

Report

UK Smoke and Sulphur Dioxide Network 2004

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Executive Summary

This report presents the results from the UK Smoke and Sulphur Dioxide Network for the calendar year 1st January to 31st December 2004. This network measures two pollutant parameters; particulate matter as black smoke, and net gaseous acidity, expressed as SO₂ equivalent. This report provides a summary of data from the 121 sites comprising the Network in 2004. These data are compared with the standards and objectives specified in the Air Quality Strategy, and with limit and guide values specified in applicable EC Directives on sulphur dioxide and suspended particles. Concentration trends are also discussed.

This is the last report in the series, as the Smoke and Sulphur Dioxide Network is to cease operation at the end of December 2005. The repeal of Directive 80/779/EEC on 1st January 2005 has ended its compliance monitoring role, and its other objectives are now increasingly fulfilled by the UK's growing number of automatic SO₂ and PM₁₀ monitoring sites. Also, ambient concentrations of sulphur dioxide have fallen significantly in recent years, and the indicative net acidity method used by the Network is in many cases no longer able to provide representative measurements of this pollutant. However, there remains some scientific interest in black smoke measurements, and Defra envisage retaining around 30 sites to monitor smoke only.

UK average concentrations for the calendar year 2004, based on "core" sites, were 6.1 µg m⁻³ and 14.3 µg m⁻³ for smoke and net acidity respectively. These concentrations are both slightly lower than the averages reported for calendar year 2003, which were 7.2 µg m⁻³ for smoke and 15.5 µg m⁻³ (SO₂ equivalent) for net acidity.

Data for the calendar year 2004 were compared with the 1st Daughter Directive (1999/30/EEC) 24-hour limit value for SO₂ (to be met by 1st January 2005), and the identical Air Quality Strategy 24-hour objective (to be met by 31st December 2004). No Network sites exceeded the AQS 24-hour mean SO₂ objective of 125 µg m⁻³ on more than the three permitted occasions.

Data for calendar year 2004 were also compared with the Stage 1 limit values and objectives for particulate matter contained in the 1st Daughter Directive and the Air Quality Strategy, which were to be met by 1st January 2005 and 31st December 2004 respectively. These specifically apply to PM₁₀, not black smoke, and the latest Technical Guidance does not recommend that black smoke data be routinely used to assess compliance with AQS objectives. However, black smoke can be considered a subset of PM₁₀, so if black smoke exceeds an objective it is reasonable to suspect that total PM₁₀ has also exceeded. There were no sites in the Network at which the daily mean black smoke concentration exceeded the 24-hour limit of 50 µg m⁻³ for PM₁₀ on more than the 35 permitted occasions.

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1 Introduction

This is the annual summary report for the Smoke and Sulphur Dioxide Network, for the calendar year 2004. This report is the final report in this series, as the Network is to cease operation at the end of 2005.

The report presents a description of the Network, its history and objectives. This is followed by a summary and review of the data for 2004. Results are compared with applicable air quality limit values and objectives. Spatial distribution of smoke and sulphur dioxide concentrations throughout the UK, data reporting commitments and data usage are discussed. The report also covers trends in smoke and net acidity concentrations, as measured over the lifetime of the Network.

The main report is followed by Appendices, which provide details of the derivation and calculation of the statistics presented in the report.

2 History of the Network

As far back as 1914, Local Authorities in the UK were carrying out measurements of air pollution. Early measurements were made using the now obsolete lead dioxide candle method for sulphur dioxide, and grit and dust samplers for deposited particulate matter in urban areas. Smoke and sulphur dioxide measurements using the present methods began in the 1950's, and were used to monitor progress in compliance with the Clean Air Acts. The Smoke and SO₂ Network (then called the National Survey of Air Pollution) was set up in 1961 as a co-ordinated national network, for this purpose. The objectives of the National Survey were-

- to monitor progress of the Clean Air Acts;
- to provide guidance on the implementation of clean air legislation;
- to provide the technical basis for future legislation; and
- to provide a consistent body of data for research.

For many years, the National Survey formed the "backbone" of the UK's Air Quality monitoring, prior to the widespread implementation of automatic monitoring techniques in the late 1980s and 1990s. Figure 2.1 shows how site numbers have changed over the years. At its largest, during the 1970's, the Network consisted of between 1200 and 1400 sites. It was rationalised to around 600 sites in the early 1980s, following the introduction of EC Directive 80/779/EEC on sulphur dioxide and suspended particulates¹. Monitoring compliance with this Directive became one of the main objectives of the Network throughout the remainder of its existence.

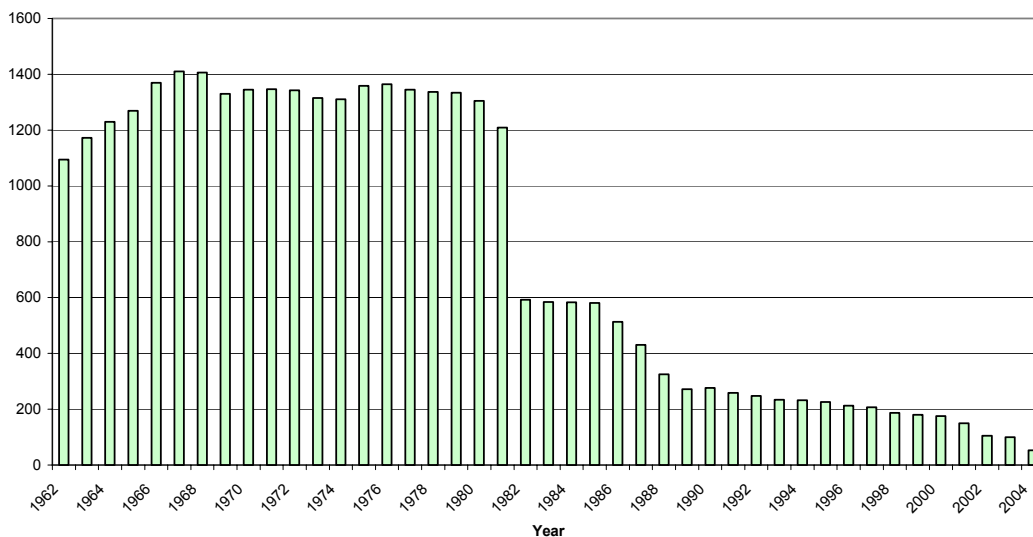


Figure 2.1: Number of Sites in the Smoke and SO₂ Network, 1962 – 2004.

There is a long historical dataset from this Network, with some sites operating since the early 1960s. It has provided a valuable record of pollutant concentrations throughout the UK over four decades. There is also a strong correlation between UK emissions of black smoke and of SO₂, and annual mean concentrations of these pollutants as measured by the Network (this is discussed in more detail in Section 7 of this report). As a record of the progress of the Clean Air Acts, the Network provides an example of how policy can successfully improve air quality.

3 Current Status and Future Developments

The UK Smoke and Sulphur Dioxide (SO₂) Network measures two pollutant parameters; particulate matter as black smoke, and net gaseous acidity, expressed as SO₂ equivalents. During 2004, there were 121 sites (Figure 3.1), all located in urban areas of the UK. Because of the network's historical role as a compliance-monitoring network, they were particularly concentrated in areas where levels of smoke and SO₂ are (or have been) relatively high. These include mining areas of Yorkshire and the East Midlands, also Northern Ireland, which until recent years had very limited availability of natural gas.

The UK Smoke and Sulphur Dioxide Network's objectives during 2004 were as follows;

- To monitor compliance with the original European Council Directive on Sulphur Dioxide and Suspended Particles (80/779/EEC)¹, until it was fully repealed in January 2005.
- To provide a long-term database of suspended particulate matter (as black smoke) and SO₂ (as net acidity) measurements, used to assess trends in concentration and spatial distribution.
- To highlight areas where elevated concentrations of black smoke or SO₂ occur, and where more detailed investigation, including the use of automated techniques, might be justified.

However, in recent years, the Network has increasingly faced a number of challenges:

The end of its compliance monitoring role, when EC Directive 80/779/EEC was fully repealed on 1st January 2005.

Increased availability and use of automatic monitoring. Formerly, results from the Smoke and SO₂ Network were used to supplement the data supplied by the Automatic Urban and Rural Network (AURN). However, the number of automatic monitoring sites, and the spatial coverage of the AURN, has increased substantially in recent years. The data provided from the AURN have now superseded the data provided by the non-automatic network.

Falling concentrations of smoke and SO₂. Concentrations of smoke are now less than 10% of those measured when the Network began, and many sites now exhibit typical concentrations of 5 µg m⁻³ or less, the level below which accuracy is reduced, although still well above the detection limit of 1 µg m⁻³. The problem is greater in the case of SO₂. Whilst the detection limit for the net acidity method used for monitoring SO₂ is 6-7 µg m⁻³, accuracy is reduced at concentrations less than 30 µg m⁻³ SO₂ equivalents. Since the early 1990s, the mean SO₂ concentration for the Network as a whole has been below 30 µg m⁻³. Therefore, annual mean SO₂ concentrations have for some time been below the range recommended for the method, and at some sites are approaching the detection limit.



Figure 3.1: Locations of Smoke & Sulphur Dioxide Network Monitoring Sites, 2004

Site retention issues: Increasingly, Local Authorities are no longer able to provide the staff time and other resources needed to operate these sites. Further, the Review and Assessment process has given Local Authorities a better understanding of which pollutants constitute a problem in their district, and which do not. Consequently, where neither sulphur dioxide nor particulate matter are likely to exceed AQS Objectives, it is difficult for the Local Authority to make a strong case for continuing to monitor them, especially where resources are limited. The number of sites at the time of writing is less than 100.

Relationship between net acidity and SO₂: In the past, when ambient concentrations of SO₂ were considerably higher than those of other acidic gases such as NO₂, the net acidity method was considered representative of SO₂ concentrations. However, at today's much lower SO₂ concentrations (relative to other pollutants such as NO₂), this is no longer always the case. Whilst net acidity measurements provide a useful indication of *peak* 24-h SO₂, where these are > 30 µg m⁻³, annual mean net acidity is no longer always a reliable estimate of annual mean SO₂ concentration. In any case, where SO₂ levels are high, and monitoring is required for LAQM purposes, automatic monitors are now prescribed.

In response to the issues listed above, earlier in 2005, Defra commissioned a review of the Network. The review's conclusions regarding the Smoke and SO₂ Network were as follows:

- That, in view of the end of its compliance monitoring role, the changes in the UK's pollution climate, and the fact that automatic monitoring techniques are now widely used, the Smoke and SO₂ Network (in its present format) has come to the end of its useful life, and should cease operation.
- That the scientific community remains interested in black smoke as a useful particulate metric, and there is a case for retaining a limited number of sites monitoring smoke only.

Accordingly, Defra have taken the decision to cease operation of the Smoke and SO₂ Network as of 31st December 2005. They envisage that a small network of around 30 sites will continue, monitoring black smoke only.

4 Data Reporting and Use

4.1 STATUTORY REPORTING: EC DIRECTIVE

The Smoke and SO₂ Network successfully fulfilled the statutory monitoring requirements of EC Directive 80/779/EEC¹ for many years, until its repeal in 2005. In July each year, the data from the previous pollution year (April - March) were compared with the requirements of the Directive. The results were supplied to the Department for Environment, Food and Rural Affairs (Defra) for formal submission to the European Commission. The last year to be assessed in this way was the year April 2004 - March 2005.

4.2 EC EXCHANGE OF INFORMATION

Under the terms of the EC Exchange of Information Decision², Defra agreed to supply to the Commission, full daily data for all sites in the Network, from 1997 onwards. The data are supplied to the European Topic Centre on Air Quality, for inclusion in their "AIRBASE" database, at <http://bettie.rivm.nl/etc-acc/appletstart.html> (Note: In AIRBASE, the term "Strong Acidity" is used for net gaseous acidity).

4.3 PUBLIC DISSEMINATION

This report provides a major route for public dissemination of data from the Network. However, data are also summarised in the Digest of Environmental Statistics, published annually by the Stationery Office³. Also, ad hoc requests for data are serviced by retrievals from the database held at Netcen. These are normally provided free of charge.

A comprehensive archive of air quality measurements, including data from the Smoke and SO₂ Network, is available on the World Wide Web, via Defra's Air Quality Archive at www.airquality.co.uk. Daily data from 1961 onwards are available, and are updated regularly. The complete dataset up to December 2005 will remain available on the Archive after closure of the Network.

4.4 REVIEW AND ASSESSMENT

Black smoke and net acidity measurements have been of limited use in the Review and Assessment process⁴. In the case of black smoke, there is no simple or universally applicable relationship between this parameter and PM₁₀, so smoke data cannot be used as a substitute for PM₁₀ measurements. However, existing smoke monitoring sites have been useful in identifying areas of high particulate pollution, which can then be targeted for PM₁₀ monitoring. Net acidity data have in some cases been used to predict possible exceedence of the 24-hour objective for SO₂.

5 Results and Discussion

5.1 METHODS AND UNITS

Both smoke and sulphur dioxide concentrations are expressed in microgrammes per cubic metre ($\mu\text{g m}^{-3}$) in this report.

Smoke: In the UK, smoke concentrations are usually calculated according to the British Standard Smoke Stain (BS) Calibration. This report primarily uses the BS calibration, and all black smoke concentrations are in this form except where stated. However, elsewhere in Europe, the Organisation for Economic Co-operation and Development (OECD) Smoke Calibration Curve (OECD Publication no. 17913: 1964) is used. Concentrations given according to the BS calibration can be converted to OECD by dividing the BS concentrations by 0.85. In any communication with the European Commission, it is normal to use the OECD calibration. Where OECD smoke concentrations appear in this report, they are indicated as OECD and shown in *italics*.

SO₂: This network uses the peroxide bubbler method to determine the total concentration of strong acidic gases in the air; the results are by convention expressed as SO₂ equivalents. The units used in this report for net acidity as SO₂ equivalents are $\mu\text{g m}^{-3}$. However, concentrations of gaseous pollutants are sometimes expressed as parts per billion by volume (abbreviated to "ppb"). For SO₂, the conversion factor used by the EC is as follows: **1 ppb = 2.66 $\mu\text{g m}^{-3}$, at a temperature of 20°C and 1013 mb pressure** (this only applies to SO₂; conversion factors are different for other gaseous pollutants).

During the earlier years of the Network, ambient levels of sulphur dioxide were considerably higher than they are now, and SO₂ comprised a larger proportion of the total concentration of strongly acidic gases in ambient air. Therefore, net acidity measurements were usually a good indicator of actual SO₂ concentration. However, ambient concentrations of SO₂ have fallen substantially in recent years, and other strongly acidic gases, such as NO₂, now make a more significant contribution to the net acidity measurement. As discussed in previous reports, it can no longer be assumed that net acidity is equivalent to SO₂.

Data from the small number of Smoke and SO₂ Network sites that are co-located with (or very close to) Automatic Urban and Rural Network (AURN) sites, indicate that:

1. Net acidity measurements appear still to provide a useful indication of peak daily average SO₂ concentrations. This is because these peak measurements often correspond to winter pollution episodes, where the majority of the gaseous acidity measured is in fact due to SO₂.
2. However, the net acidity method now tends to overestimate the annual mean SO₂ substantially. For this reason, recent reports have made it clear that annual mean statistics in particular are net acidity data.

5.2 SUMMARY OF RESULTS

Summary statistics for the year 2004 for each Network site are provided in Table 5.1. The sites are listed by Government region (Scotland, the North East, North West and Merseyside, Yorkshire and the Humber, East Midlands, West Midlands, Wales, Eastern, London, South East, South West and Northern Ireland). **As Table 5.1 is large, it has been placed at the end of the text.** Within each region, sites are grouped by the Local or Unitary Authority in whose area they are situated. In most cases, this Authority is responsible for the operation of the site, although a small number are operated by other organisations such as universities.

For sites in England, Wales and Scotland, Table 5.1 gives the location as an Ordnance Survey grid reference, to the nearest 100m. For sites in Northern Ireland, the Irish Grid is used.

The following abbreviations are used in Table 5.1:

1. "**Data Capt. %**" is percentage data capture – the number of days in the calendar year for which valid data was obtained, expressed as a percentage.
2. "**Arith. Mean**" is the arithmetic mean of all daily values (see Appendix A).
3. "**Median**" is the median, or 50th percentile, of all daily values (see Appendix A).
4. "**98th %ile**" is the 98th percentile of all daily values (see Appendix A).
5. "**Max. Day**" is the maximum daily value measured during the year.

5.3 DATA CAPTURE

The data capture objective specified by Annex IV of the First Daughter Directive (1999/30/EEC)⁵ for indicative techniques is 90%; therefore this is the target for minimum data capture in the Network. The number of sites in operation for the whole year was 99 (this excludes those which started up or closed down during this period, and so could not have achieved full data capture). The average data capture for these sites was 83% for smoke, and 80% for net acidity. Data capture for net acidity is usually slightly lower, as this parameter can be affected by factors such as alkaline interference, which are beyond the site operator's control. 62% of the 99 sites in operation for the full year achieved the data capture target of 90%.

5.4 UK AVERAGE SMOKE AND NET ACIDITY CONCENTRATIONS

Annual mean UK smoke and net acidity are estimated on the basis of a "core" subset of sites. There were 81 sites in the "core" subset during 2004. Annual mean concentrations, calculated by averaging the annual means from all core sites, excluding any with data capture of less than 70%, and for 2004 were as follows:

- Smoke: $6.1 \mu\text{g m}^{-3}$ BS ($7.2 \mu\text{g m}^{-3}$ OECD); and
- Net acidity: $14.3 \mu\text{g m}^{-3}$.

Both the annual mean smoke and net acidity concentrations for 2004 were slightly lower than the annual means for 2003 (which were $7.2 \mu\text{g m}^{-3}$ and $15.5 \mu\text{g m}^{-3}$ respectively).

As noted in Section 4.1 above, the net acidity method is likely to over-estimate network average SO₂ concentrations, due to the contribution from other acidic gases. Annual mean net acidity concentrations, as measured by this Network, have been compared to annual mean SO₂ concentrations for 2004, measured at Automatic Urban and Rural Network (AURN) sites.

Most sites in the Smoke and SO₂ Network are in locations, which would be classified as urban background or suburban. Three categories of AURN sites were therefore considered - see below.

- Suburban: there were just five AURN sites in this category during 2004, and their annual mean SO₂ concentrations ranged from 5 to 11 µg m⁻³, with a mean of 6.6 µg m⁻³.
- Urban background: there were 32 sites in 2004, and the annual mean SO₂ concentrations at these sites ranged from 2 to 16 µg m⁻³, with a mean of 5.2 µg m⁻³.
- Urban non-roadside, (i.e. urban background, urban centre, suburban and urban industrial; 65 sites in 2004). Annual mean SO₂ concentrations at these sites ranged from 2 to 17 µg m⁻³, with a mean of 6.0 µg m⁻³.

The annual mean SO₂ concentration at urban sites therefore appears to be around 6 µg m⁻³ compared with 14 µg m⁻³ for net acidity; that is, SO₂ may account for less than half the average net acidity measurement. However, it should be remembered that many Smoke and SO₂ Network sites are located in areas where SO₂ may be higher than the UK average, so any comparison between the two Networks should be treated with caution.

5.5 NATIONAL AND REGIONAL ANALYSIS

Figures 5.1 and 5.2 show annual means of smoke and net acidity respectively, for the entire Network. Only sites with at least 75% data capture are shown.

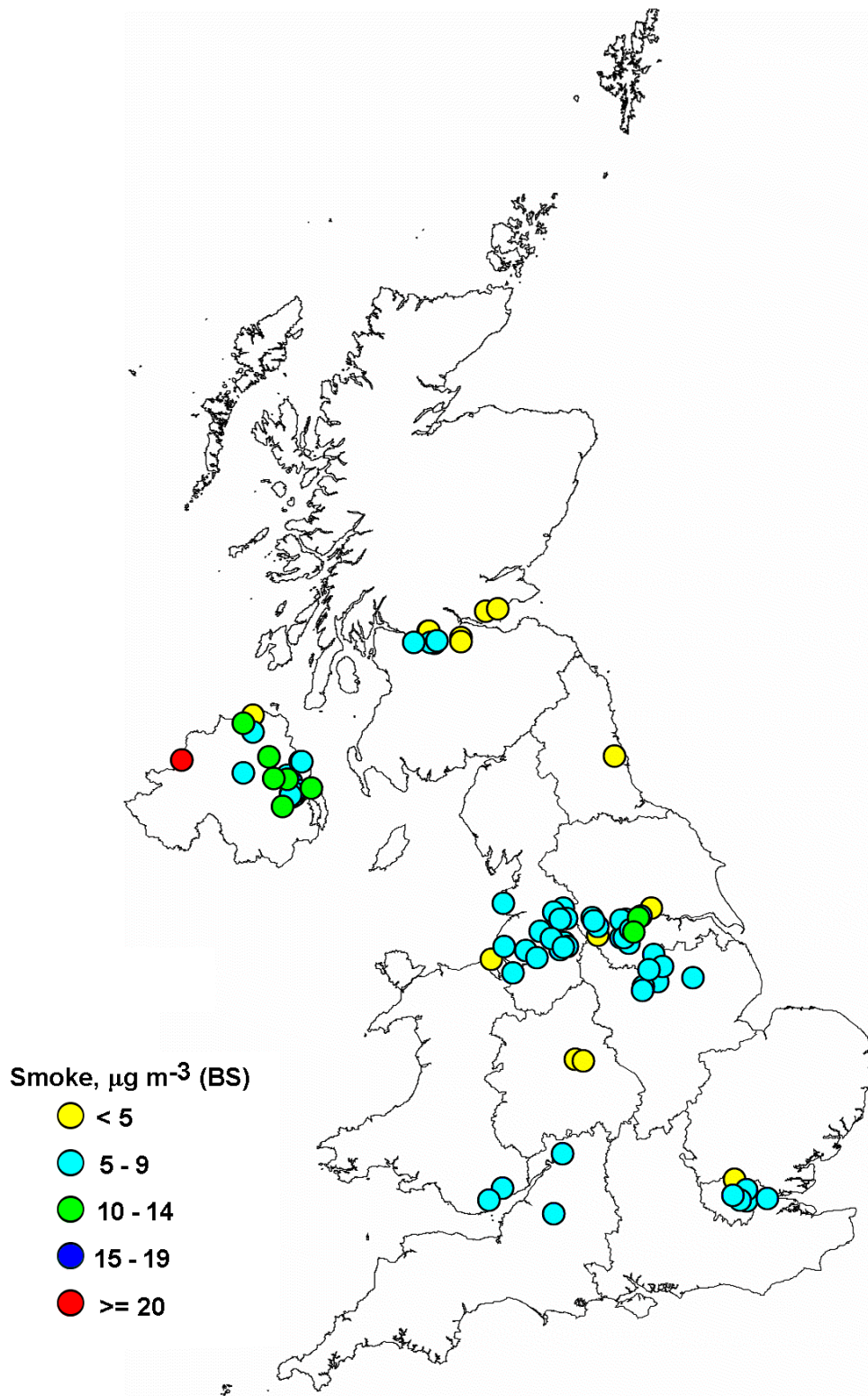


Figure 5.1: Annual Mean Smoke Concentrations (2004)

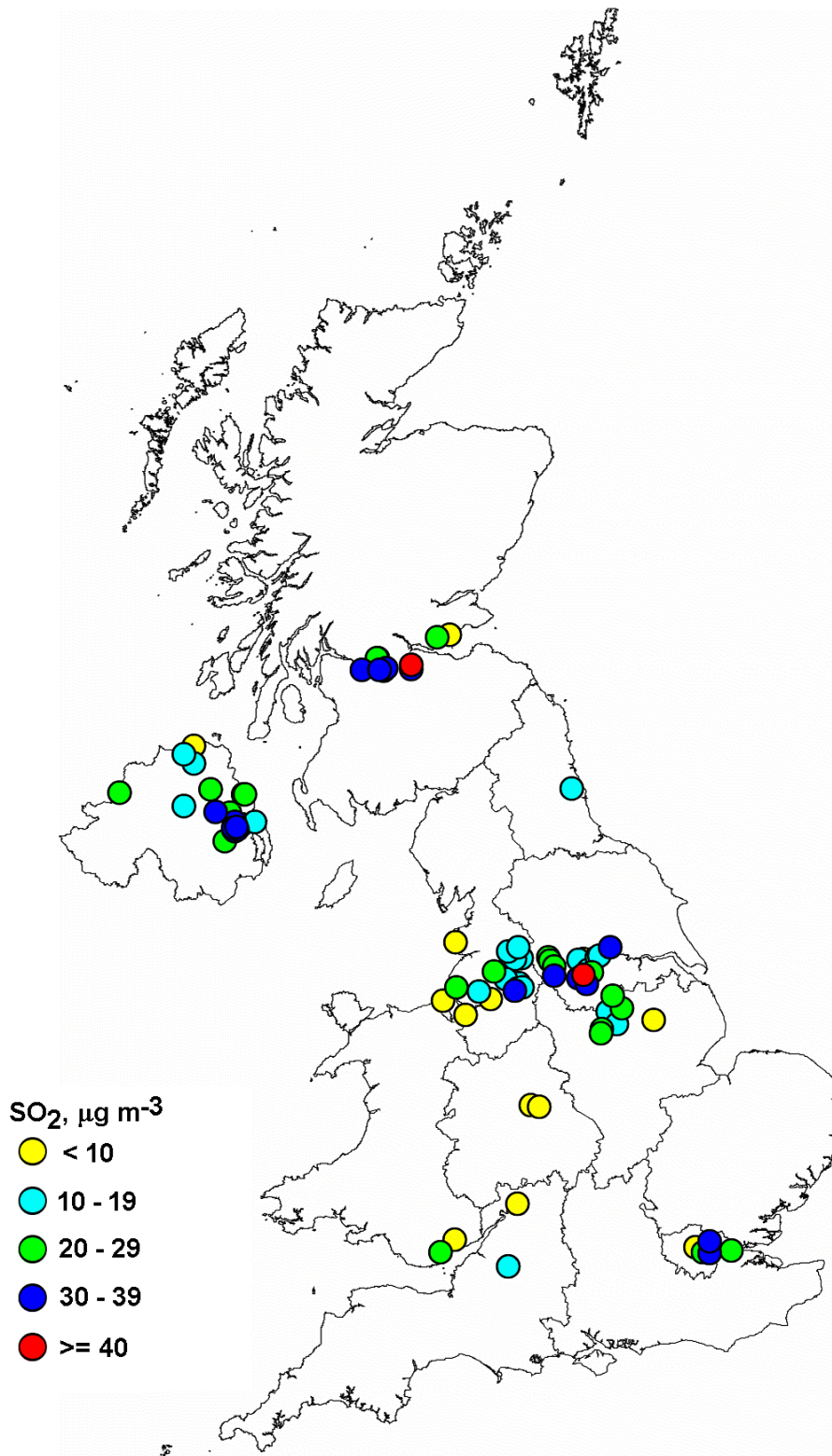


Figure 5.2: Annual Mean Concentrations of Net Acidity (2004)

Table 5.2 summarises key statistics for England and Wales, Scotland and Northern Ireland. Please note that these statistics are not necessarily representative of the region as a whole. Spatial distribution across the UK is not even, and monitoring sites are concentrated in urban areas, particularly where levels of smoke and SO₂ are likely to be highest. As there were only two sites remaining in Wales during 2004, statistics have been calculated for England and Wales together, not for Wales alone.

Table 5.2: Statistical Summary for England and Wales, Scotland and Northern Ireland

	England & Wales	Scotland	N. Ireland
Smoke			
Number of sites with > 75% data	52	10	22
Minimum Annual Mean ($\mu\text{g m}^{-3}$ BS)	2	2	3
Average Annual Mean ($\mu\text{g m}^{-3}$ BS)	6	4	8
Maximum Annual Mean ($\mu\text{g m}^{-3}$ BS)	11	6	21
Net Acidity			
Number of sites with > 75% data	52	10	20
Minimum Annual Mean ($\mu\text{g m}^{-3}$)	2	7	1
Average Annual Mean ($\mu\text{g m}^{-3}$)	14	21	17
Maximum Annual Mean ($\mu\text{g m}^{-3}$)	36	49	29

Note: All statistics in Table 2 are based only on sites with at least 75% data capture.

5.5.1 England & Wales

Smoke in England and Wales: Annual mean smoke at sites in England and Wales ranged from 2 - 11 $\mu\text{g m}^{-3}$. Only one site (South Kirkby 1, in the Wakefield area) recorded an annual mean smoke concentration greater than 10 $\mu\text{g m}^{-3}$ in 2004. The average for all sites in England and Wales was 6 $\mu\text{g m}^{-3}$. This is consistent with the mean of 6 $\mu\text{g m}^{-3}$ for the whole UK, based on core sites.

Net acidity in England and Wales: All but three sites had annual means of 30 $\mu\text{g m}^{-3}$ or less in 2004. The annual mean net acidity for all English sites was 14 $\mu\text{g m}^{-3}$. Again, this is consistent with the mean for the whole UK (based on core sites only).

5.5.2 Scotland

Smoke in Scotland: Annual mean smoke concentrations measured in Scotland were all 6 $\mu\text{g m}^{-3}$ or less. The annual mean smoke concentration for all Scottish sites was 4 $\mu\text{g m}^{-3}$; lower than the Network average of 6 $\mu\text{g m}^{-3}$.

Net acidity in Scotland: By contrast, net acidity concentrations in Scotland continue to be typically higher than the Network average. The highest annual mean was 49 $\mu\text{g m}^{-3}$, measured at Armadale 2. This site is close to industrial and domestic emission sources and high net acidity concentrations have been measured here in previous years. The mean for Scotland was 21 $\mu\text{g m}^{-3}$ – considerably higher than the average of 15 $\mu\text{g m}^{-3}$ measured for the whole Network. However, it is not necessarily the case that net acidity concentrations in Scotland are higher than in the rest of the UK: the number of sites is relatively small, and they are located in Scotland's most built-up areas.

5.5.3 Northern Ireland

Smoke in Northern Ireland: Annual mean smoke concentrations in Northern Ireland ranged from 3 - 21 $\mu\text{g m}^{-3}$. The average for Northern Ireland was 8 $\mu\text{g m}^{-3}$; slightly higher than the Network average of 6 $\mu\text{g m}^{-3}$.

Net acidity in Northern Ireland: Relatively high concentrations of net acidity have been measured in Northern Ireland, particularly Belfast, for many years. Availability of natural gas has historically been limited in this region, so greater use is made of coal and oil. However, in recent years natural gas has become more widely available, and net acidity levels in the region are declining. The overall annual mean net acidity for all Network sites in Northern Ireland has fallen steadily in the past five years, from 27 $\mu\text{g m}^{-3}$ in 2000 to 17 $\mu\text{g m}^{-3}$ in 2004. The difference between annual mean net acidity concentrations in Northern Ireland and those for the Network as a whole, is now just 3 $\mu\text{g m}^{-3}$.

6 Comparison with Air Quality Limit Values and Objectives

In previous years, data from the UK Smoke and SO₂ Network have been compared with the European Council Directive¹ 80/779/EEC on sulphur dioxide and suspended particulates. The limits of this older Directive are less stringent than those in the later 1st Daughter Directive and have been fully met throughout the UK since the early 1990s. Now that Network data are reported on a calendar year basis, comparison of results from the Smoke and SO₂ Network with this original Directive are reported separately to Defra each year. This report therefore compares results from the Smoke and SO₂ Network, for calendar year 2004, with applicable parts of the First Daughter Directive (1999/30/EEC)⁵.

In both the 1st Daughter Directive and the Air Quality Strategy, an "exceedence" of an air quality limit or guide value is defined as a concentration "greater than" the limit or guide value, as opposed to "greater than or equal to". This definition - "greater than" is therefore used in this report.

6.1 LIMITS AND OBJECTIVES FOR SO₂

Within Europe, sulphur dioxide is covered by the 1st Daughter Directive (1999/30/EC)⁵. This Directive, covering SO₂, NO₂, PM₁₀ and lead was published in April 1999 and came into force in July 2001. In the UK, the Air Quality Regulations (2000) for England⁶, Wales⁷, and Scotland⁸, and (2002) for Northern Ireland⁹ include standards and objectives for SO₂. These are explained in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (January 2000)¹⁰. The EC Limit Values, and Air Quality Strategy Standards and Objectives for sulphur dioxide, are summarised in Table 6.1. All these limits are for the protection of human health except where stated.

Table 6.1: Limit Values and Objectives for Sulphur Dioxide

Averaging Period	Limit Value	No. of Permitted Exceedances	To be achieved by
EC 1st Daughter Directive (1999/30/EC)			
1 hour	350 µg m ⁻³	24 per year	1 January 2005
24 hour	125 µg m ⁻³	3 per year	1 January 2005
Calendar year and winter (1 st October – 31 st March), for protection of vegetation (relevant in rural areas)	20 µg m ⁻³	-	19 July 2001
Air Quality Strategy Objectives			
15 minute	266 µg m ⁻³	35 per year	31 December 2005
1 hour	350 µg m ⁻³	24 per year	31 December 2004
24 hour	125 µg m ⁻³	3 per year	31 December 2004
Calendar year and winter (1 st October – 31 st March), for protection of vegetation (relevant in rural areas)	20 µg m ⁻³	-	31 December 2000

It is clearly not possible to compare data from the Smoke and SO₂ Network with the limit values or objectives relating to the 15-minute or hourly average SO₂ concentration. Nor is it relevant to compare data from this urban network with the annual and winter limits for protection of ecosystems, which are intended for protection of rural areas. However, it is possible to compare the daily net acidity data from the Network with the 24 hour limit.

No sites had more than three valid days where the 24-hour average net acidity was greater than the Daughter Directive Limit Value and AQS Standard for SO₂ of 125 µg m⁻³ during 2004. One site, Aberdeen 3, actually recorded six days above this limit value: however, it has now been confirmed that this site was being directly affected by a nearby emission source – a boiler chimney – and consequently its net acidity data have been rejected from the 2004 dataset. Net acidity monitoring at the site has since been discontinued.

By convention, a factor of 1.25 should be applied to peak data obtained using the net acidity method, when comparing it with limit values relating specifically to SO₂. This is intended to take into account any additional uncertainty of the net acidity method at higher concentrations. After application of this factor, one site exceeded the AQS objective of 125 µg m⁻³ for 24-hour mean SO₂ on more than the three permitted occasions; this site, Armadale 2, is located near industrial sources and has always recorded relatively high concentrations.

2004 was a significant year, as the AQS Objective and EC Limit Values for 24-hour mean SO₂ were to be met by 31st December 2004 and 1st January 2005. Results from the Smoke and SO₂ Network indicate that, with the possible exception of locations in the immediate vicinity of specific emission sources, these objectives and limit values have been met in the UK.

6.2 LIMITS AND OBJECTIVES FOR SMOKE

The EC Daughter Directive and the Air Quality Strategy¹⁰ provide Limit Values and Objectives for suspended particulate matter. These objectives also specifically apply to PM₁₀, not black smoke, and the Strategy acknowledges that these two techniques are not the same.

Following a recent consultation process, in August 2003 Defra announced some changes to the AQS objectives, including the setting of further PM₁₀ objectives for 2010. The new objectives include separate PM₁₀ objectives specifically for London, (in acknowledgement of the capital's higher levels of industrial and transport activity), and for Scotland where PM₁₀ concentrations are generally lower.

The EC Directive Limit Values and AQS Objectives for PM₁₀ are summarised in Table 6.2. All limits and objectives are based on European reference method for PM₁₀ (a gravimetric technique), or equivalent. Black smoke data are therefore not directly comparable.

LAQM.TG(03), available via the Defra web site <http://www.defra.gov.uk/environment/airquality/laqm/guidance/index.htm>, does not recommend that black smoke data be used to assess compliance with the AQS Objectives above. This is because there is no simple relationship between black smoke and PM₁₀, which is applicable to every site. However, as black smoke can be considered a subset of PM₁₀, if black smoke exceeds either of the above limits, it is very likely that total PM₁₀ has also done so. This was not the case for any Network sites during 2004.

Table 6.2: Limit Values and Objectives for Particulate Matter as PM₁₀

Averaging Period	Limit Value	Number of Permitted Exceedances	To be achieved by
EC 1st Daughter Directive (1999/30/EC) Stage 1			
24 hour	50 µg m ⁻³	35 per year	1 st January 2005
Annual Mean	40 µg m ⁻³	-	1 st January 2005
EC 1st Daughter Directive (1999/30/EC) Stage 2 (to be confirmed)			
24 hour	50 µg m ⁻³	7 per year	1 st January 2010
Annual Mean	20 µg m ⁻³	-	1 st January 2010
Air Quality Strategy			
24 hour	50 µg m ⁻³	35 per year	31 st December 2004
Annual Mean	40 µg m ⁻³	-	31 st December 2004
Air Quality Strategy, England (except London) and Wales			
24 hour	50 µg m ⁻³	7 per year	31 st December 2010
Annual Mean	20 µg m ⁻³	-	31 st December 2010
Air Quality Strategy, Scotland			
24 hour	50 µg m ⁻³	7 per year	31 st December 2010
Annual Mean	18 µg m ⁻³	-	31 st December 2010
Air Quality Strategy, London			
24 hour	50 µg m ⁻³	10 per year	31 st December 2010
Annual Mean	23 µg m ⁻³	-	31 st December 2010

Note: All limit values refer to gravimetric equivalent measurements.

7 Trends and Comparison with Emission Estimates

The Smoke and SO₂ Network has been in operation since 1961, and during this period it has recorded a substantial decrease in concentrations of both pollutants in the UK. This is illustrated by Figure 7.1, which shows UK annual mean concentrations of smoke and net acidity (expressed as SO₂ equivalent) have changed over the lifetime of the Network. The values shown in Figure 7.1 are means from all sites in the core subset only. For consistency with trend analyses in previous reports in this series, the annual means shown in these figures are based upon the old "pollution calendar" years, which ran from April to March.

The annual means recorded for the first full pollution year of the Network's operation (April 1962-March 1963) were 156 µg m⁻³ and 180 µg m⁻³ for smoke and net acidity respectively. The most recent annual means shown are for years April 2004-March 2005, which are 5.9 µg m⁻³ and 14.4 µg m⁻³ for smoke and net acidity respectively. It should be noted that these are slightly different from the calendar year means discussed earlier in this report. **The 2004-05 smoke and net acidity concentrations are 4% (in the case of smoke) and 8% (in the case of net acidity) of those recorded in 1962-63.**

Figure 7.1 also shows total estimated UK annual emissions of black smoke and sulphur dioxide, taken from the National Atmospheric Emissions Inventory for 1970 onwards. As highlighted by previous reports in this series, there is a strong correlation ($R^2 = 0.91$) between the total annual emission of black smoke and the UK annual mean concentration of this pollutant. Similarly, there is a strong correlation ($R^2 = 0.89$) between the total estimated annual emission of sulphur dioxide and the measured UK annual mean net acidity concentration.

Figure 7.1 shows that the steepest downward trend in smoke and net acidity concentrations occurred during the 1960s and 1970s. However, concentrations continued to decrease throughout the following decades. This report therefore also takes a more detailed look at the most recent part of this long period: years 1990 onwards.

The time series of the annual mean black smoke and net acidity concentrations for the UK as a whole (based on the core subset) are provided in Figures 7.2 and 7.3 respectively. The values shown are means from all sites in the core subset only, and are based upon "pollution calendar" years, April to March.

Figures 7.2 and 7.3 also show estimated total UK annual emissions of smoke and SO₂ for calendar years 1990 - 2003 (data for 2004 are not yet available), taken from the National Atmospheric Emissions Inventory. It should be noted however that, as PM₁₀ has superseded black smoke as a measure of airborne particulate material in many areas, there is now very little emission measurement data of black smoke for recent years. As a result, historical emission factors have had to be used. It is known that the blackening effect from sources has changed with time, and this gives rise to significant uncertainties in the black smoke emission estimates- particularly for more recent years. Therefore, the black smoke emission estimates shown here should be treated with caution. Black smoke emission estimates are no longer used, and the last year for which the NAEI provides an emission estimate is 2001.

Figure 7.2 shows that measured annual mean concentrations, of black smoke have continued to decrease gradually throughout the 1990s, and are now approximately $6 \mu\text{g m}^{-3}$ compared with $14 \mu\text{g m}^{-3}$ in 1990. Estimated emissions (which, as noted above are subject to increased uncertainty in recent years) show a similar decline from around 500 Ktonnes to 268 Ktonnes in 2001. Regression analysis of the two parameters gives a correlation coefficient (R^2) of 0.83. This indicates there is still a good correlation between the two parameters.

Figure 7.3 shows that measured mean net acidity concentrations continued to decrease throughout the 1990s. However, there is some indication that the downward trend has leveled off at approximately $15 \mu\text{g m}^{-3}$ since 2000. Estimated total emissions of SO_2 have substantially decreased, by approximately 70% since 1990. Regression analysis of the two parameters gives a correlation coefficient (R^2) of 0.97. This indicates that there is a very strong correlation between the two parameters. This is despite the fact that net acidity measurements are now over-estimating mean SO_2 concentrations considerably in some locations, due to the fact that acidic gases other than SO_2 now make a significant contribution to results obtained using the net acidity method.

The limit of detection of the net acidity method is $6\text{-}7 \mu\text{g m}^{-3}$. Its resolution is typically similar. Mean UK levels of net acidity have now decreased to concentrations at which this is likely to significantly affect the accuracy of measurements.

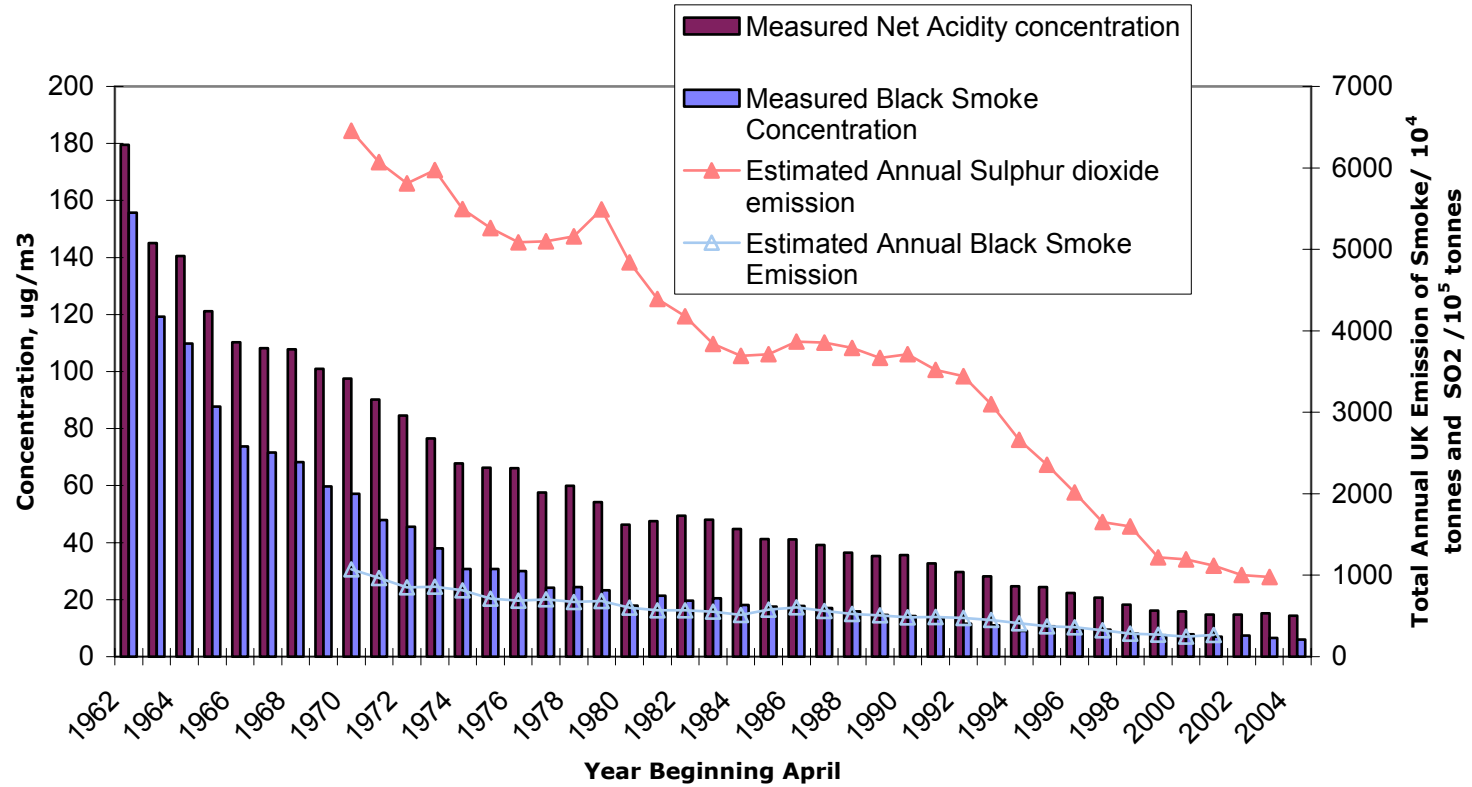


Figure 7.1: Annual Mean Smoke and Net Acidity Concentrations from 1962 Onwards, with Smoke and Sulphur Dioxide Emissions from 1970 Onwards

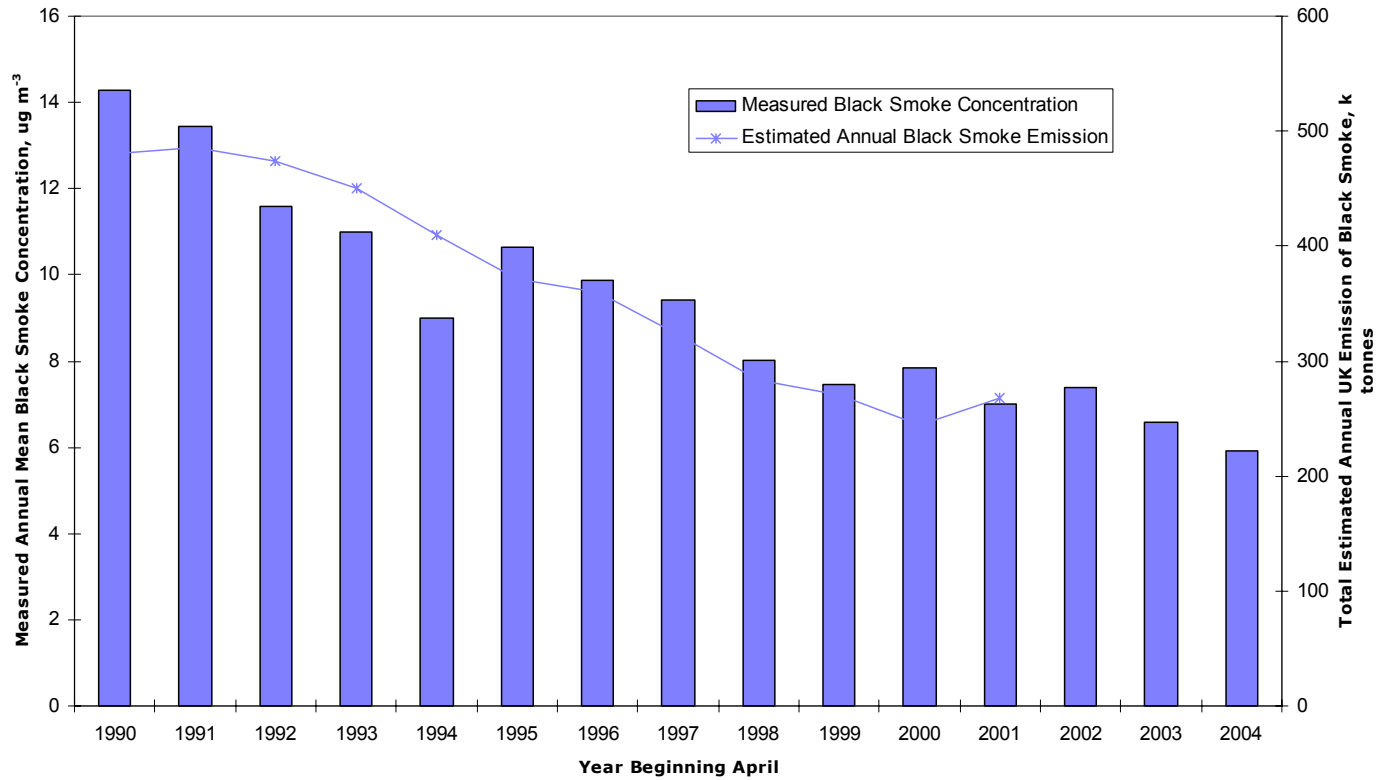


Figure 7.2: Estimated Annual UK Emission and Measured Annual Ambient Concentration of Black Smoke



Figure 7.3: Estimated Annual UK Emission of SO₂ and Measured Annual Mean Concentration of Net Acidity

8 Acknowledgements

All data presented in this report and those prepared in previous years have been obtained by participating Local Authorities and supplied to Netcen as part of this study. This contribution and cooperation from the Local Authorities, over the lifetime of the Smoke and SO₂ Network is gratefully acknowledged.

The central organisation of the study, analysis and quality assurance of the data by Netcen has been funded by the Department for Environment, Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and Department of the Environment in Northern Ireland as part of their Air and Environmental Quality research programme (Contract No. EPG 1/3/71 (A)).

9 References

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8. The Air Quality (Scotland) Regulations 2000 (Scottish Statutory Instrument 2000 No. 97), March 2000.
9. The Air Quality Limit Values Regulations (Northern Ireland) 2002 (Statutory Rule 2002 No. 94), May 2002.
10. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Working Together for Clean Air. The Stationery Office, January 2000.

Table 5.1: Summary of Smoke and Net Acidity (SO₂ equivalent) Results 2004

Code	Site Name	OS Grid Ref to 100m		Authority	Summary of Smoke Data in 2004					Summary of Net Acidity Data 2004 (SO ₂ Equivalent)				
		East	North		Data Capt. %	Arith. Mean	Median	98th %ile	Max. Day	Data Capt. %	Arith. Mean	Median	98th %ile	Max. Day
Scotland														
10003	Aberdeen 3	3931	8062	Aberdeen	68	3	2	15	19	<i>All net acidity data rejected.</i>				
1725008	Kirkintilloch 8	2670	6741	E Dumbartonshire	100	4	3	18	36	100	9	6	18	24
1725009	Kirkintilloch 9	2654	6732	E Dumbartonshire	24	6	4	24	36	24	13	13	19	19
1725010	Kirkintilloch 10	2659	6741	E Dumbartonshire	98	4	2	17	27	98	18	19	31	56
1100025	Edinburgh 25	3258	6731	Edinburgh	15	20	19	42	47	12	1	0	6	6
820301	Cowdenbeath 1	3165	6912	Fife	98	2	2	3	4	98	15	14	27	34
1721006	Kirkcaldy 6	3265	6933	Fife	88	4	3	12	14	88	7	6	13	31
1300020	Glasgow 20	2595	6653	Glasgow	31	13	12	35	48	31	30	26	79	135
1300051	Glasgow 51	2533	6641	Glasgow	96	6	4	26	47	93	22	20	39	63
1300073	Glasgow 73	2612	6627	Glasgow	42	3	3	7	10	40	14	14	28	49
1300095	Glasgow 95	2679	6642	Glasgow	84	5	3	26	36	87	29	26	66	76
1300098	Glasgow 98	2611	6678	Glasgow	66	7	5	26	37	64	12	13	27	65
760011	Coatbridge 11	2738	6652	North Lanarkshire	100	6	4	23	50	100	23	25	37	80
760012	Coatbridge 12	2715	6637	North Lanarkshire	89	5	3	23	32	89	14	13	25	49
69502	Armadale 2	2945	6681	West Lothian	78	2	1	6	12	77	49	48	109	129
3559003	Whitburn 3	2948	6650	West Lothian	99	2	1	8	10	98	22	25	37	50
North East														
915013	Darlington 13	4291	5145	Darlington	55	3	2	10	13	53	7	7	20	27
2370003	Newburn 3	4195	5674	Newcastle U. Tyne	74	9	7	25	33	74	11	12	21	28
2390024	Newcastle Upon Tyne 24	4285	5650	Newcastle U. Tyne	100	4	3	13	32	100	10	7	20	27
2390027	Newcastle Upon Tyne 27	4251	5645	Newcastle U. Tyne	70	7	5	18	31	70	12	12	24	36
3170008	Sunderland 8	4391	5585	Sunderland	55	6	4	20	28	55	13	12	24	25

Table 5.1 (Continued) Summary of Smoke and Net Acidity (SO₂ equivalent) Results 2004

Code	Site Name	OS Grid Ref to 100m		Authority	Summary of Smoke Data in 2004					Summary of Net Acidity Data 2004 (SO ₂ Equivalent)				
		East	North		Data	Arith.	98th	Max.	Data	Arith.	98th	Max.		
					Capt. %	Mean	Median	%ile	Day	Capt. %	Mean	Median	%ile	Day
North West & Merseyside														
380006	Blackpool 6	3317	4367	Blackpool	90	5	4	20	58	90	6	6	12	60
400024	Bolton 24	3715	4092	Bolton	49	6	5	19	25	49	10	7	21	21
1230008	Farnworth 8	3739	4061	Bolton	95	8	5	39	63	95	12	13	26	27
1550001	Horwich 1	3637	4118	Bolton	95	6	4	31	53	95	14	13	25	26
500012	Burnley 12	3841	4324	Burnley	100	5	4	18	38	100	12	12	24	30
715006	Chorley 6	3585	4178	Chorley	54	5	4	14	18	43	6	0	33	46
840009	Crewe 9	3703	3550	Crewe & Nantwich	7	10	9	26	33	7	16	12	32	35
1130012	Ellesmere Port 12	3398	3759	Ellesmere Port	98	6	4	23	33	98	7	6	13	19
20005	Accrington 5	3758	4285	Hyndburn	94	7	5	21	34	94	11	12	24	36
2280011	Manchester 11	3838	3981	Manchester	98	9	8	29	58	98	12	13	25	32
2280015	Manchester 15	3875	3985	Manchester	100	5	3	25	69	100	12	12	31	43
2280021	Manchester 21	3847	4023	Manchester	91	5	3	21	28	91	11	7	21	53
2320003	Middleton 3	3871	4063	Rochdale	10	4	2	10	11	10	28	18	101	105
150005	Bacup 5	3868	4231	Rossendale	96	7	5	22	26	96	9	6	19	25
2650007	Rawtenstall 7	3812	4229	Rossendale	98	8	6	23	37	98	10	7	19	26
855003	Crosby 3	3321	3990	Sefton	77	5	2	23	40	75	17	19	33	40
2800036	St Helens 36	3534	3936	St Helens	21	8	6	24	35	21	14	13	25	25
2800037	St Helens 37	3573	3953	St Helens	70	7	4	25	61	70	9	7	20	25
2800043	St Helens 43	3512	3955	St Helens	92	7	5	25	47	92	12	13	26	38
625006	Cheadle & Gatley 6	3859	3886	Stockport	9	6	5	13	16	9	5	6	15	19
90008	Ashton-Under-Lyne 8	3939	3992	Tameside	36	2	2	6	7	36	1	0	7	7
3314601	Trafford 1	3810	3958	Trafford	100	5	3	17	45	99	31	31	55	58
3430017	Warrington 17	3607	3890	Warrington	100	7	6	25	34	86	7	6	13	18
3532002	West Kirby 2	3212	3874	Wirral	100	2	2	4	14	98	7	6	18	25

Table 5.1 (Continued) Summary of Smoke and Net Acidity (SO₂ equivalent) Results 2004

Code	Site Name	OS Grid Ref to 100m		Authority	Summary of Smoke Data in 2004					Summary of Net Acidity Data 2004 (SO ₂ Equivalent)				
		East	North		Data	Arith.	98th	Max.	Data	Arith.	98th	Max.		
					Capt. %	Mean	Median	%ile	Day	Capt. %	Mean	Median	%ile	Day
YORKSHIRE & THE HUMBER														
190012	Barnsley 12	4342	4067	Barnsley	99	5	4	15	26	99	28	25	50	61
877502	Cudworth 2	4387	4091	Barnsley	99	8	6	24	48	99	36	35	69	88
2208502	Lundwood (Barnsley) 2	4372	4067	Barnsley	99	9	7	30	46	99	22	20	48	62
3710012	Worksop 12	4585	3787	Bassetlaw	81	8	6	24	35	81	11	12	31	48
430006	Bradford 6	4163	4329	Bradford	24	8	5	33	46	<i>No data</i>				
1650011	Keighley 11	4061	4412	Bradford	6	3	3	7	7	<i>No data</i>				
1120002	Elland 2	4109	4209	Calderdale	96	9	7	27	58	96	15	13	26	114
1360017	Halifax 17	4091	4240	Calderdale	93	7	5	25	53	93	14	13	26	58
962512	Dewsbury 12	4235	4212	Kirklees	49	5	4	15	23	49	12	13	25	26
1515005	Holmfirth 5	4144	4085	Kirklees	96	4	3	17	24	96	24	24	43	49
1570019	Huddersfield 19	4143	4164	Kirklees	99	6	4	20	58	99	19	18	42	55
445001	Brampton 1	4414	4019	Rotherham	93	6	4	21	43	93	31	26	65	91
3465006	Wath-Upon-Dearne 6	4433	4009	Rotherham	70	6	4	21	130	70	30	26	57	77
2872505	Selby 5	4612	4322	Selby	98	2	2	5	11	98	21	19	51	52
22501	Ackworth 1	4440	4167	Wakefield	100	7	4	24	47	97	8	7	21	33
580011	Castleford 11	4519	4255	Wakefield	82	9	6	28	39	86	13	13	37	55
1450003	Hemsworth 3	4428	4134	Wakefield	97	9	7	28	45	96	10	7	28	42
1732003	Knottingley 3	4497	4239	Wakefield	92	10	7	36	75	84	12	13	27	40
2415004	Normanton 4	4388	4228	Wakefield	100	7	5	28	48	98	5	6	19	19
2966301	South Kirkby 1	4456	4112	Wakefield	100	11	9	33	55	100	14	12	30	36
3350027	Wakefield 27	4346	4216	Wakefield	98	8	5	33	58	97	9	6	26	50
2533510	Pontefract 10	4473	4217	Wakefield MBC	40	6	4	17	21	40	7	6	20	32

Table 5.1 (Continued) Summary of Smoke and Net Acidity (SO₂ equivalent) Results 2004

Code	Site Name	OS Grid Ref to 100m		Authority	Summary of Smoke Data in 2004					Summary of Net Acidity Data 2004 (SO ₂ Equivalent)				
		East	North		Data	Arith.	98th	Max.	Data	Arith.	98th	Max.		
					Capt. %	Mean	Median	%ile	Day	Capt. %	Mean	Median	%ile	Day
EAST MIDLANDS														
40004	Alfreton 4	4417	3555	Amber Valley	48	9	8	31	41	42	44	51	86	92
348001	Bircotes 1	4627	3920	Bassetlaw	88	6	4	22	41	88	20	19	34	71
2677503	Retford 3	4707	3811	Bassetlaw	80	7	5	24	42	80	14	13	26	58
1840005	Lincoln 5	4974	3714	Lincoln	99	5	4	19	36	97	6	6	13	13
2281010	Mansfield 10	4532	3607	Mansfield	76	6	5	18	37	76	15	13	26	33
2281102	Mansfield Woodhouse 2	4538	3642	Mansfield	99	5	4	20	29	96	15	13	32	51
2364502	New Ollerton 2	4664	3682	Newark	99	5	4	15	19	98	12	13	25	38
750005	Coalville 5	4428	3142	N W Leicestershire	37	3	2	10	12	36	7	6	19	21
West Midlands														
995002	Dudley 2	3940	2897	Dudley MBC	16	6	5	17	17	16	12	13	19	31
1357508	Halesowen 8	3978	2857	Dudley MBC	54	6	6	16	21	54	15	12	29	35
3090020	Stoke-On-Trent 20	3888	3475	Stoke-On-Trent	30	7	6	24	35	<i>Smoke only site.</i>				
3380018	Walsall 18	4014	2987	Walsall	80	4	2	15	79	80	7	6	17	33
3470002	Wednesfield 2	3946	3002	Wolverhampton	100	3	3	12	21	99	2	0	13	31
Wales														
540012	Cardiff 12	3193	1773	Cardiff	100	6	5	20	30	100	18	19	31	31
2400026	Newport (Mon) 26	3313	1878	Newport	96	6	5	23	29	95	6	6	12	18
Eastern														
2430007	Norwich 7	6233	3099	Norwich	34	4	4	11	15	35	14	13	24	30
3265013	Thurrock 13	5622	1791	Thurrock	99	6	5	21	28	99	14	12	25	43
LONDON														
1140014	Enfield 14	5338	1958	Enfield	86	4	3	8	12	85	9	7	18	21
1343709	Greenwich 9	5382	1773	Greenwich	98	7	6	18	31	96	18	18	42	59
3696009	Woolwich 9	5441	1769	Greenwich	96	5	4	15	23	95	22	21	37	44
1950016	London City 16	5324	1814	City of London	100	7	6	20	24	79	3	0	18	26
1590006	Ilford 6	5440	1864	Redbridge	97	6	5	17	27	97	24	24	37	55
South West														
205006	Bath 6	3754	1656	Bath	83	8	6	25	45	83	13	13	21	21
470026	Bristol 26	3634	1763	Bristol	34	3	2	11	13	34	16	18	30	35
1305004	Gloucester 4	3832	2179	Gloucester	98	5	3	19	32	98	7	6	13	24
453003	Bridgwater 3	3298	1373	Sedgemoor	60	2	2	8	9	55	18	18	36	37
3220002	Swindon 2	4147	1858	Swindon	46	7	5	25	33	46	8	7	14	17

Table 5.1 (Continued) Summary of Smoke and Net Acidity (SO₂ equivalent) Results 2004

Code	Site Name	Irish Grid Ref to 100m		Authority	Summary of Smoke Data in 2004					Summary of Net Acidity Data 2004 (SO ₂ Equivalent)				
		East	North		Data	Arith.	98th	Max.	Data	Arith.	98th	Max.		
					Capt. %	Mean	Median	%ile	Day	Capt. %	Mean	Median	%ile	Day
Northern Ireland														
68851	Antrim 1	3162	3869	Antrim	98	13	8	68	213	98	22	24	37	43
160005	Ballymena 5	3109	4053	Ballymena	98	11	11	20	27	98	17	19	26	28
161504	Ballymoney 4	2954	4259	Ballymoney	98	8	7	21	55	98	9	6	19	27
270012	Belfast 12	3324	3737	Belfast	100	8	5	37	71	100	16	12	36	66
270013	Belfast 13	3357	3740	Belfast	98	7	5	29	51	98	26	26	50	64
270033	Belfast 33	3346	3755	Belfast	100	8	5	29	64	100	29	26	51	90
270042	Belfast 42	3322	3748	Belfast	84	7	4	39	58	84	27	26	45	71
270044	Belfast 44	3338	3740	Belfast	98	5	4	23	43	98	25	26	45	58
270045	Belfast 45	3335	3723	Belfast	100	7	4	29	40	100	26	26	45	64
270046	Belfast 46	3350	3796	Belfast	87	4	3	16	23	87	22	19	38	51
768003	Coleraine 3	2861	4328	Coleraine	100	12	11	17	19	97	10	6	37	56
2551506	Portadown 6	3004	3548	Craigavon	27	4	3	10	15	27	11	12	24	24
2190014	Londonderry 14	2443	4174	Derry	19	9	9	21	27	<i>No data</i>				
1025001	Dungannon 1	2802	3629	Dungannon	35	7	6	22	26	35	15	12	31	31
1757704	Larne 4	3386	4037	Larne	96	7	5	18	45	97	17	18	30	36
1757705	Larne 5	3401	4033	Larne	98	7	6	22	33	98	18	20	28	48
1032503	Dunmurry 3	3287	3875	Lisburn	89	10	6	47	73	90	15	13	27	31
1845003	Lisburn 3	3263	3636	Lisburn	92	10	7	46	68	93	15	13	26	32
3325001	Twinbrook 1	3281	3689	Lisburn	49	8	6	36	81	49	18	19	26	31
2233501	Magherafelt 1	2896	3901	Magherafelt	98	6	4	28	47	100	9	7	13	20
512602	Bushmills 2	2941	4407	Moyle	91	3	1	14	20	89	1	0	12	12
2410003	Newry 3	3078	3268	Newry and Mourne	57	3	2	15	16	56	6	7	13	14
2412503	Newtownabbey 3	3321	3851	Newtownabbey	99	5	3	20	71	<i>Smoke only site.</i>				
2412504	Newtownabbey 4	3283	3907	Newtownabbey	81	6	3	28	48	<i>Smoke only site.</i>				
165005	Bangor (Co Down) 5	3497	3810	North Down	100	12	9	48	74	100	11	6	37	55
1517501	Holywood 1	3397	3784	North Down	93	6	5	22	61	93	9	6	24	35
3111502	Strabane 2	2351	3972	Strabane	94	21	15	58	109	95	14	14	21	27

All concentrations in $\mu\text{g m}^{-3}$.

The following abbreviations are used in Table 1:

1. "Data Capt. %" is the percentage of the year for which valid data was obtained.
2. "Arith. Mean" is the arithmetic mean of all daily values, calculated as described in Appendix A.
3. "Median" is the median, or 50th percentile, of all daily values, calculated as described in Appendix A.
4. "98th %ile" is the 98th percentile of all daily values, see Appendix A.
5. "Max. Day" is the maximum daily value measured during the year.

Appendices

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Appendix A	Calculation of Results and Statistics
Appendix B	Data Files for 2004
Appendix C	Sites Comprising "Core" Subset

Appendix A

Calculation of Results and Statistics

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- A2. Derivation of Results
- A3. Significance of Results
- A4. Formulae used in Calculating Concentrations
- A5. Formulae used in Calculating Annual Statistics
- A6. Units

A1. Period Covered by Observations

This report covers the calendar year 1st January to 31st December 2004. The UK Smoke and Sulphur Dioxide Network is operated on the basis of the "Pollution Calendar". The pollution year always begins on the Tuesday nearest to 1 April, and contains twelve months, each of exactly 4 or 5 weeks, all beginning on Tuesdays. Pollution months April to September make up the summer period, and October to March constitute the winter period. While this "Pollution Calendar" is for operational purposes, to conveniently divide the year up into 'months' comprising whole numbers of weeks (as the samplers are normally visited weekly), data are now reported on a calendar year basis, in line with all other Networks operated on behalf of Defra. Details of the pollution calendar are available from Netcen on request.

A2. Derivation of Results

The data are processed by computer, from daily measurements made by the participating Local Authorities and other organisations. The formulae used for calculation of smoke concentrations, i.e. for relating blackness of the filter to the mass of smoke per unit volume of air sampled, have been used since winter 1961-62. The formula used for calculating SO₂ equivalent concentrations has never been changed. As in previous years, the validity of the original readings has been checked by means of an editing program.

A3. Significance of Results

It is important to note that in making comparisons of pollution in different towns, careful account must be taken of the details of the sites for which measurements are available in relation to the geographical structure of the town. That is, to the situation, extent and types of industrial, residential and commercial areas. Local variations in fuel type and quality can also have a significant effect on the measurements.

A4. Formulae used in Calculating Concentrations

A4.1 Smoke

Smoke concentrations have been calculated by the use of the British Standard Smoke Calibration Curve (BS 1747: Part 2: 1991).

For reflectometer readings of 40 to 99 the following formula is used:

$$C = \frac{F}{V} (91,679.22 - 3,332.0460 R + 49.618884 R^2 - 0.35329778 R^3 + 0.0009863435 R^4)$$

Where:

C = concentration in microgrammes per cubic metre;

V = volume of air sampled, in cubic feet (in the majority of cases, a metric meter is used, and the volume in cubic metres is converted to cubic feet by multiplying by 35.315);

F = a factor relating to the sampler clamp size, as follows:

0.288 for 1/2 inch clamp;

1.00 for 1 inch clamp;

3.68 for 2 inch clamp; or

12.8 for 4 inch clamp.

R = reflectometer reading.

This formula represents the calibration curve to within $\pm 1.3\%$ over the range of reflectometer readings between 40 and 90. When used to calculate concentrations from reflectometer readings between 91 and 98 the results may be underestimated by as much as 6%. For darker stains with reflectometer readings between 40 and 20 the formula used is:

$$C = \frac{F}{V} (214,245.1 - 15,130.512 R + 508.181 R^2 - 8.831144 R^3 + 0.0628057 R^4)$$

For stains with reflectometer readings of less than 20 this formula gives only an approximation to the concentration, the result being well below the true value. Reflectometer readings of less than 10 are impossible to assess accurately and hence the results are calculated as if the reading had been 10, which at least gives a minimum value. However, such low reflectometer readings, corresponding to very high smoke concentrations, are now rare in the UK.

A4.2 Sulphur dioxide

Sulphur dioxide concentrations have been calculated by the method described in BS 747: Part 3: 1991. The formula used to calculate sulphur dioxide concentrations is:

$$C = \frac{4520 \times m}{V}$$

where:

C = concentration in microgrammes per cubic metre;

m = volume of 0.002M (N/250) di-sodium tetraborate used, in millilitres; and

V = volume of air sampled, in cubic feet (again, in the majority of cases, a metric meter is used, and the volume in cubic metres is converted to cubic feet by multiplying by 35.315)

A5. Formulae used in Calculating Annual Statistics

A5.1 Arithmetic Mean (AM)

$$AM = \frac{\sum_{i=1}^N C_i}{N}$$

where:

AM is annual arithmetic mean;

C_i is daily concentration for day i ; and

N is number of results available for the year.

A5.2 Percentiles

Note - The median is the 50th percentile.

Daily concentrations are sorted into ascending order of concentration value, $C_1, C_2, C_3, \dots, C_i, \dots, C_N$ and the associated percentile value for each concentration value is found from:

$$P_i = \left(\frac{i}{N+1} \right) 100$$

where:

P_i is the percentile for the i th concentration in the sorted set, that is, $P_i\%$ of the concentrations will be equal to or less than C_i ; and

N is the number of results available for the year.

The concentration values for the fixed percentile values quoted are obtained by linear interpolation between the concentration values for the nearest percentile values on either side.

For example, in the sets

$$P_1, P_2, \dots, P_i, \dots, 98.8, 99.3, \dots, P_N$$

$$C_1, C_2, \dots, C_i, \dots, 150, 160, \dots, C_N$$

the 99th percentile would be $154 \mu\text{g m}^{-3}$

A6. Units

The unit employed for expressing both smoke and sulphur dioxide concentrations from this Network is microgrammes per cubic metre. However, concentrations of gaseous pollutants such as SO_2 are sometimes expressed as parts per billion by volume (abbreviated to "ppb").

For SO_2 , the conversion factor is as follows:

1 ppb = 2.62 microgrammes per cubic metre (for SO_2 only) at a temperature of 29°C and 1013 mb pressure; or

1 ppb = 2.66 microgrammes per cubic metre (for SO_2 only) at a temperature of 20°C and 1013 mb pressure.

The conversion factor is different for other gaseous pollutants.

Appendix B

Data Files for 2004

Data Files

Files containing the full year's dataset, for all Network sites, accompany this report and can be downloaded with the report, from the Air Quality Archive. The data are presented in **comma separated value** (CSV) format, a form which can be input into most spreadsheets. The data are provided in five files as follows:

1. File "site2004": a summary of site details. The data are tabulated in rows, one per site, with columns as follows:-

- Site code - the site's unique identification number of up to 7 digits.
- Site name and number - the name and number by which the site is usually known, e.g. "ABERDEEN 3".
- Grid reference easting, given to the nearest 100m.
- Grid reference northing, given to the nearest 100m. Note: for sites in Northern Ireland the grid reference refers to the Irish Grid, and both the easting and northing are preceded by a "9" to indicate this.
- Site address.
- Site Environment. The surroundings of each site are classified by a code according to the following scheme:
 - A1 Residential area with high-density housing (probably terraced), or with medium-density housing in multiple occupation, in either case surrounded by other built-up areas.
 - A2 Predominantly A1, but interspersed with some industrial undertakings.
 - A3 Residential area with high-density housing or medium-density housing in multiple occupation surrounded by, or interspersed with, other areas with low potential air pollution output (parks, fields, coast).
 - B1 Residential area with medium-density housing, typically an inner suburb or housing estate, surrounded by other built-up areas.
 - B2 Predominantly B1, but interspersed with some industrial undertakings.
 - B3 Residential area with medium-density housing surrounded by or interspersed with areas with low potential air pollution output (parks, fields, coast), or any residential area with low-density housing.
 - C1 Industrial area without domestic premises.
 - C2 Industrial area interspersed with domestic premises of high density or in multiple occupation.
 - D1 Commercial area or one with predominantly central heating.
 - D2 Town centre with limited commercial area, possibly mixed with old residential housing and/or minor industry.

- E Smoke control area or smokeless zone (the letter to be added to the primary classification).
 - R Rural community.
 - O1 Open country but not entirely without source(s) of pollution, e.g. airfields.
 - O2 Completely open country; no sources within at least 400 metres.
 - X Unclassified site, or mixed area.
- Equivalent Defra Site Type. The Smoke and SO₂ Network site classifications differ considerably from those used by Defra to categorise their automatic sites. However, the nearest equivalent is given here. Smoke and SO₂ sites of types A1, A2, and A3 will mostly fall into Defra site types Suburban (SU) or Urban Background (U4), being predominantly in urban residential areas. B1, B2 and B3 will be Suburban (SU). C1 and C2 will be roughly equivalent to Urban Industrial (U5), and D1 and D2 Urban Centre (U3) or Urban Background (U4). R, O1 and O2 sites can all be treated as Rural (R).
 - Unitary Authority. The name of the Local or Unitary Authority in whose area the site lies. In most cases this Authority is responsible for the operation of the site, although a small number of sites are operated by other organisations such as universities.
 - Government Region Code. The twelve regions are assigned code numbers from 1 to 12.
 - Government Region Name.
 - County name. The name of the county in which the site lies.

2. File "smk2004": full daily black smoke data, 1st January to 31st December 2004, for all sites. One column per site, with one row per day. Values are in $\mu\text{g m}^{-3}$. Black smoke concentrations have been calculated according to the British Standard calibration, as used in the UK. For communications with organisations elsewhere in Europe, the concentrations should be converted to the OECD calibration, by dividing by 0.85.

3. File "so22004": full daily net acidity data, as sulphur dioxide equivalent, 1st January to 31st December 2004, for all sites. One column per site, with one row per day. Values are in $\mu\text{g m}^{-3}$.

4. File "smksumm2004": this contains the smoke summary data as in Table 1, but in CSV format. The data are tabulated as follows:-

- Site code number.
- Site name.
- Region name (e.g. North East).
- Local or Unitary Authority in whose area the site lies.
- Grid reference easting.

- Grid reference northing.
- Number of valid days' smoke data.
- Data capture expressed as a percentage.
- Arithmetic mean of daily smoke measurements.
- Median (50th percentile) of daily smoke measurements.
- 98th percentile of daily smoke measurements.
- Maximum daily value.

There is one row of data per site, and these are presented by region.

5. File "so2summ2004": this contains the net acidity summary data (expressed as SO₂ equivalent) as in Table 1, but in CSV format. The data are tabulated in the same manner as the smoke data in "smksumm2004.csv" described above. Again, the top row contains column headings.

Appendix C

Sites Comprising “Core” Subset

10003	Aberdeen 3
20005	Accrington 5
40004	Alfreton 4
90008	Ashton-Under-Lyne 8
150005	Bacup 5
160005	Ballymena 5
190012	Barnsley 12
205006	Bath 6
270013	Belfast 13
270042	Belfast 42
270046	Belfast 46
380006	Blackpool 6
400024	Bolton 24
430006	Bradford 6
453003	Bridgwater 3
470026	Bristol 26
500012	Burnley 12
540012	Cardiff 12
580011	Castleford 11
625006	Cheadle & Gatley 6
715006	Chorley 6
760011	Coatbridge 11
840009	Crewe 9
855003	Crosby 3
915013	Darlington 13
995002	Dudley 2
1025001	Dungannon 1
1032503	Dunmurry 3
1100025	Edinburgh 25
1130012	Ellesmere Port 12
1140014	Enfield 14
1230008	Farnworth 8
1290010	Gateshead 10
1300051	Glasgow 51
1300073	Glasgow 73
1300095	Glasgow 95
1300098	Glasgow 98

1305004	Gloucester 4
1343709	Greenwich 9
1357508	Halesowen 8
1360017	Halifax 17
1450003	Hemsworth 3
1515005	Holmfirth 5
1550001	Horwich 1
1570019	Huddersfield 19
1590006	Ilford 6
1650011	Keighley 11
1757704	Larne 4
1840005	Lincoln 5
1845003	Lisburn 3
1950016	London City 16
2280011	Manchester 11
2280015	Manchester 15
2280021	Manchester 21
2281010	Mansfield 10
2320003	Middleton 3
2370003	Newburn 3
2390024	Newcastle Upon Tyne 24
2390027	Newcastle Upon Tyne 27
2400026	Newport (Mon) 26
2410003	Newry 3
2412503	Newtownabbey 3
2430007	Norwich 7
2470013	Oldham 13
2533510	Pontefract 10
2551506	Portadown 6
2650007	Rawtenstall 7
2677503	Retford 3
2800036	St Helens 36
2800043	St Helens 43
2872505	Selby 5
3090020	Stoke-On-Trent 20
3170008	Sunderland 8
3220002	Swindon 2

3265013	Thurrock 13
3314601	Trafford 1
3350027	Wakefield 27
3380018	Walsall 18
3430017	Warrington 17
3470002	Wednesfield 2
3532002	West Kirby 2
3696009	Woolwich 9
3710012	Worksop 12