	2826622	3	10	5	5	2	1	1	0	0	3	1	2	0	0
Yorkshire & Humberside	2514947	3	8	4	5	3	1	1	1	0	2	1	1	0	0
West Midlands	2271650	3	8	4	4	2	1	1	0	0	2	1	1	0	0
North East	1269803	3	6	3	3	1	1	0	0	0	2	1	1	0	0
Central Scotland	1813314	2	3	2	4	2	0	0	1	1	2	0	0	1	1
North East Scotland	1001499	2	3	2	2	1	0	1	0	0	1	0	1	0	0
Highlands	380062	1	0	0	1	1	1	0	0	0	0	0	0	0	0
Scottish Borders	254690	1	0	0	0	0	0	0	0	0	0	0	0	0	0
South Wales	1578773	3	7	4	5	3	1	1	1	0	2	1	1	0	0
North Wales	720022	2	2	1	2	1	1	0	0	0	1	1	0	0	0
Northern Ireland	1104991	3	6	3	4	3	1	1	1	0	1	0	1	0	0
TOTAL			**209**	**115**	**144**	**68**	**24**	**34**	**6**	**4**	**76**	**21**	**48**	**3**	**4**

The total number of PM sites in the AURN exceeds the minimum requirement of the Directive (144 compared to 115 required). The number of urban background sites is 34 PM_{10} and 48 $PM_{2.5}$ (total 82) and the number of traffic sites is 24 PM_{10} and 21 $PM_{2.5}$ (total 45). Hence, the number of urban background sites does not exceed the number of traffic sites by more than a factor of 2 – in compliance with the Directive.

4.4 $PM_{2.5}$ Average Exposure Indicator sites

Table 4.3 $PM_{2.5}$ AEI monitoring site numbers

Zone/ Agglomeration	Population (2001)	Number of Conurbations	Population summed over conurbations only	No. of urban background sites required	Number of urban background $PM_{2.5}$ sites in AURN* (AEI sites)	Number of rural and traffic $PM_{2.5}$ sites in AURN (non-AEI sites)
Greater London Urban Area	8278251	N/A	N/A	8	8	3
West Midlands Urban Area	2284093	N/A	N/A	2	2	1
Greater Manchester Urban Area	2244931	N/A	N/A	2	2	1
West Yorkshire Urban Area	1499465	N/A	N/A	1	1	1
Tyneside	879996	N/A	N/A	1	1	0
Liverpool Urban Area	816216	N/A	N/A	1	1	0
Sheffield Urban Area	640720	N/A	N/A	1	1	0
Nottingham Urban Area	666358	N/A	N/A	1	1	0
Bristol Urban Area	551066	N/A	N/A	1	1	0
Brighton/ Worthing/ Littlehampton	461181	N/A	N/A	1	1	0
Leicester Urban Area	441213	N/A	N/A	1	1	0
Portsmouth Urban Area	442252	N/A	N/A	1	1	0
Teeside Urban Area	365323	N/A	N/A	1	1	0
The Potteries	362403	N/A	N/A	1	1	0
Bournemouth Urban Area	383713	N/A	N/A	1	1	0
Reading/ Workingham Urban Area	369804	N/A	N/A	1	1	0
Coventry/ Bedworth	336452	N/A	N/A	1	1	0
Kingston Upon Hull	301416	N/A	N/A	1	1	0
Southampton Urban Area	304400	N/A	N/A	1	1	0
Birkenhead Urban Area	319675	N/A	N/A	1	1	0
Southend Urban Area	269415	N/A	N/A	1	1	0
Blackpool Urban Area	261088	N/A	N/A	1	1	0
Preston Urban Area	264601	N/A	N/A	1	1	0
Glasgow Urban Area	1168270	N/A	N/A	1	1	1
Edinburgh Urban Area	452194	N/A	N/A	1	1	0
Cardiff Urban Area	327706	N/A	N/A	1	1	0
Swansea Urban Area	270506	N/A	N/A	1	1	1
Belfast Urban Area	580276	N/A	N/A	1	1	0
Eastern	5124072	8	1,126,800	1	1	2
South West	3980991	6	862,888	1	1	2
South East	6392004	10	1,594,871	1	2	4
East Midlands	3084598	7	1,065,679	1	2	1
North West & Merseyside	2826622	5	767,341	1	2	1
Yorkshire & Humberside	2514947	4	611,924	1	1	1
West Midlands	2271650	1	138,241	1	1	1
North East	1269803	1	182,974	1	1	1
Central Scotland	1813314	0	0	0	0	2
North East Scotland	1001499	2	352,002	1	1	0
Highlands	380062	0	0	0	0	0
Scottish Borders	254690	0	0	0	0	0
South Wales	1578773	1	139,298	1	1	1
North Wales	720022	0	0	0	0	1
Northern Ireland	1104991	0	0	0	0	1
TOTAL				**47**	**50**	**26**

* includes sites designated as urban background, suburban background and urban industrial

Hence, the number of $PM_{2.5}$ Average Exposure Indicator (AEI) sites exceeds the minimum requirement by 3. At a total of 6 $PM_{2.5}$ sites, parallel monitoring with both automatic and gravimetric daily sampling is undertaken. These sites include 2 traffic, 2 urban background (AEI) and 2 rural sites.

4.5 SO_2 monitoring site numbers

Table 4.4 SO_2 monitoring site numbers

Zone/ Agglomeration	Population	Concentration 1 <LAT 2 LAT – UAT 3 >UAT	No of sites required per Annex V	No of sites required when Article 7 is applied	Total Number of Sites in AURN	Traffic - Urban	Background Urban	Background Rural	Industrial Urban
Greater London Urban Area	8278251	1	0	0	6	2	4	0	0
West Midlands Urban Area	2284093	1	0	0	2	0	2	0	0
Greater Manchester Urban Area	2244931	2	3	2	2	0	1	0	1
West Yorkshire Urban Area	1499465	1	0	0	1	0	1	0	0
Tyneside	879996	1	0	0	1	0	1	0	0
Liverpool Urban Area	816216	1	0	0	1	0	1	0	0
Sheffield Urban Area	640720	1	0	0	1	0	1	0	0
Nottingham Urban Area	666358	1	0	0	1	0	1	0	0
Birstol Urban Area	551066	1	0	0	1	0	1	0	0
Brighton/ Worthing/ Littlehampton	461181	1	0	0	0	0	0	0	0
Leicester Urban Area	441213	1	0	0	1	0	1	0	0
Portsmouth Urban Area	442252	1	0	0	0	0	0	0	0
Teeside Urban Area	365323	2	1	1	1	0	1	0	0
The Potteries	362403	1	0	0	0	0	0	0	0
Bournemouth Urban Area	383713	1	0	0	0	0	0	0	0
Reading/ Workingham Urban Area	369804	1	0	0	0	0	0	0	0
Coventry/ Bedworth	336452	1	0	0	0	0	0	0	0
Kingston Upon Hull	301416	1	0	0	1	0	1	0	0
Southampton Urban Area	304400	1	0	0	1	0	1	0	0
Birkenhead Urban Area	319675	1	0	0	0	0	0	0	0
Southend Urban Area	269415	1	0	0	0	0	0	0	0
Blackpool Urban Area	261088	1	0	0	0	0	0	0	0
Preston Urban Area	264601	1	0	0	0	0	0	0	0
Glasgow Urban Area	1168270	1	0	0	1	0	1	0	0
Edinburgh Urban Area	452194	1	0	0	1	0	1	0	0
Cardiff Urban Area	327706	1	0	0	1	0	1	0	0
Swansea Urban Area	270506	1	0	0	1	0	0	0	1
Belfast Urban Area	580276	3	2	1	1	0	1	0	0
Eastern	5124072	2	4	2	4	1	2	1	0
South West	3980991	1	0	0	0	0	0	0	0
South East	6392004	2	4	2	3	0	0	3	0
East Midlands	3084598	2	3	2	2	0	1	1	0
North West & Merseyside	2826622	1	0	0	0	0	0	0	0
Yorkshire & Humberside	2514947	2	3	2	3	0	2	1	0
West Midlands	2271650	1	0	0	2	0	2	0	0
North East	1269803	2	2	1	1	0	1	0	0
Central Scotland	1813314	1	0	0	1	0	0	0	1
North East Scotland	1001499	1	0	0	0	0	0	0	0
Highlands	380062	1	0	0	0	0	0	0	0
Scottish Borders	254690	1	0	0	0	0	0	0	0
South Wales	1578773	1	0	0	1	0	0	1	0
North Wales	720022	2	1	1	1	1	0	0	0
Northern Ireland	1104991	2	2	1	2	0	2	0	0
TOTAL			**24**	**15**	**45**	**4**	**31**	**7**	**3**

The number of SO_2 monitoring sites in each zone and agglomeration equals or exceeds the Directive requirement.

4.6 CO monitoring site numbers

Table 4.5 CO monitoring site numbers

Zone/ Agglomeration	Population (2001)	Concentration 1 = <LAT 2 = LAT – UAT 3 = >UAT	No of sites required per Annex V	No of sites required when Article 7 is applied	Total Number of Sites in AURN	Traffic - Urban	Background Urban	Background Rural	Industrial Urban
Greater London Urban Area	8278251	2	4	2	7	3	4	0	0
West Midlands Urban Area	2284093	1	0	0	0	0	0	0	0
Greater Manchester Urban Area	2244931	2	3	2	2	1	0	0	1
West Yorkshire Urban Area	1499465	1	0	0	1	0	1	0	0
Tyneside	879996	1	0	0	1	0	1	0	0
Liverpool Urban Area	816216	1	0	0	1	0	1	0	0
Sheffield Urban Area	640720	1	0	0	1	0	1	0	0
Nottingham Urban Area	666358	1	0	0	0	0	0	0	0
Birstol Urban Area	551066	2	1	1	2	1	1	0	0
Brighton/ Worthing/ Littlehampton	461181	1	0	0	0	0	0	0	0
Leicester Urban Area	441213	1	0	0	1	0	1	0	0
Portsmouth Urban Area	442252	1	0	0	0	0	0	0	0
Teeside Urban Area	365323	1	0	0	1	0	0	0	1
The Potteries	362403	1	0	0	0	0	0	0	0
Bournemouth Urban Area	383713	1	0	0	0	0	0	0	0
Reading/ Workingham Urban Area	369804	1	0	0	0	0	0	0	0
Coventry/ Bedworth	336452	1	0	0	0	0	0	0	0
Kingston Upon Hull	301416	1	0	0	1	0	1	0	0
Southampton Urban Area	304400	1	0	0	1	0	1	0	0
Birkenhead Urban Area	319675	1	0	0	0	0	0	0	0
Southend Urban Area	269415	1	0	0	0	0	0	0	0
Blackpool Urban Area	261088	1	0	0	0	0	0	0	0
Preston Urban Area	264601	1	0	0	0	0	0	0	0
Glasgow Urban Area	1168270	1	0	0	1	0	1	0	0
Edinburgh Urban Area	452194	1	0	0	1	0	1	0	0
Cardiff Urban Area	327706	1	0	0	1	0	1	0	0
Swansea Urban Area	270506	1	0	0	1	0	0	0	1
Belfast Urban Area	580276	1	0	0	1	0	1	0	0
Eastern	5124072	1	0	0	1	0	0	1	0
South West	3980991	1	0	0	0	0	0	0	0
South East	6392004	1	0	0	0	0	0	0	0
East Midlands	3084598	1	0	0	1	0	0	1	0
North West & Merseyside	2826622	1	0	0	0	0	0	0	0
Yorkshire & Humberside	2514947	1	0	0	0	0	0	0	0
West Midlands	2271650	1	0	0	0	0	0	0	0
North East	1269803	1	0	0	0	0	0	0	0
Central Scotland	1813314	1	0	0	0	0	0	0	0
North East Scotland	1001499	1	0	0	0	0	0	0	0
Highlands	380062	1	0	0	0	0	0	0	0
Scottish Borders	254690	1	0	0	0	0	0	0	0
South Wales	1578773	1	0	0	0	0	0	0	0
North Wales	720022	1	0	0	0	0	0	0	0
Northern Ireland	1104991	1	0	0	0	0	0	0	0
TOTAL			**8**	**5**	**26**	**5**	**16**	**2**	**3**

The number of CO monitoring sites in each zone and agglomeration equals or exceeds the Directive requirement.

4.7 Ozone monitoring site numbers

Table 4.6 Ozone monitoring site numbers

Zone/ Agglomeration	Population (2001)	No of sites required per Annex V	No of sites required when Article 9 is applied	Total Number of Sites in AURN	Traffic - Urban	Background Urban	Background Rural	Industrial Urban
Greater London Urban Area	8278251	6	4	9	1	7	0	1
West Midlands Urban Area	2284093	4	2	4	1	3	0	0
Greater Manchester Urban Area	2244931	4	2	3	0	2	0	1
West Yorkshire Urban Area	1499465	3	1	1	0	1	0	0
Tyneside	879996	2	1	1	0	1	0	0
Liverpool Urban Area	816216	2	1	1	0	1	0	0
Sheffield Urban Area	640720	2	1	1	0	1	0	0
Nottingham Urban Area	666358	2	1	1	0	1	0	0
Birstol Urban Area	551066	2	1	1	0	1	0	0
Brighton/ Worthing/ Littlehampton	461181	1	1	1	0	1	0	0
Leicester Urban Area	441213	1	1	1	0	1	0	0
Portsmouth Urban Area	442252	1	1	1	0	1	0	0
Teeside Urban Area	365323	1	1	1	0	0	0	1
The Potteries	362403	1	1	1	0	1	0	0
Bournemouth Urban Area	383713	1	1	1	0	1	0	0
Reading/ Workingham Urban Area	369804	1	1	1	0	1	0	0
Coventry/ Bedworth	336452	1	1	1	0	1	0	0
Kingston Upon Hull	301416	1	1	1	0	1	0	0
Southampton Urban Area	304400	1	1	1	0	1	0	0
Birkenhead Urban Area	319675	1	1	1	0	1	0	0
Southend Urban Area	269415	1	1	1	0	1	0	0
Blackpool Urban Area	261088	1	1	1	0	1	0	0
Preston Urban Area	264601	1	1	1	0	1	0	0
Glasgow Urban Area	1168270	3	1	1	0	1	0	0
Edinburgh Urban Area	452194	1	1	1	0	1	0	0
Cardiff Urban Area	327706	1	1	1	0	1	0	0
Swansea Urban Area	270506	1	1	1	0	0	0	1
Belfast Urban Area	580276	1	1	1	0	1	0	0
Eastern	5124072	6	3	6	0	2	4	0
South West	3980991	5	2	4	1	1	2	0
South East	6392004	5	2	4	0	1	3	0
East Midlands	3084598	5	2	4	0	2	2	0
North West & Merseyside	2826622	5	2	3	0	2	1	0
Yorkshire & Humberside	2514947	4	2	2	0	1	1	0
West Midlands	2271650	4	2	2	0	2	0	0
North East	1269803	3	1	1	0	1	0	0
Central Scotland	1813314	3	1	2	0	0	2	0
North East Scotland	1001499	2	1	1	0	1	0	0
Highlands	380062	2	1	3	0	1	2	0
Scottish Borders	254690	1	1	2	0	1	1	0
South Wales	1578773	3	1	2	0	1	1	0
North Wales	720022	2	1	2	0	1	1	0
Northern Ireland	1104991	3	1	2	0	1	1	0
TOTAL		**101**	**56**	**81**	**3**	**53**	**21**	**4**

The number of ozone monitoring sites in each zone and agglomeration equals or exceeds the Directive requirement.

4.8 AURN Site Location Map (Apr 2009)

The location of AURN sites operational at the beginning of April 2009 is shown in Figure 4.2

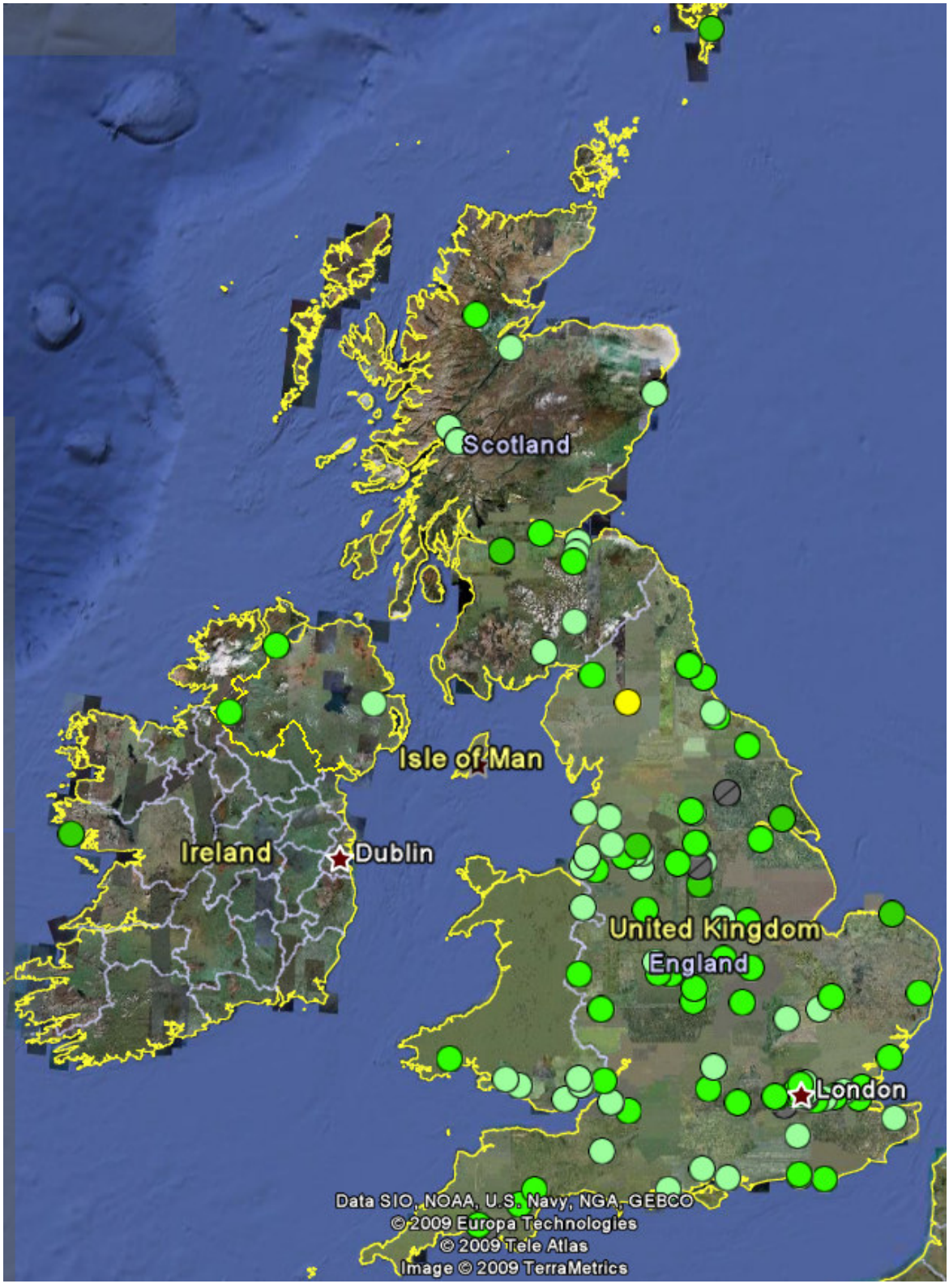

Figure 4.2 AURN sites Operational in April 2009

5 Measurement methods – type testing and equivalence of analysers

5.1 EU Requirements

Annex vi of the EU Directive 2008/50/EC defines the reference methods and the procedure for demonstration of equivalence (with the reference methods).

The reference methods specified are those developed by CEN and published in the UK through British Standards as follows:

- BS EN14211: 2005 (NOx)
- BS EN14212: 2005 (SO_2)
- BS EN14625: 2005 (O_3)
- BS EN14626: 2005 (CO)
- BS EN12341: 1999 (PM_{10})
- BS EN14907: 2005 ($PM_{2.5}$).

In compliance with Annex vi, D, all new equipment introduced into the network complies with the reference method or has been demonstrated to be equivalent.

Going forward, there is a rolling programme to replace all monitoring equipment in the network with reference or equivalent methods by Jun 2013 – as required by the Directive.

For the gaseous analysers, the relevant Standard Methods include a requirement for type testing and approval. The mechanism in the UK to conform to this is described in Section 5.2.

For particle monitoring (PM_{10} and $PM_{2.5}$) compliance is achieved by ensuring that all analysers used in the network have been demonstrated to be equivalent to the reference methods. The mechanism for demonstrating equivalence for particle monitors in the UK is provided in Section 5.3.

5.2 Type-approval of analysers for NOx, SO_2, O_3 and CO

Type-approval tests are used to evaluate a set of performance characteristics for at least two identical types of analysers in a laboratory and two analysers in the field. The standard specifies a comprehensive and rigorous set of tests and, type approval of an analyser is based on conformance of the analyser with all the individual performance criteria. The standards also require the calculation of the overall expanded uncertainty of the measurement result based on the numerical values of all the relevant tested performance characteristics - this is compared with the relevant prescribed maximum uncertainty in the Directive's DQOs (e.g. +-15% at 95% confidence level for NO_2 at the hourly limit value). The tests and calculations carried out are:

Laboratory tests:

- Short-term drift tests at zero and span concentrations (12 hrs)
- Response times rising and falling
- Repeatability at zero concentrations and at the hourly limit or target value (where appropriate)
- Lack of fit (residuals from the linear regression function including the zero value)
- Sensitivity to sample gas pressure and sample temperature
- Sensitivity to electrical voltage
- Sensitivity to the temperature surrounding the analyser
- Effects of interferences from other substances present in the atmospheric samples
- Effect of fluctuating concentrations (averaging test)
- Converter efficiency where applicable (NO_x)
- Differences between sample and span inputs, where applicable.

Field tests (3 months):

- Long-term reproducibility between two analysers during the field measurements
- Long-term drifts at zero and span levels
- Period of unattended operation, and fraction of total time the analyser is available for measurements.

Overall uncertainty of measurement results:

- Determined by combining the type approval results obtained from the relevant tests above, expressed at a 95% confidence level.

Analyser Type testing in the UK

In the UK, type testing of ambient air pollution analysers is undertaken by SIRA (http://www.sira.co.uk/index.html), to performance specifications developed within the UK Environment Agency MCERTS scheme (http://www.environment-agency.gov.uk/business/regulation/31829.aspx). These performance requirements[7] are based the CEN standard requirements.

SIRA is accredited by the United Kingdom Accreditation Service (UKAS) to ISO/IEC Guide 65:1996 'General requirements for bodies operating product certification systems'.

In addition to undertaking the relevant type tests and certifying successful analysers, SIRA also undertake continuing surveillance of the certified analysers through audits of the manufacturer.

The list of type-tested analysers in the UK is provided at http://www.sira.co.uk/MCERTS/MCERTSCertifiedProductsCAMS.pdf .

5.3 Equivalence testing for PM_{10} and $PM_{2.5}$

The requirements for equivalence testing are set out in the EU Guidance document[8]. Testing for equivalence is required to be carried out in two parts:

- Laboratory test in which the contributions of the different uncertainty sources to the measurement uncertainty will be assessed
- Field tests in which the Candidate Method will be tested side-by-side with the relevant Standard Method.

In order to assure proper functioning of the Standard Method, two reference samplers or instruments are used.

Test sites shall be representative for typical conditions for which equivalence will be claimed, including possible episodes of high concentrations. A minimum of 4 comparisons are performed with particular emphasis on the following variables, if appropriate:

- Composition of the PM fraction, notably high and low fractions of semi-volatile particles, to cover the maximum impact of losses of semi-volatiles
- Air humidity and temperature (high and low) to cover any conditioning losses of semi-volatiles during the sampling process
- Wind speed (high and low) to cover any dependency of inlet performance due to deviations from ideal behavior as dictated by mechanical design, or deviations from the designated sampling flow rate.

A minimum of 40 measurement results, each averaged over at least 24 hours, per comparison is collected.

Equivalence for PM_{10} and $PM_{2.5}$ analysers in the UK

An initial UK equivalence testing programme has been carried out by Bureau Veritas on behalf of Defra and is described in the report UK Equivalence Programme for Monitoring of Particulate Matter[9] and summarised in Chapter 9 of this report.

Equivalence testing of additional analysers is also being undertaken currently within a joint programme between Bureau Veritas, The Environment Agency and TUV Germany.

5.4 Compliance with Article 11 (Equipping the AURN with type tested or equivalent analysers)

The EU Directive requires that:

- All new equipment purchased for implementation of this Directive must comply with the reference method or equivalent by 11 June 2010
- All equipment used in fixed measurements must comply with the reference method or equivalent by 11 June 2013.

In compliance with the Directive, the UK is now only purchasing type tested equipment for use in the network and has a rolling programme to replace all non type-tested or non-equivalent equipment with type tested or equivalent analysers by the due date of 11 June 2013.

6 Establishment of AURN monitoring sites

The AURN has grown steadily since automatic monitoring commenced in the UK in 1972 (see Figure 1.1 in Chapter 1) in line with the requirements of various EU Directives and UK air quality policy. As discussed in Chapter 4, the latest phase of this work was undertaken during 2008 with the restructuring of the network to comply with the new requirements of the 2008 Framework Directive.

6.1 Process for adding new sites to the Network

For each zone and agglomeration in the UK the monitoring requirements are evaluated from the Directive requirements, taking into account:

- Concentration in the zone compared to LAT and UAT
- Population of the zone
- Site number and site type requirements based on the appropriate annex of the Directive.

In addition, all monitoring sites in the UK that are not part of the AURN, but show an exceedence of any of the Directive Limit Values are assessed annually to check whether the site needs to be incorporated into the AURN. This process is described in Chapter 11.

Where the need for additional sites is identified, the QA/QC unit firstly assesses if suitable sites already exist as part of Local Authority air quality monitoring networks. This assessment involves:

- Checking the site location for compliance with Directive siting requirements
- Checking for compliance of monitoring equipment
- Suitability for installation of additional equipment e.g. $PM_{2.5}$
- Willingness of the site owner to allow the site to be affiliated into the AURN.

The QA/QC unit produces a short report on these and any other aspects and recommends the site for affiliation.

The CMCU then makes the formal contractual arrangements with the site owner and establishes data telemetry to existing equipment (or installs and arranges telemetry links to new directly-funded equipment at the site) and arranges for the supply of accredited calibration cylinders to be supplied (if these are not in place already).

When these tasks are completed, the QA/QC Unit undertakes a commissioning audit of the site to ensure correct operation of the relevant analysers and to check calibration gas concentrations. The QA/QC unit also trains the LSO in the required method of calibration, provides the LSO manual to back up this training and, provides a copy of the electronic calibration sheet so that calibration results can be fully and correctly stored and transmitted directly back to the CMCU and QA/QC Units electronically.

When the commissioning audit has been successfully completed and suitable calibration information made available, the data from the site are formally incorporated into the AURN with a “go-live” to the UK Air Quality Information Archive. These data are then available as provisional data on an hourly basis on the Archive and subsequently undergo the data ratification as described in Chapter 8.

Data from the new sites and analysers thus incorporated into the network are then made available to the Commission annually as part of the data submission from the UK.

Where no suitable monitoring site meets the Directive requirements, a totally new site is established and is wholly funded by Defra and the Devolved Administrations. This is a much longer procedure as it normally involves planning permission, arrangements for leases, the installation of utilities and negotiation with highways to physically install the monitoring hut. These tasks are undertaken by the CMCU unit.

When the new site is running, a commissioning audit is performed prior to release of the data and full incorporation of the site into the network.

6.2 CEN Standard Method requirements for new sites

The CEN Standard Methods set a number of operational condition checks that need to be performed for each site and analyser deployed. These are summarized as follows:

- Estimate of the sample gas pressure and temperature variations
- Estimate of the air temperature and mains voltage variations
- Estimate of the H_2O, CO_2, O_3, NH_3 and benzene concentration range in the local atmosphere
- Functional check of the analyser and sampling system
- Functional check of the data telemetry system
- Lack of fit (linearity) test
- Converter efficiency check for NO_x analysers
- Determination of the required frequency of filter changes and analyser consumables changes.

These parameters need to be reviewed in order to ensure that all the analysers at all the sites are operating within the operating conditions for which they have been “type approved”, and also to determine the required frequency of certain maintenance actions which may depend on the pollutant concentrations at the particular site, or other factors.

The majority of these checks are undertaken as part of the commissioning audit. Where the checks listed are not currently part of the routine procedures, they are now being introduced.

7 Data telemetry, validation and dissemination of provisional data

In order to provide rapid data on the current air quality situation in the UK, data from the AURN are collected via telemetry from each monitoring site, every hour, and made available on the UK Air Quality Archive website. These data are validated, but not fully ratified, and hence are described as provisional data. The process for collecting, validating and disseminating the provisional data is described below.

7.1 Collecting the data from the monitoring sites

CMCU dial-up via telemetry links (e.g. land-lines, GSM modems and GPRS) to poll data acquired within the hour. Each station is automatically dialled every hour between five minutes and twenty minutes past the hour over the period 07:00 to 18:00. Between the hours of 18:00 and 07:00 the dial sequence has been revised to every other hour. Onboard and external logging systems provide for a mechanism of capturing data (either in concentration or raw electronic mV format).

7.2 Validation of the Data

Upon completion of the station poll the four x fifteen minute averages collected from the site operating system are stored in the data management system database. The collected values are referred to as “raw” since they are not scaled and remain in the data management system “raw” database as a complete record of all values collected from the station. Instrument calibration values derived from site by either LSOs or ESUs are stored in the data management system calibration files and the raw values are automatically scaled by application of the calibration factors present in the system. Automatic screening algorithms (specifically designed macros and a range of tailored scripts for manual data interrogation) are employed to validate the scaled data.

The scaled data are automatically compiled into the prescribed format consistent with the Department’s air quality bulletin system and automatically emailed to the Air Quality Communication Unit (AQCU) and the Air Quality Forecasting Unit (AQFU) by 25 minutes past the hour; the data files are received by both units one minute later. Thus, within a period of 30 minutes past each hour the data are collected, scaled, compiled, issued to and received by the AQC and AQF Units as provisional data. Upon completion of any required editing the revised values are automatically sent to both units in the next hourly cycle to over-write those previously sent.

7.3 Dissemination of Provisional Data

Data from the AURN are marked as ‘provisional’ or ‘ratified’ depending on what stage they are at in the process of ratification. When data are first collected from the analyser on site, they are scaled with calibration data from the last calibration. In many cases, this will produce satisfactory data, with problems only arising if the instrument is unstable or drifting rapidly. The data are then automatically screened using computer algorithms to highlight suspect data, but no data are deleted at this stage. This process occurs in real time and all data that are not flagged as suspect are sent to the Air Quality Information Archive (www.airquality.co.uk) within about 1 hour of being collected. Data sent to the archive at this stage are marked as provisional. These data are also available – on an hourly basis - on air quality websites operated by the UK Devolved Administrations and on teletext and freephone service. In addition, daily e-mail bulletins of AURN monitoring data are provided to over 150 media organisations and other network stakeholders - including the BBC and BSkyB, national and regional radio and newspapers and other scientists and journalists.

All of the provisional data, together with all the identified suspect data, then undergo full ratification, as described in Chapter 8 in 3-month blocks. As part of the ratification process, the suspect data may be reinstated if deemed to be genuine. Following the ratification process, the fully ratified dataset are re-

sent to the Air Quality Archive (in 3-monthly blocks, 3 months in arrears) and the provisional data are overwritten with the ratified data.

However, as the data are improved via the ratification process, they are automatically fed through to the UK Air Quality Archive. This ensures that the provisional data available on the Archive website always reflect the most up-to-date, highest quality data available. Initial polled data are maintained by CMCU through its initial polling software and are maintained as an historical record of air quality data.

The fully ratified data from the AURN are reported to the Commission annually. In future, it is likely that more provisional data will also be supplied to the Commission on a near real time basis. Currently provisional ozone data are also supplied on a daily basis to the EU Ozone website - http://www.eea.europa.eu/maps/ozone/map . The EU website system is likely to be extended and additional pollutants, particularly NO_2 and PM_{10}, are proposed for inclusion.

8 Ongoing QA/QC

The AURN generates over 9 million hourly measurements each year. All measurements, whether from automatic or manual samplers, are subject to a rigorous procedure of validation and ratification before they are published as ratified on the national Air Quality Archive.

The purpose of the QAQC Unit is to ensure that the AURN data are:

- Genuinely representative of ambient concentrations existing in the various areas under investigation
- Sufficiently accurate and precise to meet specified monitoring objectives
- Comparable and reproducible. Results must be internally consistent and comparable with international or other accepted standards, if these exist
- Consistent over time. This is particularly important if long-term trend analysis of the data is to be undertaken
- Representative over the period of measurement; for most purposes, a yearly data capture rate of not less than 90% is usually required for determining compliance with EU Limit Values
- Consistent with the Data Quality Objectives and methodology guidance defined in EU Directive for relevant pollutants and measurement techniques.

In order to produce data that are correct, meaningful and useful, the measurement techniques utilised and data handling must have a sound scientific basis. The data must be both accurate and precise.

Accuracy refers to the agreement between a measurement and the true value. It allows us to have confidence that the concentration measured is correct. In turn, this allows us to compare data over time, at different UK locations, or internationally.

Precision refers to the repeatability of measurement. A precise instrument will always give the same result if the same measurement is repeated. An imprecise instrument will show some variability in the same situation.

In order for the AURN data to meet the conditions listed above, the QAQC Unit employs a variety of quality procedures, which are described in more detail in the following pages.

8.1 Local Site Operator (LSO) calibrations

Local Site Operators (LSOs) are employed in the UK to undertake routine tasks at AURN monitoring stations to ensure that the data output is uninterrupted and of the highest possible quality. The actions of the LSO therefore affect both data quality and data capture, hence LSOs are carefully selected by an evaluation board through a round of competitive tendering undertaken by CMCU based on their expertise, experience and understanding of the AURN and the importance of data quality. Full formal training is provided for LSOs every two years, with supplementary training on request, at scheduled site audits (by the QAQC Unit) and also at the AURN Annual Review Meeting, which all LSOs are contractually required to attend.

The key responsibilities of the LSO are to:

- Carry out routine operation and calibration procedures for the equipment at the site, in conformance with the LSO manual
- Identify and report potential problems and changes to the site and surrounding area
- Identify and report potential safety issues at the site
- Undertake simple tests and repairs to the site and/or equipment as directed by CMCU
- Attend training (both formal and informal) as requested by CMCU and/or QA/QA Unit
- Attend QA/QC site audits as requested
- Liaise with other AURN stakeholders as requested by CMCU
- Carry out all activities with regard to relevant health and safety standards
- Complete the electronic calibration sheets, checklists and site servicing records in full and email to CMCU and QA/QC within 24 hours of each site visit
- Return exposed filter magazines to CMCU within 48 hours of each site visit where appropriate
- Return exposed TEOM filters to CMCU for archiving

- Undertake other reasonable requests as directed by CMCU during a pollution episode or other emergency
- Attend Annual Review meetings
- Use their experience of air pollution monitoring to identify and report any faults or potential faults as soon as possible
- Provide information on local activities that may affect the pollution climate at the station.

These responsibilities are carried out during routine visits (every 2 or 4 weeks depending on the monitoring equipment at each site) and additional emergency call outs.

Local Site Operator Manual[10]

A comprehensive operations manual for the AURN has been produced and disseminated to all site operators. This is a key QA/QC tool, serving to harmonise field procedures and improve the quality of the data produced by the monitoring equipment through accurate calibration and optimised operation. The LSO manual is available both in hardcopy form and electronically. The manual has recently been revised following the recent changes in the network monitoring equipment. The new version was published in 2009 and is available on the Air Quality Archive website (www.airquality.co.uk).

Training is also provided to any new Local Site Operators (LSOs) and training updates are available to all LSOs during at the twice-yearly site visits by the QAQC Unit.

Local Site Operators all attend an annual meeting to receive information on the operation of the network, to enable them to provide feedback or to raise any issues and, to receive additional training on specific aspects of their duties.

Local Site Operator Support

Both the CMCU and QA/QC Unit have a dedicated telephone line and email address which is used by LSOs to access specialist knowledge and advice regarding the AURN sites and equipment. There is also a password protected AURN website which provides useful information and contact details for LSOs.

8.2 Equipment Service Units (ESU) service and repair

Equipment Support Units (ESUs) are responsible for the routine and emergency maintenance and repair of the monitoring and ancillary equipment at each AURN site and are directly appointed by CMCU through following a round of competitive tendering. The ESUs are key to ensuring that the AURN data capture target of 90% is reached each year for every pollutant at every site.

Routine servicing is carried out on a 6-monthly basis and is coordinated with the audit visits of the QAQC Unit (see Section 8.4) to ensure that the necessary instrument parameters and calibrations are recorded to allow full data ratification. Minimum requirements for routine instrument maintenance, testing and calibration are provided to ESUs. All routine service visits are fully documented and completed in accordance with procedures provided by the QA/QC Unit.

In the event of an instrument malfunction, the ESU attends the site to carry out emergency repairs or fit a replacement analyser within 48 hours of notification of the problem as highlighted by CMCU. Telemetry facilities and automated data checking now also allow for rapid recognition of possible instrument malfunctions and CMCU typically use this information to inform the relevant ESU of the likely cause of malfunction.

8.3 Network inter-calibration and site audits

Within the UK, there has been a system of routine site audit and network inter-calibration, involving all network sites, for many years. The primary aims and objectives of the site audit and network inter-comparison exercise can be summarised as follows:

- Check and evaluate a wide range of analyser key functions via a comprehensive set of tests and calibrations - well beyond those that can be checked by routine LSO calibrations
- Check all on-site calibration standards against common transfer standards that are directly traceable to the AEA Gas Standards Calibration Laboratory and national metrology standards.

This network inter-calibration is undertaken by the QA/QC Unit at six-monthly intervals and includes every site and every analyser in the network. The inter-calibration therefore provides detailed and quantified information on overall network performance.

Many of the site audit and network inter-calibration procedures used in the UK have now been incorporated into the on-going QA/QC procedures detailed in the CEN Standard Methods. However, in some cases the CEN methods differ in detail or are even more exacting than previous requirements and hence, procedures used in the UK are currently being adapted to be fully compliant with the CEN requirements.

The UK Inter-calibration Procedures

The current exercises provide the following information:

- Evaluation of the concentration of site calibration cylinders, using a set of certified cylinders (transfer standards) that are taken to all the sites. The concentrations of the site cylinders are used to scale pollution datasets, so it is important to check that the concentration of gases in the cylinders remain stable over time
- Analyser accuracy and precision, using a series of calibrated gas standards, to ensure reliable datasets from the analysers
- Calibration of ozone analysers with a UKAS certified ozone photometer
- 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
- 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, to ensure reliable operation. This is the device that allows the measurement of NO_2 to be undertaken, so it must work correctly
- TEOM k_o evaluation. The analyser uses this factor to calculate mass concentrations, so the value is calculated to determine its accuracy
- Particulate analyser flow rate checks, to ensure that the flow rates through critical parts of the analyser are within specified limits
- Site infrastructure and environment checks to ensure that metadata on the station remains accurate and up to date and that any site safety issues are noted for action.

As noted above, these tests performed on site are now undertaken to the exacting requirements of CEN Standard Methods and hence are fully compliant with the Air Quality Directive. AEA is also accredited by the United Kingdom Accreditation Service (UKAS), (Calibration Laboratory Number 0401), under BS EN17025 to perform these tests.

Accreditation to BS EN17025 requires:

1. Documented procedures to calibrate analysers
2. Demonstration of competence of operators in performing calibrations
3. Demonstration of traceability of measurements to metrology standards
4. Calculation of uncertainty budgets for measurements reported on Calibration Certificates.

Results and information from the Site Audit and Network Inter-calibration

The site audit and inter-calibration results provide vital information for the data ratification process. For example if calibration cylinder concentrations or ozone monitor calibration concentrations are identified to have changed at any site then the information from the audit and inter-calibration is used to ensure that the data are correctly rescaled during the ratification process. Also, if faults such as poor converter efficiencies for NOx analysers are identified then the data are corrected or deleted in line with the CEN requirements.

8.4 Data ratification

Data validation is followed by more thorough checking at three-month intervals to ensure that the data are reliable and consistent. This latter process is called data "ratification".

The first step is to go back to the "raw" unvalidated data from the analyser - this allows traceability of all operations on the data within the ratification process to be maintained. The data have already been scaled in near real-time by the CMCU in order to provide the validated provisional data. However, for validation only the latest calibration results are available for data scaling. Re-scaling the data at the start of the ratification process allows any new information gathered over the full 3-month period to be incorporated right at the start of the process.

The "raw" data are scaled into ambient concentrations by removing any baseline zero and multiplying by the scaling factor (sensitivity). This is can be expressed mathematically as follows.

c = F x (V – Z)
where:

c = the ambient concentration (ppb)
F = the instrument sensitivity (ppb / mV)
V = the instrument measurement (mV)
Z = the instrument zero baseline (mV)

The instrument sensitivity (F) is calculated during calibrations as follows:
F = C / (S – Z)
where:

F = the instrument sensitivity (ppb / mV)
C = the concentration of the calibration standard (ppb)
S = the instrument response to the calibration standard (mV)
Z = the instrument response to the calibration zero standard (mV)

Identical formulae are used where the ambient measurements are expressed in ppm units and where the instrument records data in units other than mV: e.g. V or nominal ppb.

These scaling values (Z and F) are derived from a range of instrument calibrations:

- Routine manual LSO calibrations
- Automatic analyser calibrations
- ESU calibrations at services or repair visits
- QA/QV Unit inter-calibrations.

These are brought together in a time-series plot called a Calibration Control Chart. Figures 8.1 and 8.2 show the two charts relevant to SO_2 instruments. Understanding how calibrations are used by the QA/QC unit is key to ratifying data from the gaseous instruments and this is discussed in the following sections.

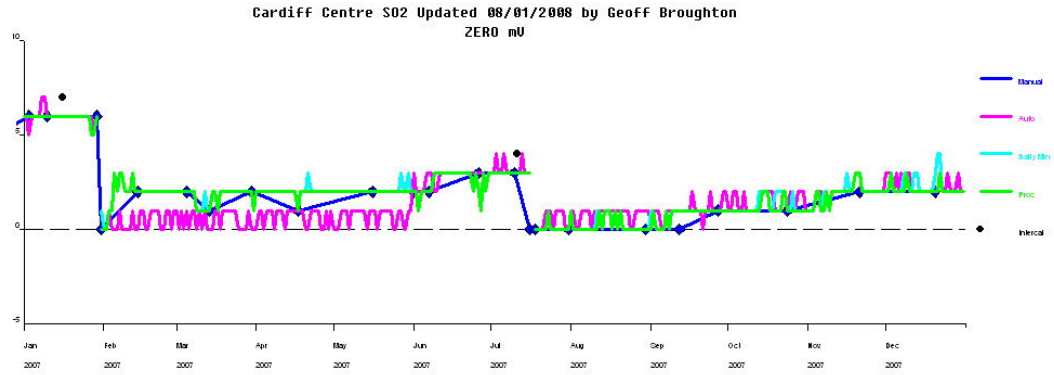

Figure 8.1. Calibration Control Charts for SO_2 Analyser Zero Baseline.

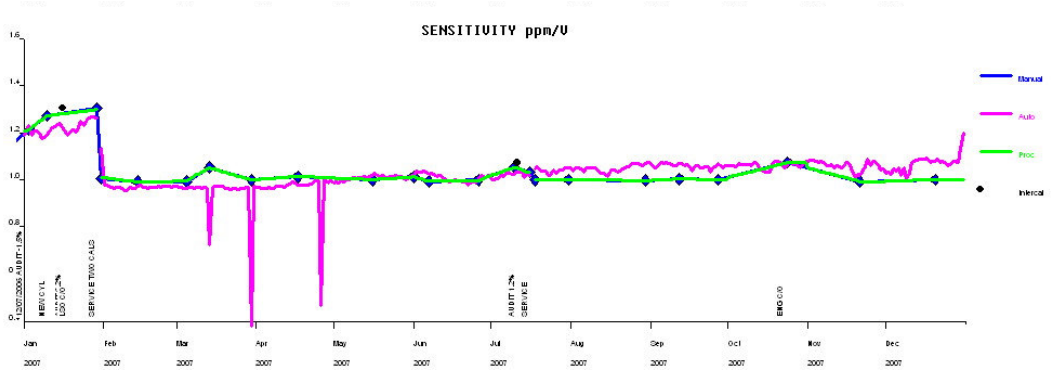

Figure 8.2. Calibration Control Charts for SO_2 Analyser Sensitivities.

Analyser Zero Baseline

The instrument zero baseline is generally measured every night during the auto-calibration cycle. These values are shown in pink in Figure 8.1. However, this auto calibration checks only analyser performance, but is not an absolute calibration. Often, the scrubbing material within the auto-calibration system is spent and hence this estimate becomes unreliable or, the relevant equipment may not be present on-site. However, this auto-calibration zero is just one estimate of the baseline.

LSOs and ESUs also perform zero baseline measurements (shown in blue) and these may also be used to estimate the measurement zero point. However, these can occasionally be unreliable for various reasons. The QA/QC Unit also provides a zero baseline measurement during the inter-calibration exercises (show as a black spot).

If necessary a zero baseline can also be estimated from the lowest ambient measurement, since concentration levels are often very low for some pollutants at certain times during a month.

Deciding on the most appropriate zero baseline must account for all these sources of information and is a difficult yet vital task since the choice will effect the reported concentrations. The baseline that was finally applied to the data (shown in green) was based on the real measurements (auto-calibration, LSO, ESU and Field Team) but required the judgement of the Data Ratifier using software algorithms developed over many years of experience.

Instrument Sensitivity

A similar decision is required for the instrument sensitivity shown in Figure 8.2. This is estimated from calibrations by certified calibration gas sources such as the SO_2 cylinders (shown in blue) used by the LSOs and ESUs. The overnight auto-calibration equipment may produce a sensitivity based on SO_2 permeation tubes or uncertified SO_2 cylinders (shown in pink). There will also be span calibrations made by the QA/QC unit during the network inter-calibration (shown as a black spot). Some of these

estimates may be unreliable due to equipment failure or the use of non-certified gases. The judgement of the Data Ratifier, aided by the software algorithms, is therefore required to decide what sensitivity should be applied (shown in green).

Instrument Drift

Besides deciding the best zero baseline and instrument sensitivity, the data ratification must also take account of any analyser drift in either zero or sensitivity. Zero and sensitivity may vary day-by-day but a rapid drift may be the sign of an instrument malfunction. Data ratification must evaluate where data can be accepted, accepted with modification or has to be deleted.

Instrument failure

Instruments may fail for numerous reasons. The equipment is serviced at the regular six-monthly ESU visits but malfunctions can arise between services. Some faults are minor, such as sample flows just below optimum but flow blockages can prevent the instrument from sampling ambient air. Ratification uses all available information: raw measurements, calibrations, alarms, engineer reports etc, to decide if the data can be corrected or needs to be rejected. The commencement of any fault must be determined. This is often a matter of judgement based on experience. In some instances these cases have to be referred to the Quality Circle for consideration by senior staff, including the instrument specialists in the Field Team.

Example of data ratification

Figure 8.4 presents a time series of 15minute SO_2 data as raw millivolts from an urban site which shows a large zero baseline offset and step changes in concentration following calibration visits. By applying the appropriate zero offset and calibration factor, reliable concentration data can be obtained (Figure 8.5).

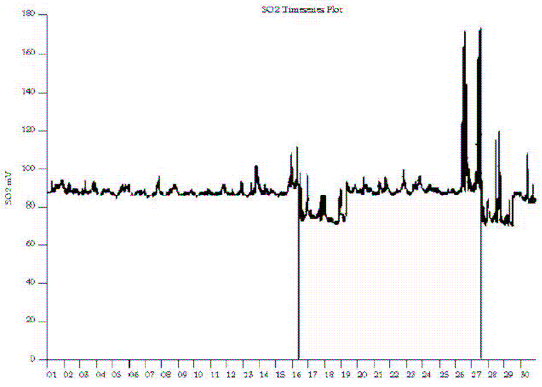

Figure 8.4 "Raw" data

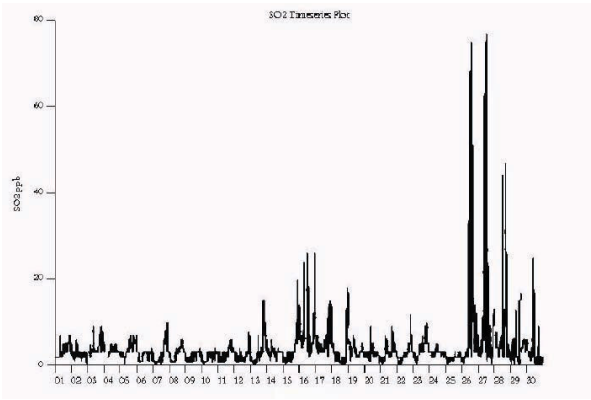

Figure 8.5 Ratified data

NO_x data processing

This is by far the most difficult gaseous pollutant to ratify but, one of the most important. The instruments used to measure NO_2, NO and NO_x use the chemiluminescent technique. These instruments can only measure NO gas by reaction with an internally generated ozone source. The instrument, therefore, splits the ambient sample into two. NO is measured in one stream. The second stream passes through a catalyst that converts any NO_2 into NO. This stream, known as NO_x, is then measured. The NO_2 is therefore the difference between the NO_x from the second stream and the NO from the first.

The efficiency of the converter is therefore crucial to correct determination of NO_2. The converted efficiency is determined at each inter-calibration visit and where this is less than the required 95%, data are rejected as they are likely to fall below the required Data Quality Objective.

When the CEN procedures are fully implemented, there will be a requirement to correct data for converters with efficiency between 95 and 100%.

To achieve reliable NO_2 concentrations, the NO and NO_x channels are ratified separately and then NO_2 calculated by subtraction. This is a more reliable and flexible system than relying on the internal calculation of NO_2 within the analyser.

Calculations must be undertaken in mole fraction units (ppb) and the conversion to mass concentration units undertaken separately. This allows NO_x concentrations to be reported correctly in the units required by the EU Directive (μgm^{-3} as NO_2)

TEOM FDMS PM_{10} or $PM_{2.}$data processing

The TEOM FDMS instruments introduce two new pollutants to ratify: volatile and non-volatile particulate matter. These parameters are used to calculate the PM_{10} or $PM_{2.5}$ depending on the type of instrument. The volatile purge concentration is measured during the Purge cycle of the instrument while the non-volatile is recorded during the Base cycle. The Purge cycle measures the volatile particulates by evaporation from the filter and the instrument, therefore, records a negative purge concentration. Negative purge concentrations are simply a function of instrument technique, what is really required is the concentration of the volatile component. Hence, we therefore multiply the negative purge concentration by – 1 to obtain a positive volatile concentration. The terms Base and Purge are not used on the UK Air Quality Archive: the terms non-volatile and volatile are used instead for better understanding by the public.

Since gravimetric equivalent PM_{10} is the sum of the volatile PM_{10} and non-volatile PM_{10} concentrations, the data processing and reporting of these three concentrations are linked. A PM_{10} concentration can only be reported if valid volatile and non-volatile measurements were made. Similarly, if the PM_{10} is judged to be unreliable (e.g. excessive noise), then both the volatile and non-volatile are deleted.

Figure 8.6 shows PM_{10} concentrations at Swansea Roadside together with the non-volatile and volatile components and has several interesting features:

- The volatile concentrations during this period were low so the PM_{10} is only slightly greater than the non-volatile concentration.
- Unfortunately, all air quality instruments are affected by noise. This noise becomes more apparent as the sensitivity is increased to detect the lower concentrations. The FDMS instrument during this period produced several periods where negative volatile concentrations were recorded. There was also a brief period on the 3rd December where the non-volatile was also recorded as a negative concentration.
- There was a long period on the 30th October where the volatile concentrations were negative. This was the day after the LSO's routine visit when the FDMS filter was changed however the same effect was not observed after the two LSO visits in November. The FDMS instruments are sometimes prone to instability after a filter change but this is not always the case. (Note that the QA/QC unit has work closely with the FDMS supplier to develop upgraded filter changing procedures to reduce these problems).

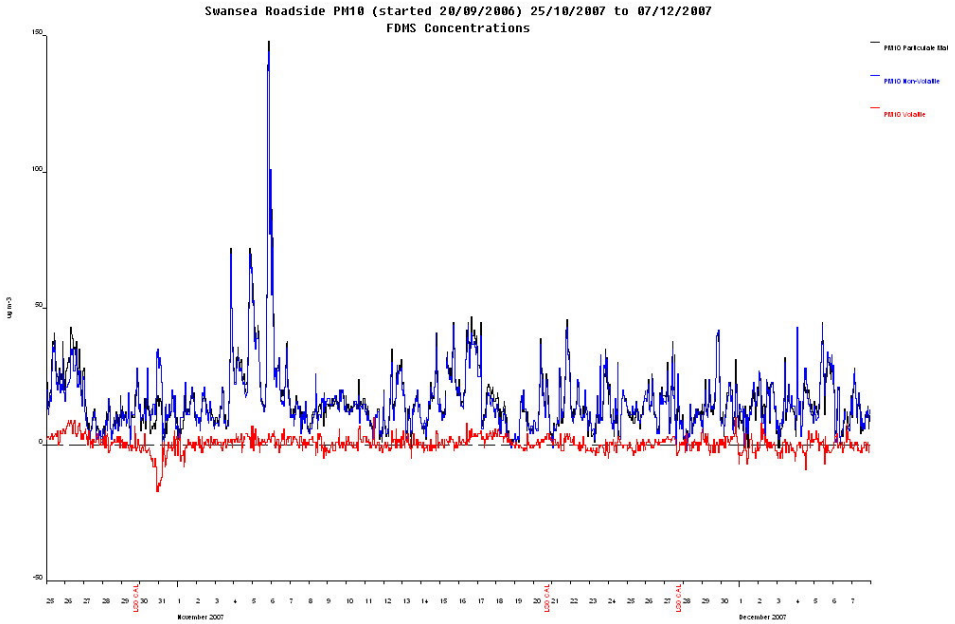

Figure 8.6. Time-series of PM_{10}, non-volatile PM_{10} and volatile PM_{10}

For correct operation, the FDMS instruments must operate within certain temperature and humidity tolerances. Hence, the ratification process also closely inspects these data. An example is shown in Figure 8.7 where the ambient temperature, internal dew point and the external dew point are plotted. There must always be at least 4°C separation between the two dew points to prevent condensation on the filter. In this case, the instrument is operating correctly.

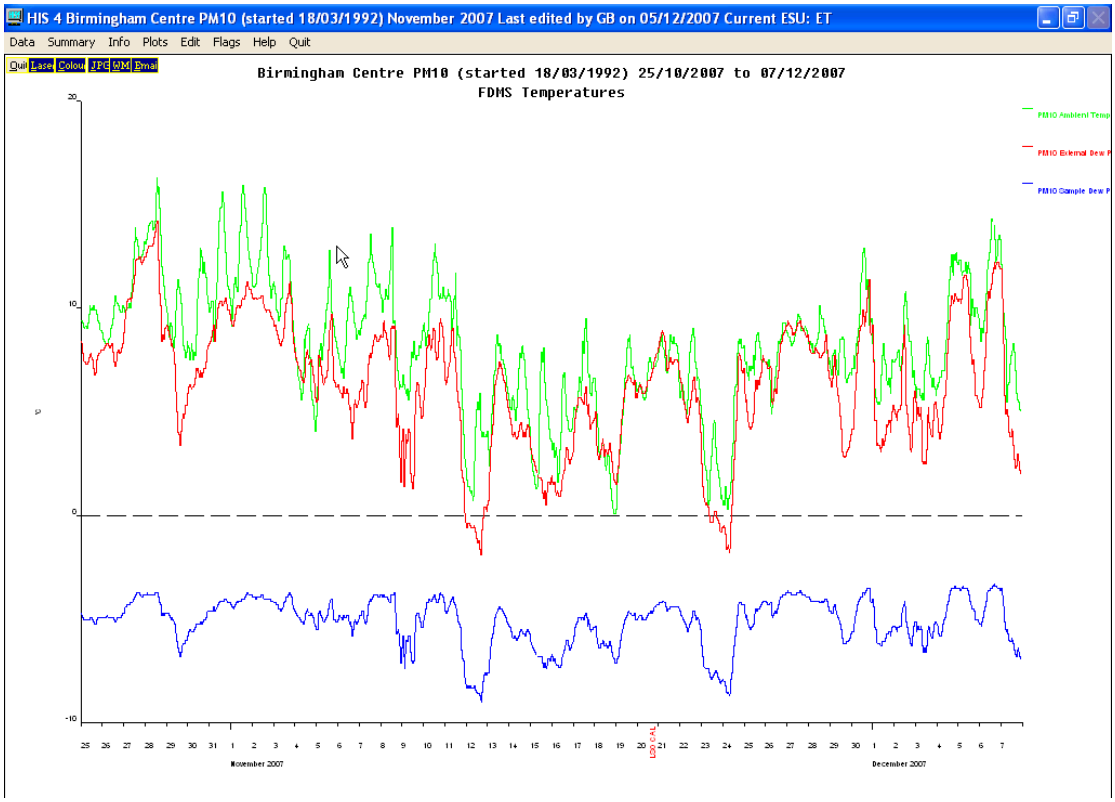

Figure 8.7. Temperature Time-series for an FDMS instrument

Non-Automatic Particle Monitor data processing and Ratification

Non-automatic PM_{10} and $PM_{2.5}$ daily mean measurements are collected manually by the CMCU and emailed monthly to QA/QC in Excel spreadsheets.

Instrument alarms and warnings (due to instrument flow outliers for example) are examined by the Data Ratifier to decide if the daily mean is valid or not.

As with other pollutants, account is taken of any measurements at nearby sites or from other instruments at the site in question in order to determine if there are any anomalies with the dataset (this applies to automatic as well as non-automatic pollutant monitoring).

Non-routine or unusual events

Ratification also has to deal with all of the "unusual" incidents that inevitably occur from time to time in a large network such as the AURN. Numerous tools and process have been developed, and continue to be developed, over time to deal with these issues.

As well as detailed data manipulation, the Data Ratifier needs also to maintain a broad overview of the data be sure that unnoticed faults do not affect data uncertainty.

The tools and techniques developed to assist in this process include a range of plotting and analysis tools. Basic examples of these include plots of all pollutants at a site to check if the expected correlations and anticorrelations are present. For example, PM_{10}, NOx and CO often track closely but ozone and NO_2 are generally anticorrelated. However, these correlations do not always occur – for example during a transboundary Saharan dust event, when PM_{10} may be elevated, but not other pollutants. A check of these events can be undertaken by plots of the same pollutant at a range of nearby sites. Examples of these plots are shown in Figures 8.8 and 8.9.

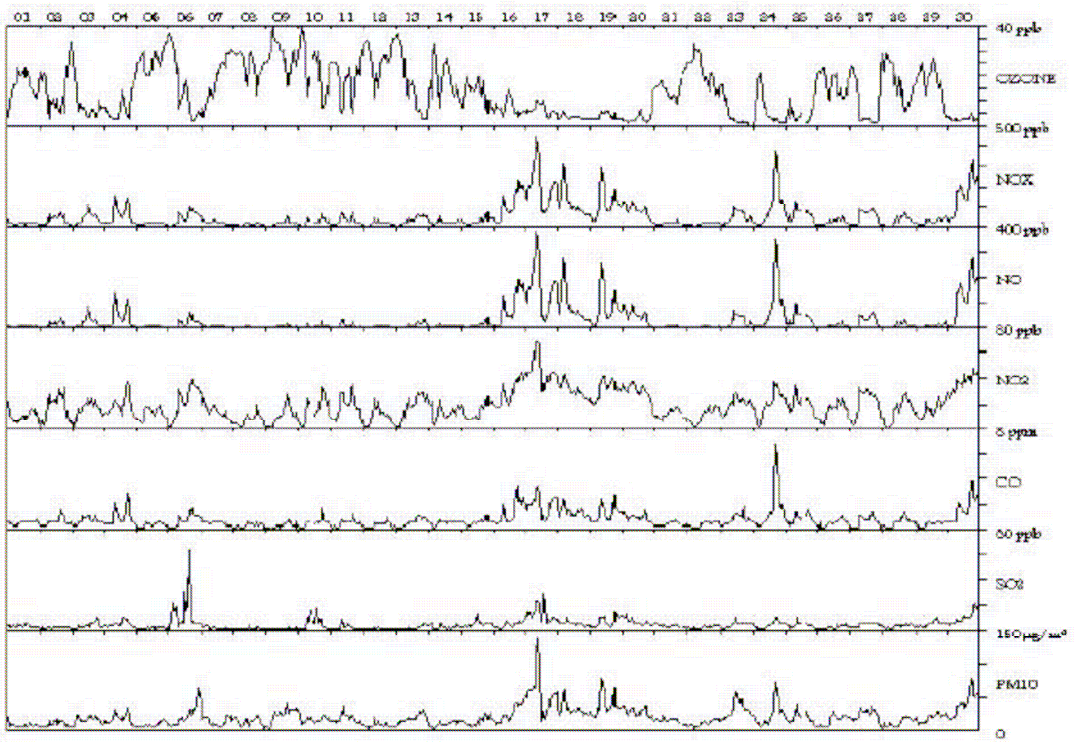

Figure 8.8 – Pollutants measured at an urban centre site; illustration of comparing patterns for different pollutants at the same site.

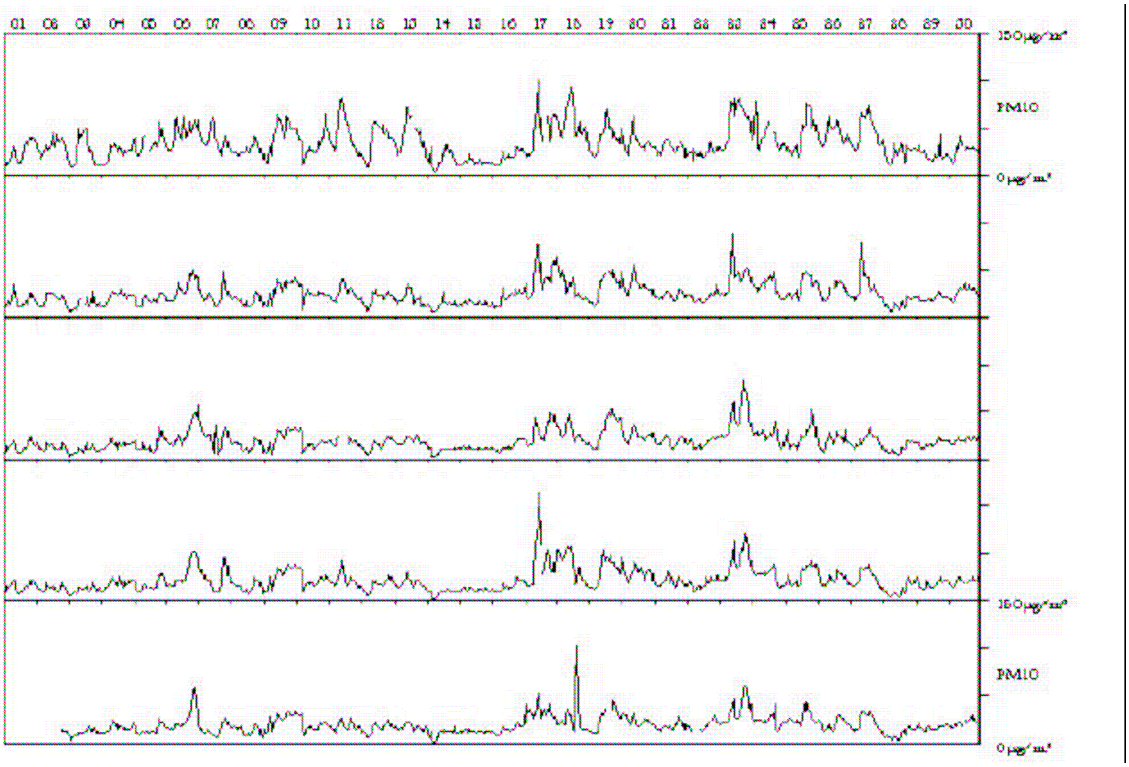

Figure 8.9 PM_{10} measurements at a range of automatic sites; illustration of comparing patterns for a given pollutant at several sites in the same region.

Data ratification procedures involve a critical review of all available information relating to a particular data set, in order to verify, amend or reject the data. A wide range of inputs need to be considered in the ratification process:

Instrument history and characteristics.	Has the equipment malfunctioned in this way before?
Calibration factors and drift.	Rapid or excessive response drift can make data questionable.
Negative or out of-range data.	Are the data correctly scaled?
Rapid excursions or "spikes".	Are such sudden changes in pollution concentrations likely?
Characteristics of the monitoring site.	Is the station near a local pollution sink or source which could give rise to these results?
Effects of meteorology.	Are such measurements likely under these weather conditions?
Time of day and year.	Are such readings likely at this time of day/week/year?
The relationship between different pollutants.	Some pollutant concentrations may rise and fall together (Figure 8.8)
Results from other sites in the network.	These may indicate whether observations made at a particular site are exceptional or questionable. Data from national network or other sites in the area can be compared for a given period to determine if measurements from a particular station are consistent with general pollution concentrations. If any high concentrations are identified (seen as spikes) at the local site, further examination is required. Figure 8.9 shows a comparison of PM_{10} concentrations measured at several sites in one region of the UK. The plots show that the pollution profile is generally consistent but occasional peaks are site specific.
QA Audit and Service reports	These will highlight any instrumental problems and determine if any correction of the data is necessary for long-term drift etc

The overall aim of the ratification process is to ensure that

- the final ratified dataset contains only valid data
- in the period between site audits, these data remain with the uncertainty level determined at the audit.

The close examination of analyser calibration service history, along with the overview procedures described above ensure that only valid data are retained.

The actual data uncertainty can only be determined at the 6-monthly site audits when all of the required parameters are measured and can be combined with analyser type testing and calibration cylinder uncertainties. The careful application of zero and span calibration data, and careful application of any corrections required as a result of the sites audit (e.g. to account for changing calibration cylinder concentrations) are designed to ensure that the data remain within the uncertainty level determined at the audit.

8.5 Quality Circle

The QA/QC Unit uses a Quality Circle approach for final review of the data. The Quality Circle comprises representation from all disciplines of the QA/QC unit: quality standards, inter-calibration team and data ratification. The meeting reviews any significant problems and decides on the appropriate actions by consensus. Data issues that are not clear to the ratification team may, for instance, be resolved by the inter-calibration manager's better understanding of the instrument detection principle. Since some decisions are derived by consensus, and the exact actions cannot be predicted from the observed data and hence, this expert judgement cannot be replaced by an automated system or written procedure.

The meeting also discusses the results of the QA/QC inter-calibration. The meeting then needs to decide if, and how, any problems observed at the inter-calibration affect the measured data.

The Quality Circle always needs to review data in the light of new information, whether this comes from the inter-calibration exercise or from other sources. Ratified data only rarely need to be revised and re-issued, though this does happen very occasionally. Where a possible fault is suspected but the results of the inter-calibration or other detailed investigations are still awaited then the data may remain as provisional on the Archive until these investigations are completed. Again this only happens infrequently.

A key role of the Quality Circle is to identify where improvements in the overall quality system can be devised. This may be through improved equipment, improved procedures, improved software or software algorithms etc. When such points are identified they are actioned by the QA/QC unit to ensure continuous improvement in the quality system.

8.6 Links to Research Groups and Research Networks

To ensure that the AURN produces the highest quality data, it is important that the QA/QC Unit is active within the field of air quality research, and is fully informed and up to date with developments concerning measurement techniques. To this end, the QA/QC Unit is represented on relevant CEN TC264 working groups. Within the UK air quality community, AEA is also active in the following Government Research Groups and fora:

Air Quality Expert Group
The Air Quality Expert Group (AQEG) is an advisory group that provides independent scientific advice on air quality, in particular the air pollutants contained in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland and those covered by the EU Directives on ambient air quality. AQEG reports to the Secretary of State for Environment, Food and Rural Affairs, Scottish Ministers, the National Assembly for Wales and the Department of the Environment in Northern Ireland.

Expert Panel on Air Quality Standards and Committee on the Medical Effects of Air Pollution

The Expert Panel on Air Quality Standards (EPAQS) was set up in 1991 to provide independent advice on air quality issues, in particular the levels of pollution at which no or minimal health effects are likely to occur. Following an independent review, EPAQS is to be merged with the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP). COMEAP is an Advisory Committee of independent experts that provides advice to Government Departments and Agencies on all matters concerning the potential toxicity and effects upon health of air pollutants.

AQUILA
The European Association of National Air Quality Reference Laboratories (AQUILA) act as a forum for providing technical expertise to the Commission, providing a means of exchange of technical expertise between all Member State Reference Laboratories, in order to improve their knowledge, enhance monitoring methods, improve the accuracy of the results, and harmonise quality-assurance and quality-control practices, across Europe. AQUILA reviews international and national inter-comparison exercises and standardisation activities in the field of ambient air-quality measurements.

EMEP
The European Monitoring and Evaluation Programme (EMEP) is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution for international co-operation to solve transboundary air pollution problems. The EMEP programme is carried out in collaboration with a broad network of scientists and national experts that contribute to the systematic collection, analysis and reporting of emission data, measurement data and integrated assessment results.

8.7 AEA Quality Systems

As the QA/QC Unit at the time of writing this report, AEA operates Quality and Environmental Management Systems that are defined in AEA Group policies and supporting procedures. These arrangements have been assessed by Lloyds Register Quality Assurance against the requirements of the BS EN ISO 9001:2000 and 14001:2004, and a certificate has been awarded, certificate number 0944198/A. Both project and senior management are responsible for ensuring that the procedures are applied and that the system is effective.

The quality of specific tasks is the responsibility of the individual doing that task at each level in the organisation. It is the responsibility of everyone to apply the relevant procedures to ensure consistency of approach across AEA. Formally appointed Project Directors and Project Managers are responsible for ensuring that projects are undertaken in accordance with the current AEA Project Management processes and that the system is effective. The Project Manager is responsible for defining the quality arrangements for the specific project. The arrangements are defined in Project QA Programmes, Quality Plans, project procedures/ instructions and other project documentation as appropriate.

The quality requirements for AEA work are extended to sub-contractors by means of contract documentation. The relevant Project Manager approves, if necessary in conjunction with the local Quality Assurance Representative, quality documentation produced by sub-contractors as part of the procurement process for products or services.

AEA is committed to Continuous Improvement by engaging management, staff, customers and other stakeholders, and by setting and reviewing objectives for quality and business excellence. In addition AEA undertakes regular internal audits to ensure that standards are being maintained and to identify opportunities for improvement.

8.8 UKAS Accreditation (ISO17025)

In any monitoring network where traceability of measurements and compliance with Data Quality Objectives are critical, it is essential that the Quality Assurance and Quality Control procedures are accredited to recognised, traceable standards. By accrediting key processes in the QA/QC programme, we demonstrate compliance of the monitoring network to the requirements of the Directive. For network inter-calibration procedures, the QA/QC unit is required to hold UKAS accreditation to BS EN17025 for the on site calibration of gaseous analysers, determination of TEOM spring constant (k_0) and flow measurement of particulate analysers.

Accreditation to BS EN17025 requires one to:

- Document the procedures used to calibrate analysers
- Demonstrate competence of operators in performing calibrations
- Demonstrate traceability of measurements to metrology standards
- Calculate uncertainty budgets for measurements reported on Calibration Certificates.

UKAS is the recognised accreditation body in the UK and performs surveillance visits to AEA (the current AURN QA/QC Unit) annually to assess competence and compliance with all the requirements of ISO17025.

The Directive 2008/50/EC requires that the measurements are traceable in accordance with ISO 17025:2005. Chapter 9 of this report describes the traceability of the UK measurements within the AURN, in compliance with this requirement.

In addition, the Directive requires that laboratory taking part in Community-wide inter-comparisons covering pollutants regulated in the Directive is accredited according to EN/ISO 17025 (by 2010) for the reference methods referred to in Annex VI. The accreditation held by the QA/QC unit ensures compliance with this requirement.

The AEA Gas Standards Calibration Laboratory is also accredited to ISO 17025 (AEA Technology is UKAS Calibration Laboratory No 401, UKAS accreditation conforms to the requirements of ISO 17025) for the certification of gas calibration standards for a range of pollutant within a specified concentration range. This includes the gases and concentrations appropriate to the AURN.

The AEA schedule of UKAS accreditation is available at
http://www.ukas.org/calibration/lab_detail.asp?Lab_id=896&vMenuOption=3

9 Traceability of measurements

The scientific concepts and principles of traceability are discussed in detail in the AQUILA document[11] – "The European network of National Air Quality Reference Laboratories: Its Roles and Responsibilities." In this section, these concepts are summarised and an indication provided as to how these are realised within the UK AURN.

The EU requirements for measurement traceability are given in Section C of Annex i of Directive 2008/50/EC. This states:

- To ensure the accuracy of measurements and compliance with the data quality objectives, the appropriate competent authorities and bodies designated pursuant to Article 3 shall ensure that:
- All inter-comparison measurements undertaken in relation to the assessment of ambient air quality discussed in Articles 6 & 9 are traceable in accordance with EN ISO 17025 Section 5.6.2. And:
- The national laboratories appointed by the competent authority, designated within Article 3, that take part in Community-wide inter-comparisons covering the regulated air pollutants, are accredited according to EN ISO 17025 for the Reference Methods given in Annex VI of the Directive.

Traceability requires an unbroken chain of measurements all with stated uncertainties - from a primary international or national standard to the final measurement result. Each step in the measurement chain results in a slight increase in overall uncertainty. The traceability chain for the gaseous pollutants in the AURN is indicated in Figure 9.1. The "chain" is shown in red – from International standards to individual measurement sites. The check procedures adopted in the UK are also highlighted – and shown in green.

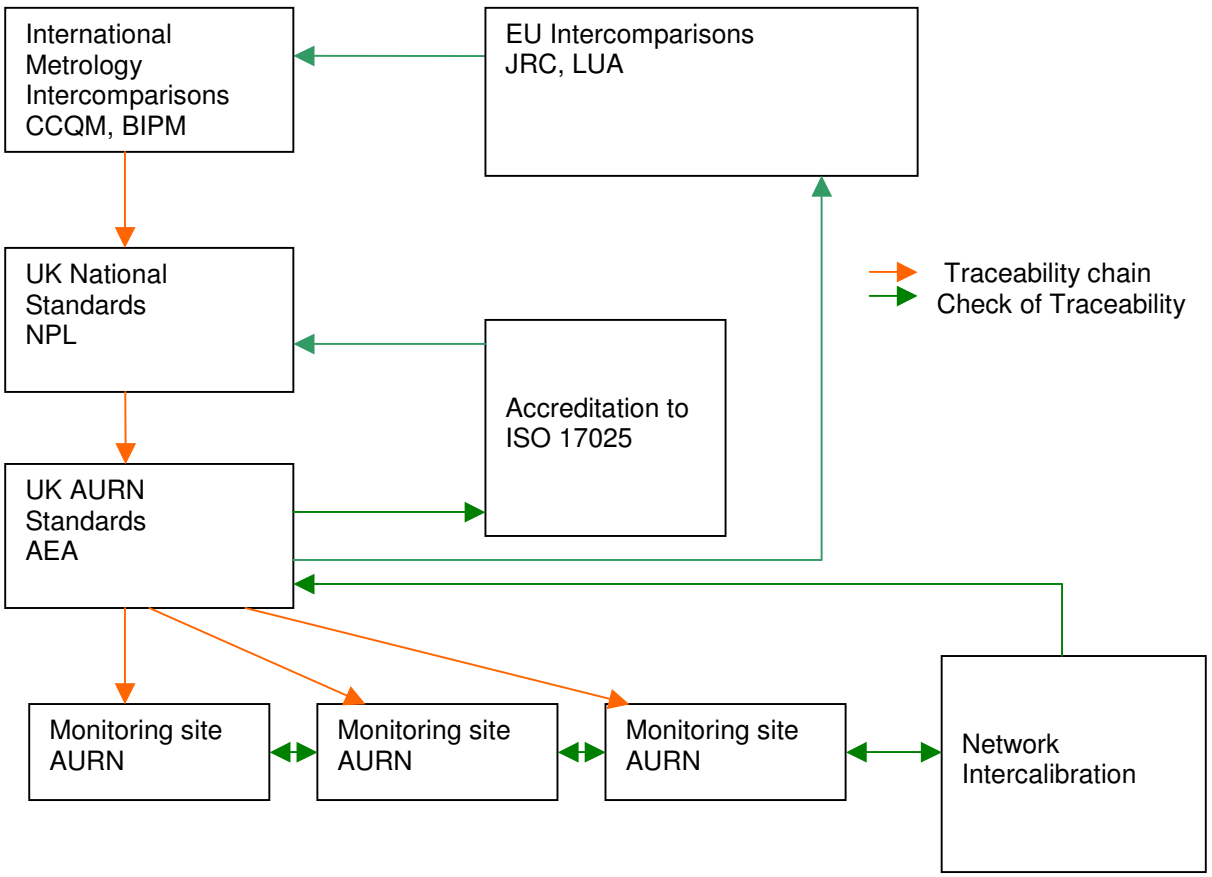

Figure 9.1 Traceability chain and traceability checks for UK AURN gaseous measurements

The methods by which calibration standards are developed and maintained at a national level fall into a number of different categories. These cover calibration standards that are:

1. Prepared in a manner that is traceable directly to SI units though mass, volume (length), flow (mass and time) etc. These apply to calibration standards for the pollutant gases measured within the AURN (NOx, SO_2, CO, Ozone), although there are different means of realizing and disseminating these, in particular between ozone and the other gases.

2. Not able to be produced in a manner that is directly traceable to SI units but traceability can be achieved by means of the realization of a potentially 'absolute' method such as optical photometry, when implemented under controlled conditions. This method applies for the measurement of metals and PAHs, for example, and is not utilised within the AURN.

3. Not able to be realized in a traceable manner, and not able to be realized as a 'primary' or 'absolute' method, but it is realized *by convention or by definition as the reference method*, preferably having the smallest measurement uncertainties achievable using that method. This method applies for PM_{10} and $PM_{2.5}$ measurements.

9.1 Traceability for NOx, SO_2, CO and zero air within the AURN

UK primary gas standards
UK Primary Gaseous Calibration standards are prepared by the UK National Physical Laboratory (NPL) using gravimetry to weigh specific pollutant gases together with relevant matrix/diluent gases into high-pressure cylinders and then, to dilute these gas mixtures to the required low concentrations for ambient air concentration calibrations, as required. An advantage is that these can be prepared for use at the low concentrations required for ambient air quality monitoring. A disadvantage is that the lower the concentrations prepared the more likely the gas standard is to be unstable for certain pollutant species. It is important to note, however, that comprehensive quality assurance and quality control procedures are undertaken within NPL to ensure valid standards are to be produced, though this becomes increasingly difficult at the low concentrations required for ambient calibrations. This method of preparation of gas standards is directly traceable to the SI mass unit, via a number of accurate weighings (gravimetry). Typical uncertainties of the UK primary gas calibration standards are as follows

- NOx 2%
- SO_2 3%
- CO 2%

These UK standards are cross-referenced with standards prepared by other national institutes through international inter-calibration exercise organised by organisations such as EUROMET[12]. Some example results for such an inter-national inter-comparison for nitric monoxide are given in Figure 9.2.

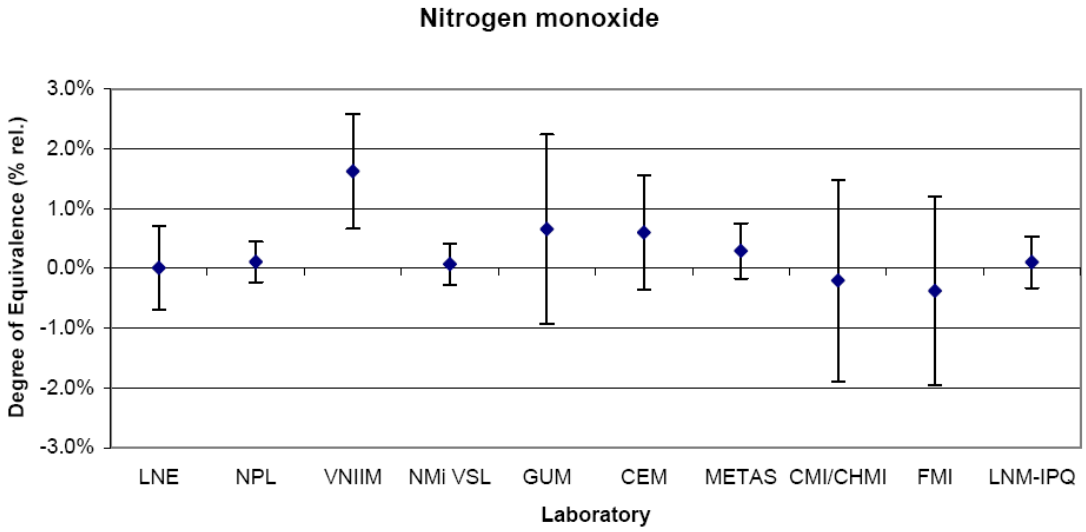

Figure 9.2 Results of an EOROMET NO inter-comparison[11]

Provision of traceable gas calibration standards to all monitoring sites in the AURN
All monitoring sites in the national network have calibration gas cylinders for NO, NO_2, CO, and SO_2, as appropriate, which remain at the site. These cylinders are prepared and supplied by Air Liquide but, prior to delivery to site they are calibrated at AEA Gas Standards Calibration Laboratory and provided with a United Kingdom Accreditation Service (UKAS) accredited certificate of calibration. (AEA Technology is UKAS Calibration Laboratory No 401, UKAS accreditation conforms to the requirements of ISO 17025).

The AEA Gas Standards Calibration Laboratory is furnished with a suite of UK primary gas calibration standards purchased from NPL. Using our UKAS accredited procedures, the calibration cylinders used at every site in the AURN are certified against these primary standards and provided with a ISO 17025 accredited certificate of calibration. Our schedule of UKAS accreditation is available at http://www.ukas.org/calibration/lab_detail.asp?Lab_id=896&vMenuOption=3. In this way, the traceability of the calibration gas used at every site is linked in an unbroken chain to national and international gas standards. The uncertainty of gas standards provided by the AEA Gas Standards Calibration Laboratory to the sites in the monitoring network is typically:

- NO 3-3.5%
- SO_2 3.5%
- CO 2%

AEA also undertakes international inter-comparisons at the EU Joint Research Centre (JRC, Ispra, Italy) to ensure the integrity of the gas standards used in the AURN. This is a requirement of both BS EN17025 and the EU Air Quality Directive in order to demonstrate comparability and traceability of measurements with similar organisations throughout Europe. Results from four recent European inter-comparison exercises for NO_2, CO, SO_2 and O_3 are summarised in Figure 9.3.

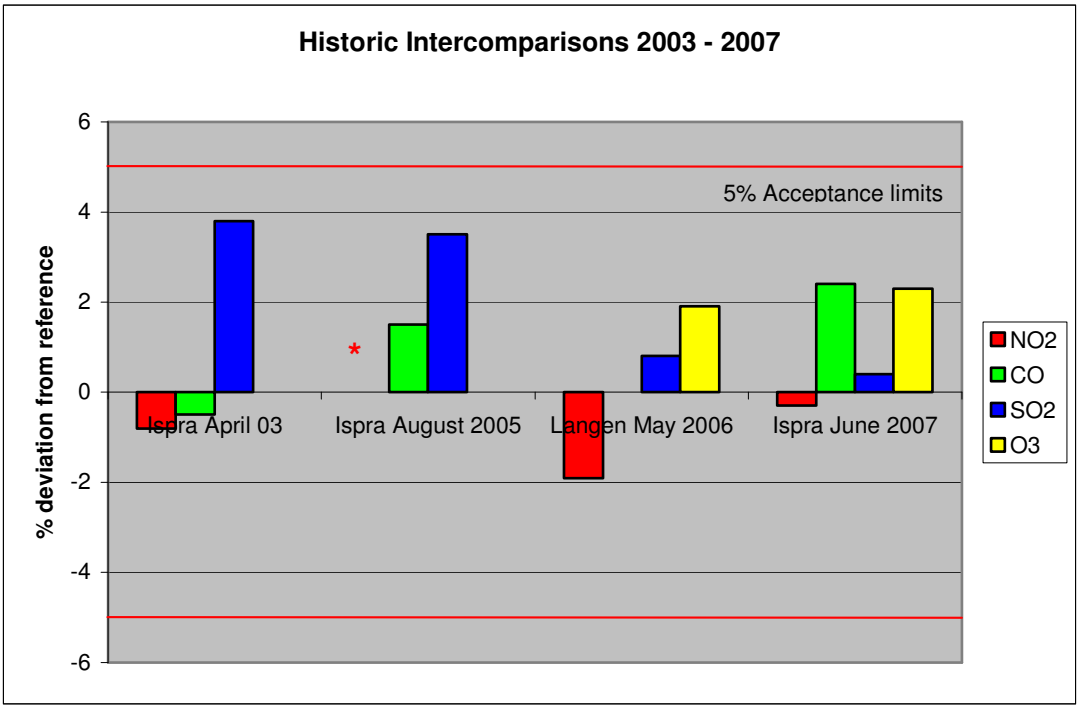

Figure 9.3. The results of International Inter-comparisons attended by QA/QC Unit

Figure 9.3 shows that all of the results fall within the required ±5% limit. (Due to a fault with the NOx instrument in August 2005, it was not possible to report inter-comparison results for this analyser.)

Zero air calibration standards
Increasingly, zero gas calibration standard cylinders are being deployed at AURN monitoring sites. As ambient concentrations approach ever-lower values the importance of the accuracy of the zero calibration increases. The zero air cylinders used in the AURN are traceable to a certified NPL zero air standard with the following specifications:

- NO 0.5 ppb
- SO_2 0.7 ppb
- CO 20 ppb

These zero gas cylinders are replacing chemical air scrubbers used previously in order to provide a more reliable and traceable basis for zero calibrations.

Site calibration and inter-calibration
The final link in the traceability chain from international gas standards to measurements of air quality at individual measurement sites is provided through the periodic calibration of the analysers with the certified cylinders at each site. At some sites automatic systems provide for daily or 3-daily calibrations. At other site 2-weekly or monthly manual calibrations are performed. (See Section 8.1).

In order to check the stability of the gas cylinders on site over a period of time, these are checked against recently certified cylinders as part of the 6-monthly site inter-calibration exercise (See Section 8.3). The procedure used is analogous to that used in the Gas Standards Calibration Laboratory, but the procedures in this case are not accredited. This is because the conditions for the calibration cannot be reliably controlled at a remote measurement site in the way that they are in the calibration laboratory.

Hence, our procedure is to check the site cylinder concentration and if this is shown to have deviated significantly from the certified value the cylinder is returned to the Cal Standards Calibration for recertification. If this recertification shows that the cylinder has in fact remained stable then the cylinder may be returned to the site for further use. However, if the cylinder concentration has changed significantly, the new concentration value is utilised as part of the process of data ratification for that site (See Section 8.4) and the cylinder is discarded.

9.2 Traceability for ozone within the AURN

Unlike stable gases such as CO, NO etc, ozone is too reactive to be prepared in gas cylinders. However, fortunately the uv absorption ozone photometer measuring device is an absolute method of monitoring which is governed by the Beer-Lambert law. Hence, the international ozone standard is realised as an ozone standard reference photometer (SRP).

The Bureau International des Poids et Mesures (BIPM) currently maintains three US National Institute of Standards and Technology (NIST) Standard Reference Photometers as ozone reference standards to underpin its international comparison programme. The BIPM and NIST are cooperating to transfer the international responsibility for the comparison of national ozone standards to the BIPM.

The BIPM organised inter-comparisons of ozone SPRs held by National metrological laboratories (NPL for the UK). Results from a recent BIPM inter-comparison are given in Figure 9.4. The figure shows the deviations from the BIPM reference at 80*nmol/mol* and the uncertainty budgets – which for the UK were less that 1%.

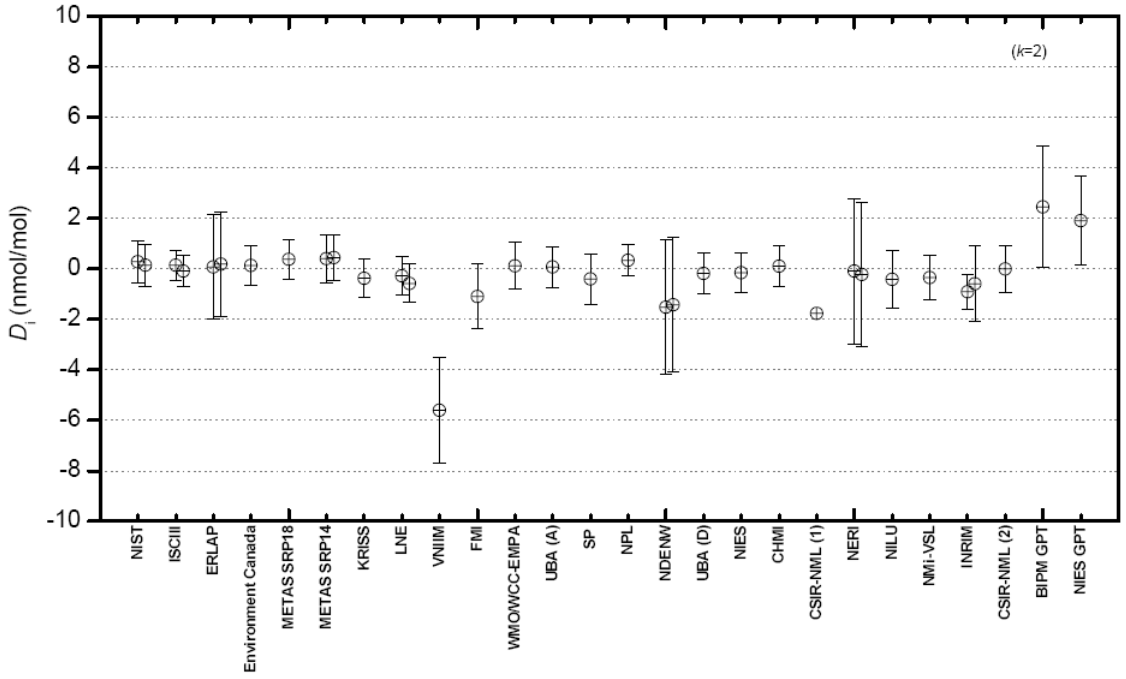

Figure 9.4 Example of inter-national ozone inter-comparison

Provision of traceable gas calibration standards to all ozone monitoring sites in the AURN
QA/QC Unit obtains calibration of their transfer reference photometers evey 6-months against the NPL UK reference photometer. This calibration is undertaken by NPL who provide UKAS accredited calibrations in the range 0 to 1 ppm with a ±3.0% relative uncertainty (at the 95% confidence level).

The AEA transfer reference photometers are commercial photometers certified to the UK standard as described above.

These photometers are taken to every site in the AURN every 6-months (every 3-months from 2010) to calibrate ozone analysers on site. The uncertainty of the calibration of on-site analysers is typically 3-4%. Hence, as for the other gaseous pollutants, there is an unbroken chain of traceability from the analysers on site to national and international ozone standards.

As an independent check, the QA/QC Unit also participates in EU network inter-calibrations for ozone, organised by the JRC Ispra. Recent results for ozone inter-comparison are shown in Figure 9.3. These show agreement of the AEA photometer with the JRC reference to with approximately 2%.

In addition, the QA/QC Unit also provides UKAS accredited calibrations of ESU photometers, to enable them to provide a traceable ozone analyser calibration as part of their routine service and maintenance of the analysers on-site.

9.3 Traceability for PM_{10} and $PM_{2.5}$ within the AURN

Manual methods for particulate monitoring of PM_{10} and $PM_{2.5}$, as specified in the European standards EN 12341 and EN 14907 respectively are defined as the European Reference methods for particle monitoring in EU Directive 2008/50/EC. These two standards specify methods that cannot be considered as traceable to the SI system of units, in a rigorous manner. The sampling is by a method defined by convention, but the mass measurement can clearly be defined as traceable to SI Units. However, the main problem is that the measurand itself is not well defined as the particulate material sampled will have different shapes, sizes and compositions.

These methods are therefore to be used as references against which other measurement techniques used for monitoring PM_{10} and $PM_{2.5}$ for EU regulatory purposes, may be compared. As a result of such comparisons, other methods of measurement may be demonstrated to be “equivalent” and accepted for the purposes of reporting results to the EU. This concept of the demonstration of “equivalence” is specified in a document prepared by the EU and involves comparisons in the field of any other method for monitoring PM_{10} or $PM_{2.5}$ with the relevant reference method[8].

The above standards therefore represent reference methods that are specified by definition and with no real traceability to the SI system of units (with the exception of a requirement to determine the mass flow of air through the monitor). This inability to achieve traceability is partially as a result of the complex variable and ill-defined size, shape and composition, of the particulate matter being monitored.

The UK has conducted a detailed and comprehensive equivalence testing programme[9] for PM_{10} and $PM_{2.5.}$

This report summarises the results of the UK Particulate Monitoring Programme, which has included the operation of seven candidate instruments collocated with the EU reference method (Low Volume Samplers for PM_{10} and $PM_{2.5}$). Instruments included in the programme are:

- Tapered Element Oscillating Micro-balance (TEOM)
- TEOM retrofitted with Filter Dynamics Measurement System (FDMS)
- Partisol 2025 Sequential Sampler
- OPSIS SM200 (Beta and Mass configurations)
- Met-One Beta Attenuation Monitor (BAM)
- Met-One BAM retrofitted with a heater (herein referred to as a “Smart BAM”).

The programme included operation of the monitoring equipment across eight studies that collectively represent particulate conditions typically encountered across the United Kingdom. Field campaigns have been undertaken during summer and winter periods at Teddington (SE England); Birmingham (Midlands); East Kilbride (Scotland) and Bristol (SW England). All instruments were operated in duplicate in order to determine the ‘between-sampler’ uncertainty.

Gravimetric analysis of particulates in the 2006 study employed the use of Emfab (Teflon coated glass fibre) filters. These were found to have many advantages in robustness and inertness over the other more commonly used media allowed in EN14907 of Teflon; quartz; and glass-fibre filters.

Table 9.1 provides an overall summary of the results of the current study for each instrument included.

Table 9.1 Results of the UK Equivalence programme

Candidate Instrument	PM Size Fraction	Manufacturer	Equivalence Criteria Met?	Correction Required
Partisol 2025	PM_{10}	Thermo Electron Corporation	Meets equivalence criteria.	No correction required.
TEOM	PM_{10}	Thermo Electron Corporation	Does not meet equivalence criteria.	Correction does not aid the adherence of equivalence criteria.
PM_{10} FDMS	PM_{10}	Thermo Electron Corporation	Meets equivalence criteria.	No correction required.
$PM_{2.5}$ FDMS	$PM_{2.5}$	Thermo Electron Corporation	Meets equivalence criteria.	No correction required.
SM200 by Beta	PM_{10}	Opsis AB	Meets equivalence criteria.	No correction required.
SM200 by Mass	PM_{10}	Opsis AB	Meets equivalence criteria after application of slope and intercept correction factors.	$SM200Mass_{corrected} = \frac{(SM200Mass - 1.286)}{0.819}$
BAM†	PM_{10}	Met-One	Meets equivalence criteria after application of a slope correction factor.	If flow reported at standard conditions $BAM_{corrected} = \frac{BAM}{1.211}$ If flow reported at ambient conditions $BAM_{ambient\ corrected} = \frac{BAM_{ambient}}{1.273}$

Use of any of the analysers demonstrated to have shown equivalence with the EU reference method therefore meet the specified Data Quality Objectives specified for PM_{10} and $PM_{2.5}$ monitoring in the EU Directive. Hence, within the terms of the definition of traceability for PM_{10} and $PM_{2.5}$, these methods of monitoring have demonstrated traceability to the EU reference method.

On-site checks

During the network 6-monthly inter-calibration exercise the flow rates of all network analysers are calibrated by UKAS accredited procedures. For TEOM and TEOM FDMS analysers the spring constant ko is also checked. This checks the most basic parameters of the measurement – flow and mass – and ensures correct operation of the analysers.

In addition on-going QA/QC equivalence checks are incorporated into the network via long-term co-located sampling of PM_{10} and $PM_{2.5}$ with both TEOM FDMS and gravimetric (Partisol) samplers at currently three, and shortly to be six, sites in the network.

10 Uncertainty of the measurements

As a result of all of the QA/QC operations undertaken within the AURN and described in this report, the uncertainty of the measurements can be reliably determined using the methodology defined in the CEN Standard Methods. This determination of uncertainty is required to demonstrate compliance of the measurements made within the AURN with the data Quality Objectives define in the EU Directive 2008/50/EC.

The Directive requires full implementation of the CEN Standard Methods of Measurement throughout the network by June 2013. As noted earlier, all new monitoring equipment introduced into the network is fully CEN compliant and there is a rolling programme of equipment upgrading to ensure compliance by the due date.

For current non-compliant equipment, analyser measurement uncertainties are expressed in terms of calibration factors determined during inter-calibration visits. These uncertainties are calculated using methodologies implemented by the QA/QC Unit and accredited by UKAS under BS EN 17025. The calculations are performed in the controlled Excel calibration form using the following root-sum-square equation:

$$u(S) = \sqrt{\{\left[\frac{u(C_s)}{(V_S - V_Z)}\right]^2 + \left[\frac{u(C_z)}{(V_S - V_Z)}\right]^2 + \left[\frac{S[u(V_s)]}{(V_S - V_Z)}\right]^2 + \left[\frac{S[u(V_z)]}{(V_S - V_Z)}\right]^2 + \left[\frac{u(D)}{(V_S - V_Z)}\right]^2 + \left[\frac{u(L)}{(V_S - V_Z)}\right]^2\}}$$

Future measurement uncertainty calculations will be undertaken using the CEN Standard Methods, according to the general equation below:

$$U_c = \sqrt{(u_{r,z}^2 + (u_{r,lv}^2 \text{ or } u_{r,f}^2) + u_l^2 + u_{gp}^2 + u_{gt}^2 + u_{st}^2 + u_v^2 + u_{H2O}^2 + u_{int}^2 + u_{av}^2 + u_{Dsc}^2 + u_{d,l,z}^2 + u_{d,l,lv}^2 + u_{cg}^2)}$$

Minor variations to this equation are made for analyser specific functions e.g. NO_x converter efficiency tests.

The QA/QC Unit has already undertaken evaluations of analyser performance using these new calculation methodologies and results produced in type approval tests, to determine whether new monitoring equipment fulfils the requirements of the Data Quality Objectives. These results are summarised in Table 10.1.

Table 10.1. Calculated Uncertainty of AURN Data using CEN methodology

	NOx	CO	SO_2	O_3
API A + E series Analysers (at Limit Value)	14%	10%	13%	12%
Horiba 370 series Analysers (at Limit Value)	12%	11%	12%	9%
Thermo I series Analysers (at Limit Value)	10%	10%	13%	11%
ME 9800(UK) series Analysers (at Limit Value)	11%	14%	11%	12%
EU Directive Data Quality Objective (at Limit Value)	15%	15%	15%	15%

Table 10.1 shows that data obtained from the analysers tested to date fulfil the requirements of the EU Directive Data Quality Objectives. The calculations at this stage necessarily contain a number of assumptions about aspects of analyser field performance that will need to be regularly evaluated on site, once the Directive is enacted and all required CEN procedures are adopted.

For PM_{10} and $PM_{2.5}$, the UK equivalence trials have demonstrated that data derived from all analysers that meet the equivalence criteria conform to the EU Directive Data Quality Objectives for PM_{10} and $PM_{2.5}$ i.e. 25% at the limit value.

11 Local Authority Air Monitoring

Defra and the Devolved Administrations assess air quality on a national basis using a combination of air quality measurements from the Automatic Urban and Rural Monitoring Network and air quality modelling. This provides a comprehensive assessment of national air quality. This national assessment is used to report UK air quality to the European Commission according to the requirements of Air Quality Daughter Directives. However, Defra and the Devolved Administrations aim to present an assessment of national air quality that is as comprehensive and accurate as possible. Monitoring data collected by Local Authorities can play an important role in improving the national assessment and hence, the AURN QA/QC Unit undertakes a study designed to assess the suitability of Local Authority data for inclusion in the national assessment.

Furthermore the national assessment provides a main part of the evidence base for developing and monitoring air quality policy. For example, progress towards meeting objectives in the Air Quality Strategy is gauged using the national monitoring and modelling assessment.

However, the national assessment, although comprehensive, is concerned with large-scale, rather than small-scale, monitoring of air quality. For example, national modelling relies on the National Atmospheric Emissions Inventory, which maps emissions to a one-by-one kilometre squared grid. This is not at a sufficient resolution to assess emissions at traffic-related hotspots such as specific junctions or small distances of road.

Local Authority air quality assessment therefore has an important supplementary role, as it is intended to estimate and monitor air quality at a local level, and on an appropriate geographic scale. Local Authority emissions inventories and modelling are likely to be much more accurate than the national assessment at a fine scale. For example it is likely that local authority assessment of air quality will find traffic-related hot spots of pollution that are not identified by the national assessment.

Defra and the Devolved Administrations aim to present as comprehensive and accurate assessment of national air quality as possible. Monitoring data collected by Local Authorities can play an important role in improving the national assessment. However, Local Authority air quality monitoring data needs to be carefully assessed to determine the appropriateness of these data to supplement the national assessment.

The purpose of this process is to identify those Local Authority monitoring sites that have reported exceedences within the UK Local Air Quality Review and Assessment process, and to provide an assessment of their suitability for inclusion in the national assessment, in particular in reports to the European Commission.

However, this assessment does not:

- ratify Local Authority monitoring data according to the same procedures used for the Automatic Urban and Rural Network; or
- assess the quality of Local Authority monitoring data in the context of Local Air Quality Management (LAQM).

It is also important to note that monitoring data assessed as inappropriate for inclusion in the national assessment may still be entirely suitable for the purposes of LAQM. The purposes of national and Local Authority monitoring are different and have different QA/QC requirements.

In the vast majority of cases, the Local Authority data confirm exceedences already identified by the national assessment, either through monitoring or modelling. Where Local Authority data identify any additional exceedences, this information is taken into consideration in the preparation of the overall national assessment for the UK. In addition, further investigation of these monitoring sites is undertaken and, where appropriate, they are considered for affiliation into the national network.

12 Data reporting

12.1 Reporting to the European Union

The fully ratified data from the AURN are reported to the Commission annually as a full set of all hourly data and as an input to the EU Questionnaire on exceedences in the UK (the questionnaire system is currently under revision). In future, it is likely that more provisional data will also be supplied to the Commission on a near real time basis. Currently, ozone exceedences, based on provisional data, are reported monthly and annually via a separate reporting system and ozone data are also supplied on an daily basis to the EU Ozone website - http://www.eea.europa.eu/maps/ozone/map . The EU website system is likely to be extended and additional pollutants, particularly NO_2 and PM_{10}, are proposed for inclusion. This supply of data to the EU is covered by a separate contract – the Air Quality Communications contract.

For the EU Questionnaire, the AURN data are combined with the extensive UK-wide modeling and mapping of pollutant concentrations within the UK Pollution Climate Mapping project[13]. The results from the AURN monitoring and the UK wide modeling are used to identify any exceedences of the relevant limit values in any zone or agglomeration in the UK. These are all reported annually to the European Commission.

In addition, the data from appropriate monitoring Local Authority sites in the UK (see Chapter 11) are also taken into consideration in providing the overall UK assessment.

12.2 PSA air quality indicator reporting

The methodology for calculating and reporting the PSA air quality indicator is described in a separate document[6].

The indicator is calculated from measured ambient air quality concentrations at air quality monitoring stations within the AURN for NO_2 and PM_{10}, the two most problematic pollutants in the UK. The indicator is calculated for England only. The indicator is updated on a quarterly basis and includes the most recently measured data which will be provisional pending ratification by the end of the following quarter.

12.3 Reporting to the Air Quality Archive

Screened and checked provisional data are updated to the UK Air Quality Archive website on an hour-by-hour basis by the AURN CMCU.

In addition, as data are received by the QAQC Unit from the CMCU, they are screened, checked and updated as necessary throughout the 3-month period of data ratification. As the data are improved, they are automatically fed through to Air Quality Archive. The AURN QA/QC software checks and uploads any amendments to the Air Quality Archive every few minutes, ensuring that the provisional data available on the Archive website always reflect the most up-to-date, highest quality data available from the QA/QC Unit. Fully ratified AURN data are updated to the Archive quarterly.

The AURN data are widely reported to stakeholders and the general public through the following other channels:

- Hourly data are also used to inform the public about current air quality on a near real time basis via websites teletext and freephone service.
- Daily e-mail bulletins of AURN monitoring data and forecasts to media organisations and other network stakeholders
- The data are also provided to each of the UK Devolved Administration air quality websites.

13 Conclusions

This report outlines the extensive procedures and operational measures adopted to ensure high quality data from the UK Automatic Urban and Rural Air Quality Monitoring Network (AURN).

The responsibility for QA/QC of the AURN lies with the network QA/QC Unit - currently AEA Technology plc. However, the operation of the AURN involves many contractors, both locally and nationally and the work of all of these organisations contributes considerably to the overall quality of the data.

This report outlines the EU and UK data quality requirements and describes how these are addressed within the AURN:

- Monitoring site numbers and location
- Measurement methods
- Establishing new monitoring sites
- Data telemetry and validation
- Ongoing QA/QC including network inter-comparisons and data ratification
- Traceability of the measurements to national and international standards.

The calculation of the overall uncertainty of the measurements is then presented and compared with the Data Quality Objectives specified in the appropriate EU Directive.

The report therefore demonstrates that air quality monitoring within the AURN meets the requirements for the UK Public Service Agreement Indicator and the relevant EU Directives on Air Quality.

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Appendices

Appendix 1: Air Quality Limit Values, Standards and Objectives for the UK

Appendix 2: Statistical Calculation Methods

Appendix 3: AURN Site Lists (by pollutant)

Appendix 1

Air Quality Limit Values, Standards and Objectives for the UK

Nitrogen Dioxide

Guideline Set By	Description		Criteria Based On	Value[1] / µgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	1-hour mean	0-95 (0-49)
		2		96-190 (50-99)
		3		191-286 (100-149)
	MODERATE	4	1-hour mean	287-381 (150-199)
		5		382-477 (200-249)
		6		478-572 (250-299)
	HIGH	7	1-hour mean	573-635 (300-332)
		8		636-700 (333-366)
		9		701-763 (367-399)
	VERY HIGH	10	1-hour mean	≥ 764 (≥ 400)
The Air Quality Strategy[2] *Set in regulations[3] for all UK:* *Not intended to be set in regulations:*	Objective for Dec. 31st 2005, for protection of human health		1-hour mean	200 (105) Not to be exceeded more than 18 times per calendar year.
	Objective for Dec. 31st 2005, for protection of human health		Annual mean	40 (21)
	Objective for Dec. 31st 2000, for protection of vegetation.		Annual mean NO_x (NO_x as NO_2)	30 (16)
European Community 1985 NO_2 Directive[4] *Limit remains in force until fully repealed 01/01/2010.*	Limit Value		Calendar year of data: 98%ile of hourly means.	200 (105)
1st Daughter Directive[5] and Directive on Ambient Air Quality [6]	Limit Value for protection of human health. To be achieved by Jan. 1st 2010		1-hour mean	200 (105) not to be exceeded more than 18 times per calendar year
	Limit Value for protection of human health. To be achieved by Jan. 1st 2010		Calendar year mean	40 (21)
	Limit Value (total NO_x) for protection of vegetation. To be achieved by Jul. 19th 2001		Calendar year mean	30 (16)
World Health Organisation[7] *(Non-Mandatory Guidelines)*	Health Guideline		1-hour mean	200
	Health Guideline		Annual mean	40

(1) Conversions between µg m^{-3} and ppb are as used by the EC, i.e. 1ppb NO_2 = 1.91 µg m^{-3} at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(3) Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)
(4) Council Directive 85/203/EEC.
(5) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(6) 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, which supersedes (5).
(7) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Particulate Matter as PM_{10}

Guideline Set By	Description		Criteria Based On	Value / μgm^{-3}
UK Government Air Pollution Index	LOW	1	24-hour mean	0-16
		2		17-32
		3		33-49
	MODERATE	4	24-hour mean	50-57
		5		58-66
		6		67-74
	HIGH	7	24-hour mean	75-82
		8		83-91
		9		92-99
	V. HIGH	10	24-hour mean	≥ 100
The Air Quality Strategy[1] **Set in regulations for all UK[2].**	Objective for Dec. 31st 2004		24-hour mean	50 Not to be exceeded more than 35 times per calendar year.
	Objective for Dec. 31st 2004		Annual mean	40
Set in regulations Scotland only[3]	Objective for Dec. 31st 2010		24-hour mean	50 Not to be exceeded more than 7 times per calendar year.
	Objective for Dec. 31st 2010		Annual mean	18
The Air Quality Strategy[1] *Not set in regulations: London only*	Objective for Dec. 31st 2010		24-hour mean	50 Not to be exceeded more than 10 times per calendar year.
	Objective for Dec. 31st 2010		Annual mean	23
1st Daughter Directive[4] **and** **Directive on Ambient Air Quality [5]**	Limit Value to be achieved by Jan 1st 2005		24-hour mean	50 Not to be exceeded more than 35 times per calendar year.
	Limit Value to be achieved by Jan 1st 2005		Annual mean	40

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

(2) Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)

(3) Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182)

(4) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations by above Statutory Instruments.

(5) 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, which supersedes (4).

Particulate Matter as $PM_{2.5}$

Guideline Set By	Description	Criteria Based On	Value / μgm^{-3}
The Air Quality Strategy(1) **Set in regulations for all UK.**	Objective for 2020, all UK except Scotland	Annual mean	25
	Objective for 2020, Scotland only	Annual mean	12
	Exposure reduction target, urban background areas	Annual mean	20% reduction in annual mean concentration between 2010 and 2020.
Directive on Ambient Air Quality and Cleaner Air for Europe (2)	Limit Value for 2020, all UK except Scotland	Annual mean	25
	Exposure reduction target, urban background areas	Annual mean	20% reduction in annual mean concentration between 2010 and 2020.

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.$PM_{2.5}$ not under regulation at this time.
(2) 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.

Sulphur Dioxide

Guideline Set By	Description		Criteria Based On	Value[1] / μgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	15-minute mean	0-88 (0-32)
		2		89-176 (33-66)
		3		177-265 (67-99)
	MODERATE	4	15-minute mean	266-354 (100-132)
		5		355-442 (133-166)
		6		443-531 (167-199)
	HIGH	7	15-minute mean	532-708 (200-266)
		8		709-886 (267-332)
		9		887-1063 (333-399)
	VERY HIGH	10	15-minute mean	≥ 1064 (≥ 400)
The Air Quality Strategy[2] *Set in regulations[3] for all UK.*	Objective for Dec. 31st 2005, for protection of human health.		15-minute mean	266 (100) Not to be exceeded > 35 times per calendar year.
	Objective for Dec. 31st 2004, for protection of human health		1-hour mean	350 (132) Not to be exceeded > 24 times per calendar year.
	Objective for Dec. 31st 2004, for protection of human health		24-hour mean	125 (47) Not to be exceeded > 3 times per calendar year.
Not intended to be set in regulations.	Objective for Dec. 31st 2000, for protection of vegetation.		Annual mean & winter (1st October – 31st March) mean	20 (8)
1st Daughter Directive[4] and Directive on Ambient Air Quality [5]	Objective for Jan 1st 2005, for protection of human health		1-hour mean	350 (132) Not to be exceeded more than 24 times per calendar year.
	Objective for Jan 1st 2005, for protection of human health		Daily 24-hour mean	125 (47) Not to be exceeded more than 3 times per calendar year.
	Objective for Jul 19th 2001, for protection of vegetation.		Annual mean & winter (1st October – 31st March) mean	20 (8)
World Health Organisation[6] *(Non-Mandatory Guidelines)*	Health Guideline		10-minute mean	500
	Health Guideline		24-hour mean	125
	Health Guideline		Annual mean	50

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb SO_2 = 2.66 $\mu g\ m^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(3) Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)
(4) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations by above Statutory Instruments.
(5) 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, which supersedes (4).
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Carbon Monoxide

Guideline Set By	Description		Criteria Based On	Value[1] / mg m^{-3} (ppm)
UK Government Air Pollution Index	LOW	1	8-hour mean	0-3.8 (0-3.2)
		2		3.9-7.6 (3.3-6.6)
		3		7.7-11.5 (6.7-9.9)
	MODERATE	4	8-hour mean	11.6-13.4 (10.0-11.5)
		5		13.5-15.4 (11.6-13.2)
		6		15.5-17.3 (13.3-14.9)
	HIGH	7	8-hour mean	17.4-19.2 (15.0-16.5)
		8		19.3-21.2 (16.6-18.2)
		9		21.3-23.1 (18.3-19.9)
	VERY HIGH	10	8-hour mean	≥ 23.2 (≥ 20)
The Air Quality Strategy[2,3,4] (Except Scotland)	Objective for Dec. 31st 2003		Max. Daily Running 8-hour mean	10 (8.6)
Scotland only[5]:	Objective for Dec. 31st 2003		Running 8-hour mean	10 (8.6)
European Community 2nd Daughter Directive[6] and Directive on Ambient Air Quality [7]	Limit Value. To be achieved by Jan 1st 2005		Max. daily 8-hour mean	10 (8.6)
World Health Organisation[8] *(Non-Mandatory Guidelines)*	Health Guideline		15-minute mean	100
	Health Guideline		30-minute mean	60
	Health Guideline		1-hour mean	30
	Health Guideline		8-hour mean	10

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppm CO = 1.16 mg m^{-3} at 20°C and 1013 mB, except where specified.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(3) Air Quality Regulations 2007 (SI 2007/64)
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(7) Council Directive 2000/69/EC. Transposed into UK Air Quality Regulations by above Statutory Instruments.

(8) 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, which supersedes (7).

Ozone

Guideline Set By	Description		Criteria Based On	Value[(1)]/ µgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	Max 1-hour and 8-hour mean	0-32 (0-16)
		2		33-66 (17-32)
		3		67-99 (33-49)
	MODERATE	4	Max 1-hour and 8-hour mean	100-126 (50-62)
		5		127-152 (63-76)
		6		153-179 (77-89)
	HIGH	7	Max 1-hour and 8-hour mean	180-239 (90-119)
		8		240-299 (120-149)
		9		300-359 (150-179)
	VERY HIGH	10	Max 1-hour and 8-hour mean	≥ 360 (≥ 180)
The Air Quality Strategy[(2)] All UK.	Objective for Dec. 31st 2005 [(2)]		Daily max. running 8-hour mean	100 (50) Not to be exceeded more than 10 times per calendar year.
	Target Value for protection of vegetation. To be achieved by 5 years, beginning 2010[(2)]		AOT40[(2)] calculated from 1h values May-July.	18,000 μg m^{-3} h averaged over 5 years.
European Community 3rd Daughter Directive[(3)] and Directive on Ambient Air Quality [(4)]	Target Value To be achieved by 3-year period beginning 2010.		Max. daily 8-hour mean.	120 μg m^{-3} Not to be exceeded on more than 25 days per year, averaged over 3 years.
	Target Value for protection of vegetation. To be achieved by 5 years, beginning 2010		AOT40[(5)] calculated from 1h values May-July.	18,000 μg m^{-3} h averaged over 5 years.
	Information threshold		1-hour mean	180
	Alert threshold		1-hour mean	240
World Health Organisation[(6)] *(Non-Mandatory Guidelines)*	Health Guideline		8-hour mean	120

(1) Conversions between μg m^{-3} and ppb are as used by the EC, i.e. 1ppb O_3 = 2.00 μg m^{-3} at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(3) Directive (2002/3/EC)
(4) 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, which supersedes (4).
(5) AOT40 statistic is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Appendix 2

Statistical Calculation Methods

A 2.1 Introduction

Various air quality guidelines and statistics are defined in the documentation published by the UK Government[R4], the European Community[R1,R5], the World Health Organisation[R6-R9] and The Expert Panel on Air Quality Standards (EPAQS) [R10-R18]. This section describes how these statistics are calculated from the original dataset. All exceedence statistics in this report are calculated using methods that are compliant with the requirements of each air quality standard.

Where the exact method of calculation of a statistic has not been precisely defined by the above bodies, a method has generally been chosen that leads to a more stringent air quality guideline.

These calculation methods have been developed over time and are not necessarily those that were used in previous reports of this series.

A 2.2 Definitions

Basic Reporting Unit
The basic reporting unit for the National automatic monitoring networks is the hourly average (the terms "mean" and "average" are taken to be equivalent in this report). All statistics of greater than one hour duration are based on hourly averages. For example, the annual mean is the arithmetic mean of the hourly means during the year. Hourly means that are invalid, for any reason, are ignored.

Hourly averages are derived from:

- At least three 15-minute averages per hour in the AURN for all gaseous analysers and original TEOMs.
- Hourly measurements from MetOne BAMs and TEOM FDMS units.
- 30-minutes of sampling in the Hydrocarbon Network

Although 15-minute averages are used in the UK National Air Quality standard for SO_2 and the WHO CO guidelines, 15-minute averages are not the basic reporting unit. Annual means, for example, based on 15-minute average may not be equal to those based on hourly averages since there may be, on occasion, insufficient 15-minute data to make a valid hourly mean. 15-minute data are only used to calculate hourly means and any statistic specifically related to 15-minute means.

Mass Units
The units that used to measure the concentrations are not always the same as those used to calculate and report statistics. For example, ozone is measured by the instrumentation in parts per billion (ppb) and the statistics are reported here in terms of the µg m^{-3} mass units. Particulate matter (PM_{10} and $PM_{2.5}$) on the other hand, is measured and reported in terms of µg m^{-3}.

To calculate statistics, therefore, the measured data are first converted into the reporting units, then the statistics are calculated. Comparison with any limit values is only performed in terms of mass units. This method will give slightly different results, due to rounding errors, to calculations using data in ppb and comparing with limit values converted into ppb.

Dates and Times
All data are recorded as Greenwich Mean Time (GMT). Please note that diurnal variations are calculated in local time.

Daily means are defined as midnight to midnight; 24-hour running means are means over any 24-hour period, for example 0800 to 0759.

Data Precision

All concentrations are recorded and reported to a number of decimal places that is greater than or equal to the measurement precision of individual hourly means. For example:

- Ozone is measured to 2 ppb and reported to 1 ppb or 2 µg m^{-3}
- Benzene is measured to 0.1 ppb and reported to 0.1 ppb or 0.3 µg m^{-3}

Note that 15-minutes means, where available, are also recorded to the same data precision as hourly means.

Percentiles

Percentiles of SO_2 daily means are calculated using the method described in EU Directive 80/779/EEC on sulphur dioxide and suspended particulates[R19] (repealed at end of 2005).

All other percentiles use the method described in the 1985 NO_2 Directive (85/203/EC) [R20] which was superseded by the 1st Daughter Directive[R21], 1999/30/EC, and subsequently by the most recent Directive on ambient air quality and cleaner air for Europe (2007/50/EC)[R1] but remains in force until fully repealed in January 2010.

For example: after sorting the data into ascending numerical order, the 98th percentiles are at the following ranks:

SO_2	0.98 times the number of valid means rounded up to the nearest integer
NO_2	0.98 times the number of valid means rounded to the nearest integer

For example, the 98th percentile of 365 daily means (rank 357.7) is the 8th highest concentration using the SO_2 Directive method and also the 8th highest concentration using the NO_2 Directive method.

Data Capture Threshold

A 75% data capture threshold is set for all short-term averages of up to the duration of a month. For example:

- An hourly mean requires at least three 15-minute means
- A monthly mean requires at least 75% of daily means and each daily mean requires at least 18 hours of data

Note that it is possible to have a month with 75% data capture for hourly means, but with less than 75% daily means.

Annual and seasonal statistics, such as the summer mean and the annual 98th percentile of hourly means, should be interpreted with respect to the quoted data capture. These statistics are generally not shown if the data capture is less than 25%. However, some short-term values such as the date of the annual maximum hourly mean are shown, since these may still be of interest.

Air Quality Standards and Guidelines

Air quality guidelines used in this report are those defined in the documentation published by the UK Government[R4], the European Community[R5-6], and the World Health Organisation[R7-R10].

The following conversion factors from measured units to mass units are defined in the EU Decision on Exchange of Information[R22] (and have now been incorporated into the 2007 Directive[R1])

Conversion Factors Between ppb and $\mu g\ m^{-3}$ and ppm and mgm^{-3}

Pollutant	WHO	EC
	25°C and 1013mb	**20 °C and 1013mb**
Ozone	1 ppb = 1.9622 $\mu g\ m^{-3}$	1 ppb = 1.9957 $\mu g\ m^{-3}$
Nitrogen dioxide	1 ppb = 1.8804 $\mu g\ m^{-3}$	1 ppb = 1.9125 $\mu g\ m^{-3}$
Carbon monoxide	1 ppm = 1.1447 mg m^{-3}	1 ppm = 1.1642 mg m^{-3}
Sulphur dioxide	1 ppb = 2.6163 $\mu g\ m^{-3}$	1 ppb = 2.6609 $\mu g\ m^{-3}$
Benzene	1 ppb = 3.189 $\mu g\ m^{-3}$	1 ppb = 3.243 $\mu g\ m^{-3}$
1,3-butadiene	1 ppb = 2.2075 $\mu g\ m^{-3}$	1 ppb = 2.2452 $\mu g\ m^{-3}$

Additional conversion factors used in the UK are as follows:

- NO_x in μg m^{-3} is expressed as NO_2, i.e. (NO ppb + NO_2 ppb)* 1.91 = NO_x μg m^{-3}
- In the UK, gravimetric equivalent PM_{10} data are calculated from TEOM monitoring data by applying a conversion factor of 1.3

Note that the minimum data period that can be compared to a guideline is fifteen minutes, since this is currently the time resolution of most UK automatic data. The WHO 10-minute SO_2 guideline is not, therefore, reported.

Running Means
Wherever possible, running means, rather than simple means, are used for comparison with air quality standards.

For example: the Air Quality Strategy CO 8-hour standard in this report is based on all possible 8-hour means during a year. Calculating all possible means can produce twenty-four possible exceedences every day. This is a more stringent method than taking simple, non-overlapping, means (e.g. three 8-hours means in a day).

Please note that in this report:

- The WHO 30-minute guideline is calculated as a running mean based on 15-minute averages
- The UK National Air Quality standard running annual means for benzene and 1,3-butadiene requires a 75% data capture. Newly established sites cannot, therefore, report the running annual mean.

Exceedence
An exceedence of an air quality guideline is generally defined in this report as a concentration **greater than** the guideline threshold. This definition was changed from "**greater than or equal"** the guideline threshold, in order to be consistent with EU Directives.

There is one exception, which is in the calculation of exceedences of the Air Quality Bandings. In this case the "**greater than or equal" definition** continues to be used, in order to afford maximum public health protection.

Exceedence Counting
The following method is used where an air quality guideline is based on an average:

1. Calculate the average
2. Apply the 75% data capture threshold
3. Round the average to the data precision
4. Compare with the guideline

For example: at stage 3, an 8-hour average ozone concentration of 100.4999 µg m^{-3} is rounded to 100 µg m^3. This does not exceed the UK National Air Quality standard running 8-hour ozone mean of 100 µg m^{-3}.

However, if no rounding occurs, the concentration would exceed the standard. Also, if this value is the highest running 8-hour during the year, an anomaly would occur in the report since the maximum would be reported as 100 µg m^{-3} yet there would be an exceedence.

To calculate the number of days with an exceedence, the date (in GMT) of the last hour of the running mean is used.

Diurnal Variations
Diurnal variations are the average concentration for each hour of day during the period of interest. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of manmade emissions.

Long-Term Trends
Long-term trends reported here are based a non-parametric linear regression method which has the following stages:

- The gradient is calculated by "Theil's incomplete" method[R23]

- The null hypothesis (i.e. the statistical significance of the trend) is tested by the Spearman's rank correlation coefficient[R24]
- The 95th confidence interval for the gradient is given by Kendall's Tau[R25]

Values for the Spearman's rank correlation coefficient used in this report are as published by Conover[R26].

This method does not assume that the errors on the data points are normally distributed and is, therefore, more appropriate than simple linear regression by least squares. However, the results obtained have been demonstrated to be broadly similar[R27].

Exponential regressions may be appropriate for some time series, e.g. SO_2 in London, but for the majority of cases a linear trend over recent years is of most interest. Only linear trends are provided in this report.

Trends are reported for sites where there are at least five valid annual measurements. A valid measurement requires a data capture of at least 50%.

Where a site has a statistically significant trend of more than five years, the five-year trend and the trend over the full monitoring period are reported. Ten-year trends are highlighted in the summary tables in Appendix 4.

A 2.3 Particulate measurements and conversion factors used in this report

With gaseous pollutants, it is possible to express concentrations as an amount fraction – the ratio of pollutant molecules to the total number of air molecules – for example, parts per billion (ppb). This is not possible for PM, and measurements are always given in units of particulate mass per unit volume of air (typically μgm^{-3}). When these units are used without specifying the temperature and pressure of the air, the same 'packet' of air will have a different concentration as these properties of the air change. The European legislation for PM measurement therefore requires that the air volume used must be at the same ambient air temperature and pressure as at the time of sampling. In practice, this means that appropriate corrections need to be made if the flow rate used to calculate the sampled volume is not based on the actual volume of sampled air.

Different measurement techniques, although nominally measuring the same PM, may treat the airstream in different ways, leading to significantly different results. For clarity, all mass measurements of PM_{10} and $PM_{2.5}$ in this report are expressed as $\mu g\ m^{-3}$ for both gravimetric and TEOM analysers.

The updated Air Quality Directive (2008/50/EC) specifies that measurements of PM_{10} should be carried out using the reference method, as defined in European Standard EN12341, or one that has demonstrated equivalence. This standard refers to three sampling devices that may be used:

- Superhigh volume sampler – the WRAC (Wide Range Aerosol Classifier);
- High-volume sampler – the HVS PM_{10} sampler (68 $m^3\ h^{-1}$);
- Low-volume sampler – the LVS PM_{10} sampler (2.3 $m^3\ h^{-1}$).

None of these instruments can provide real-time (continuous hourly) measurements.

During 2007 the Tapered Element Oscillating Microbalance (TEOM) analyser continued to be widely used in both the UK and throughout the rest of the world for measuring continuous concentrations of PM. The instrument is based on the principle that the frequency of oscillation of a glass, tapered tube (element) changes by an amount that is directly proportional to the mass of the tube Therefore, any change in mass of the tube, due to the deposition of particles onto a small filter affixed to one end, will result in a change in the resonant frequency that is proportional to the additional mass.

In order for the TEOM to be used as a USEPA-equivalent method for PM_{10} measurement, a default adjustment factor (1.03 * TEOM reading + 3 μgm^{-3}) must be applied to the raw data. This adjustment factor was derived to account for moisture equilibration differences between the TEOM and the HI-vol sample media. The adjustment factor was determined at sites where non-volatile PM dominated and is intended to reflect the filter character more than the PM. It is understood that USEPA has no general

policy on the use of this empirical adjustment factor for $PM_{2.5}$ measurements. All TEOM analysers in the UK measuring both PM_{10} and $PM_{2.5}$ are currently set up with this default adjustment factor included. In addition, TEOM analysers within the UK networks are set to report concentrations corrected to 293K and 101.3 kPa.

Due to the need to eliminate the effect of changing humidity on the mass measurement, the TEOM is required to maintain the sample filter at an elevated temperature. This has led to reported differences in concentrations of PM between the TEOM and the European reference sampler (Allen *et al*., 1997; APEG, 1999; Ayers *et al*., 1999; Soutar *et al*., 1999; Salter and Parsons, 1999; Cyrys *et al*., 2001; Williams and Bruckmann, 2001). This is largely attributed to the loss of volatile species such as ammonium nitrate. As an interim measure, a default 'scaling factor' (also known as correction factor) of 1.3 has historically been applied to all TEOM PM_{10} data reported in this series of reports, as recommended by the EU Working Group on Particulate Matter (2001).

However, UK equivalence trials for particulate instruments established that the TEOM did not meet the equivalence criteria, even after application of the scaling factor of 1.3. Therefore, the original TEOMs are in the process of being phased out of the UK monitoring networks. This has been an ongoing process during 2007, where the original instruments have been either replaced or upgraded to "Reference Equivalent" TEOM FDMS (Filter Dynamics Measurement System) instruments. The FDMS upgrade to the TEOM instrument enables the measurement and reporting of both the volatile and non-volatile components of particulate matter. (The TEOM FDMS model B system has demonstrated equivalence with the PM_{10} reference method, as also has the Met-One Beta Attenuation Monitor BAM 1020 and the gravimetric R&P Partisol daily sampler).

Once the upgrade and replacement programme is complete, this will mean that results can be directly compared, with full confidence, against the EU Directive limit values and objectives.

'***Box and whisker' plots:***
Box and whisker plots – such as that in Figure 7.3 of the present report - are used to illustrate measured concentrations at air quality monitoring stations around the UK and how they compare with the UK's Air Quality Strategy Objectives. For each objective, the average concentration (of the appropriate metric) for all of the sites is shown, together with the highest concentration from that group of sites.

Data for each pollutant are obtained from the national networks. This is mainly from the Automatic Urban and Rural Network (AURN) but also from the Hydrocarbons Network, Heavy Metals Network and PAH Network where applicable to that pollutant. The data represent a broad range of monitoring environments including roadside and background sites. All data used in the calculations undergo a rigorous quality assurance procedure and are fully ratified prior to analysis.

The checked and validated data are used to calculate the appropriate metric (annual average, maximum daily running 8-hour concentration, and so on). The metrics presented generally correspond to those on which the legislation is based. This allows a direct comparison of measured levels against the objectives.

Some objectives allow for a specific number of permissible exceedences. It is more difficult to analyse progress against these objectives, because the metric provides no indication of air quality below the number of permissible exceedences. For this reason, an equivalent percentile is used. For example, the SO_2 15-minute objective allows up to 35 exceedences in a calendar year; the corresponding percentile would be 99.9% of 15-minute means. If this value is below the 266 $\mu g\ m^{-3}$ objective, then there are fewer than the 35 permissible exceedences and the difference will provide an indication of how far below the objective the measured values are. This allows us to meaningfully average concentrations from a range of sites and to compare them directly against the objective.

Data capture statistics are used to screen out sites where the volume of data is too low to provide meaningful comparisons against the legislative objectives. A data capture threshold of 75% has been used for this purpose, below which data are omitted from the analysis.

When the data have been screened to include only those sites with 75% or more, the data range is sorted in order to group sites into their respective countries. The average and maximum concentrations are then calculated for the appropriate group of sites to which specific objectives apply.

These are presented in simple box and whisker (‘cricket bat’ plots), where the bar represents the average concentration of all the sites in the range and the whisker represents the site with the highest concentration. These can also be presented in simple line charts to show the same information in a time series - as in Figure 7.4 in this report.

Appendix 3

AURN Site Lists (by pollutant)

Table A3.1 NO_2 Site List

Zone/ Agglomeration	Population (2001)	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start date for NO_2	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Sites in AURN to meet require-ments
Greater London Urban Area	8278251	3	10	5	London Harlington	01/01/2004	AIRPORT	Industrial	urban	6	8	0	1	15	Y
					Camden Kerbside	16/05/1996	KERBSIDE	Traffic	urban						
					London Marylebone Road	17/07/1997	KERBSIDE	Traffic	urban						
					Tower Hamlets Roadside	01/04/1996	ROADSIDE	Traffic	urban						
					Haringey Roadside	16/05/1996	ROADSIDE	Traffic	urban						
					Southwark Roadside	01/04/1997	ROADSIDE	Traffic	urban						
					London Cromwell Road 2	20/05/1998	ROADSIDE	Traffic	urban						
					London Eltham	01/04/1996	SUBURBAN	Background	suburban						
					London Bexley	01/05/1994	SUBURBAN	Background	suburban						
					London Hillingdon	02/08/1996	SUBURBAN	Background	suburban						
					London N. Kensington	01/04/1996	URBAN BACKGROUND	Background	urban						
					London Teddington	08/08/1996	URBAN BACKGROUND	Background	urban						
					London Westminster	17/07/2001	URBAN BACKGROUND	Background	urban						
					London Bloomsbury	23/01/1992	URBAN CENTRE	Background	urban						
					London Haringey	29/11/2007	URBAN CENTRE	Background	urban						
West Midlands Urban Area	2284093	3	6	3	Birmingham Tyburn Roadside	11/02/2009	ROADSIDE	Traffic	urban	1	3	0	0	4	Y
					Walsall Willenhall	29/04/1997	SUBURBAN	Background	suburban						
					Sandwell West Bromwich	04/11/1998	URBAN BACKGROUND	Background	urban						
					Birmingham Tyburn	16/08/2004	URBAN BACKGROUND	Background	urban						
Greater Manchester Urban Area	2244931	3	6	3	Bury Roadside	20/01/1997	ROADSIDE	Traffic	urban	1	2	0	1	4	Y
					Manchester South	06/12/1996	SUBURBAN	Background	suburban						
					Manchester Piccadilly	18/12/1995	URBAN CENTRE	Background	urban						
					Salford Eccles	20/03/1997	URBAN INDUSTRIAL	Industrial	urban						
West Yorkshire Urban Area	1499465	3	4	2	Leeds Headingley Kerbside	17/02/2008	KERBSIDE	Traffic	urban	1	1	0	0	2	Y

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					Leeds Centre	04/01/1993	URBAN CENTRE	Background	urban						
Tyneside	879996	3	3	2	Newcastle Cradlewell Roadside	10/03/2008	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Newcastle Centre	08/03/1992	URBAN CENTRE	Background	urban						
Liverpool Urban Area	816216	3	3	2	Liverpool Queen's Drive Roadside	01/01/2008	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Liverpool Speke	21/05/2003	URBAN BACKGROUND	Background	urban						
Sheffield Urban Area	640720	3	2	1	Sheffield Centre	22/12/1995	URBAN CENTRE	Background	urban	0	1	0	1	2	Y
					Sheffield Tinsley	28/11/1990	URBAN INDUSTRIAL	Industrial	urban						
Nottingham Urban Area	666358	3	2	1	Nottingham Centre	02/09/1996	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Birstol Urban Area	551066	3	2	1	Bristol Old Market	01/07/1996	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Bristol St Paul's	15/06/2006	URBAN BACKGROUND	Background	urban						
Brighton/ Worthing/ Littlehampton	461181	3	2	1	Brighton Roadside	10/02/1998	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Brighton Preston Park	03/11/2004	URBAN BACKGROUND	Background	urban						
Leicester Urban Area	441213	3	2	1	Leicester Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Portsmouth Urban Area	442252	3	2	1	Portsmouth	01/01/2001	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Teeside Urban Area	365323	3	2	1	Billingham	01/01/1987	URBAN INDUSTRIAL	Industrial	urban	0	0	0	2	2	Y
					Middlesbrough	21/04/1995	URBAN INDUSTRIAL	Industrial	urban						
The Potteries	362403	3	2	1	Stoke-on-Trent Centre	11/03/1997	URBAN CENTRE	Background	urban	0	1	0	0	1	Y

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Bournemouth Urban Area	383713	3	2	1	Bournemouth	05/03/2001	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Reading/ Workingham Urban Area	369804	3	2	1	Reading New Town	17/10/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Coventry/ Bedworth	336452	3	2	1	Coventry Memorial Park	26/02/2001	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Kingston Upon Hull	301416	3	2	1	Hull Freetown	06/11/2002	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Southampton Urban Area	304400	3	2	1	Southampton Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Birkenhead Urban Area	319675	3	2	1	Wirral Tranmere	14/05/2000	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Southend Urban Area	269415	3	2	1	Southend-on-Sea	24/07/2000	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Blackpool Urban Area	261088	3	2	1	Blackpool Marton	14/06/2005	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Preston Urban Area	264601	3	2	1	Preston	06/06/2000	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Glasgow Urban Area	1168270	3	4	2	Glasgow Kerbside	10/03/1997	KERBSIDE	Traffic	urban	1	2	0	0	3	Y
					Glasgow City Chambers	06/01/1987	URBAN BACKGROUND	Background	urban						
					Glasgow Centre	26/07/1996	URBAN CENTRE	Background	urban						
Edinburgh Urban Area	452194	3	2	1	Edinburgh St Leonards	24/11/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y

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Zone/ Agglomeration	Population (2001)	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start date for NO_2	UK Classification	EU classification: type_of_station	EU classification station_type_ of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Sites in AURN to meet require-ments
Cardiff Urban Area	327706	3	2	1	Cardiff Centre	12/05/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Swansea Urban Area	270506	3	2	1	Swansea Roadside	20/09/2006	ROADSIDE	Traffic	urban	1	0		1	2	Y
					Port Talbot Margam	24/07/2007	URBAN INDUSTRIAL	Industrial	urban						
Belfast Urban Area	580276	3	2	1	Belfast Centre	08/03/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Eastern	5124072	3	9	5	Cambridge Roadside	26/06/1999	ROADSIDE	Traffic	urban	3	2	2	0	7	Y
					Stanford-le-Hope Roadside	22/01/2008	ROADSIDE	Traffic	urban						
					Sandy Roadside	28/07/2008	ROADSIDE	Traffic	urban						
					Wicken Fen	12/11/1997	RURAL	Background	rural						
					St Osyth	11/05/2002	RURAL	Background	rural						
					New Urban Background		URBAN BACKGROUND	Background	urban						
					Thurrock	01/09/1996	URBAN BACKGROUND	Background	urban						
South West	3980991	3	8	4	Exeter Roadside	02/07/1996	ROADSIDE	Traffic	urban	2	2	2	0	6	Y
					Bath Roadside	18/11/1996	ROADSIDE	Traffic	urban						
					Yarner Wood	15/09/2003	RURAL	Background	rural						
					Charlton Mackrell	03/09/2008	RURAL	Background	rural						
					Plymouth Centre	29/09/1997	URBAN CENTRE	Background	urban						
					New Urban Background		URBAN BACKGROUND	Background	urban						
South East	6392004	3	10	5	Oxford Centre Roadside	15/04/1996	ROADSIDE	Traffic	urban	2	4	3	0	9	Y
					New Roadside		ROADSIDE	traffic	urban						
					Harwell	11/09/1995	RURAL	Background	rural						
					Lullington Heath	29/09/1988	RURAL	Background	rural						
					Rochester Stoke	26/01/1996	RURAL	Background	rural						
					Horley	21/11/2007	SUBURBAN	Background	suburban						
					Canterbury	01/02/2001	URBAN BACKGROUND	Background	urban						
					Oxford St Ebbes	01/01/2008	URBAN BACKGROUND	Background	urban						
					Eastbourne		URBAN BACKGROUND	Background	urban						

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Zone/ Agglomeration	Population (2001)	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start date for NO_2	UK Classification	EU classification: type_of_station	EU classification station_type_ of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Sites in AURN to meet require-ments
East Midlands	3084598	3	7	4	Chesterfield Roadside	11/03/2008	ROADSIDE	Traffic	urban	2	2	2	0	6	Y
					New Roadside		ROADSIDE	Traffic	urban						
					Ladybower	27/10/1988	RURAL	Background	rural						
					Market Harborough	10/12/2003	RURAL	Background	rural						
					Northampton	23/05/2001	URBAN BACKGROUND	Background	urban						
					Chesterfield	13/03/2008	URBAN BACKGROUND	Background	urban						
North West & Merseyside	2826622	3	7	4	Carlisle Roadside	14/02/2008	ROADSIDE	Traffic	urban	2	3	0	0	5	Y
					New Roadside		ROADSIDE	Traffic	urban						
					Glazebury	26/01/2004	SUBURBAN	Background	suburban						
					Wigan Centre	08/10/2004	URBAN BACKGROUND	Background	urban						
					Warrington	21/10/2008	URBAN BACKGROUND	Background	urban						
Yorkshire & Humberside	2514947	3	6	3	York Fishergate	01/01/2008	ROADSIDE	Traffic	urban	1	1	1	1	4	Y
					High Muffles	20/10/2003	RURAL	Background	rural						
					Barnsley Gawber	07/07/1997	URBAN BACKGROUND	Background	urban						
					Scunthorpe Town	10/01/2008	URBAN INDUSTRIAL	Industrial	urban						
West Midlands	2271650	3	6	3	New Roadside		ROADSIDE	Traffic	urban	1	2	0	0	3	Y
					Leominster	18/07/2005	SUBURBAN	Background	suburban						
					Leamington Spa	26/07/1996	URBAN BACKGROUND	Background	urban						
North East	1269803	3	4	2	Stockton-on-Tees Eaglescliffe	21/01/2009	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Sunderland Silksworth	09/12/2004	URBAN BACKGROUND	Background	urban						
Central Scotland	1813314	3	5	3	New Roadside		ROADSIDE	Traffic	urban	1	1	1	1	4	Y
					Bush Estate	09/10/2003	RURAL	Background	rural						
					New Urban Background		URBAN BACKGROUND	Background	urban						
					Grangemouth	01/01/2001	URBAN INDUSTRIAL	Industrial	urban						

Table A3.1 NO_2 Site List

Zone/ Agglomeration	Population (2001)	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start date for NO_2	UK Classification	EU classification: type_of_station	EU classification station_type_ of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Sites in AURN to meet require-ments
North East Scotland	1001499	3	4	2	Aberdeen Union Street Roadside	01/01/2008	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Aberdeen	18/09/1999	URBAN BACKGROUND	Background	urban						
Highlands	380062	1	0	0	Inverness	17/07/2001	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Fort William	22/06/2006	SUBURBAN	Background	rural						
Scottish Borders	254690	3	2	1	Dumfries	01/03/2001	ROADSIDE	Traffic	urban	1	1	1	0	3	Y
					New Urban Background		URBAN BACKGROUND	Background	urban						
					Eskdalemuir	09/12/2004	RURAL	Background	rural						
South Wales	1578773	3	5	3	Narberth	20/01/1997	REMOTE	Background	rural	1	2	1	0	4	Y
					Chepstow A48	01/01/2008	ROADSIDE	Traffic	urban						
					Cwmbran	20/07/2001	URBAN BACKGROUND	Background	urban						
					Newport	01/01/2008	URBAN BACKGROUND	Background	urban						
North Wales	720022	3	2	1	Wrexham	06/03/2002	ROADSIDE	Traffic	urban	1	1	1	0	3	Y
					New Urban Background		URBAN BACKGROUND	Background	urban						
					Aston Hill	21/10/2003	RURAL	Background	rural						
Northern Ireland	1104991	3	4	2	New Roadside		ROADSIDE	traffic	urban	1	1		0	2	Y
					Derry	29/04/1997	URBAN BACKGROUND	Background	urban						
TOTAL				82				TOTAL Site Numbers		36	62	14	8	120	

* 1 = <LAT
2 = LAT – UAT
3 = >UAT

urban background:traffic 1.7
Directive satisfied Y

Table A3.2 PM_{10} $PM_{2.5}$ Site List

Zone/ Agglomeration	Population	Concentration*	Annex V**	Artivle 7***	PM10 Sites	UK Classification	Start date for PM10	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	PM2.5 Sites	UK Classification	Start date for PM2.5	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Total PM10 +PM2.5	Directive satisfied
Greater London Urban Area	8278251	3	15	8	London Harlington	AIRPORT	01/01/2004	Industrial	urban	4	2	0	1	7	London Harlington	AIRPORT	16/09/2008	Industrial	urban	3	7	0	1	11	18	Y
					Camden Kerbside	KERBSIDE	16/05/1996	Traffic	urban						London Marylebone Road	KERBSIDE	01/04/1998	Traffic	urban							
					London Marylebone Road	KERBSIDE	17/07/1997	Traffic	urban						Camden Kerbside	KERBSIDE	19/02/2009	Traffic	urban							
					Haringey Roadside	ROADSIDE	16/05/1996	Traffic	urban						Haringey Roadside	ROADSIDE	18/02/2009	Traffic	urban							
					Southwark Roadside	ROADSIDE		Traffic	urban						London Bexley	SUBURBAN	25/02/2008	Background	suburban							
					London N. Kensington	URBAN BACKGROUND	01/04/1996	Background	urban						London Eltham	SUBURBAN	15/05/2008	Background	suburban							
					London Bloomsbury	URBAN CENTRE	23/01/1992	Background	urban						London Bloomsbury	URBAN CENTRE	26/03/1998	Background	urban							
															London Teddington	URBAN BACKGROUND	08/12/2008	Background	urban							
															London Harrow Stanmore	URBAN BACKGROUND	16/12/2008	Background	urban							
															London N. Kensington	URBAN BACKGROUND	17/12/2008	Background	urban							
															London Westminster	URBAN BACKGROUND	25/12/2008	Background	urban							
West Midlands Urban Area	2284093	3	8	4	Birmingham Tyburn	URBAN BACKGROUND	16/08/2004	Background	urban	1	1	0	0	2	Birmingham Tyburn Roadside	ROADSIDE	11/02/2009	Traffic	urban	1	2	0	0	3	5	Y
					Birmingham Tyburn Roadside	ROADSIDE	11/02/2009	traffic	urban						Birmingham Tyburn	URBAN BACKGROUND	15/12/2008	Background	urban							
															Sandwell West Bromwich	URBAN BACKGROUND		Background	urban							
Greater Manchester Urban Area	2244931	3	8	4	Bury Roadside	ROADSIDE	20/01/1997	Traffic	urban	1	0	0	1	2	Bury Roadside	ROADSIDE		Traffic	urban	1	2	0	0	3	5	Y
					Salford Eccles	URBAN INDUSTRIAL	20/03/1997	Industrial	urban						Manchester Piccadilly	URBAN CENTRE	15/01/2009	Background	urban							
															Salford Eccles	URBAN INDUSTRIAL	26/11/2008	Industrial	urban							
West Yorkshire Urban Area	1499465	3	6	3	Leeds Headingley Kerbside	KERBSIDE	17/02/2008	Traffic	urban	1	1	0	0	2	Leeds Headingley Kerbside	KERBSIDE	06/04/2009	Traffic	urban	1	1	0	0	2	4	Y
					Leeds Centre	URBAN CENTRE	04/01/1993	Background	urban						Leeds Centre	URBAN CENTRE	02/12/2008	Background	urban							
Tyneside	879996	3	4	2	Newcastle Centre	URBAN CENTRE	08/03/1992	Background	urban	0	1	0	0	1	Newcastle Centre	URBAN CENTRE	24/08/2008	Background	urban	0	1	0	0	1	2	Y
Liverpool Urban Area	816216	3	4	2	Liverpool Speke	URBAN BACKGROUND	21/05/2003	Background	urban	0	1	0	0	1	Liverpool Speke	URBAN BACKGROUND	17/09/2008	Background	urban	0	1	0	0	1	2	Y
Sheffield Urban Area	640720	3	3	2	Sheffield Centre	URBAN CENTRE	22/12/1995	Background	urban	0	1	0	0	1	Sheffield Centre	URBAN CENTRE	10/12/2008	Background	urban	0	1	0	0	1	2	Y

Table A3.2 PM_{10} $PM_{2.5}$ Site List

Zone/ Agglomeration	Population	Concentration*	Annex V**	Artivle 7***	PM10 Sites	UK Classification	Start date for PM10	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	PM2.5 Sites	UK Classification	Start date for PM2.5	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Total PM10 +PM2.5	Directive satisfied
Nottingham Urban Area	666358	3	3	2	Nottingham Centre			Background	urban	0	1	0	0	1	Nottingham Centre	URBAN CENTRE	19/12/2008	Background	urban	0	1	0	0	1	2	Y
Birstol Urban Area	551066	3	3	2	Bristol St Paul's	URBAN BACKGROUND	15/06/2006	Background	urban	0	1	0	0	1	Bristol St Paul's	URBAN BACKGROUND	12/08/2008	Background	urban	0	1	0	0	1	2	Y
Brighton/ Worthing/ Littlehampton	461181	2	2	1	N/A			#N/A	#N/A	0	0	0	0	0	Brighton Preston Park	URBAN BACKGROUND	30/05/2008	Background	urban	0	1	0	0	1	1	Y
Leicester Urban Area	441213	3	3	2	Leicester Centre	URBAN CENTRE	04/01/1994	Background	urban	0	1	0	0	1	Leicester Centre	URBAN CENTRE	01/09/2008	Background	urban	0	1	0	0	1	2	Y
Portsmouth Urban Area	442252	3	3	2	Portsmouth	URBAN BACKGROUND	01/01/2001	Background	urban	0	1	0	0	1	Portsmouth	URBAN BACKGROUND	23/12/2008	Background	urban	0	1	0	0	1	2	Y
Teeside Urban Area	365323	3	3	2	Middlesbrough	URBAN INDUSTRIAL	21/04/1995	Industrial	urban	0	0	0	1	1	Middlesbrough	URBAN INDUSTRIAL	13/11/2008	Industrial	urban	0	0	0	1	1	2	Y
The Potteries	362403	3	3	2	Stoke-on-Trent Centre	URBAN CENTRE	11/03/1997	Background	urban	0	1	0	0	1	Stoke-on-Trent Centre	URBAN CENTRE	05/11/2008	Background	urban	0	1	0	0	1	2	Y
Bournemouth Urban Area	383713	2	2	1	Bournemouth	URBAN BACKGROUND	18/07/2001	Background	urban	0	1	0	0	1	Bournmouth Centre	URBAN CENTRE		Background	urban	0	1	0	0	1	2	Y
Reading/ Workingham Urban Area	369804	3	3	2	Reading New Town	URBAN BACKGROUND	17/10/2003	Background	urban	0	1	0	0	1	Reading New Town	URBAN BACKGROUND	25/09/2008	Background	urban	0	1	0	0	1	2	Y
Coventry/ Bedworth	336452	3	3	2	Coventry Memorial Park.	URBAN BACKGROUND		Background	urban	0	1	0	0	1	Coventry Memorial Park	URBAN BACKGROUND	16/12/2008	Background	urban	0	1	0	0	1	2	Y
Kingston Upon Hull	301416	3	3	2	Hull Freetown	URBAN CENTRE	06/11/2002	Background	urban	0	1	0	0	1	Hull Freetown	URBAN CENTRE	02/09/2008	Background	urban	0	1	0	0	1	2	Y
Southampton Urban Area	304400	3	3	2	Southampton Centre	URBAN CENTRE	04/01/1994	Background	urban	0	1	0	0	1	Southampton Centre	URBAN CENTRE	05/11/2008	Background	urban	0	1	0	0	1	2	Y
Birkenhead Urban Area	319675	2	2	1	N/A			#N/A	#N/A	0	0	0	0	0	Wirral Tranmere	URBAN BACKGROUND	28/01/2009	Background	urban	0	1	0	0	1	1	Y
Southend Urban Area	269415	2	2	1	N/A			#N/A	#N/A	0	0	0	0	0	Southend-on-Sea	URBAN BACKGROUND	30/01/2009	Background	urban	0	1	0	0	1	1	Y

Table A3.2 PM_{10} $PM_{2.5}$ Site List

Zone/ Agglomeration	Population	Concentration*	Annex V**	Artivle 7***	PM10 Sites	UK Classification	Start date for PM10	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	PM2.5 Sites	UK Classification	Start date for PM2.5	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Total PM10 +PM2.5	Directive satisfied
Blackpool Urban Area	261088	2	2	1	N/A			#N/A	#N/A	0	0	0	0	0	Blackpool Marton	URBAN BACKGROUND	28/01/2009	Background	urban	0	1	0	0	1	1	Y
Preston Urban Area	264601	2	2	1	N/A			#N/A	#N/A	0	0	0	0	0	Preston	URBAN BACKGROUND	27/01/2009	Background	urban	0	1	0	0	1	1	Y
Glasgow Urban Area	1168270	3	6	3	Glasgow Kerbside	KERBSIDE	10/03/1997	Traffic	urban	1	1	0	0	2	Glasgow Kerbside	KERBSIDE		Traffic	urban	1	1	0	0	2	4	Y
					Glasgow Centre	URBAN CENTRE	26/07/1996	Background	urban						Glasgow Centre	URBAN CENTRE	16/12/2008	Background	urban							
Edinburgh Urban Area	452194	2	2	1	Edinburgh St Leonards	URBAN BACKGROUND	24/11/2003	Background	urban	0	1	0	0	1	Edinburgh St Leonards	URBAN BACKGROUND	01/10/2008	Background	urban	0	1	0	0	1	2	Y
Cardiff Urban Area	327706	3	3	2	Cardiff Centre	URBAN CENTRE	12/05/1992	Background	urban	0	1	0	0	1	Cardiff Centre	URBAN CENTRE	13/08/2008	Background	urban	0	1	0	0	1	2	Y
Swansea Urban Area	270506	3	3	2	Swansea Roadside	ROADSIDE	20/09/2006	Traffic	urban	1	1	0	0	2	Swansea Roadside	ROADSIDE	29/09/2006	Traffic	urban	1	0	0	1	2	4	Y
					Port Talbot Margam	URBAN INDUSTRIAL	24/07/2007	Industrial	urban						Port Talbot Margam	URBAN INDUSTRIAL	23/04/2008	Industrial	urban							
Belfast Urban Area	580276	3	3	2	Belfast Centre	URBAN CENTRE	08/03/1992	Background	urban	0	1	0	0	1	Belfast Centre	URBAN CENTRE	01/10/2008	Background	urban	0	1	0	0	1	2	Y
														0												
Eastern	5124072	3	13	7	Stanford-le-Hope Roadside	ROADSIDE	22/01/2008	Traffic	urban	2	2	0	0	4	Sandy Roadside	ROADSIDE	27/01/2009	Traffic	urban	2	1	0	0	3	7	Y
					Sandy Roadside	ROADSIDE	28/07/2008	Traffic	urban						Stanford-le-Hope Roadside	ROADSIDE	01/04/2009	Traffic	urban							
					New Urban Background	URBAN BACKGROUND	Background	urban							New Urban Background	URBAN BACKGROUND		Background	urban							
					Thurrock	URBAN BACKGROUND	01/09/1996	Background	urban																	
South West	3980991	3	11	6	Saltash Roadside	ROADSIDE	30/07/2008	Traffic	urban	2	1	0	0	3	New Roadside Site	ROADSIDE		Traffic	urban	2	1	0	0	3	6	Y
					New Roadside site	ROADSIDE		Traffic	urban						New Roadside Site	ROADSIDE		Traffic	urban							
					Plymouth Centre	URBAN CENTRE	29/09/1997	Background	urban						Plymouth Centre	URBAN BACKGROUND		Background	urban							
South East	6392004	3	15	8	New Roadside site	ROADSIDE		Traffic	urban	2	2	2	0	6	New Roadside site	ROADSIDE		Traffic	urban	2	2	2	0	6	12	Y
					New Roadside site	ROADSIDE		Traffic	urban						New Roadside site	ROADSIDE		Traffic	urban							
					Harwell	RURAL	14/04/1998	Background	rural						Harwell	RURAL	17/04/1998	Background	rural							
					Rochester Stoke	RURAL	26/01/1996	Background	rural						Rochester Stoke	RURAL	28/04/1998	Background	rural							
					Eastbourne	URBAN BACKGROUND		Background	urban						Eastbourne	URBAN BACKGROUND		Background	urban							
					Oxford St Ebbes	URBAN BACKGROUND	01/01/2008	Background	urban						Oxford St Ebbes	URBAN BACKGROUND	18/12/2008	Background	urban							

Table A3.2 PM_{10} $PM_{2.5}$ Site List

Zone/ Agglomeration	Population	Concentration* Annex V**	Artivle 7***	PM10 Sites	UK Classification	Start date for PM10	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	PM2.5 Sites	UK Classification	Start date for PM2.5	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Total PM10 +PM2.5	Directive satisfied
East Midlands	3084598	3	10	5	Chesterfield Roadside	ROADSIDE	11/03/2008	Traffic	urban	1	1	0	0	2	Chersterfield Roadside	ROADSIDE		Traffic	urban	1	2	0	0	3	5	Y
					Chesterfield	URBAN BACKGROUND	13/03/2008	Background	urban						Northampton	URBAN BACKGROUND	05/09/2008	Background	urban							
															Chesterfield	URBAN BACKGROUND	17/12/2008	Background	urban							
North West & Merseyside	2826622	3	10	5	Carlisle Roadside	ROADSIDE	14/02/2008	Traffic	urban	1	1	0	0	2	Carlisle Roadside	ROADSIDE	17/03/2009	Traffic	urban	1	2	0	0	3	5	Y
					Warrington	URBAN BACKGROUND	01/11/2008	Background	urban						Wigan Centre	URBAN BACKGROUND	27/11/2008	Background	urban							
															Warrington	URBAN BACKGROUND	27/11/2008	Background	urban							
Yorkshire & Humberside	2514947	3	8	4	York Fishergate	ROADSIDE	01/01/2008	Traffic	urban	1	1	1	0	3	York Fishergate	ROADSIDE		Traffic	urban	1	1	0	0	2	5	Y
					York Bootham	URBAN BACKGROUND	01/01/2008	Background	urban						York Bootham	URBAN BACKGROUND	03/12/2008	Background	urban							
					Scunthorpe Town	URBAN INDUSTRIAL	06/06/2004	Industrial	urban																	
West Midlands	2271650	3	8	4	New Roadside Site	ROADSIDE		Traffic	urban	1	1	0	0	2	Leamington Spa Roadside	ROADSIDE		Traffic	urban	1	1	0	0	2	4	Y
					Leamington Spa	URBAN BACKGROUND	26/07/1996	Background	urban						Leamington Spa	URBAN BACKGROUND	22/12/2008	Background	urban							
North East	1269803	3	6	3	Stockton-on-Tees Eaglescliffe	ROADSIDE	01/09/2008	Traffic	urban	1	0	0	0	1	Stockton-on-Tees Eaglescliffe	ROADSIDE	01/09/2008	Traffic	urban	1	1	0	0	2	3	Y
															Sunderland Silksworth	URBAN BACKGROUND	09/12/2008	Background	urban							
Central Scotland	1813314	2	3	2	Auchencorth Moss	RURAL	14/08/2007	Background	rural	0	0	1	1	2	Auchencorth Moss PM10 PM25	RURAL	01/12/2006	Background	rural	0	0	1	1	2	4	Y
					Grangemouth	URBAN INDUSTRIAL	01/01/2001	Industrial	urban			0	0		Grangemouth	URBAN INDUSTRIAL	03/12/2008	Industrial	urban							
North East Scotland	1001499	2	3	2	Aberdeen	URBAN BACKGROUND	18/09/1999	Background	urban	0	1	0	0	1	Aberdeen	URBAN BACKGROUND		Background	urban	0	1	0	0	1	2	Y
Highlands	380062	1	0	0	Inverness	ROADSIDE	11/07/2001	Traffic	urban	1	0	0	0	1	N/A		#N/A	#N/A		0	0	0	0	0	1	Y
Scottish Borders	254690	1	0	0	N/A		#N/A	#N/A		0	0	0	0	0	N/A		#N/A	#N/A		0	0	0	0	0	0	Y
South Wales	1578773	3	7	4	Narberth	REMOTE	20/01/1997	Background	rural	1	1	1	0	3	Chepstow A48			Traffic	urban	1	1	0	0	2	5	Y
					Chepstow A48	ROADSIDE	01/01/2008	Traffic	urban						Newport	URBAN BACKGROUND	12/12/2008	Background	urban							
					Newport	URBAN BACKGROUND	01/01/2008	Background	urban																	

Table A3.2 PM_{10} $PM_{2.5}$ Site List

Zone/ Agglomeration	Population	Concentration*	Annex V**	Artivle 7***	PM10 Sites	UK Classification	Start date for PM10	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	PM2.5 Sites	UK Classification	Start date for PM2.5	EU classification: type_of_station	EU classification station_type_of_area	Traffic Urban	Background urban	Background rural	industrial urban	Total	Total PM10 +PM2.5	Directive satisfied
North Wales	720022	2	2	1	Wrexham	ROADSIDE	01/03/2002	Traffic	urban	1	0	0	0	1	Wrexham Roadside.			Traffic	urban	1	0	0	0	1	2	Y
Northern Ireland	1104991	3	6	3	New Roadside Site	ROADSIDE		Traffic	urban	1	1	1	0	3	Derry	URBAN BACKGROUND	21/02/2008	Background	urban	0	1	0	0	1	4	Y
					Lough Navar	REMOTE	02/10/1996	Background	rural																	
					Derry	URBAN BACKGROUND	29/04/1997	Background	urban																	
TOTAL				115						24	34	6	4	68						20	48	3	4	75	144	

68

Total PM10 + Pm2.5		143
2*pm2.5		150
Directive satisfied	Y	

* 1 = <LAT
2 = LAT – UAT
3 = >UAT
** No of sites required per Annex V
*** No of sites required when Article 7 is applied

Table A3.3 $PM_{2.5}$ Average Exposure Indicator Site List

Zone/ Agglomeration	Population	Number of conurbations	Population summed over conurbations only	No. urban background sites required	PM2.5 Background Sites AEI sites	PM2.5 Start date	UK Classification	EU: type_of_station	DEM - classification station_type_of_area	urban and suburban background industrial	Sites in AURN to meet requirement	PM2.5 Sites Other	UK Classification
Greater London Urban Area	8278251	N/A	N/A	8	London Harlington	16/09/2008	AIRPORT	Industrial	urban	8	Y	London Marylebone Road	KERBSIDE
					London Bexley	25/02/2008	SUBURBAN	Background	suburban			Camden Kerbside	KERBSIDE
					London Eltham	15/05/2008	SUBURBAN	Background	suburban			Haringey Roadside	ROADSIDE
					London Bloomsbury	26/03/1998	URBAN CENTRE	Background	urban				
					London Teddington	08/12/2008	URBAN BACKGROUND	Background	urban				
					London Harrow Stanmore	16/12/2008	URBAN BACKGROUND	Background	urban				
					London N. Kensington	17/12/2008	URBAN BACKGROUND	Background	urban				
					London Westminster	25/12/2008	URBAN BACKGROUND	Background	urban				
West Midlands Urban Area	2284093	N/A	N/A	2	Sandwell West Bromwich		URBAN BACKGROUND	Background	urban	2	Y	Birmingham Tyburn Roadside	ROADSIDE
					Birmingham Tyburn	15/12/2008	URBAN BACKGROUND	Background	urban				
Greater Manchester Urban Area	2244931	N/A	N/A	2	Manchester Piccadilly	15/01/2009	URBAN CENTRE	Background	urban	2	Y	Bury Roadside	ROADSIDE
					Salford Eccles	26/11/2008	URBAN INDUSTRIAL	Industrial	urban				
West Yorkshire Urban Area	1499465	N/A	N/A	1	Leeds Centre	02/12/2008	URBAN CENTRE	Background	urban	1	Y	Leeds Headingley Kerbside	KERBSIDE
Tyneside	879996	N/A	N/A	1	Newcastle Centre	24/08/2008	URBAN CENTRE	Background	urban	1	Y		
Liverpool Urban Area	816216	N/A	N/A	1	Liverpool Speke	17/09/2008	URBAN BACKGROUND	Background	urban	1	Y		
Sheffield Urban Area	640720	N/A	N/A	1	Sheffield Centre	10/12/2008	URBAN CENTRE	Background	urban	1	Y		
Nottingham Urban Area	666358	N/A	N/A	1	Nottingham Centre	19/12/2008	URBAN CENTRE	Background	urban	1	Y		
Birstol Urban Area	551066	N/A	N/A	1	Bristol St Paul's	12/08/2008	URBAN BACKGROUND	Background	urban	1	Y		
Brighton/ Worthing/	461181	N/A	N/A	1	Brighton Preston Park	30/05/2008	URBAN BACKGROUND	Background	urban	1	Y		

Table A3.3 $PM_{2.5}$ Average Exposure Indicator Site List

Zone/ Agglomeration	Population	Number of conurbations	Population summed over conurbations only	No. urban background sites required	PM2.5 Background Sites AEI sites	PM2.5 Start date	UK Classification	EU: type_of_station	DEM - classification station_type_of_area	urban and suburban background industrial	Sites in AURN to meet requirement	PM2.5 Sites Other	UK Classification
Littlehampton													
Leicester Urban Area	441213	N/A	N/A	1	Leicester Centre	01/09/2008	URBAN CENTRE	Background	urban	1	Y		
Portsmouth Urban Area	442252	N/A	N/A	1	Portsmouth	23/12/2008	URBAN BACKGROUND	Background	urban	1	Y		
Teeside Urban Area	365323	N/A	N/A	1	Middlesbrough	13/11/2008	URBAN INDUSTRIAL	Industrial	urban	1	Y		
The Potteries	362403	N/A	N/A	1	Stoke-on-Trent Centre	05/11/2008	URBAN CENTRE	Background	urban	1	Y		
Bournemouth Urban Area	383713	N/A	N/A	1	Bournmouth Centre		URBAN CENTRE	Background	urban	1	Y		
Reading/ Workingham Urban Area	369804	N/A	N/A	1	Reading New Town	25/09/2008	URBAN BACKGROUND	Background	urban	1	Y		
Coventry/ Bedworth	336452	N/A	N/A	1	Coventry Memorial Park	16/12/2008	URBAN BACKGROUND	Background	urban	1	Y		
Kingston Upon Hull	301416	N/A	N/A	1	Hull Freetown	02/09/2008	URBAN CENTRE	Background	urban	1	Y		
Southampton Urban Area	304400	N/A	N/A	1	Southampton Centre	05/11/2008	URBAN CENTRE	Background	urban	1	Y		
Birkenhead Urban Area	319675	N/A	N/A	1	Wirral Tranmere	28/01/2009	URBAN BACKGROUND	Background	urban	1	Y		
Southend Urban Area	269415	N/A	N/A	1	Southend-on-Sea	30/01/2009	URBAN BACKGROUND	Background	urban	1	Y		
Blackpool Urban Area	261088	N/A	N/A	1	Blackpool Marton	28/01/2009	URBAN BACKGROUND	Background	urban	1	Y		
Preston Urban Area	264601	N/A	N/A	1	Preston	27/01/2009	URBAN BACKGROUND	Background	urban	1	Y		
Glasgow Urban Area	1168270	N/A	N/A	1	Glasgow Centre	16/12/2008	URBAN CENTRE	Background	urban	1	Y	Glasgow Kerbside	KERBSIDE

Table A3.3 $PM_{2.5}$ Average Exposure Indicator Site List

Zone/ Agglomeration	Population	Number of conurbations	Population summed over conurbations only	No. urban background sites required	PM2.5 Background Sites AEI sites	PM2.5 Start date	UK Classification	EU: type_of_station	DEM - classification station_type_of_area	urban and suburban background industrial	Sites in AURN to meet requirement	PM2.5 Sites Other	UK Classification
Edinburgh Urban Area	452194	N/A	N/A	1	Edinburgh St Leonards	01/10/2008	URBAN BACKGROUND	Background	urban	1	Y		
Cardiff Urban Area	327706	N/A	N/A	1	Cardiff Centre	13/08/2008	URBAN CENTRE	Background	urban	1	Y		
Swansea Urban Area	270506	N/A	N/A	1	Port Talbot Margam	23/04/2008	URBAN INDUSTRIAL	Industrial	urban	1	Y	Swansea Roadside	ROADSIDE
Belfast Urban Area	580276	N/A	N/A	1	Belfast Centre	01/10/2008	URBAN CENTRE	Background	urban	1	Y		
Eastern	5124072	8	1126800	1	New Urban Background		URBAN BACKGROUND	Background	urban	1	Y	Sandy Roadside Stanford-le-Hope Roadside	ROADSIDE ROADSIDE
South West	3980991	6	862,888	1	Plymouth Centre		URBAN BACKGROUND	Background	urban	1	Y	New Roadside Site New Roadside Site	ROADSIDE ROADSIDE
South East	6392004	10	1594871	1	Eastbourne Oxford St Ebbes	18/12/2008	URBAN BACKGROUND URBAN BACKGROUND	Background Background	urban urban	2	Y	New Roadside site New Roadside site Harwell Rochester Stoke	ROADSIDE ROADSIDE RURAL RURAL
East Midlands	3084598	7	1065679	1	Northampton Chesterfield	05/09/2008 17/12/2008	URBAN BACKGROUND URBAN BACKGROUND	Background Background	urban urban	2	Y	Chersterfield Roadside	ROADSIDE
North West & Merseyside	2826622	5	767,341	1	Wigan Centre Warrington	27/11/2008 27/11/2008	URBAN BACKGROUND URBAN BACKGROUND	Background Background	urban urban	2	Y	Carlisle Roadside	ROADSIDE
Yorkshire & Humberside	2514947	4	611,924	1	York Bootham	03/12/2008	URBAN BACKGROUND	Background	urban	1	Y	York Fishergate	ROADSIDE
West Midlands	2271650	1	138,241	1	Leamington Spa	22/12/2008	URBAN BACKGROUND	Background	urban	1	Y	Leamington Spa Roadside	ROADSIDE
North East	1269803	1	182,974	1	Sunderland Silksworth	09/12/2008	URBAN BACKGROUND	Background	urban	1	Y	Stockton-on-Tees	ROADSIDE

Table A3.3 $PM_{2.5}$ Average Exposure Indicator Site List

Zone/ Agglomeration	Population	Number of conurbations	Population summed over conurbations only	No. urban background sites required	PM2.5 Background Sites AEI sites	PM2.5 Start date	UK Classification	EU: type_of_station	DEM - classification station_type_of_area	urban and suburban background industrial	Sites in AURN to meet requirement	PM2.5 Sites Other	UK Classification
												Eaglescliffe	
Central Scotland	1813314	0	N/A	0						0	Y	Auchencorth Moss PM10 PM25	RURAL
												Grangemouth	URBAN INDUSTRIAL
North East Scotland	1001499	2	352,002	1	Aberdeen		URBAN BACKGROUND	Background	urban	1	Y		
Highlands	380062	0	N/A	0	N/A			#N/A	#N/A	0	Y		
Scottish Borders	254690	0	N/A	0	N/A			#N/A	#N/A	0	Y		
South Wales	1578773	1	139,298	1	Newport	12/12/2008	URBAN BACKGROUND	Background	urban	1	Y	Chepstow A48	
North Wales	720022	0	N/A	0	N/A			N/A	N/A	0	Y	Wrexham Roadside.	
Northern Ireland	1104991	0	N/A	0						0	Y	Derry	URBAN BACKGROUND
TOTAL				47						50			

Table A3.4 SO_2 Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_SO2	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban background urban		Background rural	industrial urban	total	Sites in AURN to meet requirement
Greater London Urban Area	8278251	1	0	0	London Bexley	01/05/1994	SUBURBAN	Background	suburban	2	4	0	0	6	Y
					London Bloomsbury	23/01/1992	URBAN CENTRE	Background	urban						
					London Cromwell Road 2	20/05/1998	ROADSIDE	Traffic	urban						
					London Marylebone Road	17/07/1997	KERBSIDE	Traffic	urban						
					London N. Kensington	01/04/1996	URBAN BACKGROUND	Background	urban						
					London Westminster	17/07/2001	URBAN BACKGROUND	Background	urban						
West Midlands Urban Area	2284093	1	0	0	Birmingham Tyburn	16/08/2004	URBAN BACKGROUND	Background	urban	0	2	0	0	2	Y
					Sandwell West Bromwich	04/11/1998	URBAN BACKGROUND	Background	urban						
Greater Manchester Urban Area	2244931	2	3	2	Manchester Piccadilly	18/12/1995	URBAN CENTRE	Background	urban	0	1	0	1	2	Y
					Salford Eccles	20/03/1997	URBAN INDUSTRIAL	Industrial	urban						
West Yorkshire Urban Area	1499465	1	0	0	Leeds Centre	04/01/1993	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Tyneside	879996	1	0	0	Newcastle Centre	08/03/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Liverpool Urban Area	816216	1	0	0	Liverpool Speke	21/05/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Sheffield Urban Area	640720	1	0	0	Sheffield Centre	22/12/1995	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Nottingham Urban Area	666358	1	0	0	Nottingham Centre	02/09/1996	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Birstol Urban Area	551066	1	0	0	Bristol St Paul's	15/06/2006	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Brighton/ Worthing/ Littlehampton	461181	1	0	0						0	0	0	0	0	
Leicester Urban Area	441213	1	0	0	Leicester Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y

Table A3.4 SO_2 Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_SO2	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban background urban	Background rural	industrial urban	total	Sites in AURN to meet requirement
Portsmouth Urban Area	442252	1	0	0						0	0	0	0	Y
Teeside Urban Area	365323	2	1	1	Middlesbrough	21/04/1995	URBAN INDUSTRIAL	Industrial	urban	0	1	0	0	1	Y
The Potteries	362403	1	0	0						0	0	0	0	0	Y
Bournemouth Urban Area	383713	1	0	0						0	0	0	0	0	Y
Reading/ Workingham Urban Area	369804	1	0	0						0	0	0	0	0	Y
Coventry/ Bedworth	336452	1	0	0						0	0	0	0	0	Y
Kingston Upon Hull	301416	1	0	0	Hull Freetown	06/11/2002	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Southampton Urban Area	304400	1	0	0	Southampton Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Birkenhead Urban Area	319675	1	0	0						0	0	0	0	0	Y
Southend Urban Area	269415	1	0	0						0	0	0	0	0	Y
Blackpool Urban Area	261088	1	0	0						0	0	0	0	0	Y
Preston Urban Area	264601	1	0	0						0	0	0	0	0	Y
Glasgow Urban Area	1168270	1	0	0	Glasgow Centre	26/07/1996	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Edinburgh Urban Area	452194	1	0	0	Edinburgh St Leonards	24/11/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Cardiff Urban Area	327706	1	0	0	Cardiff Centre	12/05/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Swansea Urban Area	270506	1	0	0	Port Talbot Margam	24/07/2007	URBAN INDUSTRIAL	Industrial	urban	0	0	0	1	1	Y

Table A3.4 SO_2 Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_SO2	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban background urban	Background rural	industrial urban	total	Sites in AURN to meet requirement
Belfast Urban Area	580276	3	2	1	Belfast Centre	08/03/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Eastern	5124072	2	4	2	Stanford-le-Hope Roadside	22/01/2008	ROADSIDE	Traffic	urban	1	2	1	0	4	Y
					Thurrock	01/09/1996	URBAN BACKGROUND	Background	urban						
					Wicken Fen	12/11/1997	RURAL	Background	rural						
					New Urban Background			Background	urban						
South West	3980991	1	0	0						0	0	0	0	0	Y
South East	6392004	2	4	2	Harwell	11/09/1995	RURAL	Background	rural	0	0	3	0	3	Y
					Lullington Heath	16/03/1988	RURAL	Background	rural						
					Rochester Stoke	26/01/1996	RURAL	Background	rural						
East Midlands	3084598	2	3	2	Ladybower	07/08/1988	RURAL	Background	rural	0	1	1	0	2	Y
					Northampton	12/02/2001	URBAN BACKGROUND	Background	urban						
North West & Merseyside	2826622	1	0	0						0	0	0	0	0	
Yorkshire & Humberside	2514947	2	3	2	Barnsley 12	21/03/1994	URBAN BACKGROUND	Background	urban	0	2	1	0	3	Y
					Barnsley Gawber	07/07/1997	URBAN BACKGROUND	Background	urban						
					Scunthorpe Town	06/06/2004	URBAN INDUSTRIAL	Industrial	urban						
West Midlands	2271650	1	0	0	Leamington Spa	26/07/1996	URBAN BACKGROUND	Background	urban	0	2	0	0	2	Y
					Leominster	06/02/2008	SUBURBAN	Background	suburban						
North East	1269803	2	2	1	Sunderland Silksworth	01/04/2008	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Central Scotland	1813314	1	0	0	Grangemouth	01/01/2001	URBAN INDUSTRIAL	Industrial	urban	0	0	0	1	1	Y
North East Scotland	1001499	1	0	0						0	0	0	0	0	Y

Table A3.4 SO_2 Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_SO2	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban background urban	Background rural	industrial urban	total	Sites in AURN to meet requirement
Highlands	380062	1	0	0						0	0	0	0	Y
Scottish Borders	254690	1	0	0						0	0	0	0	Y
South Wales	1578773	1	0	0	Narberth	20/01/1997	REMOTE	Background	rural	0	0	1	0	1	Y
North Wales	720022	2	1	1	Wrexham	06/03/2002	ROADSIDE	Traffic	urban	1	0	0	0	1	Y
Northern Ireland	1104991	2	2	1	Derry	29/04/1997	URBAN BACKGROUND	Background	urban	0	2	0	0	2	Y
					New Urban Background Site			Background	urban						
TOTAL				15						4	31	7	3	45	

* 1 = <LAT
2 = LAT – UAT
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Table A3.5 CO Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_CO	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Greater London Urban Area	8278251		4	2	London Marylebone Road	17/07/1997	KERBSIDE	Traffic	urban	3	4	0	0	7	Y
					Tower Hamlets Roadside	01/04/1996	ROADSIDE	Traffic	urban						
					London Cromwell Road 2	20/05/1998	ROADSIDE	Traffic	urban						
					London Bexley	01/05/1994	SUBURBAN	Background	suburban						
					London N. Kensington	01/04/1996	URBAN BACKGROUND	Background	urban						
					London Westminster	17/07/2001	URBAN BACKGROUND	Background	urban						
					London Bloomsbury	23/01/1992	URBAN CENTRE	Background	urban						
West Midlands Urban Area	2284093	1	0	0						0	0	0	0	0	Y
Greater Manchester Urban Area	2244931	2	3	2	Bury Roadside	20/01/1997	ROADSIDE	Traffic	urban	1	0	0	1	2	Y
					Salford Eccles	20/03/1997	URBAN INDUSTRIAL	Industrial	urban						
West Yorkshire Urban Area	1499465	1	0	0	Leeds Centre	04/01/1993	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Tyneside	879996	1	0	0	Newcastle Centre	08/03/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Liverpool Urban Area	816216	1	0	0	Liverpool Speke	21/05/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Sheffield Urban Area	640720	1	0	0	Sheffield Centre	22/12/1995	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Nottingham Urban Area	666358	1	0	0						0	0	0	0	0	Y
Birstol Urban Area	551066	2	1	1	Bristol Old Market	01/07/1996	ROADSIDE	Traffic	urban	1	1	0	0	2	Y
					Bristol St Paul's	15/06/2006	URBAN BACKGROUND	Background	urban						
Brighton/ Worthing/ Littlehampton	461181	1	0	0						0	0	0	0	0	Y

Table A3.5 CO Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_CO	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Leicester Urban Area	441213	1	0	0	Leicester Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Portsmouth Urban Area	442252	1	0	0						0	0	0	0	0	Y
Teeside Urban Area	365323	1	0	0	Middlesbrough	21/04/1995	URBAN INDUSTRIAL	Industrial	urban	0	0	0	1	1	Y
The Potteries	362403	1	0	0						0	0	0	0	0	Y
Bournemouth Urban Area	383713	1	0	0						0	0	0	0	0	Y
Reading/ Workingham Urban Area	369804	1	0	0						0	0	0	0	0	Y
Coventry/ Bedworth	336452	1	0	0						0	0	0	0	0	Y
Kingston Upon Hull	301416	1	0	0	Hull Freetown	06/11/2002	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Southampton Urban Area	304400	1	0	0	Southampton Centre	04/01/1994	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Birkenhead Urban Area	319675	1	0	0						0	0	0	0	0	Y
Southend Urban Area	269415	1	0	0						0	0	0	0	0	Y
Blackpool Urban Area	261088	1	0	0						0	0	0	0	0	Y
Preston Urban Area	264601	1	0	0						0	0	0	0	0	Y
Glasgow Urban Area	1168270	1	0	0	Glasgow Centre	26/07/1996	URBAN CENTRE	Background	urban	0	1	0	0	1	Y

Table A3.5 CO Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_CO	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Edinburgh Urban Area	452194	1	0	0	Edinburgh St Leonards	24/11/2003	URBAN BACKGROUND	Background	urban	0	1	0	0	1	Y
Cardiff Urban Area	327706	1	0	0	Cardiff Centre	12/05/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Swansea Urban Area	270506	1	0	0	Port Talbot Margam	01/01/2008	URBAN INDUSTRIAL	Industrial	urban	0	0	0	1	1	Y
Belfast Urban Area	580276	1	0	0	Belfast Centre	08/03/1992	URBAN CENTRE	Background	urban	0	1	0	0	1	Y
Eastern	5124072	1	0	0	St Osyth	11/05/2002	RURAL	Background	rural	0	0	1	0	1	Y
South West	3980991	1	0	0						0	0	0	0	0	Y
South East	6392004	1	0	0						0	0	0	0	0	Y
East Midlands	3084598	1	0	0	Market Harborough	10/12/2003	RURAL	Background	rural	0	0	1	0	1	Y
North West & Merseyside	2826622	1	0	0						0	0	0	0	0	Y
Yorkshire & Humberside	2514947	1	0	0						0	0	0	0	0	Y
West Midlands	2271650	1	0	0						0	0	0	0	0	Y
North East	1269803	1	0	0						0	0	0	0	0	Y
Central Scotland	1813314	1	0	0						0	0	0	0	0	Y
North East Scotland	1001499	1	0	0						0	0	0	0	0	Y
Highlands	380062	1	0	0						0	0	0	0	0	Y

Table A3.5 CO Site List

Zone/ Agglomeration	Population	Concentration*	No of sites required per Annex V	No of sites required when Article 7 is applied	Site Name	Start_CO	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Scottish Borders	254690	1	0	0						0	0	0	0	0	Y
South Wales	1578773	1	0	0						0	0	0	0	0	Y
North Wales	720022	1	0	0						0	0	0	0	0	Y
Northern Ireland	1104991	1	0	0						0	0	0	0	0	Y
TOTALS				5						5	16	2	3	26	

* 1 = <LAT
2 = LAT – UAT
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Table A3.6 Ozone Site List

Zone/ Agglomeration	Population	No of sites required per Annex V	No of sites required when Article 9 is applied	Site Name	Start_O3	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	EU station_ozone_classification	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Greater London Urban Area	8278251	6	4	London Bloomsbury	23/01/1992	URBAN CENTRE	Background	urban	urban	1	7	0	1	9	Y
				London Eltham	01/04/1996	SUBURBAN	Background	suburban	urban						
				London Haringey	16/05/1996	URBAN CENTRE	Background	urban	urban						
				London Harlington	01/01/2004	AIRPORT	Industrial	urban	urban						
				London Hillingdon	02/08/1996	SUBURBAN	Background	suburban	urban						
				London Marylebone Road	17/07/1997	KERBSIDE	Traffic	urban	urban						
				London N. Kensington	01/04/1996	URBAN BACKGROUND	Background	urban	urban						
				London Teddington	08/08/1996	URBAN BACKGROUND	Background	urban	urban						
				London Westminster	17/07/2001	URBAN BACKGROUND	Background	urban	urban						
West Midlands Urban Area	2284093	4	2	Birmingham Tyburn	16/08/2004	URBAN BACKGROUND	Background	urban	urban	1	3	0		4	Y
				Sandwell West Bromwich	04/11/1998	URBAN BACKGROUND	Background	urban	urban						
				Birmingham Tyburn Roadside	11/02/2009	ROADSIDE	Traffic	urban	urban						
				New Background site		URBAN BACKGROUND	Background	urban	urban						
Greater Manchester Urban Area	2244931	4	2	Manchester Piccadilly	18/12/1995	URBAN CENTRE	Background	urban	urban	0	2	0	1	3	Y
				Manchester South	06/12/1996	SUBURBAN	Background	suburban	urban						
				Salford Eccles	20/03/1997	URBAN INDUSTRIAL	Industrial	urban	urban						
West Yorkshire Urban Area	1499465	3	1	Leeds Centre	04/01/1993	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Tyneside	879996	2	1	Newcastle Centre	08/03/1992	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Liverpool Urban Area	816216	2	1	Liverpool Speke	21/05/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Sheffield Urban Area	640720	2	1	Sheffield Centre	22/12/1995	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y

Table A3.6 Ozone Site List

Zone/ Agglomeration	Population	No of sites required per Annex V	No of sites required when Article 9 is applied	Site Name	Start_O3	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	EU station_ozone_classification	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Nottingham Urban Area	666358	2	1	Nottingham Centre	02/09/1996	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Birstol Urban Area	551066	2	1	Bristol St Paul's	15/06/2006	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Brighton/ Worthing/ Littlehampton	461181	1	1	Brighton Preston Park	03/11/2004	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Leicester Urban Area	441213	1	1	Leicester Centre	04/01/1994	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Portsmouth Urban Area	442252	1	1	Portsmouth	15/04/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Teeside Urban Area	365323	1	1	Middlesbrough	21/04/1995	URBAN INDUSTRIAL	Industrial	urban	urban	0	0	0	1	1	Y
The Potteries	362403	1	1	Stoke-on-Trent Centre	11/03/1997	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Bournemouth Urban Area	383713	1	1	Bournemouth	27/02/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Reading/ Workingham Urban Area	369804	1	1	Reading New Town	17/10/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Coventry/ Bedworth	336452	1	1	Coventry Memorial Park	26/02/2001	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Kingston Upon Hull	301416	1	1	Hull Freetown	06/11/2002	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Southampton Urban Area	304400	1	1	Southampton Centre	04/01/1994	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Birkenhead Urban Area	319675	1	1	Wirral Tranmere	14/05/2000	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Southend Urban Area	269415	1	1	Southend-on-Sea	24/07/2000	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y

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Zone/ Agglomeration	Population	No of sites required per Annex V	No of sites required when Article 9 is applied	Site Name	Start_O3	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	EU station_ozone_classification	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
Blackpool Urban Area	261088	1	1	Blackpool Marton	14/06/2005	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Preston Urban Area	264601	1	1	Preston	06/06/2000	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Glasgow Urban Area	1168270	3	1	Glasgow Centre	26/07/1996	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Edinburgh Urban Area	452194	1	1	Edinburgh St Leonards	24/11/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Cardiff Urban Area	327706	1	1	Cardiff Centre	12/05/1992	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Swansea Urban Area	270506	1	1	Port Talbot Margam	24/07/2007	URBAN INDUSTRIAL	Industrial	urban	urban	0	0	0	1	1	Y
Belfast Urban Area	580276	1	1	Belfast Centre	08/03/1992	URBAN CENTRE	Background	urban	urban	0	1	0	0	1	Y
Eastern	5124072	6	3	Sibton	01/07/1973	REMOTE	Background	rural	rural	0	2	4	0	6	Y
				St Osyth	11/05/2002	RURAL	Background	rural	rural						
				Thurrock	01/09/1996	URBAN BACKGROUND	Background	urban	urban						
				Weybourne	30/05/2001	RURAL	Background	rural	rural						
				Wicken Fen	15/10/1997	RURAL	Background	rural	rural						
				New Urban Background			Background	urban	urban						
South West	3980991	5	2	Charlton Mackrell	03/09/2008	RURAL	Background	rural	rural	1	1	2	0	4	Y
				Exeter Roadside	02/07/1996	ROADSIDE	Traffic	urban	urban						
				Plymouth Centre	29/09/1997	URBAN CENTRE	Background	urban	urban						
				Yarner Wood	26/06/1987	RURAL	Background	rural	rural						
										0	1	3	0	4	
South East	6392004	5	2	Harwell	22/06/1976	RURAL	Background	rural	rural						Y
				Lullington Heath	04/10/1986	RURAL	Background	rural	rural						
				Rochester Stoke	26/01/1996	RURAL	Background	rural	rural						
				New Urban Background site			Background	urban	urban						

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Zone/ Agglomeration	Population	No of sites required per Annex V	No of sites required when Article 9 is applied	Site Name	Start_O3	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	EU station_ozone_classification	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
East Midlands	3084598	5	2	Bottesford	01/10/1977	SUBURBAN	Background	suburban	urban	0	2	2	0	4	Y
				Ladybower	15/07/1988	RURAL	Background	rural	rural						
				Market Harborough	10/12/2003	RURAL	Background	rural	rural						
				Northampton	13/03/2003	URBAN BACKGROUND	Background	urban	urban						
North West & Merseyside	2826622	5	2	Glazebury	01/04/1988	SUBURBAN	Background	suburban	urban	0	2	1	0	3	Y
				Great Dun Fell	09/05/1986	REMOTE	Background	rural	rural						
				Wigan Centre	08/10/2004	URBAN BACKGROUND	Background	urban	urban						
Yorkshire & Humberside	2514947	4	2	Barnsley Gawber	07/07/1997	URBAN BACKGROUND	Background	urban	urban	0	1	1	0	2	Y
				High Muffles	16/07/1987	RURAL	Background	rural	rural						
West Midlands	2271650	4	2	Leamington Spa	26/07/1996	URBAN BACKGROUND	Background	urban	urban	0	2	0	0	2	Y
				Leominster	18/07/2005	SUBURBAN	Background	suburban	urban						
North East	1269803	3	1	Sunderland Silksworth	09/12/2004	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Central Scotland	1813314	3	1	Auchencorth Moss	29/10/2006	RURAL	Background	rural	rural	0	0	2	0	2	Y
				Bush Estate	01/04/1986	RURAL	Background	rural	rural						
North East Scotland	1001499	2	1	Aberdeen	01/08/2003	URBAN BACKGROUND	Background	urban	urban	0	1	0	0	1	Y
Highlands	380062	2	1	Fort William	22/06/2006	SUBURBAN	Background	rural	suburban	0	1	2	0	3	Y
				Lerwick	25/05/2005	RURAL	Background	rural	rural						
				Strath Vaich	18/03/1987	REMOTE	Background	rural	rural						
Scottish Borders	254690	1	1	Eskdalemuir	23/04/1986	RURAL	Background	rural	rural	0	1	1	0	2	Y
				New site					urban						

Table A3.6 Ozone Site List

Zone/ Agglomeration	Population	No of sites required per Annex V	No of sites required when Article 9 is applied	Site Name	Start_O3	UK Classification	EU classification: type_of_station	EU classification station_type_of_area	EU station_ozone_classification	traffic Urban	background urban	Background rural	industrial urban	total	Sites in AURN to meet requirements
South Wales	1578773	3	1	Cwmbran	29/04/2003	URBAN BACKGROUND	Background	urban	urban	0	1	1	0	2	Y
				Narberth	20/01/1997	REMOTE	Background	rural	rural						
North Wales	720022	2	1	Aston Hill	26/06/1986	RURAL	Background	rural	rural	0	1	1	0	2	Y
				New site					urban						
Northern Ireland	1104991	3	1	Derry	29/04/1997	URBAN BACKGROUND	Background	urban	urban	0	1	1	0	2	Y
				Lough Navar	02/04/1987	REMOTE	Background	rural	rural						
			56							3	53	21	4	81	

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