Air Pollution in the UK: 2007

A report prepared by
AEA Energy and Environment
for Defra and the
Devolved Administrations

Front cover image

Couple walking on Wittenham Clumps, Oxfordshire, on a long summer day © Jon Bower, Apexphotos 2007

Air Pollution in the UK: 2007

A report prepared for the Department for Environment, Food and Rural Affairs, the Welsh Assembly Government, the Scottish Government and the Department of Environment in Northern Ireland

This year's report has been compiled and written by Jon Bower, Rachel Yardley, Alison Loader, Jaume Targa, Andy Cook, Andy Glynn, Geoff Broughton, John Stedman, Andrew Kent, Marios Valiantis, Ioannis Tsagatakis, Paul Willis and many others within AEA; however, the data here presented represent the end-product of the efforts of many persons and organisations in the private sector, local and central government.

December 2008

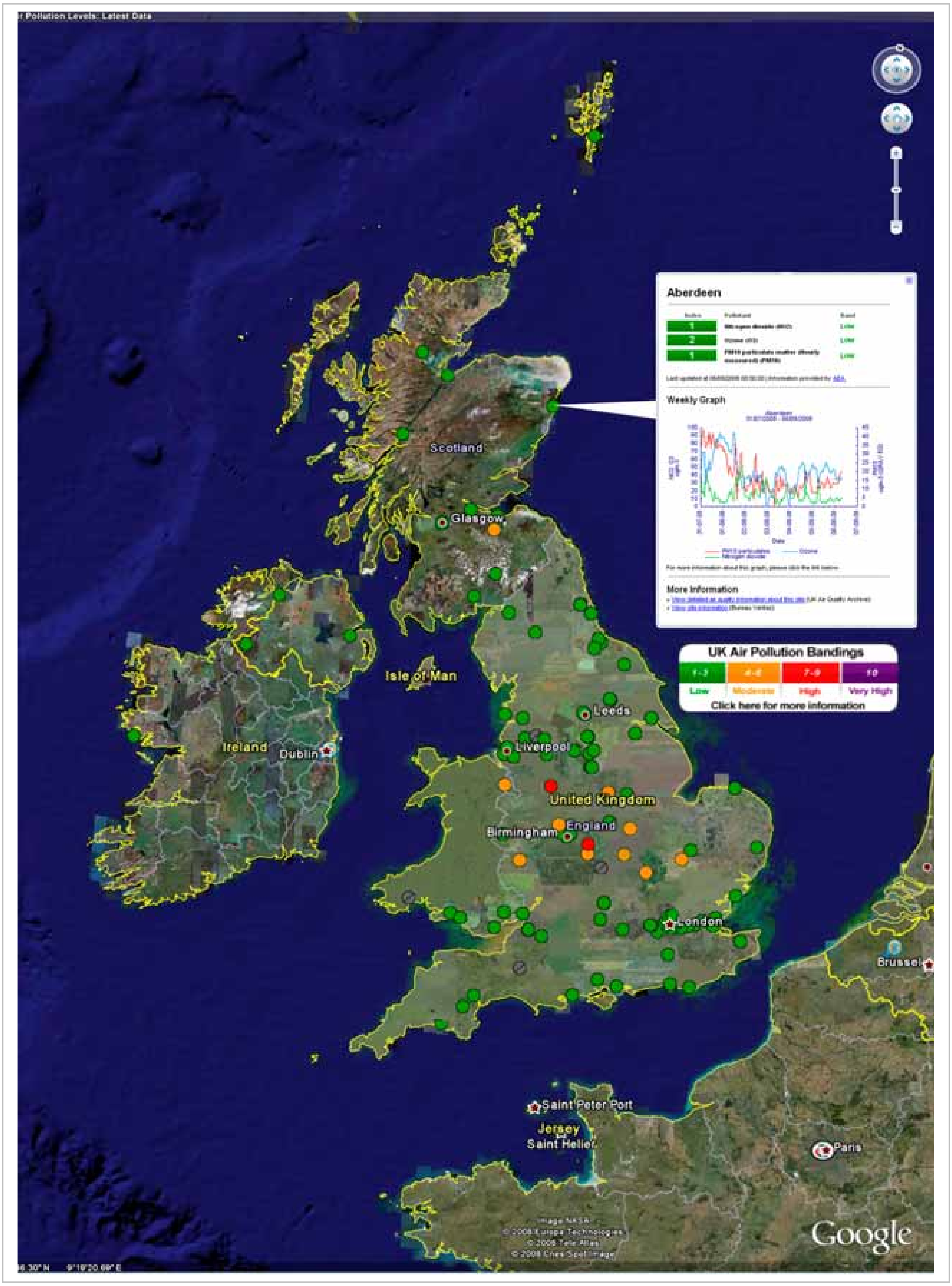
Title	Air Pollution in the UK: 2007
Customer	Defra and the Devolved Administrations
Confidentiality, copyright and reproduction	Crown Copyright
File reference	ED48692008/Issue 1
Reference number	AEA/ENV/R/2544

AEA Energy and Environment
The Gemini Building
Fermi Avenue
Harwell international Business Centre
Didcot
Oxfordshire OX11 0QR
England

Telephone +44(0)870 190 6416
Facsimile +44(0)870 190 6607

AEA is certificated to ISO9001:2000 and ISO14001

Authors	Name	Jon Bower, Rachel Yardley, Alison Loader, Jaume Targa, Andy Cook, Andy Glynn, Geoff Broughton, John Stedman, Andrew Kent, Marios Valiantis, Ioannis Tsagatakis and many others
Edit, design, graphics and layout by	Name	Jon Bower
Reviewed by	Name	Jon Bower, John Branson, Rachel Yardley, Alison Loader
Approved by	Name	Alan Collings
	Date	November 2008



In 2007, the UK Air Quality Archive first incorporated a range of advanced new data visualisation and real-time data presentation technologies from Google™. Further enhancements are planned. More detail on these new services is provided in Section 9. This screenshot is reproduced by kind permission of Google™

Executive Summary

For those of you who are a bit short of time…

This is the latest in a long-running series of annual reports summarising measurements from national air pollution monitoring networks operated on behalf of Defra (the Department for Environment, Food and Rural Affairs) and the Devolved Administrations of Scotland, Wales and Northern Ireland. It includes data and analyses from the calendar year (January to December) of 2007. The pollutants we summarise and analyse are:

- Ozone (O_3)
- Nitrogen oxides (NO_x = NO and NO_2)
- Sulphur dioxide (SO_2)
- Carbon Monoxide (CO)
- PM_{10} and $PM_{2.5}$ particles
- Benzene
- 1,3-butadiene
- Lead and metals (reviewed in Section 6 for the first time in this report series)

Because of their potential impacts on human health, welfare and natural environments, ambient concentrations of these pollutants are measured at a wide range of urban, roadside, industrial and rural locations throughout the UK.

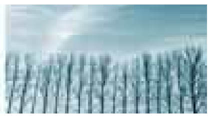
The measurements we report here were primarily made in national automatic air monitoring networks, comprising 139 stations during 2007. These networks serve a wide range of policy, regulatory, scientific research and public health objectives.

In this report, we:

1. ***Consider ongoing UK and European efforts to tackle air pollution.*** These both progressed significantly during 2007; we discuss the major developments, including a major new EC Air Quality Directive.
2. ***Describe current UK air monitoring networks, their objectives and methodologies.*** Continuing changes to these programmes are reviewed.
3. ***Summarise the UK's Air Quality Objectives*** and examine how and where these were exceeded during the year.
4. ***Investigate how pollution levels vary across the country***, examining important national-scale patterns of pollution.
5. ***Examine major periods of elevated pollution*** ('episodes') that occurred during 2007. This year, we examine an interesting particle episode, Bonfire Night pollution and also review the incidence of photochemical episodes over recent years.
6. ***Assess long-term trends*** in order to identify how pollution levels in the atmosphere have changed over time.
7. ***Look back at the history and major achievements of sampler networks.*** We review over 30 years of monitoring of lead and other metals, highlighting major long-term changes in the UK's pollution climate for these toxic pollutants.
8. ***Identify published, web and media sources for information*** on UK air quality. In particular, we provide details of major new web features & resources.
9. ***Consider how UK pollution levels compare with other parts of Europe and the world*** Extending our innovative analyses from last year, we seek to place the UK's pollution issues in a broader European and global context, as well as answering the question: just how bad is air quality here in the UK?

The report, together with the family of UK Air Quality websites at www.airquality.co.uk, www.scottishairquality.co.uk, www.welshairquality.co.uk and www.airqualityni.co.uk provides the most comprehensive and complete analytical picture of UK's air pollution during 2007.

Contents



1 Introduction

A quick outline of what's in this report…

The quality of the air that we breathe can have important effects on our health and quality of life. It can also have major impacts on ecosystems and climate change. Measuring and understanding air pollution provides a sound scientific basis for its management and control. Considerable effort is therefore devoted in the UK to the systematic measurement of levels of air pollution nationwide. This effort started in earnest following the infamous coal-burning smogs of the 1950s and 60s, but has expanded massively in scope, coverage and sophistication since then.

Air quality monitoring, together with the information derived from it, should not be seen as an end in itself; rather, it offers us the best way of understanding our pollution problems, so that they can be tackled effectively at local, national and international level. Some of the very latest actions being taken on a number of fronts in the UK and Europe are described in further detail in this report.

The following broad objectives of monitoring air pollution in the UK remain:

- To provide a sound scientific basis for the development of cost-effective control policies and solutions under the UK Air Quality Strategy and Local Air Quality Management (LAQM)
- To assess how far air quality standards, limit values and objectives are being met
- To evaluate potential impacts on population health and welfare
- To determine the impact of air pollution on ecosystems and our natural environment
- To provide the public with open, reliable and up-to-date information on air pollution
- To fulfil statutory air quality reporting requirements

Figure 1.1. Calibrating PM_{10} particle monitors at Harwell, a rural air pollution measurement station in Oxfordshire © Jon Bower

This report aims to provide a simple guide, written as far as possible in non-technical language, to what the latest measurements tell us about air pollution in the UK. It comprises three parts. The **first part** is primarily descriptive. In it, we will:

- Summarise current UK and European policy efforts and initiatives to tackle air pollution. This year, we highlight a number of significant developments in both areas, in particular covering the pivotal new European Air Quality Directive *(Section 2)*.
- Review where and how air pollution is measured in this country, examining monitoring networks, site locations and measurement techniques, as well as recent changes to UK measurement programmes *(Section 3)*.
- Examine key episodes - major periods of elevated pollution - that occurred in 2007. We give particular prominence this year to particle episodes, as well as reviewing the frequency of photochemical smog episodes over recent years *(Section 4).*
- Investigate - through a series of detailed maps and analyses - how pollution levels vary across the UK *(Section 5).*
- Look back at over 30 years of sampler-based monitoring of lead and heavy metals; we see how this monitoring has revealed long-term changes in UK's air quality as lead levels in petrol were reduced *(Section 6)*
- Assess long-term pollution trends in order to see whether pollution levels are declining over time. (*Section 7).*
- Examine how air quality in the UK compares with that in other parts of Europe *(Section 8).*
- In a new and expanded section, we provide information on where and how to find out more about air pollution emissions, levels and effects in the UK. We introduce important new map-based air quality information resources on the web, as well as a new TV information service (*Section 9).*

The **second part** of the report, from Sections 10 to 18, is primarily statistical; this provides a detailed pollutant and site-specific specific summary of measurements made in the UK automatic and hydrocarbon monitoring networks during 2007. Each section offers:

- Information on measurement and calibration techniques, instruments utilised, estimated accuracy and precision
- A summary of relevant UK objectives
- A map of the measurement sites
- A detailed statistical summary of all the measurements made during the year
- Matching information on exceedences of UK Air Quality Objectives
- Graphs showing variations in pollutant concentrations throughout the year at typical urban, rural and other site types
- Analyses showing typical variations in pollutant concentrations during the day
- Long-term trends in annual average measured concentrations.

In the **third part** of the report, a series of Appendices provide:

- Background information on the air pollutants measured in the national networks, their sources and effects
- Detailed maps showing the location of automatic monitoring stations in different parts of the UK
- More information on the various air monitoring networks and their objectives
- A summary and analysis of UK monitoring locations showing statistically significant trends in pollution levels over time
- A full listing of current UK, European and World Health Organisation Air Quality Standards, Objectives, Limit Values and Guidelines for the major air pollutants
- An explanation of some of the terminology used in this report, together with a discussion of measurement accuracy, trend calculation and the mathematical methods used to calculate measurement statistics.

This page has been left intentionally blank

Air Pollution in the UK: 2007

Part 1

In this part of the report, we describe the reasons for monitoring air quality and examine how the UK networks have evolved over the years to meet our changing needs and objectives.

We review recent air pollution episodes and assess variations in pollution levels across the country. We examine long-term trends in order to see if pollution is getting worse over time.

We then review the long-term history of lead and metals monitoring in the UK and assess our current pollution levels in a broader European context.

Finally, we provide details of how to obtain more information about our air quality, particularly from the World Wide Web.

2 UK & International Policy

What actually drives all the monitoring we do…

To understand why and how we measure air pollution in the UK, it's first necessary to consider the broader policy and regulatory background to the monitoring, both at national and international level. There are also increasingly important local drivers and factors related to air monitoring nationwide.

Over the past decade, air pollution has become an increasingly important focus of interest for UK, European and international policy makers. This has been prompted by increasing evidence that air pollution still poses significant risks to our health and amenity, as well as threatening our natural environment.

In recognition of this, the European Union's Sixth Environment Action Programme - 'Environment 2010: Our future, Our choice' [B1] - includes Environment and Health as one of the four main areas where new effort is targeted, with air pollution identified as one of the priority issues to be tackled. The need to protect human health and welfare is also a central feature of the UK's Air Quality Strategy[B2,B3,B4], discussed later in this section.

And what does it all mean for Climate Change?

Another factor in the increased attention paid to air pollution is emerging evidence of its close relationship to broader global issues. Our atmosphere is a complex, dynamic and fragile system, in which global warming, climate change, ecosystem impacts and stratospheric ozone depletion are all intimately inter-linked with air pollution.

This Air Pollution report focuses primarily on gases and particles in the UK, which are known to have harmful effects on human health or cause damage to our ecosystems. However, these common air pollutants can also have an effect on atmospheric temperatures and have the potential to contribute to climate change.

Carbon dioxide is the most widely known and important greenhouse gas, but several other pollutants are also linked to climate change. Particulate Matter (PM) is a broad term that encompasses a large number of different species. Some species, for example sulphate and nitrate, reflect sunlight and have an overall cooling effect on the atmosphere. On the other hand, species such as ozone and methane absorb infrared radiation and cause warming. If we also consider secondary pollutant formation, this becomes more complicated. For example, sulphur dioxide forms a sulphate aerosol under certain atmospheric conditions; therefore we might say that sulphur dioxide has an indirect cooling effect.

Particulate matter also plays a major part in cloud formation, and as such, has an indirect effect on the earth's overall heat balance, in particular affecting heat entering and escaping the atmosphere.

These important issues are addressed in greater detail in a recent authoritative report from the UK Air Quality Expert Group.[B5] It concluded that:

- Air pollutants, such as particulate matter and ozone, influence climate change. Control of the gases that lead to the formation of particulate matter and ozone can therefore affect both air quality and climate change.
- Hot summers like the 2003 heat wave are likely to become the norm by 2040, leading to increased summer smogs, unless emissions affecting ozone

concentrations are substantially reduced. Episodes of winter smog, by contrast, are likely to be less prevalent.

- It is essential that the inter-linkages between emissions of air quality and climate change pollutants are recognised in assessments of the impacts of policies and developments for industry, transport and housing
- Most measures that lead to a reduction in demand or an improvement in the efficiency of an activity or product, benefit both air quality and climate change. Such measures should be actively promoted.
- Local, National and European policies must recognise the interactions between air quality and climate change pollutants in developing measures to reduce them

So, the pollutants analysed in this report not only have the potential to effect local and regional conditions; they can also have profound impacts on our world.

2.1 European background

2.1.1 Aspirations and instruments

European Environmental Directives place a duty on each EU Member State to institute policies to protect and improve its environment and the health of its citizens; the majority of the UK's air quality standards and related requirements are ultimately derived from Directives. European Community action is designed to:

- Protect the environment and
- Reduce exposure to air pollution while ensuring sustainable development and
- Promote better regulation

It is intended to achieve these goals through:

- Introducing innovative legislation, such as the new Air Quality Directive - discussed below – and the proposed recasting of several industrial emissions directives into a new directive on industrial emissions;
- Enhanced international cooperation, aimed at reducing cross-border pollution and the better integration of air pollution and climate change policies;
- More effective liaison with national, regional authorities and Non-Governmental Organisations (NGOs.)
- Making better use of the research undertaken in its own or Member States' institutes and universities.
- Sharing environmental information.

A series of Air Quality Directives and Decisions over the last twelve years has:

- Assessed the ambient air quality in Member States on the basis of common methods and criteria;
- Generated information on ambient air quality in order to help combat air pollution and nuisance and to monitor long-term trends and improvements resulting from national and community measures;
- Ensured that such information on ambient air quality has been made available to the public;
- Maintained air quality where it is good and improving it in other cases;
- Promoted increased cooperation between the Member States in reducing air pollution.

A new AQ Directive (2008/50/EC of the European Parliament and of the Council of 21st May 2008, on ambient air quality and cleaner air for Europe[B6]) was adopted in June 2008. The new directive, which comes intro force in mid-2011, will streamline the

European Union's air quality legislation with a single integrated instrument replacing the five directives listed below:

- Directive 96/62/EC on Ambient Air Quality Assessment and Management, 'The Framework Directive' [B7], 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) [B8], 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) [B9], which set limit values for carbon monoxide (CO) and benzene.
- The Third Daughter Directive (or EC Ozone Directive, 2002/3/EC) [B10], which set target values for protection of human health and vegetation.
- Council Decision 97/101/EC [B11], which established a reciprocal exchange of air quality monitoring information and data, between the Member States.

Directive (2004/107/EC) [B12] - which covers polycyclic aromatic hydrocarbons (PAHs) and the metallic elements cadmium, arsenic, nickel and mercury - will remain in force but may be merged with the Ambient Air Quality Directive in the future.

Directive 2008/50/EC retains all existing air quality standards, and also introduces Limit Values for $PM_{2.5}$* particulate matter, together with an exposure-reduction target. This new Directive has:

- Combined and streamlined a wide range of pre-existing Directives and Decisions, as noted above, in line with better regulation principles.
- Confirmed many of the existing Directives' obligations, but introduced some flexibility in meeting those obligations under some circumstances:
    - The possibility to extend the attainment deadline for some limit values in exceptional circumstances
    - The ability to identify and discount the contribution to air pollution from natural sources – for example natural wind-blown dusts - when determining compliance with limit values
    - Greater clarity on where to assess air quality, so that the focus is on areas where members of the public could be exposed.
- Introduced controls on fine particulate, measured as $PM_{2.5}$, in the light of clear scientific evidence that fine particles are hazardous to health.
- Introduced an "exposure reduction" approach, which would aim to improve air quality in areas where the greatest numbers of people are exposed, not just in areas that exceed a Limit Value.

Member States must transpose the new Directive's requirements into their own legislation by June 2010.

A list of current EC Directive Limit and Target Values for air pollutants covered by the new Directive is provided in Appendix 5. Further detailed information on the major sources and impacts of these pollutants is summarised in Appendix 1.

2.1.2 Sharing environmental information

The Community continues to build on the "three pillars" of the UNECE's Åarhus Convention (1998) [B13]; this guarantees open access to information, public participation and access to justice in environmental matters. New environmental directives have requirements that Member States report information to the European Commission, share information with one another, and make it available to the public. The information reported to the Commission is usually made publicly available via the European Environment Agency and Eurostat; examples of this include:

- The European Environment Information and Observation Network (EIONET), a collaborative network that provides the information that is used for making

** PM_{10} is measure of particles in the atmosphere with a diameter of less than ten or equal to a nominal 10 micrometers. $PM_{2.5}$ is similarly defined* decisions for improving the overall state of the environment in Europe and making EU policies more effective.

- The European Pollutant Emission Register (EPER) and European Pollutant Release and Transfer Register (E-PRTR). National governments of all EC Member States are required to maintain inventories of emission data from specified industrial sources and to report emissions from individual facilities to the European Commission. The reported data are accessible in a public register (EPER), which is intended to provide environmental information on major industrial activities. E-PRTR is the European Pollutant Release and Transfer Register, succeeding the EPER.

Directive 2008/50/EC specifies the detailed requirements for the Member States and the Commission to collect, exchange, and disseminate air quality information. A new feature is the embodiment of the requirements of Directive 2007/2/EC, the INSPIRE Directive, that Member States adopt procedures for data provision, assessment and reporting electronically and to use the Internet as the main means of its dissemination.

INSPIRE[B14] is a step towards the creation of a Community wide online system for collecting, public viewing, reporting and analysis of environmental data. The "Shared Environment Information System" (SEIS) is intended to gradually eliminate paper-based reporting and bring all EU spatial data flows into a network of interconnected national and sub-national data hubs open to all user communities.

We identify throughout this report the numerous open-access information resources that can be used by government, local authorities and the public to obtain up-to-date information on local or national air quality; this report, in itself, represents one of the range of published, media and web resources intended specifically for this purpose in the UK.

2.1.3 The Thematic Strategy on air pollution

An important focus within the European Community over the period from 2002 to 2012 will be the implementation of air quality standards whilst further increasing the coherence of all air legislation and related policy effort.

The Sixth Environment Action Programme (6th EAP) [B1], now in the second phase of its operation, first introduced the concept of 'Thematic Strategies'- coherent and integrated policies addressing specific environmental issues in an integrated manner. This approach acknowledged that the effects of decisions in one policy area may impact on others. The 6th EAP identified seven thematic strategies; these covered waste prevention and recycling, the marine environment, soil, pesticides, natural resources, the urban environment, and *air pollution*.

The Thematic Strategy on Air Pollution[B15] was published in September 2005; this is available at http://ec.europa.eu/environment/archives/air/cafe/pdf/strat_com_en.pdf

This strategy establishes interim objectives for air pollution throughout the European Union, as well as proposing appropriate measures for achieving them. It has:

1. Resulted in the modernisation of legislation
2. Focused on the most serious pollutants and
3. Attempted to integrate environmental concerns into other policies and programmes.

It is designed, in particular, to:

1. Substantially improve Europe's air quality over time
2. Prevent premature deaths from pollution-related illnesses and
3. Reduce damage to crops, forests and other ecosystems.

Although it is recognised that there will be significant costs involved in improving air quality, detailed cost/benefit analyses demonstrate that these will be offset many-fold by the overall benefits to society as a whole.

Fig 2.1 Cost benefit analysis- an important part of European Air Quality Strategy – demonstrates conclusively that the costs of improving air quality throughout Europe will be offset by benefits to health and society as a whole

The Strategy represents a modern way of decision-making. It has been based on extensive research and consultation with stakeholders under the CAFE programme [B16], and seeks to address the core issues in a holistic way that fully takes into account links with other problems and policy areas. At the same time, it involves an integrated assessment of different environmental and health effects, and aims to provide the most cost-effective solution for the chosen level of objectives.

2.1.4 Delivering the objectives of the Thematic Strategy

It is still relatively early to see the results of the 6th EAP. The actions taken will take many years to come to fruition. Nevertheless an interim review, conducted in 2007, identified three specific underlying problems that could hamper efficient and effective progress towards 6th EAP objectives over the second half of its life:

- Poor integration of policies;
- The existing implementation gap; and
- Insufficient international co-operation.

Even if all relevant technically feasible measures available were applied irrespective of cost, it would not be possible by 2020 to meet the ambitious objective of attaining "*levels of air quality that do not give rise to significant negative impacts on, and risks to, human health and the environment*". Consequently, the Community uses a science-based policy development process that makes extensive use of impact modelling to identify the most promising policy options; these are then subject to comprehensive cost/ benefit analysis and regulatory impact assessment.

While covering all major air pollutants, the Air Strategy pays special attention to particles and ground-level ozone pollution. This is because, in the view of the World Health

Organisation, these pose the greatest danger to human health. Moreover, no safe levels have yet been identified for either pollutant.

The Commission has proposed, via Directive 2008/50/EC, to start regulating $PM_{2.5}$. This will require reductions in fine particle concentrations throughout each Member State and a cap on concentrations in the most polluted areas. These developments are likely to have wide-ranging implications for the UK's national monitoring networks measuring particulate matter (see Section 3).

The most recent actions proposed under the Thematic Strategy on Air Pollution are:

1. The revision and streamlining of current air quality legislation.

This resulted in the 2008 Air Quality Directive, which – as discussed previously - combined and streamlined a broad range of existing air quality Directives and Decisions. In fact, several of the requirements of Directive 2008/50/EC specifically addressed the problem areas identified in the interim review of the 6th EAP.

In this context, streamlining is the process of amending legal instruments to achieve more efficient, faster and simpler reporting systems, while maintaining and where possible improving data usefulness and reliability. Streamlining, while continuing to protect the environment and human health, should increase clarity and minimize red tape for operators and regulators; it focuses on proportionate regulation while encouraging best practice and innovation.

2. Revision of the National Emissions Ceiling Directive.

The European Commission is in the process of revising the National Emissions Ceilings Directive[B17]. This will ensure reduced emissions of a range of pollutants – SO_2, NO_x, primary particulate matter, VOCs and ammonia - in line with the interim objectives proposed in the Air Strategy for 2020. It is likely that this revision will take account of the work being carried out as part of the on-going revision of the UN ECE LRTAP Gothenburg Protocol*[B18] on long-range transboundary air pollution - to abate acidification, eutrophication and ground-level ozone.

3. To integrate air quality concerns into other policy areas.

These include –

- Energy, in line with the European Union's existing target of producing 21% of all energy, and 21% of electricity, from renewable sources by 2010. Measures to ensure more efficient use of energy are also included.
- Improved regulation of industrial emissions to ensure cost-effectiveness. Industrial activities play an important role in the economic well-being of Europe but also account for a considerable proportion of emissions of air pollutants. The Commission has proposed an Industrial Emission Directive that recasts, within a single legal instrument, the Integrated Pollution Prevention and Control – IPPC Directive (96/61/EC), the Large Combustion Plant Directive (2001/80/EC) and Solvent Emissions Directive (1999/13/EC) and others. This would extend the coverage of IPPC to combustion plant of capacity between 20 and 50 MW, include more solvent using processes, and strengthen Member State implementation and enforcement measures.
- Transport: encouraging shifts towards cleaner vehicles, alternative fuels, reducing congestion and other measures.
- Initiatives already in place to revitalise and integrate European rail systems, together with measures to improve efficiency of inter-modal freight transport.

** The United Nations Economic Commission for Europe- Convention on Long Range Transboundary Air Pollution*

2.2 The UK perspective

Although the lethal smogs in London and other cities caused by domestic and industrial coal burning have now gone for good, air pollution remains a problem in the UK. Medical evidence shows that many thousands of people die prematurely every year because of the effects of air pollution. Air pollution from man-made particles is currently estimated to reduce the life expectancy of every person in the UK by an average of eight months; many more become unwell or may require hospital treatment. The health impacts of this form of pollution alone are estimated to cost the UK between £9.1 billion and £21.4 billion every year. The very young, old and infirm are often particularly affected, as well as people living in deprived areas.

In addition, our sensitive ecosystems are also affected by air pollution. More than half of all natural and semi-natural habitats in Britain still have too high levels of harmful acidity and/or nutrient deposition.

As highlighted in Section 2.1, the UK - as a Member State of the European Community - has a range of statutory obligations to address air pollution issues. However, the UK also has its own Air Quality Strategy in place, and this is discussed below.

2.2.1 The UK Air Quality Strategy

The Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland, first published in March 1997, and reviewed in 2000 and 2007, has established a strong framework for tackling air pollution over the coming years [B4]. The Strategy is available in full at www.defra.gov.uk/environment/airquality/strategy/. The continuing objectives of the Strategy are 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. These Air Quality Objectives are at least as stringent as the Limit Values of the relevant EC Directives – in some cases more so. In the majority of cases, these are incorporated into UK legislation for the purpose of Local Air Quality Management by means of the Air Quality Regulations 2000 and subsequent Amendments. However, there are some exceptions for pollutants such as ozone, which are in practice difficult to control by local action.

The UK Air Quality Strategy's main focus is on protecting the health of the population at large; however, the Strategy has also established corresponding targets for the protection of vegetation, ecosystems and the natural environment. Air monitoring provides a key tool in assessing how far the health objectives and other environmental targets are being met throughout the UK.

As our knowledge of the health effects of these pollutants has deepened, the objectives have been progressively refined and strengthened. Objectives for a ninth pollutant, Polycyclic Aromatic Hydrocarbons (PAHs) were introduced in 2003.

However, despite overall improvements in UK's air quality, it had become clear that additional controls may be needed to meet the Strategy's objectives for particulate matter, nitrogen dioxide, ozone and polycyclic hydrocarbons in some urban areas. Also, emerging research has highlighted two important aspects relating to the health impacts of particulate pollution: firstly, the importance of the fine particulate fraction $PM_{2.5}$, and secondly, that there appears to be no 'threshold' below which exposure to particles has no effect on health. Air pollution also caused over half the UK's natural and semi-natural habitats to exceed harmful levels of acidity in 2003.

These concerns formed the basis for the detailed review of the Strategy, which was undertaken during 2006. Its overall aim was to assess:

- The UK's predicted air quality to 2020
- Progress towards meeting the current AQS objectives
- Additional policy measures required to improve air quality
- The current AQS Objectives, and the case for new ones (in particular for $PM_{2.5}$)

A number of possible additional national policy measures were considered in order to cut air pollution, reduce breaches of air quality objectives and improve human health. Climate change and ecosystem protection were also taken into account. These measures covered transport, industry, fuel use and other areas.

Within the review, detailed cost-benefit analyses were carried out to assess the overall efficacy and cost-effectiveness of a range of possible policy options. Extensive use was made of modelling techniques, to assess the effectiveness of the various policy options in improving air quality. A study by the Committee on the Medical Effects of Air Pollution (COMEAP) on the long-term effects of exposure to air pollution was carried out concurrently with the review, and its report published to coincide with the release of the new strategy in July 2007[B4].

All the previously existing Air Quality Strategy Objectives are retained, apart from the provisional PM_{10} objectives originally proposed for 2010 in England, Wales and Northern Ireland, which have been dropped. Instead, the Strategy introduces for the first time an objective for annual mean particulate matter as $PM_{2.5}$, to be achieved by 2020. This acknowledges the latest research, indicating that the health impacts of particulate pollution are particularly associated with this very fine fraction.

The Strategy also introduces a new exposure reduction approach for managing exposure to $PM_{2.5}$ particles. There is clear evidence that there is no 'safe' level for exposure to fine particles – no "threshold" below which no health impacts are expected to occur. The Strategy therefore concludes that, for this pollutant, a policy based on achieving standards or objectives alone is not going to generate the maximum benefit in public health for the investment made; this is because such a policy would focus only on the areas where concentrations are highest, while - in reality - adverse effects on health are likely to be much more widespread.

The exposure reduction approach takes the view that the maximum benefit for the most people will be obtained cost-effectively by reducing pollutant levels across the whole urban area, rather that focussing action on 'hot-spot' areas exceeding Objectives. There are two aspects to the new Air Quality Strategy's exposure reduction approach for $PM_{2.5}$:

- An air quality objective or limit value, which defines the maximum acceptable concentrations for public exposure, as at present. This is referred to as a 'backstop' objective.
- An exposure reduction target for $PM_{2.5}$ is introduced: urban background annual mean concentrations are to be reduced by a set percentage over a defined timescale. This is intended to generate further improvements over and above the protection afforded by the backstop objective.

These two aspects of the new approach are inseparable: the concept of the 'backstop objective' is an essential counterpart to the exposure reduction target. This ensures a minimum level of acceptable air quality for all – an essential aspect of social justice. The backstop objectives for annual mean $PM_{2.5}$ - to be met by 2010 - are 12µg m^{-3} in Scotland (where levels are typically lower) and 25 $µgm^{-3}$ in the rest of the UK.

The exposure reduction target for the whole UK is for annual mean concentrations in urban background areas to be reduced by 15% between 2010 and 2020.

In addition to the new objectives for $PM_{2.5}$, a new ozone objective has been introduced for protection of ecosystems, in line with the target value set in the relevant EC Directive. The existing objectives for PAH (as benzo(a)pyrene) and for 15-minute mean SO_2 concentration, have been retained.

No objectives have been set for ammonia. The nature of ammonia emissions and its behaviour in the environment are complex, and dealing with this pollutant therefore requires a holistic approach taking in industrial and agricultural emissions. The Strategy concludes that it is not appropriate at this time to set objectives for ammonia without consideration of the wider environmental issues and regulatory frameworks.

As well as setting Air Quality Objectives, the review also considered specific measures to reduce pollutant emissions and improve ambient air quality. Policies to be considered include:

- Incentivising the early uptake of new tighter European vehicle emission standards (Euro 5 and Euro 6 for cars).
- Increasing uptake of low emission vehicles.
- Reducing emissions from ships – reduction of sulphur content of marine fuels, and reducing emissions of NOx from ships' engines.
- National road use charging.
- Low emission zones, similar to that already being implemented in London from February 2008.
- Retrofitting catalyst-based diesel particulate filters to existing HGV vehicles, buses and coaches to bring them up to Euro 5 standards.
- Reducing emissions from small combustion plants (20 – 50 MW).

A summary of the current UK Air Quality Strategy Objectives is provided in Tables 2.1a and 2.1b overleaf. The new objectives arising from the recent review of the Strategy are highlighted by shading.

Table 2.1a UK Air Quality Objectives for protection of human health, July 2007. New objectives highlighted in shading

Pollutant	Air Quality Objective: Concentration	Air Quality Objective: Measured as	Date to be achieved by
Benzene All authorities	16.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
England and Wales only	5.00 $\mu g\ m^{-3}$	Annual mean	31.12.2010
Scotland and Northern Ireland	3.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
Carbon monoxide England, Wales & N. Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31.12.2003
Scotland only	10.0 mg m^{-3}	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g\ m^{-3}$ 0.25 $\mu g\ m^{-3}$	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 $\mu g\ m^{-3}$ not to be exceeded more than 18 times a year 40 $\mu g\ m^{-3}$	1-hour mean Annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric) All authorities	50 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year 40 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2004 31.12.2004
Scotland only	50 $\mu g\ m^{-3}$, not to be exceeded more than 7 times a year 18 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2010 31.12.2010
Particles ($PM_{2.5}$) (gravimetric) * All authorities	25 µg m^{-3} (target) 15% cut in urban background exposure	Annual mean Annual mean	2020 2010 - 2020
Scotland only	12 µg m^{-3} (limit)	Annual mean	2010
Sulphur dioxide	350 $\mu g\ m^{-3}$, not to be exceeded more than 24 times a year 125 $\mu g\ m^{-3}$, not to be exceeded more than 3 times a year 266 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year	1-hour mean 24-hour mean 15-minute mean	31.12.2004 31.12.2004 31.12.2005
PAH *	0.25 ng m^{-3}	Annual mean	31.12.2010
Ozone *	100 $\mu g\ m^{-3}$ not to be exceeded more than 10 times a year	Daily maximum of running 8-hour mean	31.12.2005

* *not included in regulations at present.*

Table 2.1b UK air quality objectives for protection of vegetation and ecosystems, July 2007. New objectives highlighted in shading

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	**Measured as**	
Nitrogen dioxide *(for protection of vegetation & ecosystems) **	30 µg m^{-3}	Annual mean	31.12.2000
Sulphur dioxide *(for protection of vegetation & ecosystems) **	20 µg m^{-3} 20 µg m^{-3}	Annual mean Winter average (Oct-Mar)	31.12.2000 31.12.2000
**Ozone **	18 mg m^{-3}	AOT40**, calculated from 1h values May-July. Mean of 5 years, starting 2010	01.01.2010

** Not included in regulations at present*
*** AOT 40 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.*

2.2.2 The Air Quality Banding System

Although comprehensive and soundly science-based, the UK's Air Quality Objectives are not particularly easy for non-scientists to understand, particularly on a day-to-day basis.

A simpler air quality banding system is therefore used extensively for media-based reporting of air quality and potential health effects to the public. This is summarised in Box 1.

The use of air quality bands on the home page of the UK Air Quality Archive (www.airquality.co.uk) is illustrated in Figure 2.2.

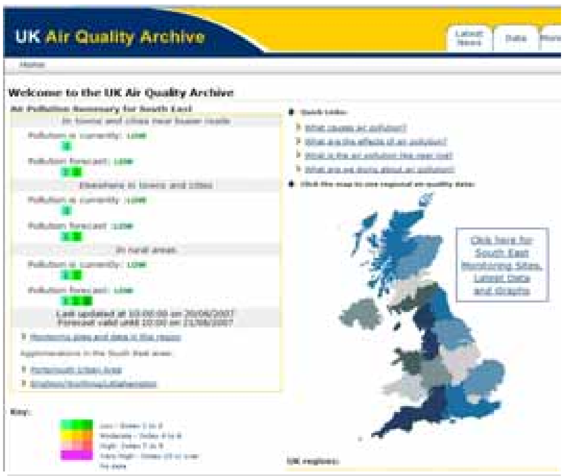


Fig 2.2 Air Quality bands are easy to understand

Box 1. The UK Air Quality Banding System

- When air pollution is LOW (1-3) effects are unlikely to be noticed even by those who are sensitive to air pollution.
- When air pollution is MODERATE (4-6) sensitive people may notice mild effects but these are unlikely to need action.
- When air pollution is HIGH (7-9) sensitive people may notice significant effects and may need to take action.
- When air pollution is VERY HIGH (10) effects on sensitive people, described for HIGH pollution, may worsen.

2.2.3 The air quality indicator for sustainable development

Air quality is one of the UK Government's 68 key headline indicators of sustainable development. These provide a 'quality of life barometer' measuring everyday concerns, and are intended to give a broad overview of whether we are achieving a better quality of life for everyone, now and for generations to come.

A set of statistical parameters has been defined as the UK's 'Air Quality Indicator'. These statistics are reported annually by Defra, soon after the end of the calendar year.

An air quality headline indicator was first introduced in support of the UK Sustainable Development Strategy in 1999. It was expanded when the strategy was revised in 2005, to include more components, better reflecting the effects on health of long term exposure to lower levels of pollution.

The air quality indicator now comprises two parts:

- Part a), which includes trends for annual levels of particulate and ozone pollution, the two pollutants thought to have the greatest health impacts.
- Part b), which covers the number of days on which levels of any one of a basket of five pollutants were 'moderate or higher', as defined by the banding system used by the Air Pollution Information Service (www.airquality.co.uk/archive/standards.php#band). (Part b is the same as the air quality headline indicator of the former (1999) sustainable development strategy.

We'll be looking more closely at the latest air quality indicator levels for 2007 in Section 7 of this report.

2.3 A local focus: grass-roots monitoring

Central Government and the Devolved Administrations of Scotland, Wales and Northern Ireland are responsible for overall policy and legislation affecting the UK environment, including air quality. However, over recent years, the UK's Air Quality Strategy – discussed in the previous section - has progressively enabled and encouraged Local Government to take a central role in air quality management. Authorities are required regularly to ***Review and Assess*** air quality in their area and take decisive action when the objectives in regulation cannot be met by the specified target dates.

When this happens, an Authority must declare an 'Air Quality Management Area' (AQMA) and develop an Action Plan to tackle problems in the affected areas. Such a plan may include a variety of measures such as congestion charging, traffic management, planning and financial incentives.

Local authorities in England, Scotland and Wales have completed both their first and second rounds of reviews and assessments against the Strategy's objectives prescribed in the 2000 Air Quality Regulations [B19], together with subsequent amendments [B20, B21, B22, B23] and are currently at the final stage of the third round of assessment.

To date, 223 Local Authorities – roughly 52% of those in the UK - have established one or more AQMAs. Most of these are in urban areas and result from traffic emissions of nitrogen dioxide or PM_{10}. The location of current UK AQMAs is shown in Figure 2.3.

Road traffic emissions are the main source in 95% of the AQMAs; only a few have been designated as a result of industrial sources, domestic or shipping emissions. A full list of these authorities declaring such areas may be found at:
http://www.airquality.co.uk/archive/laqm/list.php.

More information on AQMAs is summarised in Table 2.2 below.

Table 2.2 Current UK-wide status of Air Quality Management Areas (AQMAs) and appraised Action Plans (as of June and July 2008)

Region	Total No. of Local Authorities (LAs)	LAs with AQMAs at end of Round 1 (April03)	Number of LAs with AQMAs (July 08)	Due to NO_2	Due to PM_{10}	Due to SO_2	Due to Benzene	Action plans submitted (June 2008)
England (ex London)	320	82	162	150	35	9	1	161
London	33	31	33	33	28	0	0	27
Scotland	32	4	10	6	3	1	0	3
Wales	22	4	7	6	1	0	0	2
N. Ireland	26	3	10	4	3	1	0	6
TOTAL	**433**	**135**	**222**	**199**	**70**	**11**	**1**	**199**

The local authorities declaring AQMAs have undertaken further detailed assessments of the areas concerned, with a view to submitting a report within 12 months following initial designation of the AQMA. The authorities have been advised to prepare their action plans within 12-18 months of designation. 196 authorities have now produced such action plans, setting out the measures they propose to take to work towards meeting the air quality objectives. Inevitably, the majority of the action plans focus on measures dealing with road traffic, such as:

- Local traffic management schemes
- Setting up Clean Air or Low Emissions zones - particularly in London - or
- Working with the Highways Agency (or the Scottish Government in Scotland, Welsh Assembly Government in Wales) to tackle pollution on the motorways/trunk roads.

Recognising the strong linkage between transport and air quality, English local authorities (other than those classified as 'excellent') now have the discretion to either produce a stand alone Air Quality Action Plan or integrate this plan within their Local Transport Plan.

More details are available from the Defra website at:
http://www.defra.gov.uk/environment/airquality/local/guidance/index.htm

Methodologies for local review and assessment continue to develop and improve throughout the UK. To date, since the end of the 1st round in April 2003, approximately 82 authorities in England, six in Scotland and three in Wales have identified the need to designate new AQMAs as a result of Detailed Assessments carried out as part of the third round of reviews and assessments. The increase in the number of AQMAs required is due in large part to:

- The improved methodologies being employed to identify areas of poor air quality for the second and subsequent rounds
- The increasing scale of monitoring being undertaken by local authorities
- The fact that UK-wide NO_2 concentrations are not decreasing as rapidly as was originally predicted.

Under the Environment (Northern Ireland) Order 2002, Local Authorities in Northern Ireland are required to carry out a Review and Assessment of their local air quality. All 26 District Councils completed Round 1, which was undertaken on a different timescale to the rest of the UK. Round 1 resulted in 11 AQMAs being declared. Of these, six have been declared for PM_{10} only, two for NO_2 and PM_{10} together, two for NO_2 only, and one for SO_2. The review and assessment timetable in Northern Ireland is now running in parallel to that in the rest of the UK. Authorities in Northern Ireland are well into Round 2 of their reviews and assessments.

Through the UK-wide process of Local Air Quality Management, tackling air pollution is progressively focussing more on local 'grass-roots' concerns, initiatives and actions.

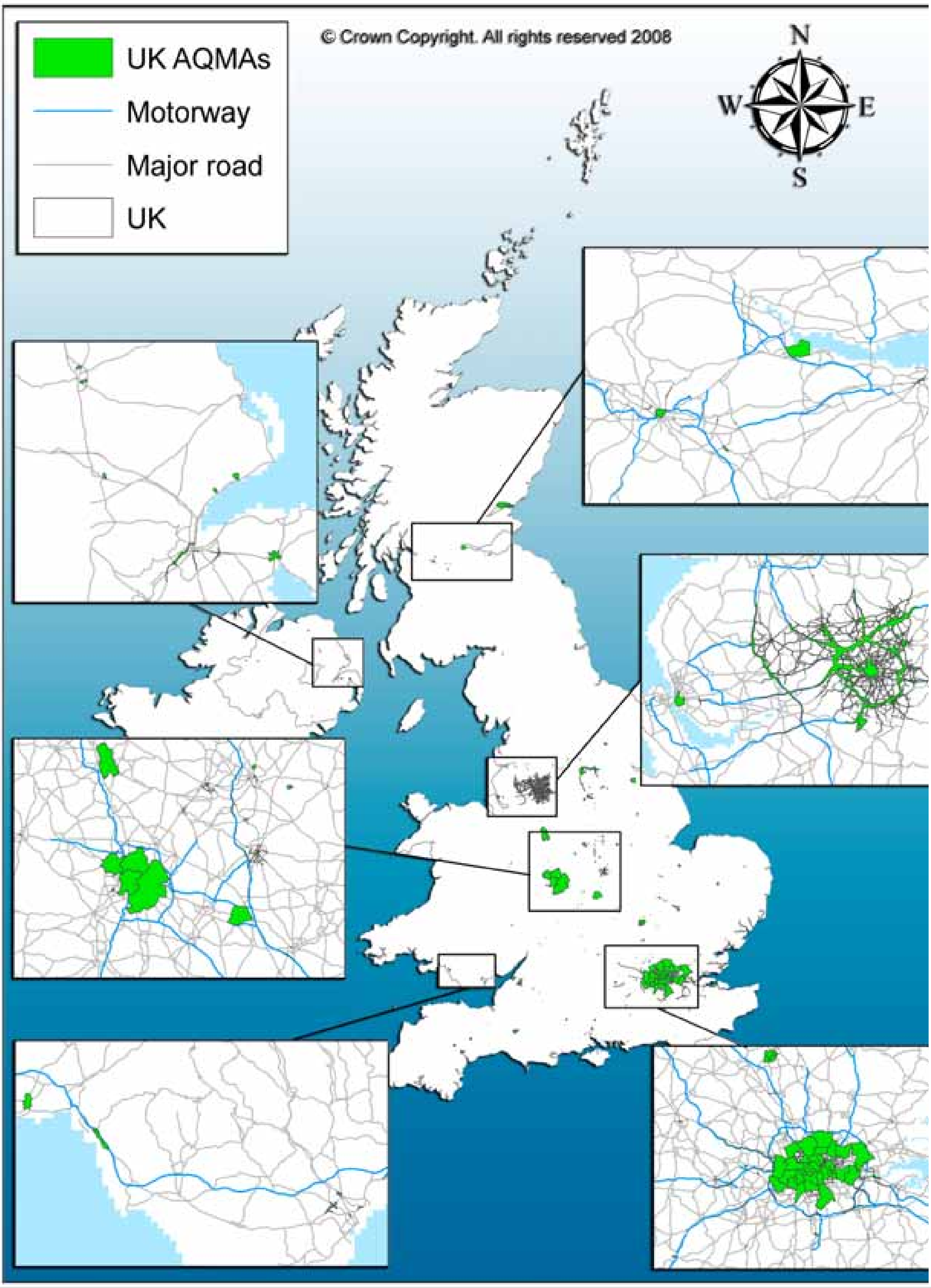


Figure 2.3 Map of UK Air Quality Management Areas (AQMAs), 2007

3 Where, how and why we measure air quality in the UK

To manage something effectively, you first have to measure it…

3.1 The role of ambient air quality monitoring

Air quality monitoring is a key component of any effective approach to Air Quality Management (AQM). In order to develop or implement an effective air quality management plan at local, city or national level, it is first necessary to obtain reliable information on ambient pollution levels. This point was fully recognised in Agenda 21 of the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992 and during the Johannesburg Summit[C2] held in 2002.

The ultimate purpose of air quality monitoring is not merely to collect data, but to provide the necessary information required by scientists, policy makers and planners to enable them to make informed decisions on managing and improving our environment.

Air monitoring fulfils a central role in this process, providing the necessary sound scientific basis for policy and strategy development, objective setting, compliance measurement against targets, and enforcement action. Viewed in this context, monitoring serves the following essential key functions:

- Comparison of existing air quality against local, national or international standards
- Assessment of population health and ecosystem impacts
- Identification of problem areas and pollutants requiring regulatory/control action
- Provision of baseline data for predictive models and environmental impact assessments
- Validation of emission inventory and model predictions
- Determination of long-term trends
- Assessment of the effectiveness - or otherwise - of control strategies over time
- Raising public awareness and promoting responsible action to tackle pollution

Monitoring data are therefore used - directly or indirectly- by a wide variety of people, from pollution-sensitive individuals to policy-makers, toxicologists and epidemiologists.

In the UK, air pollution policy development relies heavily on the national air quality monitoring networks to provide basic and scientifically robust data on ambient pollution concentrations. These data are used to establish priorities for policy development and to assess the effectiveness of control or regulatory action in reducing air pollution concentrations over time.

Air quality monitoring is a legislative requirement (see Section 2). The UK is obliged to report levels of various pollutants to the European Commission on a regular basis. These are used to assess compliance with international targets from the European Union's Air Quality Directives. Monitoring data also play a key role in the development of the UK's Air Quality Strategy and in formulating national Air Quality Objectives.

We are all polluters. From the energy we use to supply our homes, the products we buy and – often - the food we eat, almost every aspect of our lives has an effect on the quality of the air we breathe. Public awareness and co-operation is therefore an important pre-requisite to tackling air pollution at local, national and international level.

To ensure a fully informed public, UK monitoring data are communicated rapidly and efficiently to air quality stakeholders and data users through a wide range of web and media outlets. These media and web-based approaches to achieving open and free public access to air quality data are discussed further in Section 9.

3.2 A brief history of monitoring in the UK

Figure 3.1. The notorious London Smog of 1952 © unknown

Air pollution has been a problem in the UK for centuries, with doctors and scientists recognising links between air pollution and population health as far back as the 16th century. Pollution became an increasingly serious problem during the industrial revolution, as coal became increasingly widely used within industry and for domestic space heating. Inner cities, including London, were particularly badly affected.

During this period, it was not uncommon for the combination of pollution and unfavourable weather conditions to cause serious urban smogs. Historic sources suggest that each smog episode could cause thousands of premature deaths in susceptible people. These lethal 'pea-soupers' finally culminated in the infamous smogs of the 1950s and 60s (Figure 3.1), which finally precipitated both vociferous public concern and decisive Government action.

In response to this situation, the UK Government introduced its first Clean Air Act [C3] in 1956; this targeted both domestic and industrial coal burning with a range of different emission control and regulatory measures. A few years later, in 1961, the UK established the world's first co-ordinated national air pollution monitoring network, called the National Survey, monitoring black smoke and sulphur dioxide at around 1200 sites in the UK. Following the Clean Air Acts, several further pieces of legislation and additional monitoring networks were introduced to combat and measure air quality in the UK.

As discussed at length in last year's annual air quality report, the National Survey and its early predecessors was able to monitor over 60 years the dramatic decline in both black smoke and sulphur dioxide concentrations (Figure 3.2). This historic decline has been due to a number of factors, including fuel switching, the introduction of cleaner fuels and technologies, and successful legislation.

Over recent decades, black smoke levels have remained low; as a result, monitoring of this species has declined, with black smoke now measured in the UK through a monitoring network of just 21 sites. As coal burning has decreased, however, the importance of other pollutants – and primarily those from traffic - has increased. Road transport is currently the dominant source of pollution across the UK – both in cities and sometimes in more rural areas. For this reason, the UK's focus has shifted progressively to the monitoring of pollutants created (directly or indirectly) through vehicular emissions; these include, in particular, ozone, nitrogen dioxide and fine particulate matter.

The earliest air quality measurements used relatively simple, manual techniques. Often a sample would 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 low labour costs and could provide highly resolved, 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 EC 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.

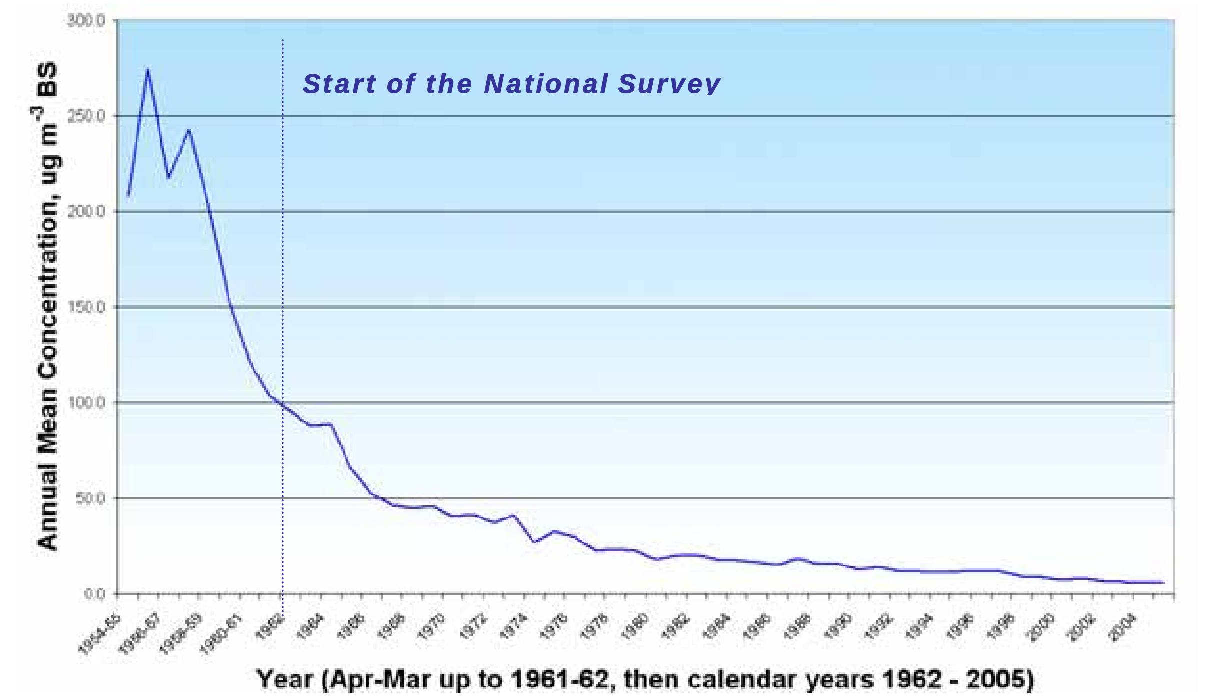


Figure 3.2 The decline in black smoke concentrations in London over 60 years, including data from 1954 to 2005

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 1) where this met national monitoring objectives and 2) when appropriate quality and consistency standards could be maintained. At the same time, increased decentralisation in the management and quality assurance of the networks was actively promoted. The net effect of these measures was to substantially increase the number and diversity of stakeholders and participants in the national monitoring effort, thus increasing competition and improving standards.

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. In 1998, the previously separate UK urban and rural automatic networks were then combined to form the current Automatic Urban and Rural Network (AURN), which is the most important and comprehensive automatic national monitoring network; in 2007, this comprised 133 sites, operational for all or part of the year.

The expansion in automatic monitoring is clearly illustrated in Figures 3.3 and 3.4, where we show the increase in the number of sites and the total hourly measurements made since the commencement of automatic air quality monitoring in the UK.

Data from the AURN, together with corresponding measurements from the UK's five automatic stations monitoring hydrocarbon pollutants, are presented in this report. The

UK's non-automatic (sampler-based) networks are described briefly in section 3.4, and reports and data from these other statutory and research-based monitoring networks are available from the national Air Quality Archive at www.airquality.co.uk.

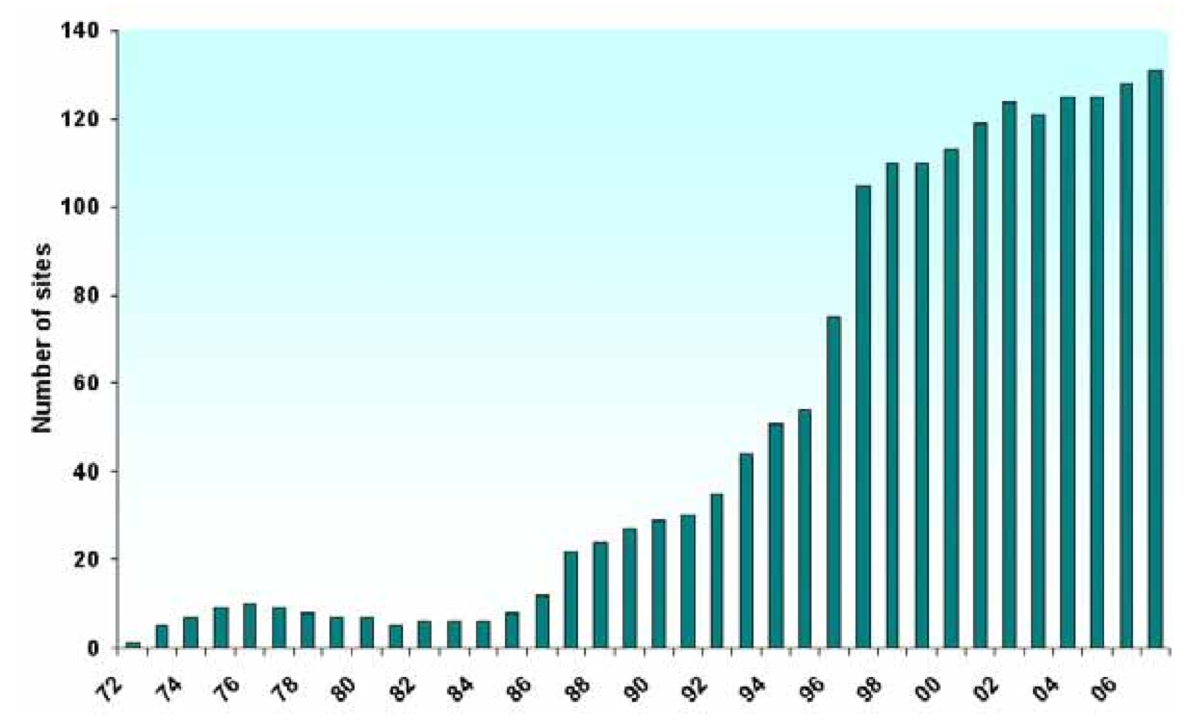


Figure 3.3 The number of government-funded automatic measurement stations in the UK has grown substantially since 1972

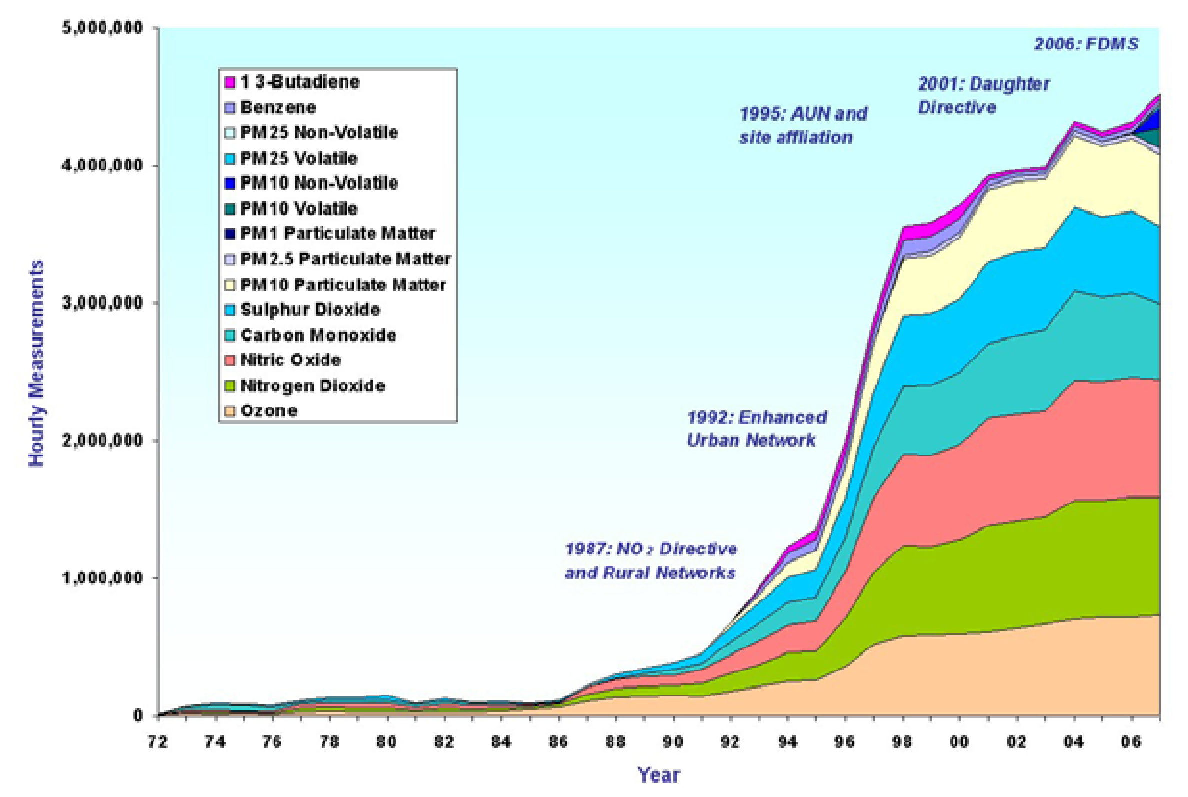


Figure 3.4 The number of hourly measurements made every year has also increased dramatically for all pollutants in the automatic monitoring networks (O_3, NO_2, CO, SO_2 and PM_{10}) and for other UK Strategy pollutants
Note: FDMS- *Tapered Element Oscillating Microbalance Filter Dynamic Measurement System*

3.3 Changes in the monitoring networks

Automatic Urban and Rural Network

During 2007 there were widespread changes to the AURN network:

- **Monitoring of CO ceased at 52 sites**
- **Monitoring of NO_x ceased at 19 sites**
- **Monitoring of SO_2 ceased at 37 sites**
- **Monitoring of O_3 ceased at 13 sites**

The following Defra and affiliated sites were closed:

Belfast East
Bradford Centre
Brentford Roadside
Hove Roadside
London A3 Roadside
London Brent
London Bromley
London Hackney
London Lewisham
London Southwark
London Wandsworth
Manchester Town Hall
Norwich Forum Roadside
Redcar
Rotherham Centre
Stockport Shaw Heath
Sunderland
Walsall Alumwell
West London
Wolverhampton Centre

Further changes to the AURN during 2007 are summarised in Table 3.1 below

Table 3.1 Changes to the UK automatic networks in 2007

Sites	Date started up/closed	Pollutants
Newly established sites		
Inverness PM_{10}*	May 2007	PM_{10}
Wrexham PM_{10}	Mar 2007	PM_{10}
Stewartby	Nov 2007	SO_2
Site relocations		
Port Talbot relocated to Port Talbot Margam	Port Talbot closed in Jul 2007 Port Talbot Margam opened in Jul 2007	NO_x O_3 SO_2 and PM_{10} NO_x O_3 SO_2 CO PM_{10} and $PM_{2.5}$
New pollutants monitored		
Horley	Nov 07	NO_2
London Haringey	Nov 07	NO_2

** Automatic hourly monitors installed to run in parallel with existing daily gravimetric samplers*

Other monitoring networks

Changes to networks are driven by many factors, including increasing concern about health impacts, government's desire to inform the public of the quality of our air, the UK's Air Quality Strategy and a range of European commitments. Several other UK monitoring networks have seen major changes in 2007; these are detailed in Section 3.4.

3.4 Current UK monitoring programmes

There are currently over 400 national air quality monitoring sites across the UK, organised into automatic and non-automatic networks; each of these has different objectives, scope and coverage. The non-automatic sites measure average concentrations over a specified sampling period (typically from a day to a month) instead of instantaneous concentrations; nevertheless, these still provide invaluable data for assessing levels and impacts of pollution across the country as a whole. This section seeks to provide a brief description of the largest and most high profile networks.

Additional information on all these programmes is provided in Appendix A3. Details of the pollutants measured are provided in Appendix A1. Maps of the monitoring network sites appear as Figures 3.7 to 3.10.

1) Automatic Urban and Rural Network (AURN)

The AURN is currently the largest automatic monitoring network in the UK. In 2007, there were 133 operating sites, split between the different countries as shown in Table 3.2. These sites provide high-resolution hourly information on a range of pollutants that is communicated rapidly to the public.

Table 3.2. AURN sites across the UK

Country	Site numbers
England	103
N. Ireland	3
Wales	9
Scotland	16

Figure 3.5. AURN monitoring station at Aston Hill, Wales

Table 3.3. Summary of measurements made by the AURN in 2007

Pollutant	Major sources	Site numbers	Areas covered
Nitrogen Dioxide (NO_2)	Road transport and industry	114 automatic 24 non-auto	Mostly urban Rural
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	91 automatic	Urban and rural
Particles (PM_{10}, $PM_{2.5}$)	Road transport, industry, construction, soil and natural sources	76 PM_{10} 7 $PM_{2.5}$	Mostly urban
Sulphur Dioxide	Industry and fuel combustion	78 automatic	Urban and rural
Carbon Monoxide (C0)	Road transport	78 automatic	Urban

2) Ammonia Network

Two methods - active denuders and diffusion tubes - are currently used to measure ammonia and the ammonium ion on a monthly basis at 95 UK sites. The aim is to assess spatial and seasonal patterns of this pollutant for different areas of the country; this is designed to help us understand ammonia exchange processes and budgets, together with resulting ecosystem and acidification effects.

3) Acid Deposition Monitoring Network

The Acid Deposition Monitoring network was established in 1986 to monitor the composition of precipitation nationwide. This provides information on deposition of acidifying compounds in the UK, and assessment of their potential impacts on ecosystems. Other measurements – including sulphur dioxide, nitrogen dioxide, and particulate sulphate - have also been made within the programme, in order to provide a more complete understanding of precipitation chemistry in the UK.

The acid deposition network currently comprises 38 sites in the UK, measuring wet bulk deposition on a fortnightly basis; 24 measuring NO_2 by diffusion tubes at rural sites; and five measuring daily particulate sulphate. This network also includes the monitoring of nitric acid by denuder measurements on a monthly basis at 30 locations.

4) PAH and TOMPs Monitoring Networks

Polycyclic aromatic hydrocarbons (PAHs) are a large group of persistent bio-accumulative organic compounds with toxic or human carcinogenic effects; they are produced through industrial, chemical and combustion processes. A target value of 1 ngm^{-3} has been set for the 'marker' PAH, benzo[a]pyrene, by the European Fourth Daughter Directive. At the start of 2007, there were 24 sites monitoring PAHs; by the end of the year this had increased to 29 high volume samplers capturing gas and particle-phase PAHs on glass fibre filters and polyurethane foam pads. The pollutant is extracted from the filter media in a laboratory and the 39 PAH species are analysed by gas chromatography-mass spectrometry.

Toxic Organic Micro Pollutants (TOMPs) include several highly toxic and persistent species, many of which are formed as unwanted by-products during various industrial, chemical and combustion processes. There were measured at six urban background and rural sites during 2007.

5) Particulate Concentrations and Numbers Network

This research-oriented network currently consists of four measurement sites in London, Harwell and Birmingham. However, during the first half of 2007, there were nine sites around the UK (also including Belfast, Glasgow, Port Talbot and Manchester). The following pollutants are measured within the scope of this network:

- Total particle numbers per cubic centimeter of ambient air;
- Particle numbers in different particle size fractions;
- Nitrate, sulphate, and chloride;
- Organic and elemental carbon.

The network provides data on the chemical composition of particulate matter, primarily for the use of researchers of atmospheric processes, epidemiology and toxicology.

6) Black Smoke Monitoring Network

In September 2006, the large national network measuring black smoke and SO_2 was replaced by a smaller network monitoring black smoke only. In 2007, this network included 21 sites across the UK. Particulate matter is collected daily onto filters using a traditional 8-port sampler shown in Figure 3.6.

The resulting smoke stains on the filters are measured using a reflectometer, and a black smoke index calculated. This dated equipment will be replaced during 2008 with an automatic instrument called an aethalometer, which measures black carbon using a real-time optical transmission technique.

Figure 3.6. Traditional 8-port black smoke sampler

7) Heavy Metals Network

This network provides data to demonstrate compliance with European Directives. The network is currently expanding to include the required number of sites in the zones and agglomerations in the UK. PM_{10} particulate samples are collected weekly onto cellulose filters, which are analysed in a laboratory environment, by digestion of the samples in a hot acidic solution, followed by analysis by mass spectrometry. Twelve different metals are analysed, including the four regulated by Europe: arsenic, cadmium, lead and nickel. This network is discussed in more detail in Section 6 of this report.

8) Non-automatic Hydrocarbon Network

This network measures benzene at 35 sites around the UK and, up until August 2007, also measured 1,3-butadiene at ten locations. Measurement of benzene involves pumping air across an adsorption tube to trap the compound, which is later analysed in the laboratory by gas chromatography.

Benzene emissions arise from the evaporation and combustion of petroleum products; measurements of its concentrations in ambient air are necessary to determine compliance with the new European Directive (see Section 2). 1,3-Butadiene is emitted from engines as part of the combustion processes, as well as during its production and use in the chemicals industry.

9) Automatic Hydrocarbon Network

At the start of 2007 the UK Automatic Hydrocarbon Network consisted of six sites, located at Cardiff, Glasgow, Harwell, London Eltham, London Marylebone Road and Auchencorth Moss. This network uses two different types of automated gas chromatographs to analyse 26 different hydrocarbons on an hourly basis, including:

- Benzene – this is regulated by Europe and the UK;
- 1,3-butadiene - this has an associated objective in the national Air Quality Strategy;
- Ozone precursors – measurement data must be reported to the European Commission.

During 2007, a strategic review of the UK monitoring networks resulted in the cessation of VOC (Volatile Organic Compound) monitoring at the Cardiff Centre monitoring site.

More information on all these programmes is detailed below:

- A summary of the UK national networks is provided in Table 3.4.
- The pollutants monitored by these networks are summarised in Table 3.5
- Network maps appear as Figures 3.7 to 3.10.
    - Fig 3.7 Automatic monitoring sites- AURN, measuring O_3, PM_{10}, CO, SO_2 and NO_X
    - Fig 3.8 Air toxics – PAHs. TOMPs and heavy metals
    - Fig 3.9 Acidifying pollutants – acid deposition, nitric acid and ammonia
    - Fig 3.10 Hydrocarbons (automatic and sampler monitoring)
    - *See also Fig 6.11 for metals*
- More details on each network are available in Appendix 3.
- The UK Archive at http://www.airquality.co.uk/archive/networks_home.php

Table 3.4 The major UK Air Quality Monitoring Networks

Network	Auto or Sampler?	No of Sites
The Automatic Urban and Rural Network (AURN)	A	133 (87 urban, 22 rural, 24 London)
Ammonia Network	S	95
Rural acid deposition, gases and particles	S	38 (acid deposition)
Nitric Acid Network	S	30
Toxic Organic Micropollutants (TOMPS) Polycyclic Aromatic Hydrocarbons (PAHs)	S S	6 29
Particle concentrations and numbers	S	9
Black Smoke	S	21
UK Heavy Metals Monitoring Network	S	17
Rural metal deposition network	S	10 particle and rain, Hg in rain & air 5 rainwater 2 cloud water
Non automatic hydrocarbon-Benzene and 1,3-butadiene	S	35 (benzene) 10 (1, 3-butadiene)
Automatic Hydrocarbon	A	6

In order to meet the primary objectives of these networks (as stated in Section 3.1) the data produced must be high quality, robust, and effectively communicated to the appropriate stakeholders. Each network utilises strong quality assurance and control (QA/QC) measures to maximise measurement integrity and reliability (see Section 3.5). Moreover, a strong emphasis is placed on achieving the widest possible dissemination and use of both monitoring data and the information derived from this.

Local Authority monitoring

In addition to the AURN and other non-automatic national monitoring networks, there are also many non-network monitoring sites, operated by Local Authorities as part of their Local Air Quality Management obligations. Many of these sites contribute data to nationally organised measurement programmes that are funded and supported by Central Government and the Devolved Administrations. However, it should be noted that this report deals only with measured data from national monitoring programmes, including Local Authority sites that are affiliated to these programmes.

Many of the networks, and particularly those involving automatic measurements, are large-scale and involve a wide range of participating organisations. There is also an important role for local organisations, which are typically responsible for ongoing site operations. The data from these and similar networks presented in this report therefore represent the end product of the efforts of many persons and organisations in the private sector, local and central government.

Table 3.5. Summary of UK measurements made for the key air pollutants

Pollutant	Major sources	Site Numbers	Areas Covered
Volatile Organic Compound (VOCs)	Industry, transport, solvent and some natural sources	5 automatic, 35 non-auto benzene	Mostly urban
Dioxins and PCBs	Combustion (dioxins) and historic uses (PCBs)	6 non-auto	Urban and rural
Particulate Sulphate	Industry and fuel combustion	5 non-auto	Rural
Polycyclic Aromatic Hydrocarbons (PAHs)	Industry, domestic combustion traffic (PAHs)	29 non-auto	Industrial, urban and rural
Metals- Pb, Cd, As, Ni and Hg	Industrial and other processes	17 non-auto	Industrial, urban and rural
Black Smoke	Road transport, industry, construction, soil and natural sources	21 non-auto	Mostly urban
Acid Deposition	Atmospheric reactions involving fuel burning, agricultural and other emissions	38 non-auto	Rural
Ammonia	Agricultural activities - decomposition and volatilisation of animal wastes	95 non-auto	Rural
Nitric Acid	Combustion and photochemistry	30 non-auto	Rural

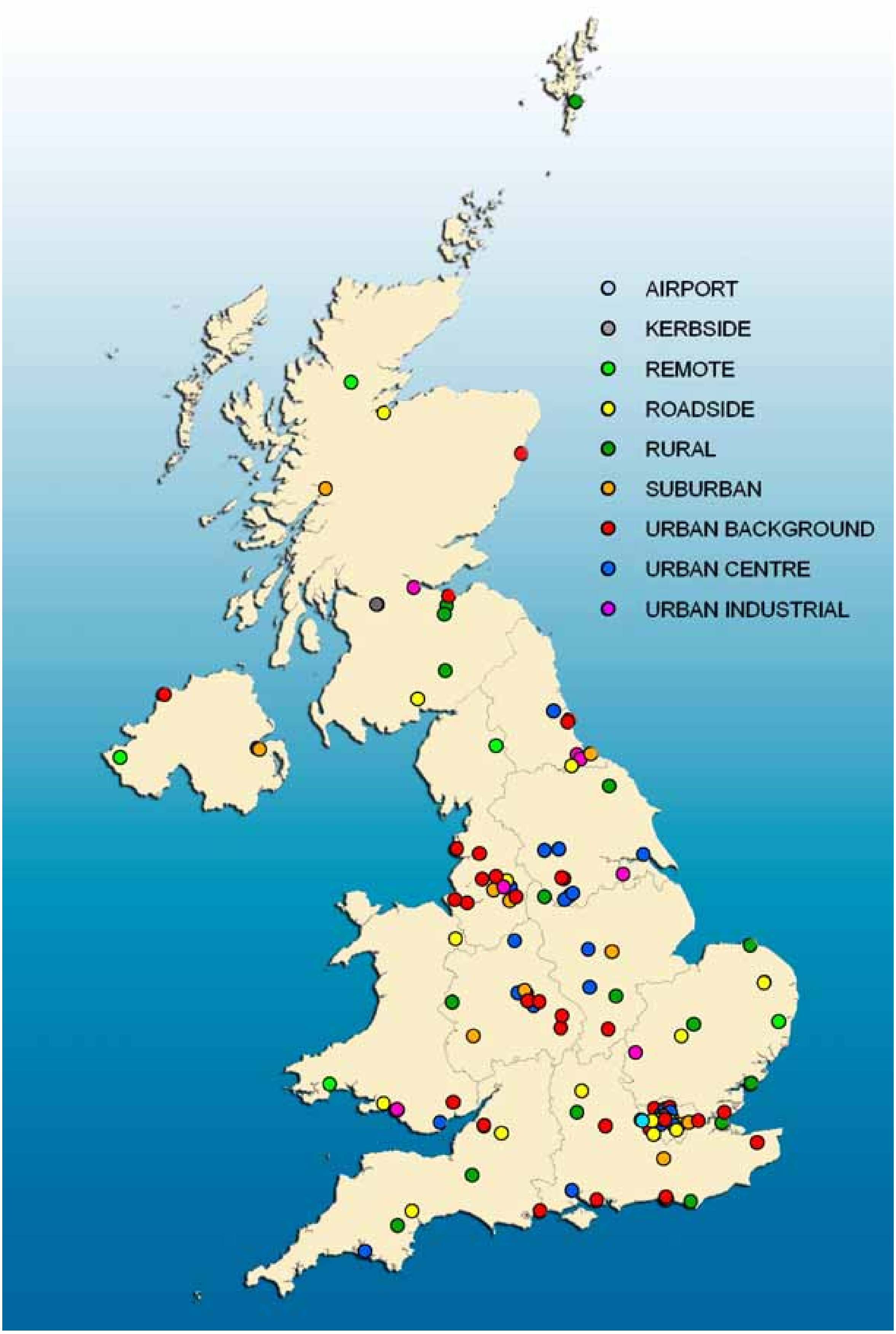


Figure 3.7 Automatic monitoring stations in the National Automatic Urban and Rural Network (AURN) during 2007

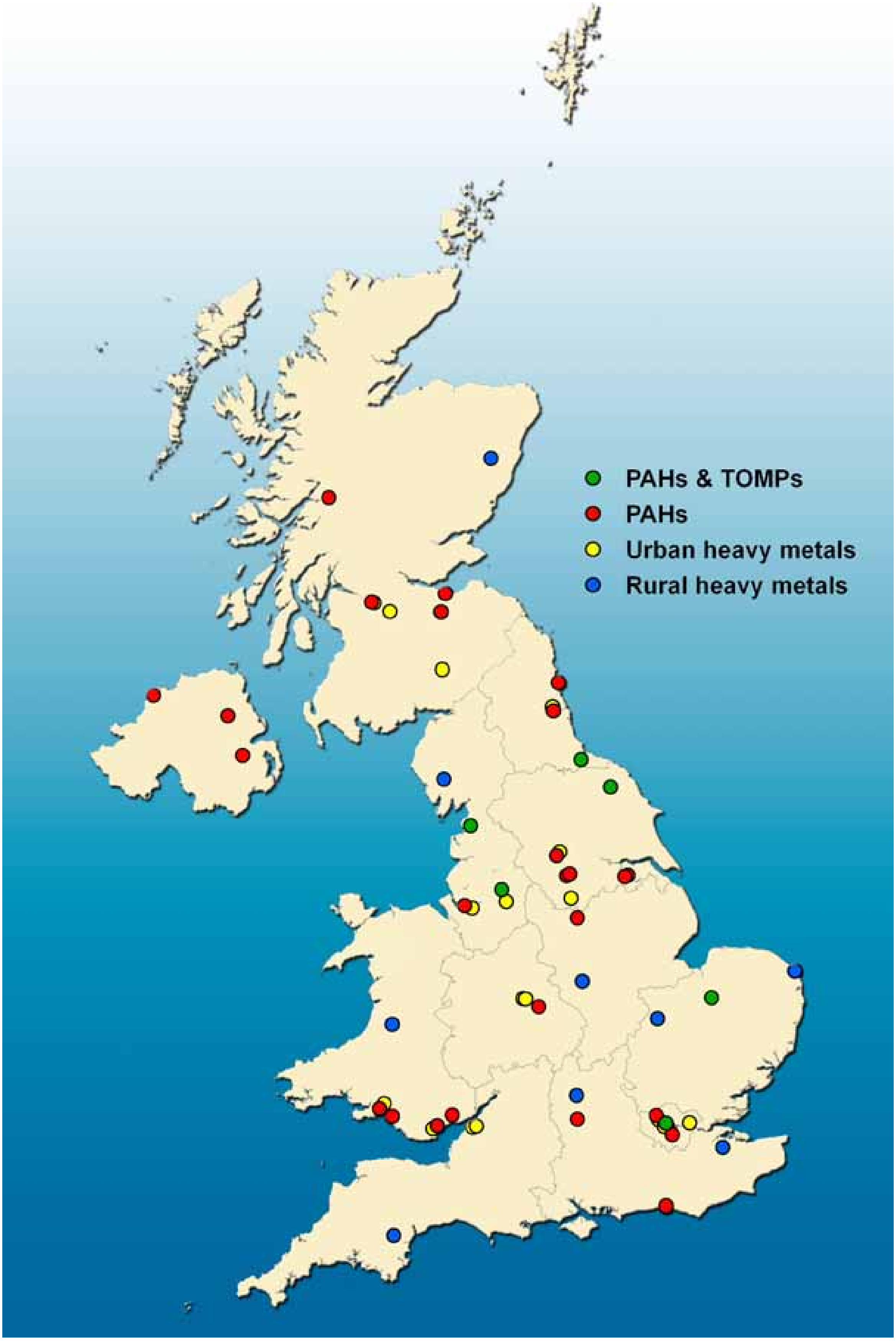


Figure 3.8 Non-automatic monitoring stations for Metals, PAHs (Polyaromatic hydrocarbons) and TOMPs (Toxic Organic MicroPollutants)

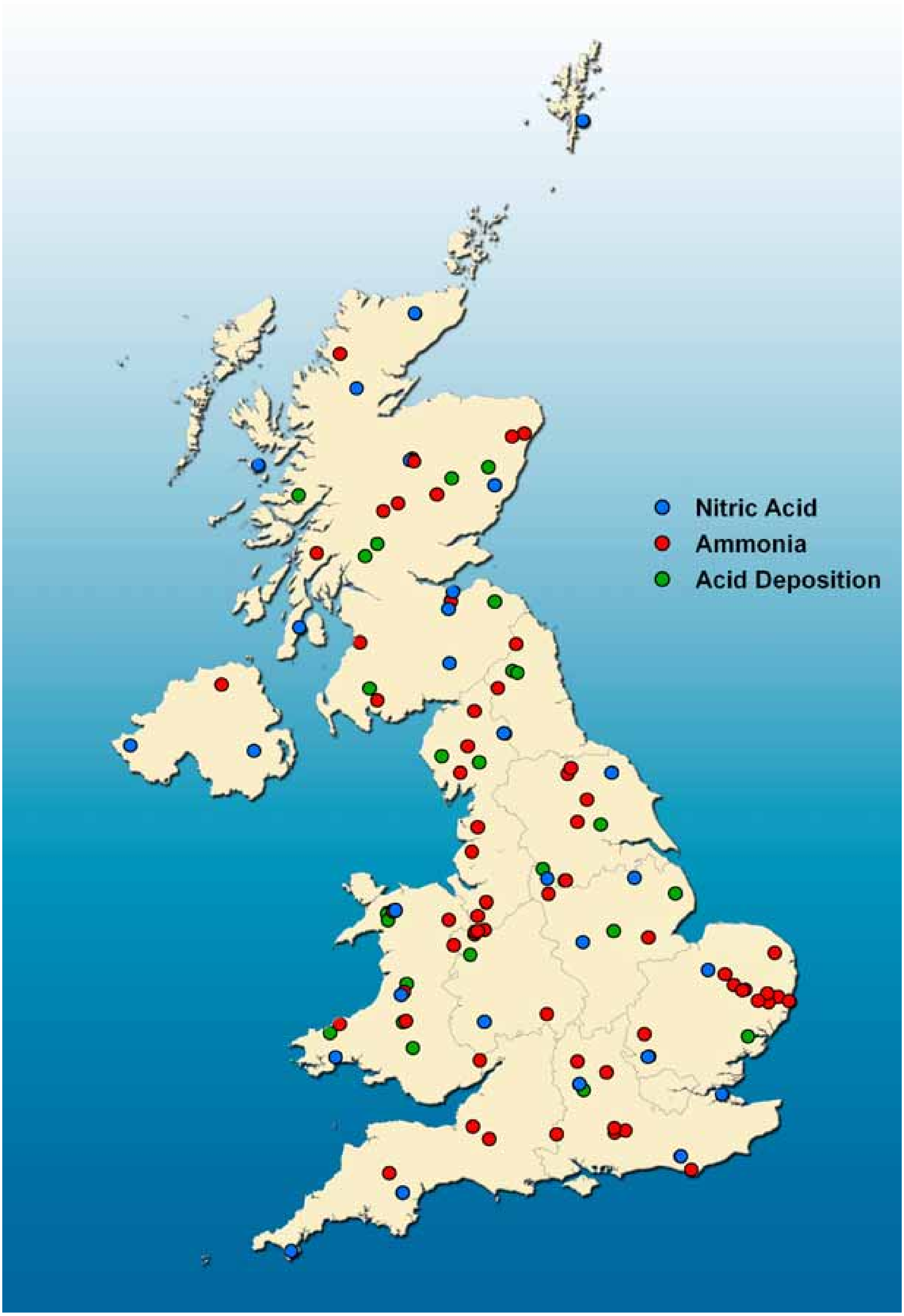


Figure 3.9 Non-automatic monitoring stations for acid deposition, nitric acid and ammonia during 2007

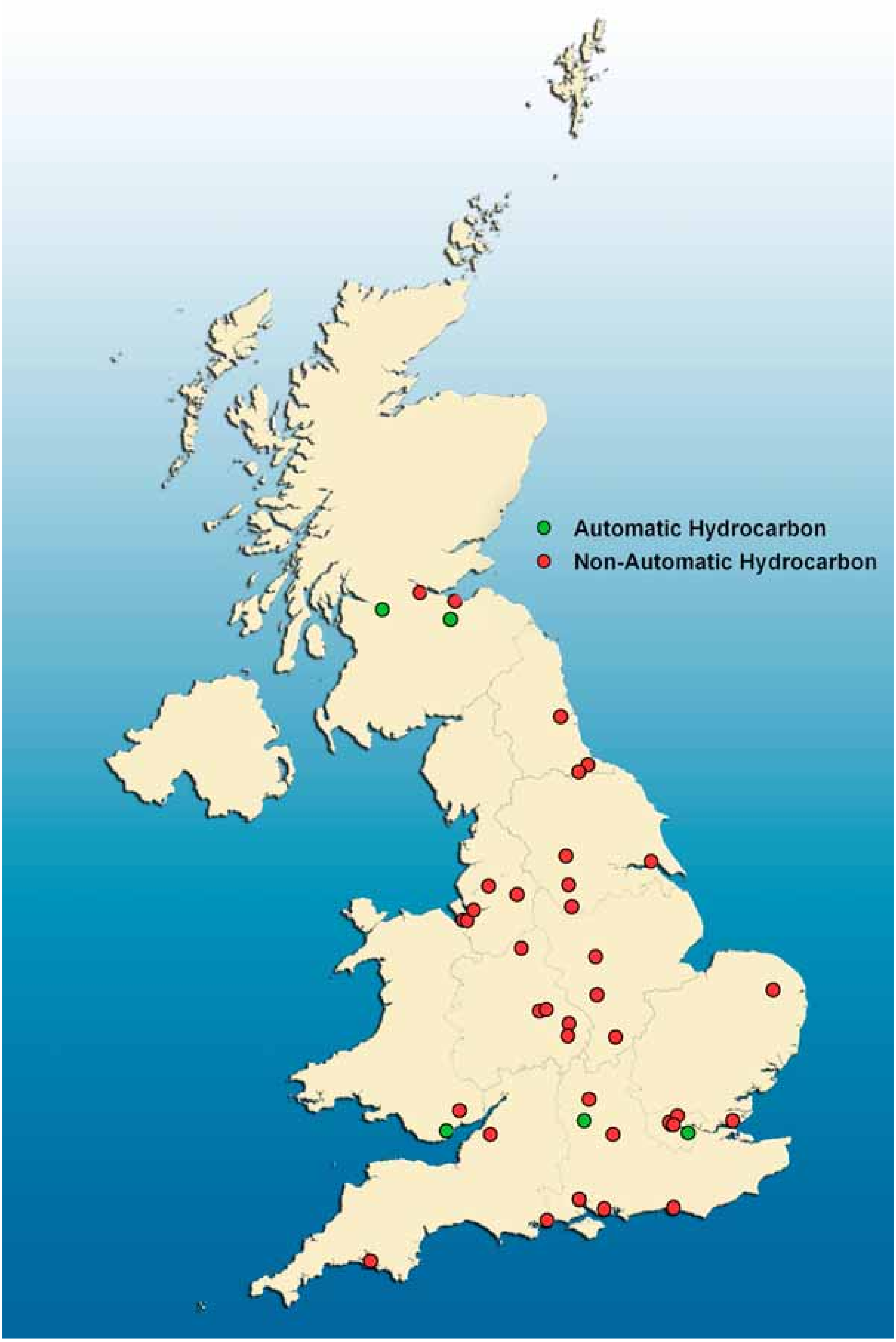


Figure 3.10. UK monitoring stations for automatic and non-automatic hydrocarbons during 2007

3.5 Emphasis on data quality

The UK's national air monitoring networks currently generate over 20 million raw individual measurements every year; in the AURN alone, this amounts to over 9 million hourly measurements archived. All measurements, whether from automatic or manual samplers, are subject to a rigorous procedure of validation and ratification before they are published on the national Air Quality Archive.

Accurate and reliable measurements are essential if the monitoring data are to fulfill the objectives listed in Section 3.1. Considerable scientific development, time and attention are invested in each measurement procedure, to provide data that are of suitable quality to be used by all stakeholders for their different purposes.

> ***Quality Assurance and Control***
>
> ***A system of activities that assures that measurements meet defined standards of quality with a stated level of confidence. The system includes quality assurance of the measurement process and quality control of the measurement outputs.***

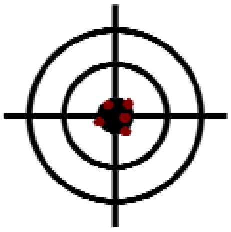
Each UK network therefore has in place a strong QA/QC programme designed to ensure that its measurements meet defined standards of quality with a stated level of confidence. Essentially, each programme serves to ensure that the data obtained are:

(i) Genuinely representative of ambient concentrations existing in the various areas under investigation
(ii) Sufficiently accurate and precise to meet specified monitoring objectives
(iii) Comparable and reproducible. Results must be internally consistent and comparable with international or other accepted standards, if these exist
(iv) Consistent over time. This is particularly important if long-term trend analysis of the data is to be undertaken
(v) 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 EC Limit Values where applicable
(vi) Consistent with the Data Quality Objectives and methodology guidance defined in EC Daughter Directives for relevant pollutants and measurement techniques.

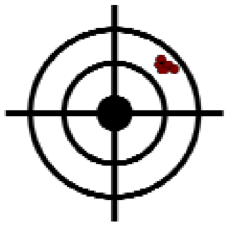
The UK's Quality Assurance and Control programmes typically include a broad spectrum of system design, operational management, training and review activities. These differ from programme to programme, depending on network objectives, methodologies and data quality targets. We highlight here some of the procedures and overall principles employed for selected programmes.

Some terminology: accuracy, precision and uncertainty

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. Often these two terms are confused, or thought to mean the same. In the context of air quality measurements:



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 practice, few instruments are perfectly precise, and that is why, often, repeat measurements are made and the average value is calculated.

Sometimes a pollutant concentration will be assigned an uncertainty, which essentially gives a range of values that could be correct. Consider the following statement:

The PM_{10} concentration is 20 ± 2 μgm^{-3} (95% confidence)

This means that we are 95% certain that the correct concentration lies between 18 and 22 μgm^{-3}, and that it is most likely to be 20$\mu g\ m^{-3}$. The probability of the concentration being at the extremes of the stated range is small. (There are some measurements where the probability is equal throughout the range, but in complex air quality monitoring this will rarely be the case).

Structure of UK monitoring networks

Responsibility for the UK monitoring networks rests with the UK Government. Key tasks are contracted to a number of organisations. The structure of the AURN, depicted below in Figure 3.11, is reasonably decentralised. In particular, all QA/QC tasks are assigned to an independent operational unit.

Standardisation of methods

The European Committee for Standardisation (CEN) has published a series of Standard Methods for the measurement of air pollutants. UK air quality monitoring experts continue to work closely with CEN to develop appropriate methods for ensuring high quality data, and integrating these into the networks. The following are examples of relevant standards:

- 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 ($PM_{2.5}$).

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. The CEN/BS (British Standard) procedures are specifically targeted at quality assurance of a monitoring network, by ensuring that the quality of the measurement inputs and systems are tightly specified. These standards have been incorporated into the latest EC Directive on Air Quality (2008/50/EC), making it mandatory for Member States to operate monitoring networks to these standards by June 2010.

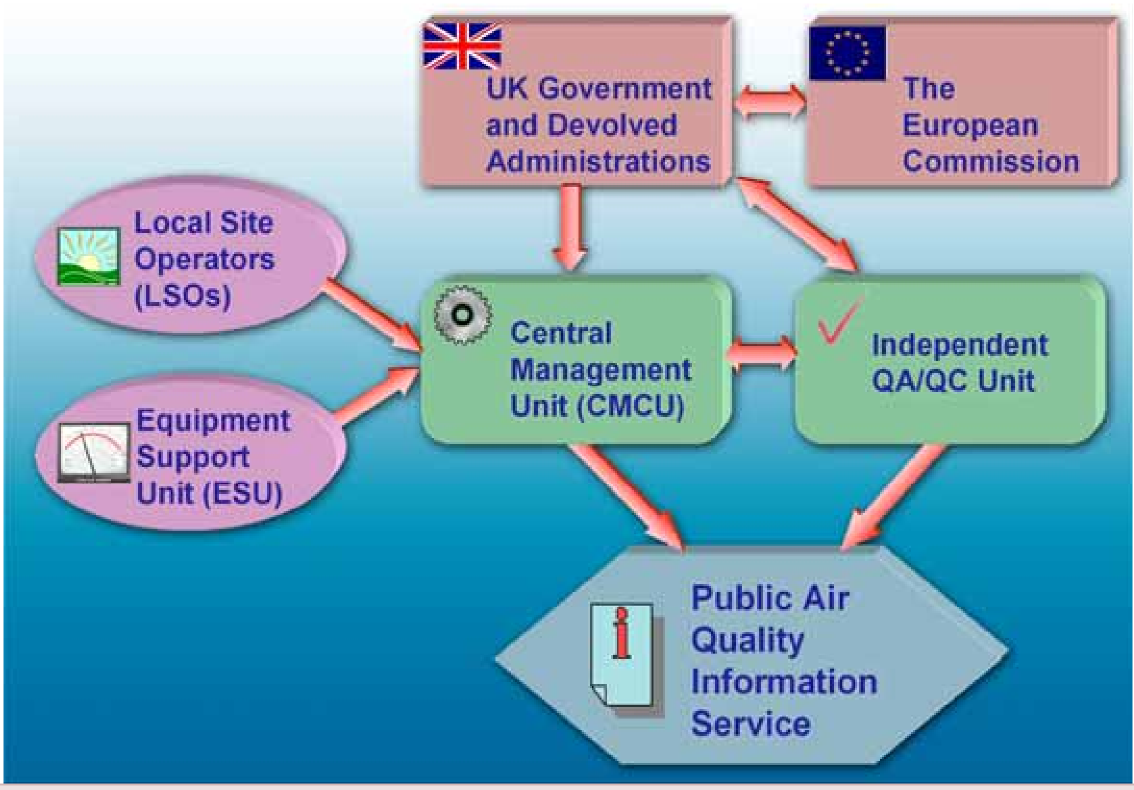


Figure 3.11 Devolved monitoring network structure, as currently utilised within the AURN

The immediate future of the AURN will therefore see a significant tightening of the performance requirements of air pollution analysers. The requirements of the CEN performance tests are exhaustive, but in general include the following:

- All analysers must pass a rigorous series of tests using prescribed laboratory and field approval tests. The analysers must be field tested in the environments in which they are intended to be used
- In addition to passing the individual performance tests, the analysers must also pass an overall uncertainty evaluation. The results of the individual tests above are used as components to calculate the overall uncertainty of measurement. For NO_x, CO, O_3 and SO_2, the requirement is a measurement uncertainty of ±15% at the relevant EC Limit Value, while for PM and benzene the requirement is ±25%.
- Once deployed in a monitoring network, the analysers have to pass a number of ongoing performance tests. The results from these tests are used to determine ongoing measurement uncertainties, reported annually to the EC.

The UK Automatic Urban and Rural Monitoring Network already has a comprehensive suite of ongoing operational and performance tests that are used to evaluate the performance of site analysers (figure 3.12). The majority of the tests required by CEN are either undertaken already, or require only minor modifications to ensure full compliance with the requirements. The procedures used to perform these tests are continuously refined and revised; they are sufficiently developed that they will be fully compliant with CEN well in advance of required timeframes.

Demonstration of Quality Assurance and Quality Control

In establishing and operating a large monitoring network, appropriate control measures must be employed to ensure that all data produced are robust, defensible and fit for purpose. Table 3.6 summarises the QA/QC activities used in the AURN; however, these are broadly applicable to any network-based air pollution measurement processes:

Figure 3.12. All AURN automatic monitoring stations are audited regularly as part of their core quality assurance and control programme.

This involves:

- Performance tests of all analysers on-site
- Verifying calibration gases
- Inter-calibration of the network as a whole
- Monitoring performance of local site operators
- Providing training

Particulate Matter: problems and pitfalls

A number of monitoring networks and research programmes in the UK are currently focused on particle measurements. Particulate matter (PM) can consist of a variety of different components - either liquid or solid particles - ranging from a few nanometres to several microns in diameter. The predominant reason for monitoring PM is because of the risk it carries to human health. Generally speaking, the smaller the size of the particle, the further it can penetrate into the lungs and the more potential it has to cause damage to health. Moreover, the toxicity of different species within particulate matter can vary considerably.

It is therefore very important that this pollutant is measured accurately and reliably in the AURN, the UK's major automatic monitoring programme, as well as by Local Government for the purpose of Local Air Quality Management. For this reason, the UK carries out thorough tests of the equipment used to monitor this pollutant, to ensure that the data produced by the AURN and other networks are accurate, reliable and comparable to the reference method.

The reference method for measuring PM_{10} and $PM_{2.5}$ is gravimetric, by collecting the sample onto a pre-weighed filter at a controlled flow rate for 24 hours, thus presenting a daily mean concentration. However, this method has the significant disadvantage that exposure data are not available for many days (or weeks) after the data are collected. The UK monitoring networks therefore make use of automatic analysers, to provide near real-time data that can be used to forecast and provide rapid alerts to elevated levels of air pollution. It is, however, widely accepted that historic automatic PM data does not accurately reflect gravimetric PM exposure in the UK.

Table 3.6. Typical network QA/QC activities

Quality assurance of measurement processes	
Activity	**Function**
Advice on network design, site selection and siting	To ensure the data quality objectives of a network are fulfilled at the design stage
Support in instrument selection and sample system design	To ensure that the equipment used to sample ambient air are fit for purpose
Development of operations manual and monitoring compliance	To ensure that all monitoring stations are operated according to a consistent standard
Operator and personnel training	To ensure that all network participants perform to a consistent standard
Rigorous equipment testing and method development	To ensure the instrument and method is fit for purpose and meets specifications set by CEN
Duplicate measurements	To allow estimation of the uncertainty in the measurement and increase confidence in the result
Sample/instrument conditioning	For consistency between measurements and instruments; to remove the effect of external factors such as weather on the measurement
Routine maintenance and cleaning of equipment	For optimal instrument performance as intended by the manufacturer
Calibration of instruments and standards	To ensure the result is accurate, traceable and thus comparable across Member States
Quality control of measurement outputs	
Activity	**Function**
Monitoring routine site visits and operations	To check that calibrations and operations are undertaken according to the prescribed procedures
Monitoring calibration gases and instrument response	To check that the equipment and gases used are performing within acceptable limits
Routine data inspection review and validation	To check, on a daily basis, that the data from analysers are scaled provisionally and are free from any obvious errors
Drift corrections	To improve accuracy of the result by removing variations in instrument sensitivity over time
Data ratification/finalisation before archival	Comprehensive checks every three months to: scale data, identify and remove any spurious information, use the network audit results to confirm satisfactory analyser performance
Quality Assessment	
Activity	**Function**
Regular network audits and site inspections including measurement of sampler flow rates and leak checks	These tests assess the performance of the entire measurement system at a site: the stability of the site calibration cylinders, the performance of the analysers, ability of the Local Site Operators and the safety and general environment around the monitoring station.
UKAS Accreditation	UKAS accreditation to BS EN17025 for the calibration of site gases and the on-site calibration of analysers
Inter-comparisons	To compare the measurement result of different countries, laboratories or analysers when measuring the exact same sample
Recovery and/or testing against certified reference materials	To validate the response of the instrument, and measurement results against a known sample

Figure 3.13 A range of different particle analysers and sampling inlets on test at a rural monitoring station © Jon Bower

Many studies have been undertaken to demonstrate that results from alternative analysers can be made equivalent to the reference methods. In 2005, two automatic methods (TEOM FDMS – Type B and Met One Beta Attenuation Monitor- the latter with slope correction) and one daily gravimetric sampler (R&P Partisol) were shown to be equivalent.

In 2008, two additional extensive assessments of PM analyser performance will commence. Firstly, an EC-led programme of instrument inter-comparison will be undertaken at Port Talbot, South Wales, where ambient PM_{10} and $PM_{2.5}$ data reported by the national network will be compared against reference method measurements made at the site by the European Reference Laboratory.

In addition, an Environment Agency-led programme of assessment will be undertaken at two locations to measure the performance of a range of monitoring equipment against PM_{10} and $PM_{2.5}$ reference samplers.

Local Site Operators (LSO) site operations manual

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 operational, calibration and other procedures utilised throughout the entire programme. The LSO manual is available both in hardcopy form and on CD; the latter contains detailed instructions for operating all measurement and instrumentation types currently deployed in the programme. The manual is also available for the UK Air quality Information Archive at www.aeat.co.uk/netcen/airqual/reports/lsoman/lsoman.html

Local Authority NO_2 diffusion tube monitoring

Despite the closure of the national network (see last year's report), many UK Local Authorities continue to use diffusion tubes as a cost-effective and convenient way of monitoring ambient concentrations of NO_2. These are 'passive' samplers, which work by absorbing the pollutants directly from the surrounding air and therefore need no power supply. The type of NO_2 diffusion tube most commonly used in the UK is the Palmes-type sampler [C4], shown in Figure 3.14: this consists of a small plastic tube, approximately 7 cm long. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case NO_2.

Fig 3.14 Diffusion Tubes

Tubes are mounted vertically at the measurement site (for example, fixed to a lamp post or other street furniture) with the open end at the bottom. Ambient NO_2 diffuses up the tube during exposure, and is absorbed as nitrite.

After the exposure period - typically several weeks or a month - the tube is removed for analysis. The average ambient pollutant concentration for the exposure period is calculated from the amount of pollutant absorbed.

Diffusion tubes are available for a range of pollutants (see Figure 3.14 opposite), but those most commonly used in the UK in the context of Local Air Quality Management (LAQM) are for NO_2.

A typical deployment method for diffusion tubes is illustrated in Figure 3.15 below.

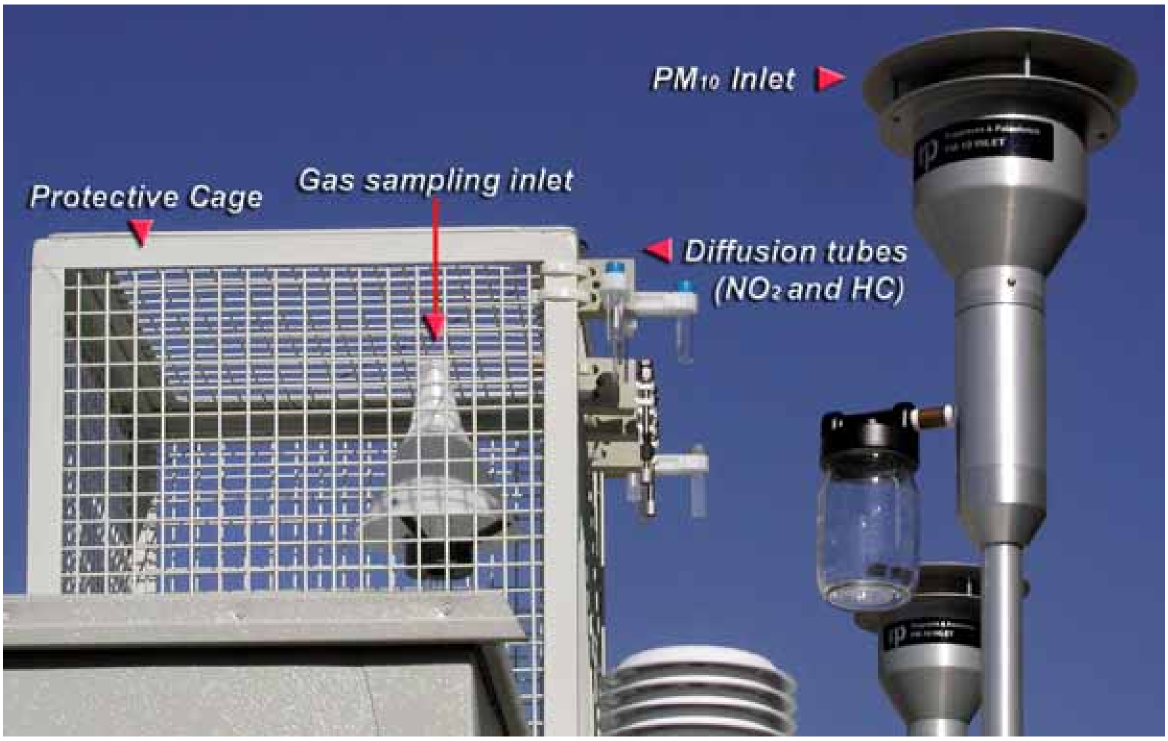


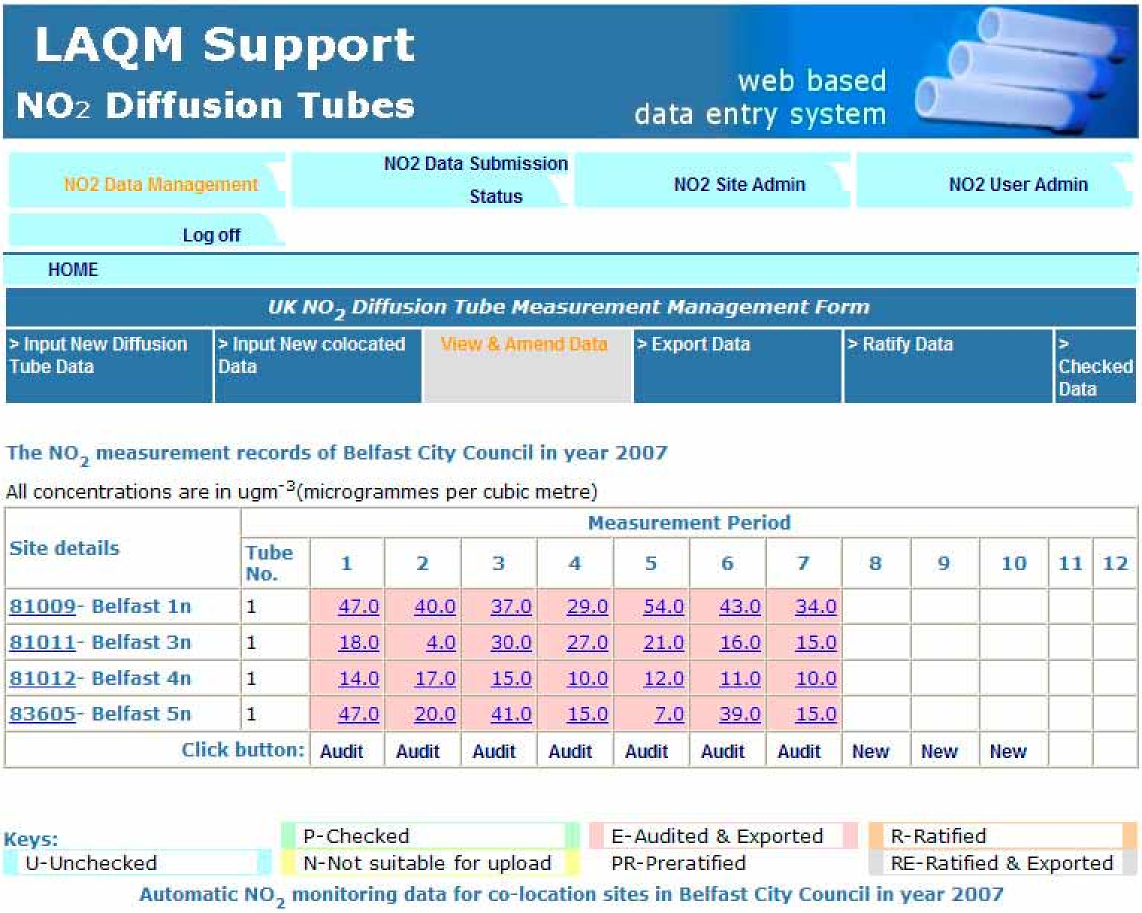
Figure 3.15 Typical deployment of diffusion tubes (NO_2 and BTX) on the rooftop of an automatic air monitoring station- *(Jaume Targa)*

Diffusion tubes are an indicative method: they do not provide the same level of precision and accuracy as automatic monitoring methods; for example, the accuracy of diffusion tube measurements is typically recognised as ~ ±25%. Nor can they be used for short-term (hourly or daily) measurements. However, they are a useful, low-cost supplement to more expensive and sophisticated automatic methods. Often, indicative sampler-based methods such as diffusion tubes can be used where it is not practical to install an automatic analyser. NO_2 diffusion tubes have therefore become a widely used tool in Local Air Quality Management throughout the UK.

Accordingly, since the closure in 2005 of the former national NO_2 Diffusion Tube Network, Defra and the Devolved Administrations have continued to provide a range of support services to Local Authorities using diffusion tubes, as part of the overall contract support to Local Authorities for Air Quality Management'; this also includes the Air Quality Monitoring and Modelling Helpdesks, discussed further in Section 9.

These national support services include:

- QA/QC support for laboratories supplying and analysing NO_2 diffusion tubes
- Information and guidance to the Local Authorities using them.
- A web-based central NO_2 diffusion tube data collation system (Fig 3.16) - a convenient way for Local Authorities to store and share their diffusion tube data.
- Operation of a Working Group aimed at harmonisation of diffusion tube methods for NO_2. This completed its work in 2007, and has produced in 2008 a comprehensive practical guidance manual detailing harmonised methods for diffusion tube preparation, deployment and analysis.


LAQM Support
NO_2 Diffusion Tubes
web based
data entry system
NO2 Data Management
NO2 Data Submission Status
NO2 Site Admin
NO2 User Admin
Log off
HOME
UK NO_2 Diffusion Tube Measurement Management Form
> Input New Diffusion Tube Data
> Input New colocated Data
View & Amend Data
> Export Data
> Ratify Data
> Checked Data

The NO_2 measurement records of Belfast City Council in year 2007

All concentrations are in ugm^{-3}(microgrammes per cubic metre)

Site details	Measurement Period												
	Tube No.	1	2	3	4	5	6	7	8	9	10	11	12
81009- Belfast 1n	1	47.0	40.0	37.0	29.0	54.0	43.0	34.0					
81011- Belfast 3n	1	18.0	4.0	30.0	27.0	21.0	16.0	15.0					
81012- Belfast 4n	1	14.0	17.0	15.0	10.0	12.0	11.0	10.0					
83605- Belfast 5n	1	47.0	20.0	41.0	15.0	7.0	39.0	15.0					
Click button:		Audit	Audit	Audit	Audit	Audit	Audit	Audit	New	New	New		

Keys:
U-Unchecked
P-Checked
N-Not suitable for upload
E-Audited & Exported
PR-Preratified
R-Ratified
RE-Ratified & Exported

Automatic NO_2 monitoring data for co-location sites in Belfast City Council in year 2007

Figure 3.16 – Web-based data entry system for diffusion Tubes

The practical guidance document is available from http://www.airquality.co.uk/archive/reports/cat05/0802141004_NO2_WG_PracticalGuidance_Issue1a.pdf .

It is recommended that all diffusion tubes used by Local Authorities for LAQM purposes be prepared and analysed using the harmonised methods set out in this guidance document. Laboratories supplying and analysing diffusion tubes used in LAQM are expected to fully implement the harmonised method by 1st January 2009.

Since the publication of the above guidance, the Directorate General Environment (DG-ENV) of the European Commission has announced its decision to develop a CEN standard method for NO_2 monitoring in ambient air using diffusive samplers. However, it is likely to be several years before the CEN standard method is finalised. It is envisaged that the findings and recommendations of the Defra working group, and the UK's experience in implementing them, will provide useful input to this process.

Further details of the overall national support project for diffusion tube users can be found at http://www.laqmsupport.org.uk

4 High pollution episodes

By examining periods during 2007 when pollution levels were particularly high, either locally or UK-wide, we can identify their causes and assess potential impacts

4.1 Causes and types of air pollution episode

Air pollution levels can vary considerably from day to day, as well as from one part of the country to another. In this section, we'll look at short-term variations over time, and in particular some recent periods when pollution levels were particularly high. These are usually referred to as ***episodes***.

Pollution levels can vary significantly over time for two main reasons:

1) Variations in pollutant emissions
2) Changes in atmospheric conditions that allow pollution levels to build up, resulting in the transport of pollutants from other areas or encouraging their formation through chemical reactions.

All episodes occur because of a combination of these factors.

There are two major types of pollution episode in the UK: winter and summer smogs. ***Winter smogs*** typically occur in cold, still and foggy weather; this traps pollution produced by motor vehicles, space heating and other sources close to the ground and allows it to build up over time. City areas - in particular those close to major roads - are usually worst affected, together with sheltered or low-lying parts of the country. Winter episodes are usually characterised by elevated levels of nitrogen dioxide (NO_2), particles (PM_{10}) and volatile organic compounds (VOCs) such as benzene. High sulphur dioxide levels can also occur in some industrial or coal-burning regions. Winter smogs appear to be becoming less frequent over recent mild UK winters.

By contrast, ***summer smogs*** occur in hot and sunny weather. Sunlight and high temperatures accelerate chemical reactions in mixtures of air pollutants that are emitted from road vehicles, fuel burning and solvent usage. The pollutants that cause such an episode can often travel long distances - sometimes from other parts of Europe. During this large-scale air movement, they react together to produce high levels of ozone (O_3), together with other pollutants such as nitrogen dioxide and fine particles. Unlike the ozone layer in the upper levels of the atmosphere that protects us from ultraviolet radiation, ground level ozone produced in this way is harmful both to human health and vegetation, as well as damaging some man-made materials.

Another important type of pollution episode can be caused by ***long-range transport*** of pollutants from Europe, or occasionally from North Africa or North America. This tends to occur during the summer months, either in isolation or in combination with summer smog. Local transport episodes involving elevated levels of primary (directly emitted) pollutants may also occur in the proximity of busy roads or large industrial plant.

Air pollution episodes in the UK vary widely in terms of the size and location of the areas they affect, as well as their duration and seriousness. Episode numbers can also vary markedly from year to year, as we have seen throughout this long-running series of annual reports.

In this section, we review the most significant UK air pollution events during 2007. Although the poor summer resulted in no photochemical smog episodes, we take the opportunity to review the frequency of this type of episode over recent years. We also examine a particle episode during March – April 2007, as well as the air quality impacts of this year's Bonfire Night.

4.2 A particle episode involving long-range transport: 24th March – 2nd April 2007

As noted in the previous section, long-range transport of pollutants from outside the country can, on occasions, affect parts of the UK. Here we examine one such incident.

Over a 9 day period, from 24th March to 2nd April, 57 sites in the UK Automatic Urban and Rural monitoring network (AURN) measured levels of PM_{10} particulate matter in the MODERATE band and approximately twenty of these sites also went on to record HIGH band levels. A time series plot of hourly averaged gravimetric equivalent measurements made at selected sites in the south of the UK is shown in Figure 4.1 below.

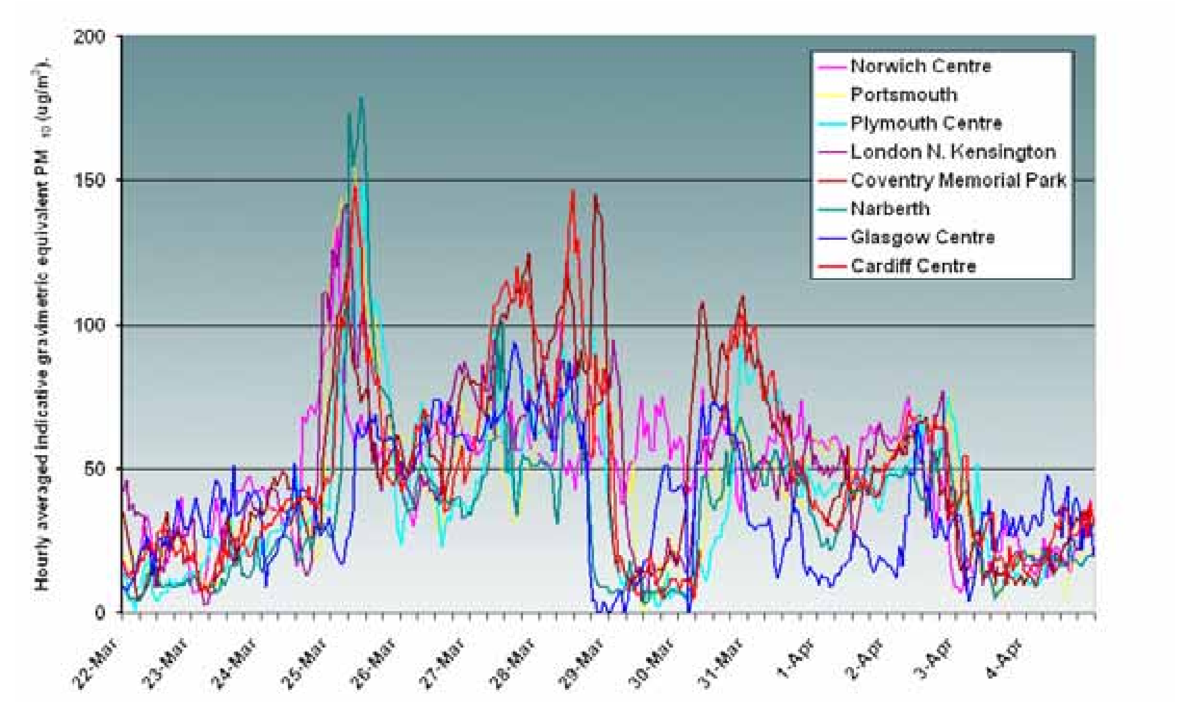


Figure 4.1 Hourly mean gravimetric equivalent PM_{10} measurements at selected southern sites (with a site in Scotland also plotted as a comparison).

Air source models indicated that the dust particles had been transported to the UK on easterly air currents and further research suggested that the cause was likely to have been a combination of:

- Agricultural fires in the Ukraine and western Russia
- Transported secondary particulate pollution associated with air passing over mainland Europe and
- Long range transport of dust from sandstorms in North Africa.

How can we tell this? A number of modelling and other techniques were utilised[D1]. Figure 4.2 shows a 4-day air mass back-trajectory for the second day of the episode. This model suggests that the air arriving in the UK had passed over areas of central Europe from Western Russia. Both satellite imagery and particle modelling studies also showed that dust from the storms in North Africa were possible contributors, especially during the early stages of the episode.

Figure 4.3 shows the results from the Met Office's 'NAME' model, which was run specifically to determine the history of the air arriving at Narberth, in Wales on the first full day of the episode. The model result indicates that the air arriving at this location had passed primarily over Germany and Denmark in transit from the vicinity of Western Russia, with a smaller component of the air having passed over parts of Scandinavia, southern Europe and North Africa.

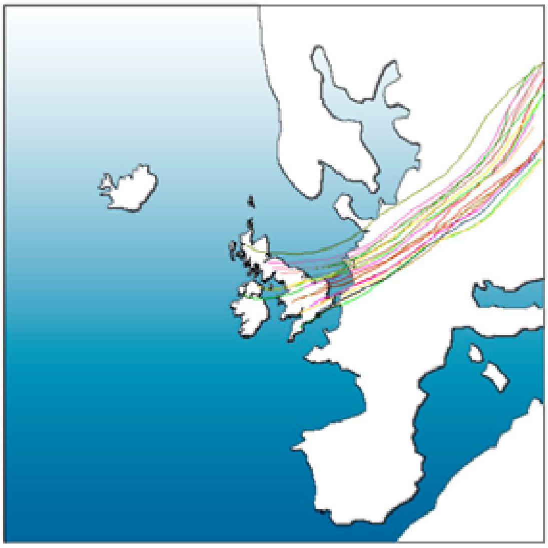


Figure 4.2 Air mass back-trajectories for the UK, 26th March 2007

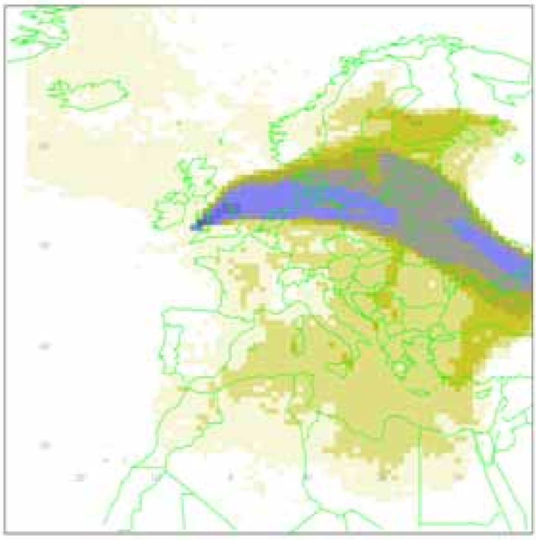


Figure 4.3 NAME back-trajectory for air arriving at Narberth on Sunday 25th March 2007.

Figures 4.4 show an interpolated, false colour satellite image of the sandstorm in North Africa, with dust propagating northwards over Turkey approximately four days before the UK episode. Figure 4.5 depicts a NAME dust model result run to determine the distribution of the North African sand storm dust on the first full day of the episode.

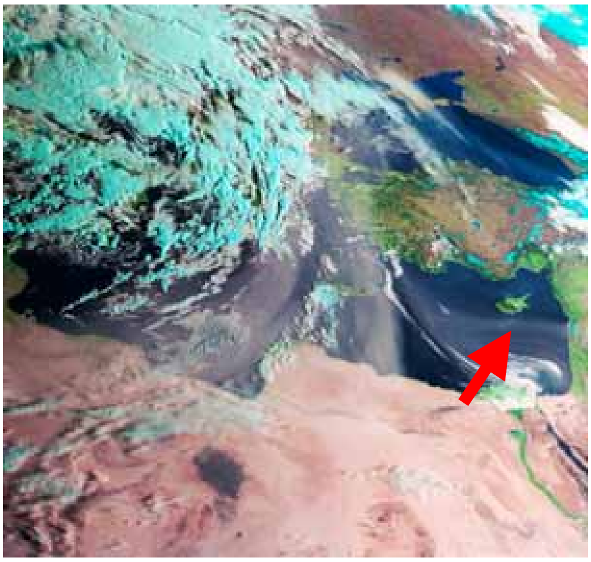


Figure 4.4 Interpolated satellite image captured on the 21st March; northerly transport of sand shown by arrow.

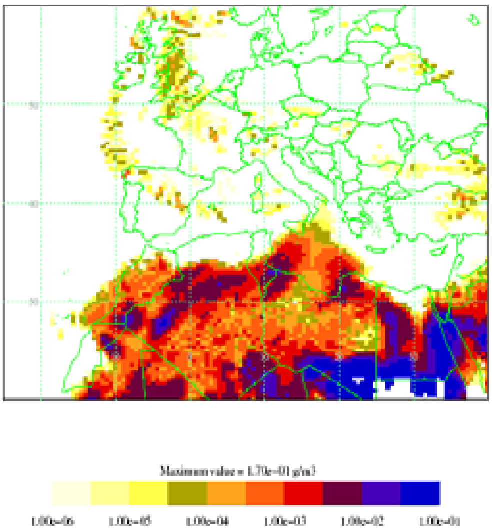


Figure 4.5 Distribution of dust from the sandstorm, at midnight GMT on 25th March 2007

Other satellite imagery captured during this period also clearly showed smoke emissions from the Ukraine, with predominantly westerly transport of the particles - as shown in Figure 4.6.

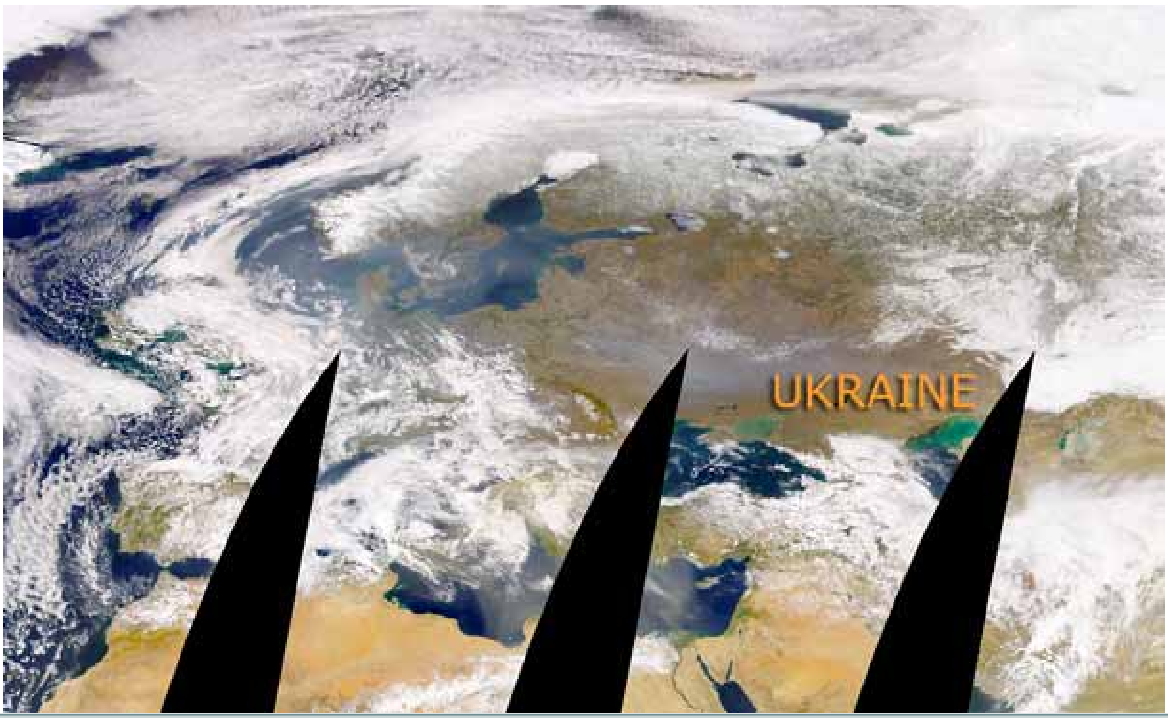


Figure 4.6 Satellite image captured on the 29th March 2007, showing smoke emissions from the Ukraine

Further analysis of the particulate measurements during this episode indicated that air reaching the UK during the mid and late stages of the episode was likely to have contained secondary particulates formed from emissions across continental Europe, as shown by the increase in the volatile component of the PM_{10} measured between the 27th and 31st March (Figure 4.7).

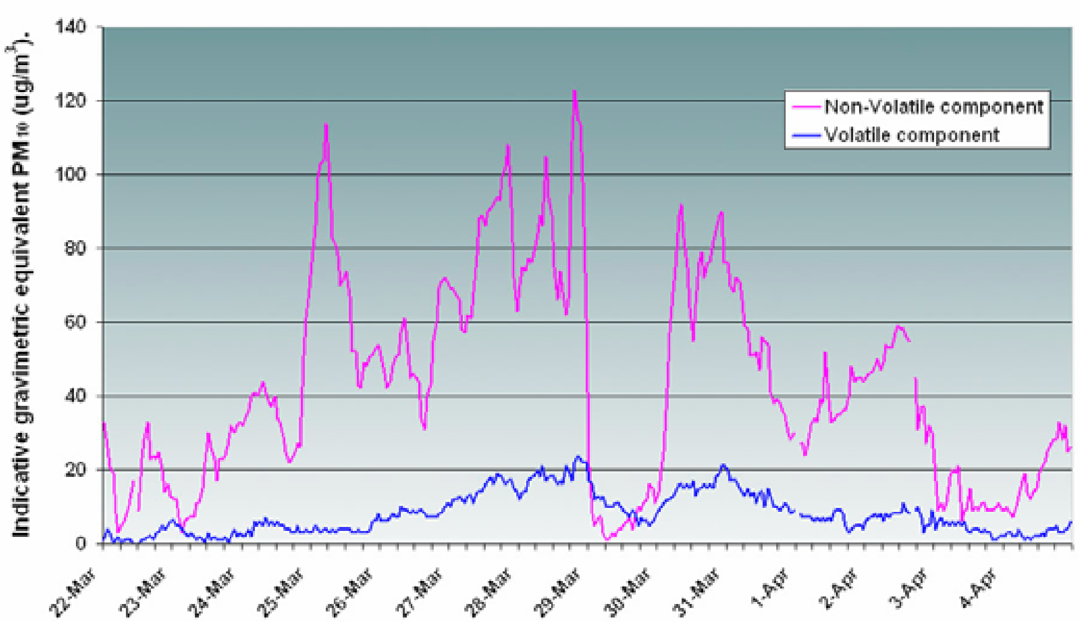


Figure 4.7 FDMS measurements of PM_{10} made at Coventry Memorial Park monitoring station over the period of the episode, 22nd March to 2nd April.

The volatile component of the dust collected in the UK is normally associated with long-range transport of pollution from Mainland Europe. A day of rain in the UK on the 29th

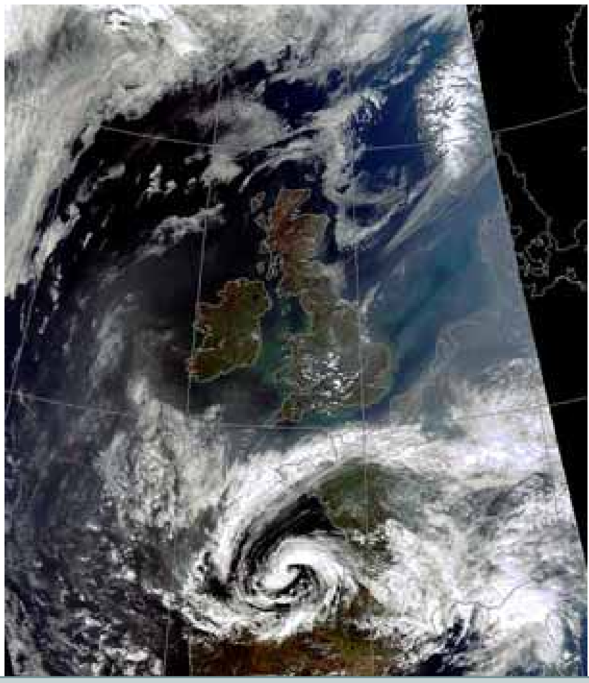


Figure 4.8 Satellite image captured on 31st March 2007

March led to the temporary suppression of particulate levels mid way through the period of the episode.

Towards the end of the episode, around the 31st March, an area of low pressure atmospheric air centred to the north of Spain gradually began to clear the polluted air away from the UK, as shown in Figure 4.8.

Additional contributions to the PM_{10} above normal background levels at various air quality sites in the UK were estimated for the whole period of the episode, as shown in Figure 4.9 below.

This shows an average figure of approximately 60% of the PM_{10} measured over the course of the episode originating from the long-range transport of dust from outside the UK.

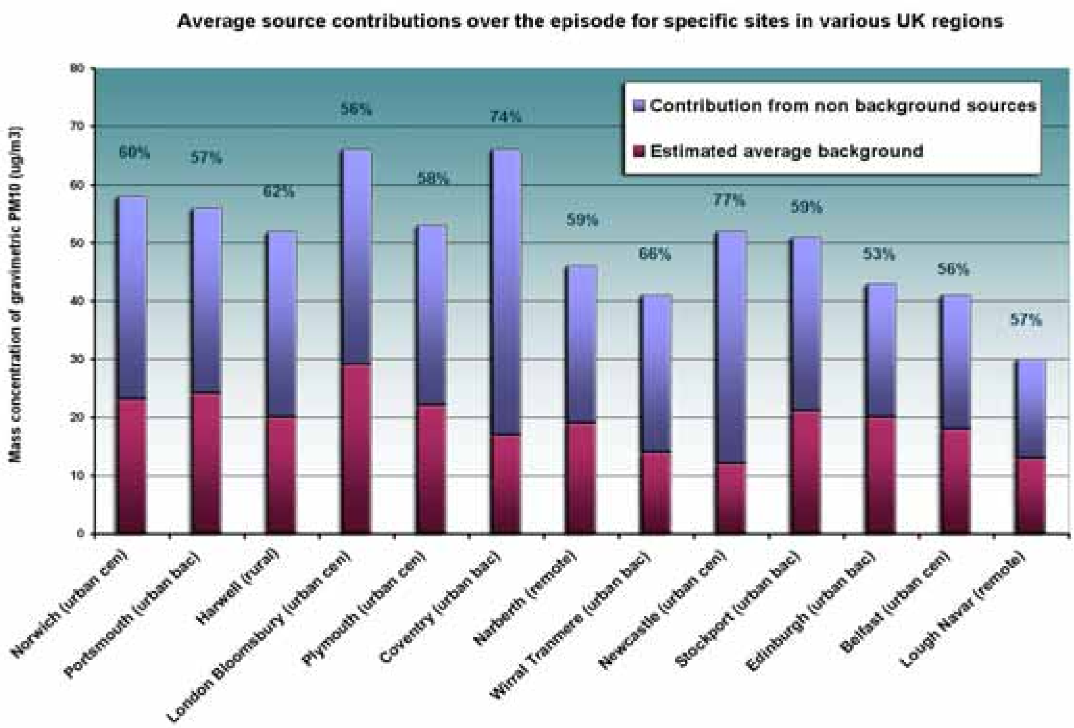


Figure 4.9 Estimated average additional contributions of particulate PM_{10} for the whole episode at sites in various UK regions

4.3 Bonfire Night particle episode 2007

Fireworks and bonfires emit large quantities of particulate matter. Bonfire Nights may, therefore cause short-lived pollution episodes across many parts of the UK. The extent and magnitude of these events is crucially dependent on meteorology. Wet and windy conditions may completely suppress high particle levels; by contrast, cold stable conditions - which minimise dispersion and may even trap pollution close to the ground- can result in extremely high transient pollution peaks.

Figure 4.10.

Measurements every year show that fireworks and bonfires are a major source of particulate matter.

This image actually shows the extent of particle emissions from a large burst of fireworks © Jon Bower

This year, Bonfire Night (the 5th of November) was on a Monday. As a result, most large-scale municipal bonfire celebrations were held on the evenings of Saturday 3rd or Sunday 4th. Elevated particle levels were seen at some sites on the Friday (2nd) and the Monday; however the bulk of the pollution was seen during the weekend.

Evening air temperatures on both the 4th and 5th were near freezing in many areas of the UK with a very light breeze. These conditions are normally conducive to high particle levels. On the evening of Saturday 3rd, an area of high pressure was centred over the north of England with stable, clear conditions over much of the UK (Figure 4.11). By the 4th twelve sites, exclusively in the Midlands and the north of England, entered the HIGH band for PM_{10}. All of these appear to have been the result of sites being located downwind of bonfires on the Saturday evening. A further nine sites entered the MODERATE band on the same day, many in central England. (Please note the bandings for particulates are based on a running 24-hour mean, therefore there is a time delay until the effect of a pollution event is measured within the banding statistics).

On Sunday evening, England and Wales were centred beneath a high-pressure system, as shown in Figure 4.12, with unsettled conditions beginning to spread in to the UK from the northwest. On Monday 5th November, eleven sites entered the HIGH band, two in London and the remaining nine in central or northern England. A further 17 sites entered the MODERATE band, also as a result of bonfires on the Sunday evening; five in London and the majority of the remainder in central or northern England. The location of the high-pressure centre appears to have been pivotal in determining where in the UK the highest levels particulate pollution were experienced.

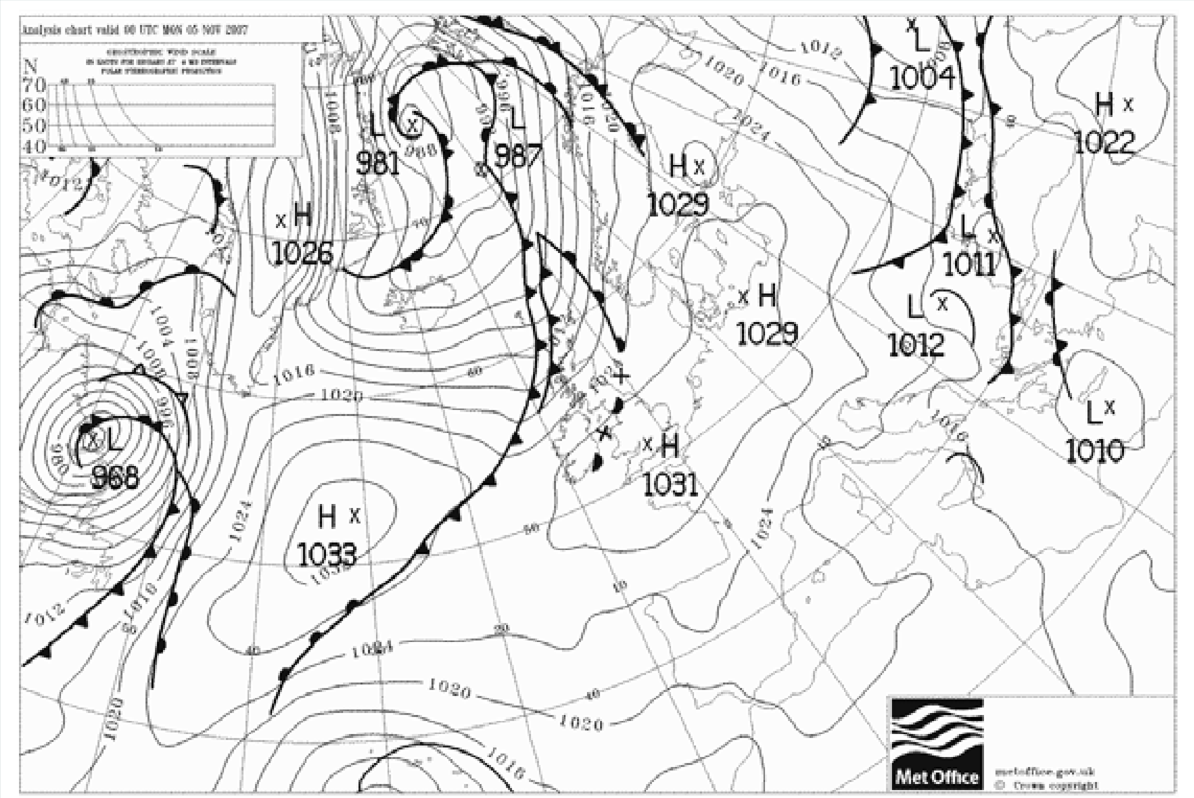


Figure 4.11 Atmospheric pressure chart for midnight on the evening of Saturday 3rd November 2007.

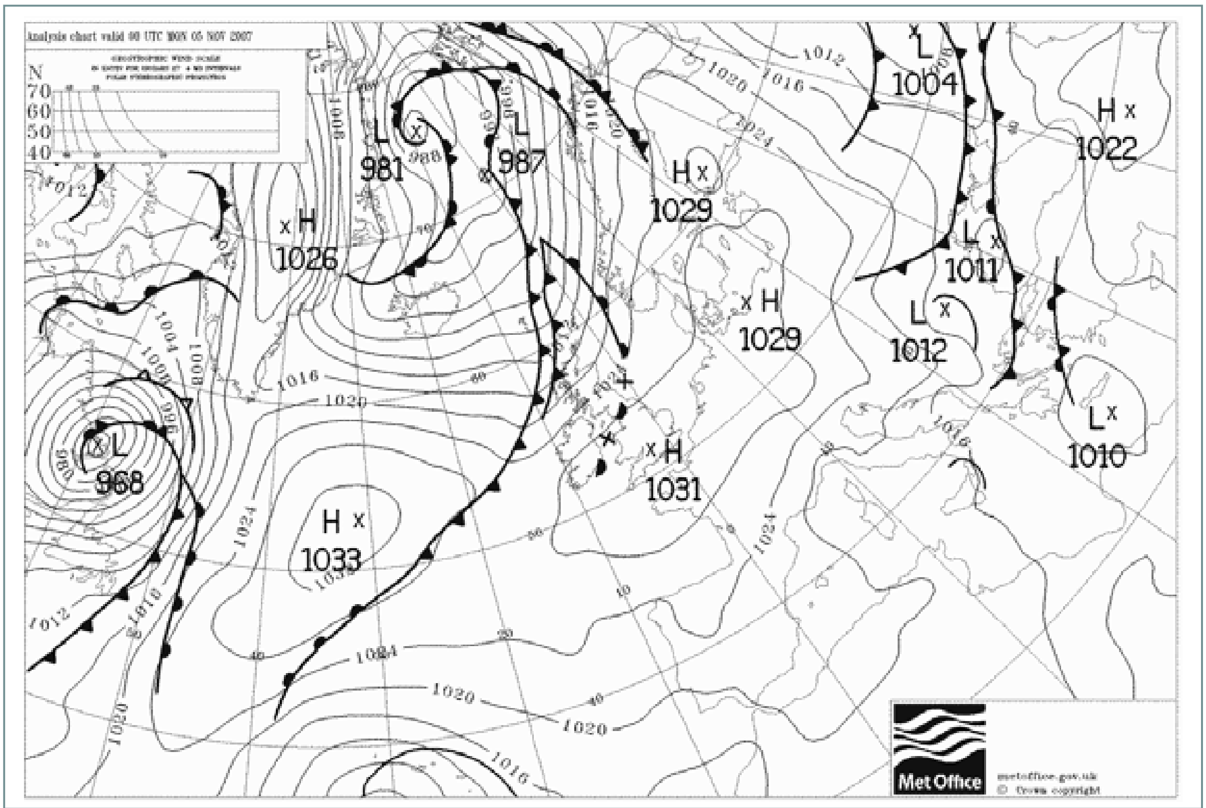


Figure 4.12 Atmospheric pressure chart for midnight on the evening of Sunday 4th November.

Due to its relatively cold, stable weather, Bonfire Night 2007 saw a higher number of HIGH band particle exceedences than all previous years from 2000 onwards; it was also the second highest year for MODERATE exceedences, with only 2006 producing a greater number [D2].

Figure 4.13 shows a comparison of exceedences in 2007 with these earlier years.

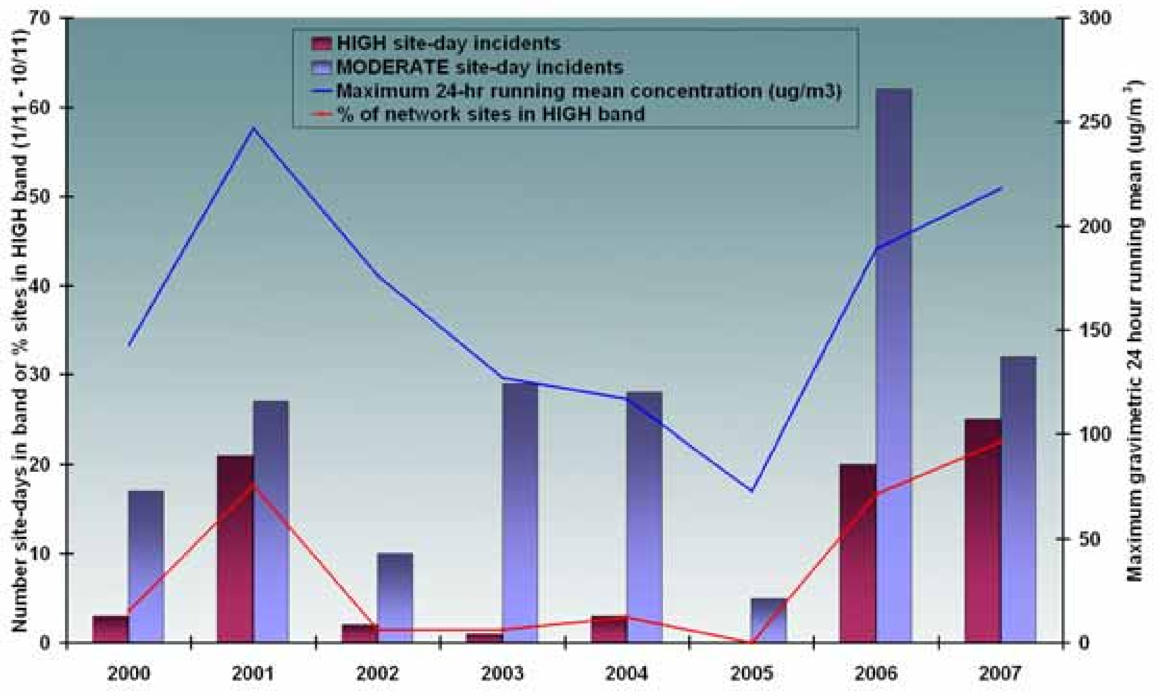


Figure 4.13 Number of sites exceeding the MODERATE and HIGH PM_{10} bands over 1st November to 10th November annually from the year 2000 onwards, with additional descriptive statistics.

4.4 Summer ozone levels, 2000-2007: domestic and European impacts

Having reviewed in the previous section how Bonfire Night pollution has changed over this decade, we now turn to examining similar multi-year variations in the number of photochemical ozone episodes.

Figure 4.14 shows the number of network days measured above various thresholds for ozone over the summers of the last seven years. The total number of days in the MODERATE band in 2007 was very similar to that seen in 2000, formerly the lowest year for ozone exceedences over the last seven years. Moreover, for the first time this decade, 2007 saw no days in the ozone HIGH band, and no days when the EC alert threshold level of 240 μgm^{-3} hourly average concentrations was exceeded.

As noted previously, this is primarily due to the poor, wet summer of 2007, without any extended periods of the sort of hot and sunny conditions conducive to summer smog formation.

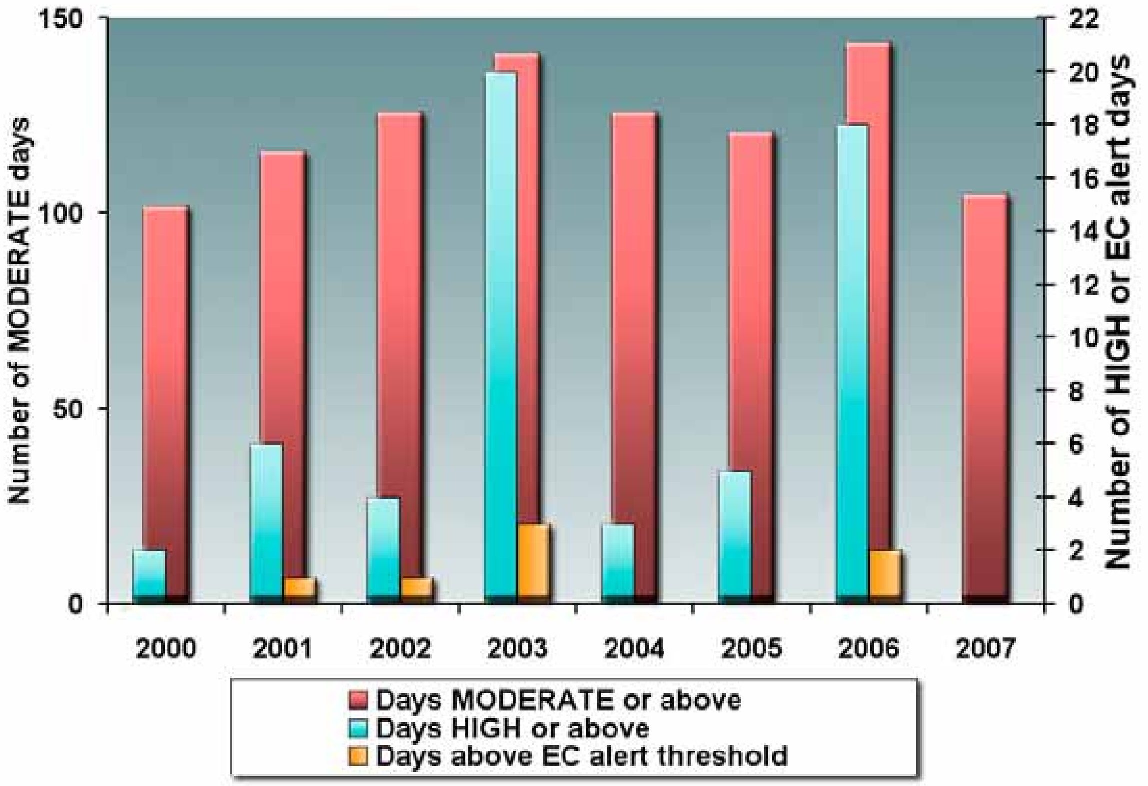


Figure 4.14 –Total network days exceeding various thresholds for ozone over the summers of 2000 onwards.

It is also of great interest to examine the proportion of 'home grown' domestic ozone against Continental European ozone contributions during this decade.

Accordingly, Figure 4.15 shows the percentage contribution to the UK's ozone from 1) mainland Europe 2) from within the UK. The lighter coloured (lower) bars show the percentage of days with ozone levels categorised as 'moderate' or above, when the UK was receiving air masses from the Atlantic, or air was being re-circulated over the UK.

The darker (upper) bars show the percentage of days with "moderate" or higher ozone, when the UK was receiving air from mainland Europe. Summer data only are shown, for summers 2000 onwards.

The data for this chart have been derived from analysis of one-day ahead forecast air mass back-trajectory plots for all moderate' days from April to the end of September.

Figure 4.15 confirms that that 2007 was the lowest year seen so far, over the past 7 years, for the percentage contribution of European air masses to UK ozone levels. In addition to the poor summer we experienced in the UK, this is clearly another factor involved in the depressed ozone concentrations during the summer months.

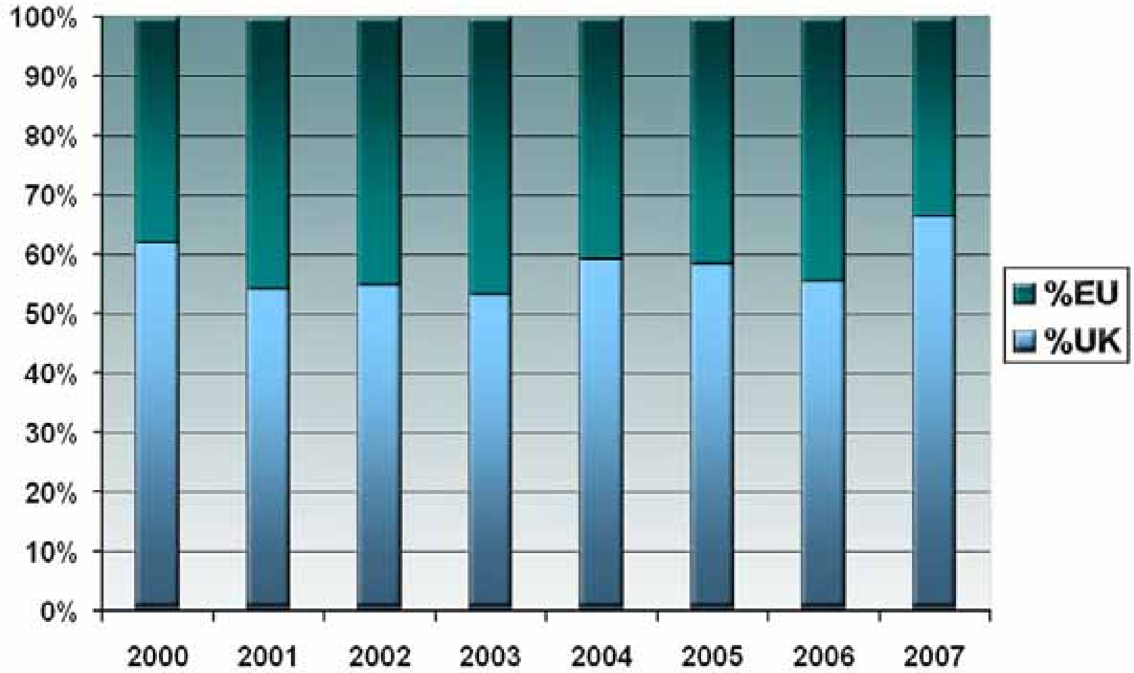


Figure 4.15 – Continental and domestic source contributions for MODERATE or above ozone over summers from 2000 to 2007.

5 How air pollution varies across the UK

We examine how levels of air pollution vary across the UK, and see how these variations relate both to emissions and the behaviour and transport of pollutants once emitted into the atmosphere. Air quality objectives, limit values and targets have recently been set for $PM_{2.5}$ and we show this year how the map for $PM_{2.5}$ compares with that for PM_{10}.

5.1 Introduction

Levels of air pollutants vary markedly across the country. Measurements from the national air monitoring networks clearly show that these patterns differ for each pollutant, depending on how they are formed and where their major sources are located.

Levels of ***primary pollutants***, those emitted directly into the atmosphere, tend to be highest around their sources; these are usually located in urban and industrial areas. Sulphur dioxide provides a good example of such a pollutant, with domestic or industrial fuel burning being the major emission sources nationwide.

Motor vehicles are a major source of primary pollution in many large cities. In particular, traffic is an important source of carbon monoxide, oxides of nitrogen and volatile hydrocarbons (VOCs) such as benzene and 1,3-butadiene; it also emits a significant proportion of particles ($PM_{2.5}$ and PM_{10}). Concentrations of all these pollutants are therefore usually highest in built-up urban areas.

In general, patterns of ***secondary pollutants*** such as ground-level ozone and secondary particulate matter, which are formed by chemical reaction in the atmosphere, are markedly different from those of primary pollutants; they are characteristically less dependent on local emission patterns, and tend to be more strongly influenced by regional emission patterns, meteorology and atmospheric chemistry. As a result, they also change more from year to year than those of primary pollutants.

The vast majority of Air Quality Management Areas (AQMAs) in the UK are due to current or predicted exceedences of air quality objectives for nitrogen dioxide (NO_2) or PM_{10}.

5.2 Mapping methods

We have used two different approaches for modelling and mapping levels of air pollution across the UK.

For NO_2, $PM_{2.5}$ and PM_{10}, maps have been estimated using a combination of atmospheric dispersion models, the UK's National Atmospheric Emissions Inventory (NAEI) and data from the UK monitoring networks. Together, these provide the basis for robust pollutant models, which enable us to produce detailed maps (1km resolution) of annual average pollutant concentrations across the country. The mapping method is detailed in a number of published reports on the UK Air Quality Archive: for example, Kent et al (2007) [E1]. Similarly, the mapping methods for $PM_{2.5}$ and PM_{10} have been described in detail by Stedman, et al (2007) [E2]

An important feature of these models is that they are directly related to the real-world measurements. Unlike monitoring, however, modelling can help the understanding of the source apportionment of air pollutants and predict future concentrations by taking into account the projected changes in emissions over the coming years.

The maps produced by the modelling enable the UK to fulfil its European commitments to assess nationwide pollution patterns as part of implementing the European Air Quality Directives. They also provide an extremely powerful tool for identifying pollutant 'hot-spots' and managing UK-wide air quality problems in the most direct and cost-efficient manner.

An empirical approach has been adopted to map a range of metrics describing ozone concentrations. These maps have been calculated by interpolation of measurements from rural monitoring sites. Ozone concentrations are generally lower in urban areas as a result of reaction with local emission of nitrogen monoxide (NO). This has been taken into account by the application of an empirically derived urban decrement, which is related to the mapped local concentration of oxides of nitrogen (NO_x). The methods used to map ozone concentrations have been described by Kent and Stedman (2007) [E3].

The mapped air pollutant concentrations presented in this section are clearly subject to greater uncertainty than corresponding values derived directly from measurements made at monitoring sites. This is due to a number of factors including:

- Uncertainties surrounding the emission inventories
- Uncertainties relating to the atmospheric dispersion model
- Complexities of the atmospheric chemistry
- Uncertainties relating to the source apportionment of ambient concentrations; this is particularly important for $PM_{2.5}$ and PM_{10}, for which a number of the sources are less well characterised.

The mapped concentrations have been verified by comparison with automatic monitoring data, including data from non-national network sites that are of known high quality.

5.3 NO_x and NO_2

UK-wide patterns of nitrogen dioxide concentrations in 2007 are shown in Figure 5.2. Although some NO_2 is emitted directly from vehicles or other sources, most is formed by rapid chemical reaction (oxidation of emitted NO) in the atmosphere. This pollutant therefore has both primary and secondary characteristics. Concentrations of NO_2 tend to be highest in urban areas such as in London, where traffic levels are high.

Although the data mapped in these figures are for background rather than roadside pollution levels, they nevertheless clearly follow closely the country's major motorways and road network infrastructure. Not surprisingly, though, this overall pattern is even more clearly apparent for primary NO_X (Figure 5.1) than for NO_2.

5.4 $PM_{2.5}$ and PM_{10} particles

Particulate matter (PM) is not a distinct chemical species like the other pollutants measured in the automatic networks; rather, it consists of material from many sources and is usually classified on the basis of size and not chemical composition. $PM_{2.5}$ is PM of average aerodynamic diameter less than 2.5 microns (where one micron is a thousandth of a millimetre). PM_{10} is PM of average aerodynamic diameter less than 10 microns; thus

$PM_{2.5}$ is a subset of PM_{10}, which also includes particles of average aerodynamic diameter between 2.5 and 10 microns, sometimes described as the coarse fraction.

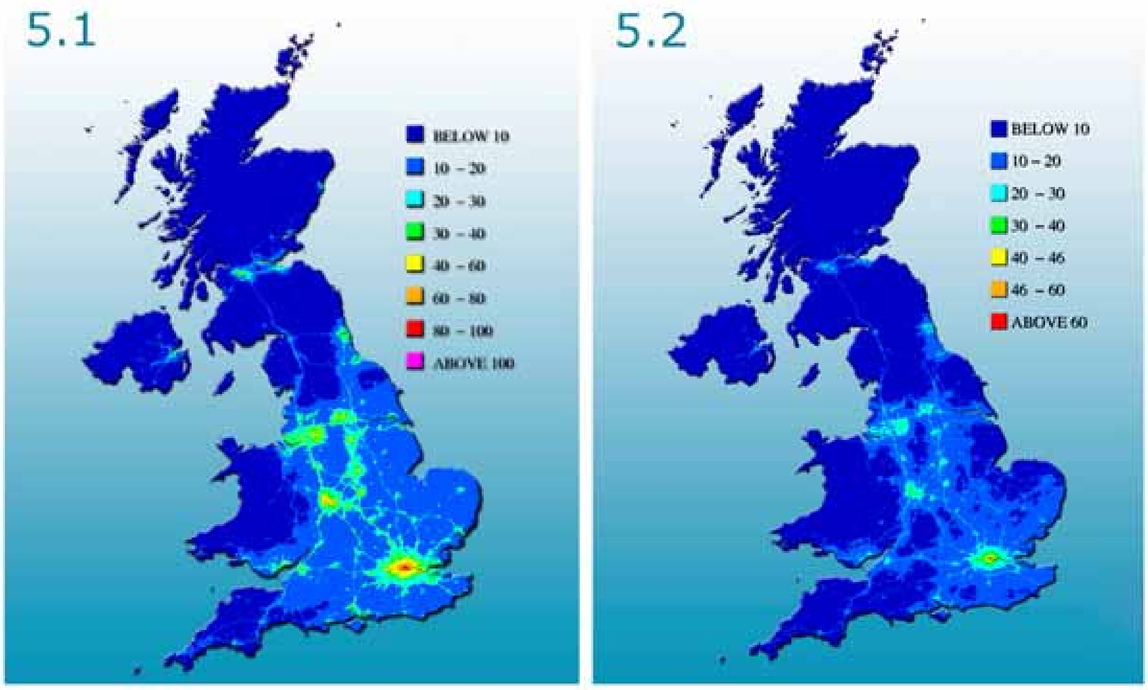


Figure 5.1 Annual mean background NO_X (μgm^{-3})
Figure 5.2 Annual mean background NO_2 (μgm^{-3})

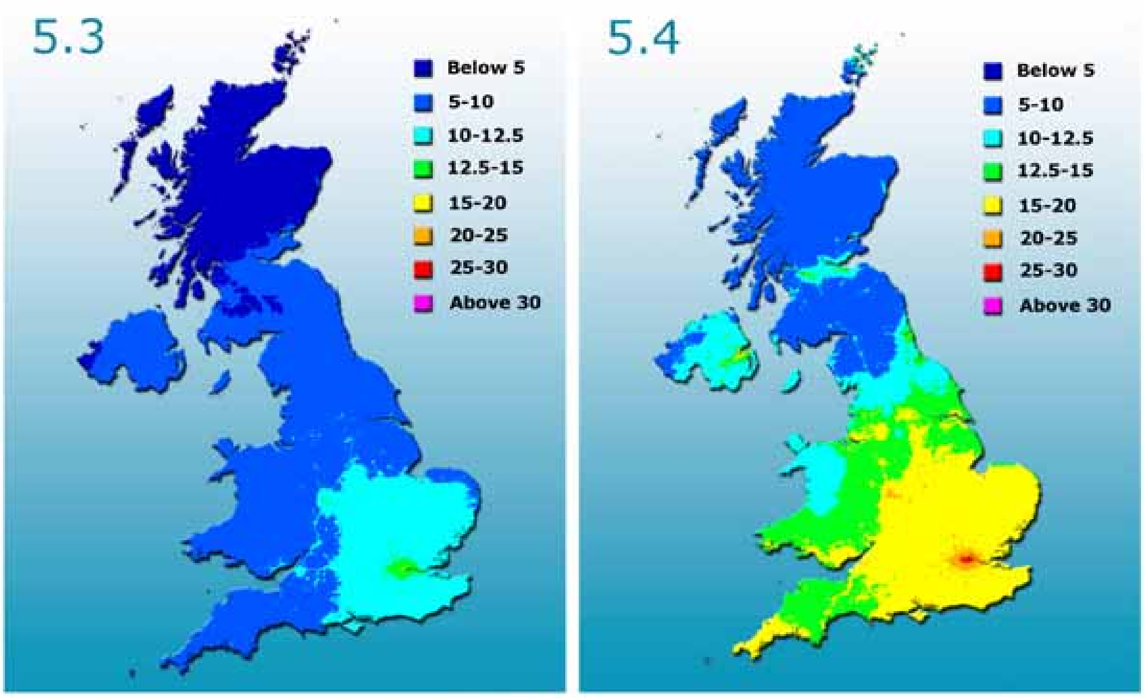


Figure 5.3 Annual mean background $PM_{2.5}$ (μgm^{-3})
Figure 5.4 Annual mean background PM_{10} (μgm^{-3})

The maps of $PM_{2.5}$ and PM_{10} concentrations in 2007 are shown in Figures 5.3 and 5.4. PM includes a wide range of chemical species, which can be usefully broken down into primary, secondary, and other PM. However, it is important to realise that ambient particulate matter can both be transported and react chemically in the atmosphere; in consequence, individual particles generally include a range of components from a variety of sources.

The contribution from primary PM is generally greatest in urban areas, close to emission sources. The sources of primary PM are diverse. Elemental and organic carbon is produced by combustion processes, such as from motor vehicles, fuel burning and industrial emissions. The majority of the contributions from these sources is found in the fine ($PM_{2.5}$) fraction, whereas most of the contribution from mechanically generated particles - produced by building work and quarrying and soil and road dust - is found in the coarse fraction of particles.

A significant proportion of PM is secondary, formed by the reaction of gases in the air. Sulphate, nitrate and ammonium (secondary inorganic aerosol) are formed by chemical reactions in the atmosphere from emissions of SO_2, NO_x and NH_3. Similarly, secondary organic aerosol is formed from reactions of organic compounds. Like ozone, secondary PM can therefore be produced considerable distances from the emission sources.

Figures 5.3 and 5.4 demonstrate that secondary PM concentrations are generally greatest in the south and east of the UK: these areas are more often downwind of and closest to polluted areas of Northern Europe. Most secondary PM is found in the fine fraction, although there is also a contribution from coarse nitrate. The majority of sea salt PM is found in the coarse fraction.

PM_{10} concentrations are higher than those of $PM_{2.5}$ because they include the contribution from the coarse fraction. Concentrations of both $PM_{2.5}$ and PM_{10} are generally highest in urban areas and this urban increment of largely primary PM is superimposed on the spatial pattern of regional concentrations, which is largely driven by the spatial distribution of secondary PM. The influence of sea salt PM is greater for PM_{10}.

5.5 Ozone

Ground-level ozone is formed by a series of chemical reactions involving precursor pollutants - oxides of nitrogen and hydrocarbons – together with oxygen. Ultraviolet radiation drives these reactions and, as a result, ozone production rates are highest in hot, sunny weather. Ozone formation can take from hours to days to complete. Consequently, high levels of ozone can often be formed considerable distances downwind of the original pollution sources in UK or Europe.

UK-wide patterns of ground-level ozone are also influenced by other factors. Concentrations in busy urban areas are often lower than in the surrounding countryside. This is because road transport emissions of NO react very quickly with ozone to produce NO_2.

The net result of these effects, acting together, is shown in Figures 5.5 and 5.6. The highest summer ozone concentrations are seen in the rural parts of South and Eastern England; these areas tend to be hotter and sunnier than other parts of the UK, and are often downwind of polluted areas of Northern Europe. Concentrations of ozone are characteristically depressed in urban areas, as a result of reactions the atmosphere with local road transport emissions.

Ozone concentrations were relatively low in 2007, as highlighted in both Sections 4 and 7 of this report. As a result, the levels graphed in these maps are markedly lower than those shown in previous annual reports.

Ozone concentrations over several years are assessed against the target values specified in the EU Ambient Air Quality Directives. UK-wide concentrations of ozone (expressed here as the accumulated hours above 80μg m^{-3}) over the five-year period 2003 - 2007 are shown in Figure 5.5. This way of expressing ozone has been chosen to represent the impact of this pollutant on vegetation. The target value for the protection of vegetation within the EU Directives is that a level of 18,000 μg m^{-3}.hours averaged over five years should not be exceeded. The long-term objective is 6000 μg m^{-3}.hours in a single year. Values of this metric will be highest at locations with either higher average concentrations or where concentrations are elevated due to summer ozone episodes.

Figure 5.6 shows UK ozone concentration expressed as the number of days with running 8-hour mean concentrations greater than 120 μg m^{-3} for the three-year period 2005 - 2007. (The target value for the protection of human health within the EU Ambient Air Quality Directives is that this level should not be exceeded more than 25 times per year, averaged over 3 years. The long-term objective is that this level should not be exceeded). Values of this metric will be highest at locations where concentrations are elevated due to summer ozone episodes.

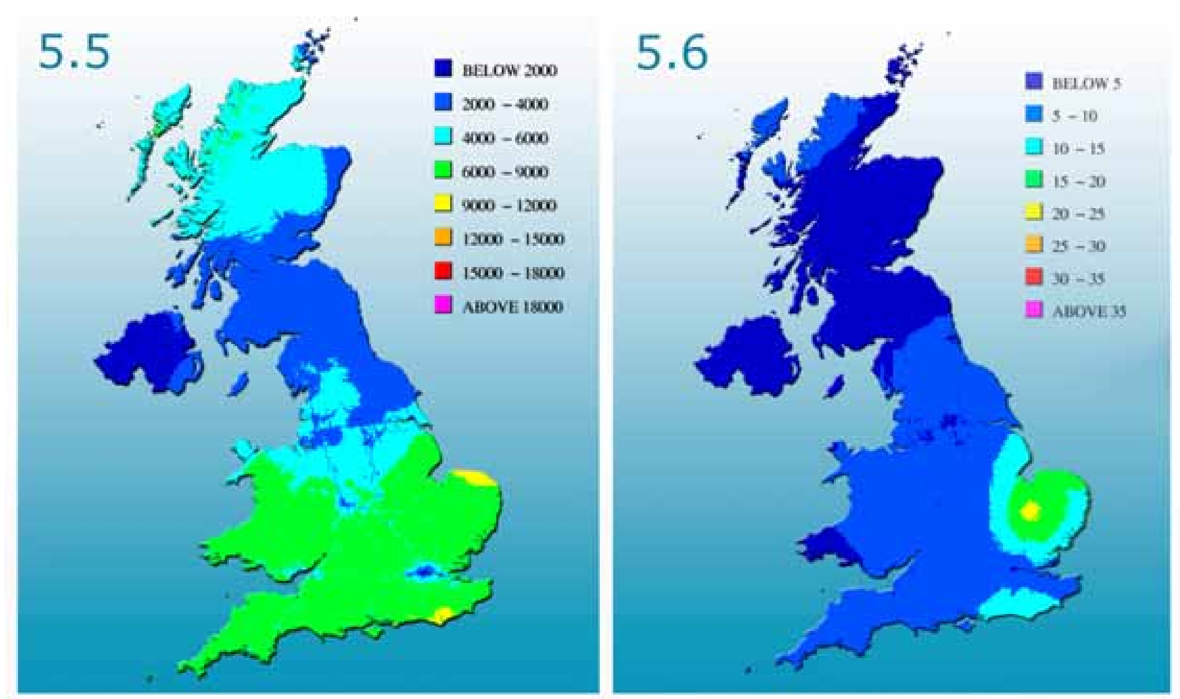


Figure 5.5 AOT40 (Above Ozone Threshold 40) metric (µgm^{-3}.hours)
Figure 5.6 Estimated number of Ozone days > 120 µgm^{-3} (max daily running 8hr mean)

6 What historic sampler networks have taught us

Monitoring networks utilising simple chemical and mass-sampling techniques have been in operation since the 1960s. They have shown how pollution levels, and UK's overall pollution climate, have changed over the decades. This year we examine UK's heavy metals monitoring programmes.

Following last years' review of key results and findings from the UK's non-automatic air monitoring programmes, we here focus our attention on one of the UK's longest running sampler-based monitoring networks – the Heavy Metals Network. Over the past quarter of a century, this network has recorded significant changes in the levels of metals in the UK ambient air, and continues to play an important role in the monitoring and understanding of ambient metal pollution in our atmosphere.

6.1 Origins of the Heavy Metals Network

Heavy metals have been polluting the UK's air for centuries, in fact ever since the first crude metal processing began. Not surprisingly, though, the problem became much more serious as the Industrial Revolution began in the 18^{th} Century. It is only recently, however, that the scientific and medical communities have identified the specific health effects of airborne heavy metals, and acknowledged the need to monitor the levels of these pollutants.

UK-wide measurement of airborne metals began in the 1970s. In the years that followed, several different monitoring networks were established to examine different metal concentrations at a variety of sites. These included:

- Five urban multi-element monitoring sites providing measurements of 9 important trace elements (Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and V);
- Eight sites monitoring lead from petrol (2 rural, 3 urban and 3 kerbside);
- Eight sites operating in three industrial areas monitoring lead at Walsall (IMI and Brookside works) and Newcastle (Elswick works).

In 2003, these disparate programmes were rationalised and consolidated into two comprehensive networks, the Heavy Metals Network and the Rural Trace Element Network, This section of the report focuses on the UK Heavy Metals Network, which currently comprises some 24 sites in England, Scotland, Wales and Northern Ireland, monitoring no less than 12 species at each location. Its companion rural network consists of 10 sites, established to assess corresponding baseline metal concentrations at locations away from major sources.

The UK Heavy Metals Network has a number of objectives, including:

- Compliance with monitoring requirements set out in European legislation (see Section 6.3);
- Provision of data to the European Commission on the UK's compliance with the limit values, target values and data quality objectives described in the relevant legislation;
- Assessing impacts around 'hot spots' of metal pollution, particularly in industrial areas;
- Producing accurate and reliable data for dissemination to the general public and for use by scientific and medical researchers and the air quality community.

6.2 Sources and health effects

Heavy metals can enter the atmosphere from a variety of sources: industrial processes, power generation, production of metal alloys, stationary combustion, traffic and transport sources. In the past, the primary source of lead in ambient air was from its use as an additive in petrol. However, the sale of leaded petrol was gradually phased out following regulations in the late 1980s and then was totally banned in the EU in January 2000. The predominant anthropogenic sources of lead now are therefore iron, steel and non-ferrous metal production, coal- fired power stations and chemical processing.

Figure 6.1 and 6.2. Traffic during the 1950s (above) and Battersea Power Station (below). Traffic was historically an important source of lead; industry and power generation are the most important remaining sources today. © Unknown

Heavy metals are primarily monitored due to the effect they have on human health. Airborne heavy metals are contained within particulate matter, which enters the lungs easily due to the small particle size. Lung damage has been widely reported in people with a high exposure to nickel and cadmium.

The other main route for metals to enter the body is via deposition to soil and subsequent contamination of foodstuffs, as reported in 2000 by the World Health Organisation and United Nations Economic Commission for Europe.

Studies have also shown that many metals are toxic and carcinogenic and may impair the central nervous system, respiratory system and other parts of the body. Lead is particularly dangerous to children and pregnant women, affecting brain development in the very young or the unborn child.

6.3 Legislation

Legislation on heavy metals has been established through two European Directives:

- Directive 2008/50/EC (and its 1999 predecessor, the 1st Daughter Directive) on ambient air quality and cleaner air for Europe, which sets a target for lead;
- Directive 2004/107/EC, which relates to nickel, arsenic and cadmium, and is commonly refered to as the 4th Daughter Directive.

A summary of target and limit values applicable to these metals is given in Table 6.1. All concentrations refer to metals measured in the PM_{10} fraction of ambient air (particles with an aerodynamic diamter of less than 10 microns). Limit and target values are established based on scientific research and are linked to the levels at which these pollutants are assessed as having no or negligible negative effect on human health. The 4th Daughter Directive also requires monitoring of mercury although no limit or target values have been set.

Table 6.1. Summary of European legislation for metals

Metal	Objective Type	Concentration	Achieve by
Lead	Annual Mean limit value	0.25 μgm^{-3}	31 Dec 2008
Nickel	Annual Mean target value	20 ngm^{-3}	_
Arsenic	Annual Mean target value	6 ngm^{-3}	_
Cadmium	Annual Mean target value	5 ngm^{-3}	_

6.4 Monitoring and Measurements

In 2007, the UK Heavy Metals monitoring network comprised 17 sites in England, Scotland, Wales and Northern Ireland. Each monitoring station is equipped with a low volume air sampler, such as that shown in Figure 6.3.

The sampler draws ambient air through a small cellulose filter, which collects the particulate matter (PM_{10}) containing heavy metals. Trained local site operators change the filter on a weekly basis.

Sampling of heavy metals in the air has been carried out in this way for many years. It is a reliable and accurate method, although it lacks the time resolution of automatic instruments seen in some other monitoring networks.

Figure 6.3 Eskdalemuir metals sampler

This procedure is very similar to those methods used by other EU Member States, as required by European legislation and standard measurement practice.

Analysis of the sampled cellulose filters is also carried out in accordance with European Standards. The laboratory-based method currently used by the UK involves dissolving the metals on the filter in a mixture of hot nitric acid and hydrogen peroxide or hydrochloric acid, in a closed vessel microwave digestion procedure. The resulting acidic solution is analysed using a technique called Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

This employs argon plasma at 6000°C to ionise the sample, followed by the measurement of each metal consecutively. Much of this process is automated and is therefore quick and inexpensive. ICP-MS is a very sensitive analysis method, and is therefore able to detect very low levels of metals in the samples. This is essential for measurements of samples from rural sites.

The full suite of metals analysed in each sample is as follows:

Arsenic (As)	Iron (Fe)	Nickel (Ni)
Cadmium (Cd)	Lead (Pb)	Platinum (Pt)
Chromium (Cr)	Manganese (Mn)	Vanadium (V)
Copper (Cu)	Mercury (Hg)	Zinc (Zn)

Figure 6.4 shows the annual mean concentrations for these metals across all monitoring sites operational in 2007. No exceedences were seen for lead, arsenic or cadmium at any of the sites during this year. There was, however, one incidence at one site (a nickel refinery) where the target value for nickel was exceeded. Although the annual average for nickel across all sites was only 3.8 ng.m^{-3}, the annual average for the nickel refinery site was 28.0 ng.m^{-3}, with a maximum of 50.2 ng.m^{-3} recorded during June 2007.

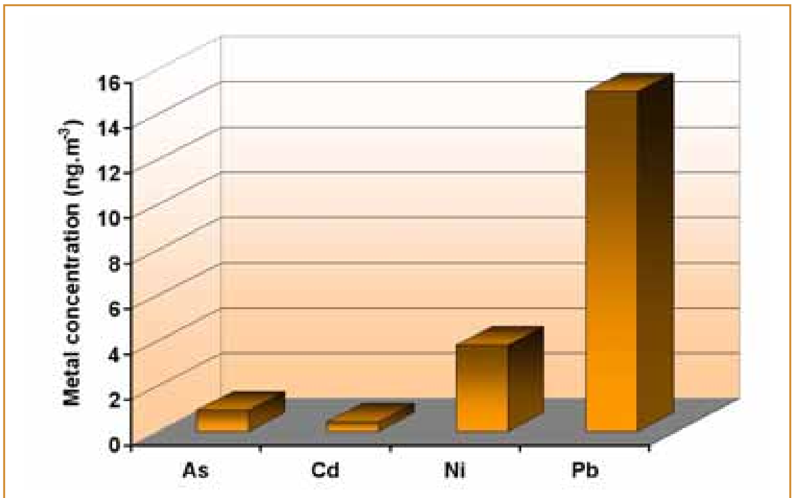


Figure 6.4

Annual average concentrations for 2007 for metals covered by the European Directives.

There were no exceedences of Limit Values for lead, arsenic and cadmium, but one for Nickel.

A breakdown of the concentrations recorded for all metals at all sites during 2007 and previous years can be found on the national Air Quality Archive at www.airquality.co.uk

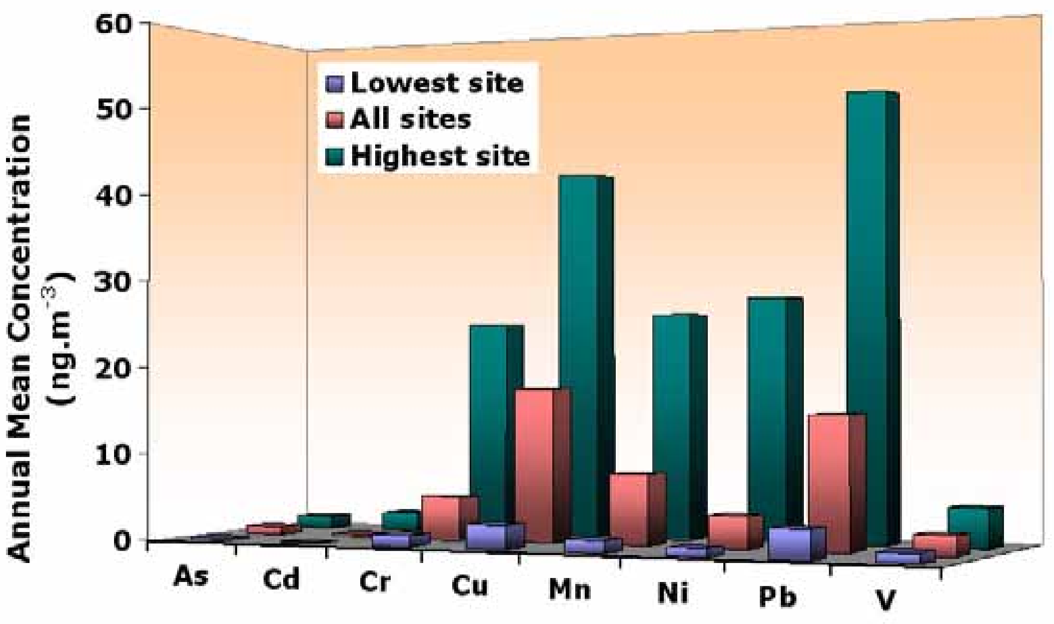


Figure 6.5. Annual mean concentrations for 2007 for arsenic, cadmium, chromium, copper, manganese, nickel, lead and vanadium in the PM_{10} fraction of ambient air.

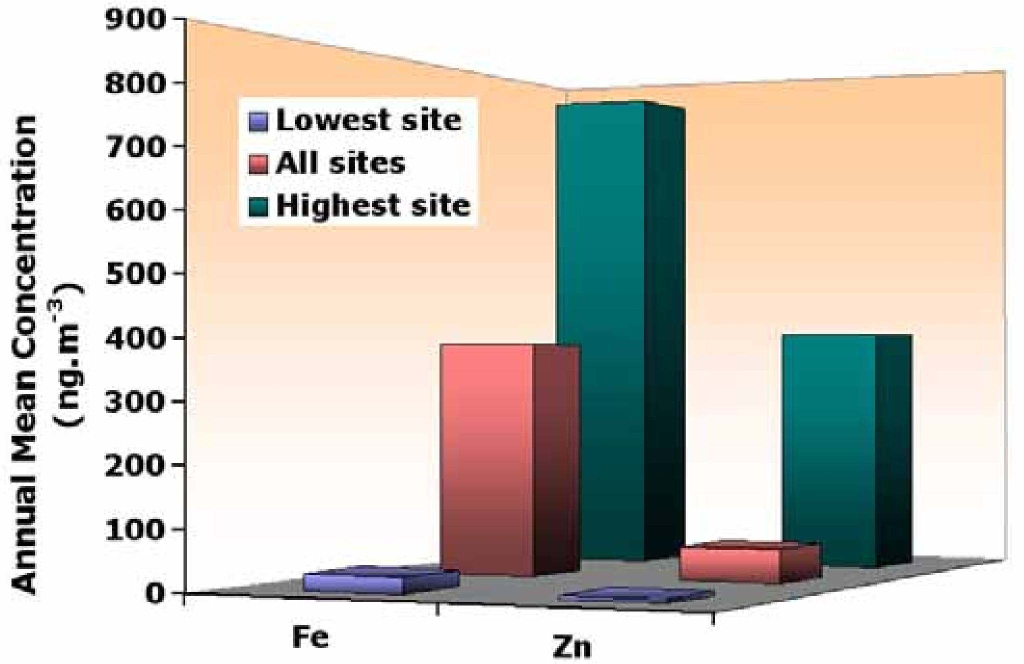


Figure 6.6. Annual mean concentrations for 2007 for iron and zinc in the PM_{10} fraction of ambient air.

Figures 6.5 and 6.6 show the annual mean concentrations across all sites (indicated by the red bars) for each of the analysed metals, with the exception of mercury and platinum. Mercury concentrations for 2007 are discussed separately in Section 6.5. Platinum concentrations are extremely low at all sites, with an annual average of less than 0.01 ngm^{-3}.

To indicate the range of concentrations seen across the UK, annual averages from the most polluted and the cleanest sites are also shown, by the emerald and blue bars respectively.

6.5 Mercury

Unlike other heavy metals, approximately 95% of mercury in ambient air is present in the gaseous phase, whilst the remaining 5% is contained in particulates. The 4th Daughter Directive requires that total gaseous mercury be monitored at sites throughout the UK, although target values have not been established for this pollutant. Ambient air is pumped through an adsorption tube, over a period of 4 weeks. The mercury is captured within the tube and is later removed at high temperatures and measured by atomic fluorescence in a laboratory environment.

Apart from combustion sources of mercury, which remain the predominant anthropogenic source, this pollutant is emitted into the atmosphere from crematoria (due to the high mercury content of traditional dental fillings) and through certain industrial practices. In the UK this includes a chlor-alkali plant in Runcorn, which uses mercury-processing technology. This is quite clearly apparent from Figure 6.7.

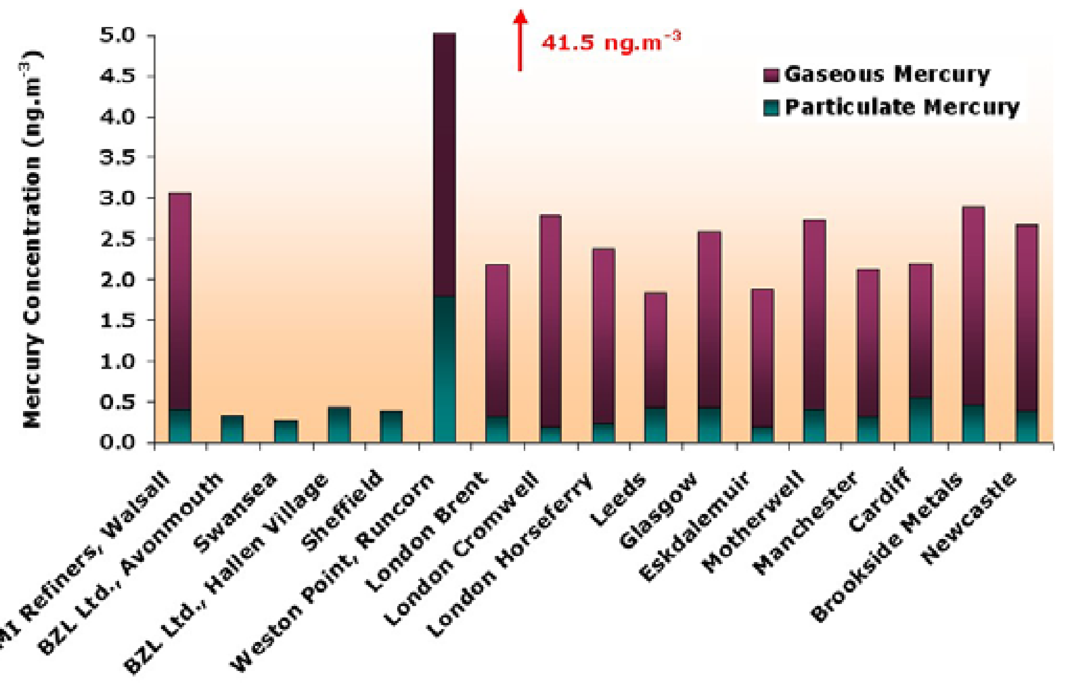


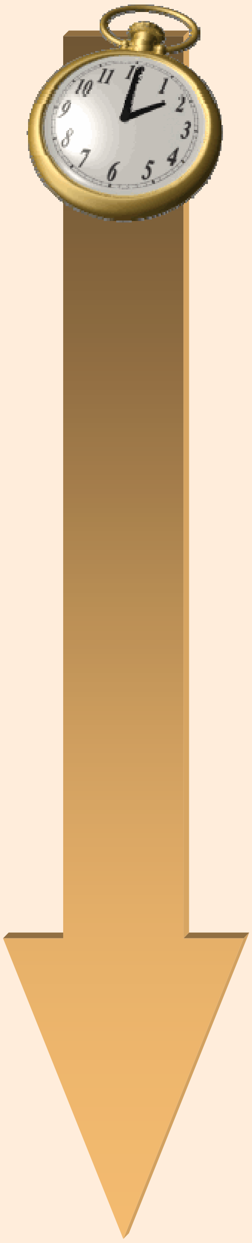
Figure 6.7. Annual averages for particulate and gaseous mercury for 2007 from all network sites.

A report by the Environment Agency in 2003 [F1] predicted that 'mercury emissions from crematoria in the UK will increase by two thirds from 2000 to 2020' and that this source could constitute up to one third of the UK's mercury emissions by that time. An independent study estimated that the average cremation gives rise to 0.9 grams of mercury, a figure which is not insignificant given the rise in popularity of cremation over burial in recent years.

However, due to the change in dental practices in the 1980s – when the use of mercury amalgam in dentistry started to decline - it is anticipated that crematoria emissions and UK ambient mercury levels will begin to fall again in the middle of the 21st century.

6.6 Historical data and timeline

The timeline below (Figure 6.8) highlights some of the major dates relating to the monitoring or regulation of heavy metals in the UK. The most up to date legislation can always be found at http://www.defra.gov.uk/environment/airquality/index.htm



1976 – The first metals monitoring network was established, with 20 sites in 17 UK urban areas. The first regulations governing the lead content of petrol are published.

1978 – The network was reduced to five sites in the most polluted areas, including London, Glasgow and Motherwell.

1985 – Six sites started to monitor particulate lead, in the lead in petrol survey.

1989 – The Motor Fuel (Lead Content of Petrol) Regulations were published.

1999 – First Daughter Directive sets limit value for lead (this legislation was succeeded in 2008 by the current Air Quality Directive described in Section 2).

2000 – The first rural site was added to the network at Eskdalemuir, Scotland. The sale of leaded petrol was totally banned in the EU on the 1st January 2000, through the Directive on the Quality of Petrol and Diesel Fuels. As a result, the lead in petrol survey was reduced to just two sites. A year-long monitoring network was established at 30 industrial site locations across the UK in order to establish the UK's position with respect to the requirements of the 4th Daughter Directive, which was being drafted.

2003 – Rationalisation of all heavy metals monitoring to two networks – the UK Heavy Metals Network and the Rural Trace Element Network.

2004 – The 4th Daughter Directive set target values for Ni, As and Cd and required monitoring of Hg.

2007 – Deadline for Member States to transpose the 4th Daughter Directive into national law (15th February 2007).

2008 – Directive 2008/50/EC is published, replacing earlier legislation regarding the limit value for lead.

Figure 6.8. Timeline of dates in the history of the Heavy Metals Network.

This cumulative legislation shown in Figure 6.8 has had the effect of substantially driving down emissions of lead from vehicle exhausts. The combination of widespread cleaner industrial practices and the decrease in heavy industry in the UK over the past two decades has also drastically reduced the concentration of metals present in the air that we breathe. This is demonstrated by the following figures (6.9 and 6.10), which show long-term trends of the four key metallic pollutants over time.

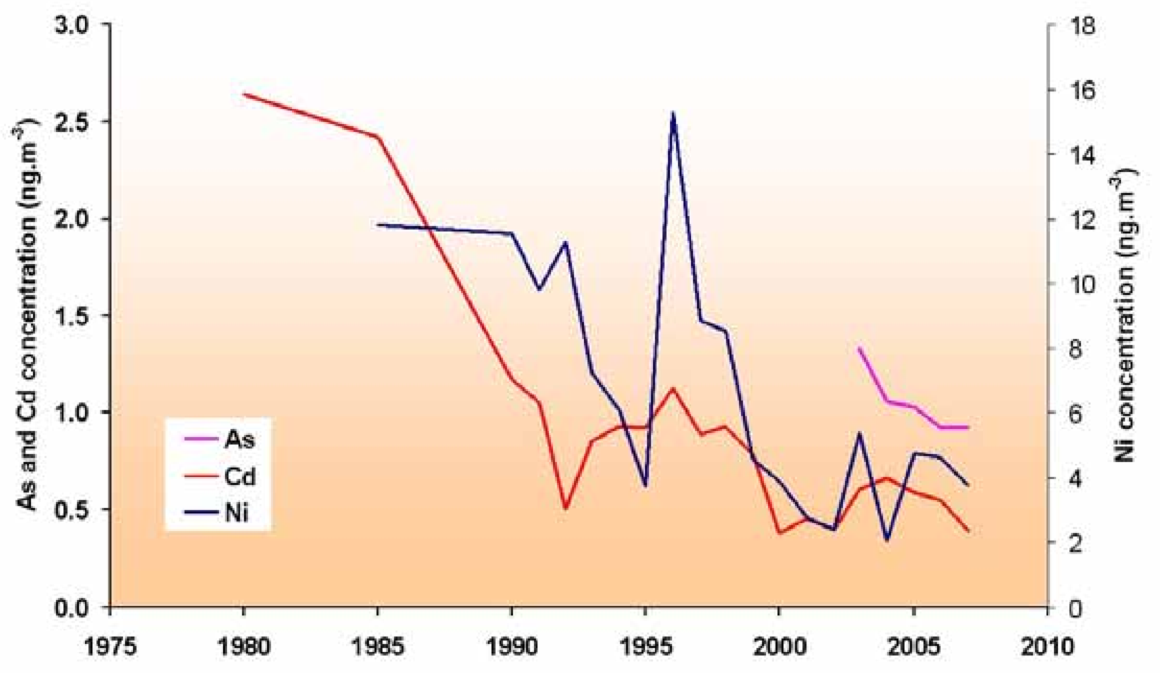


Figure 6.9. Trends in UK concentrations of arsenic, cadmium and nickel between 1980 and 2007.

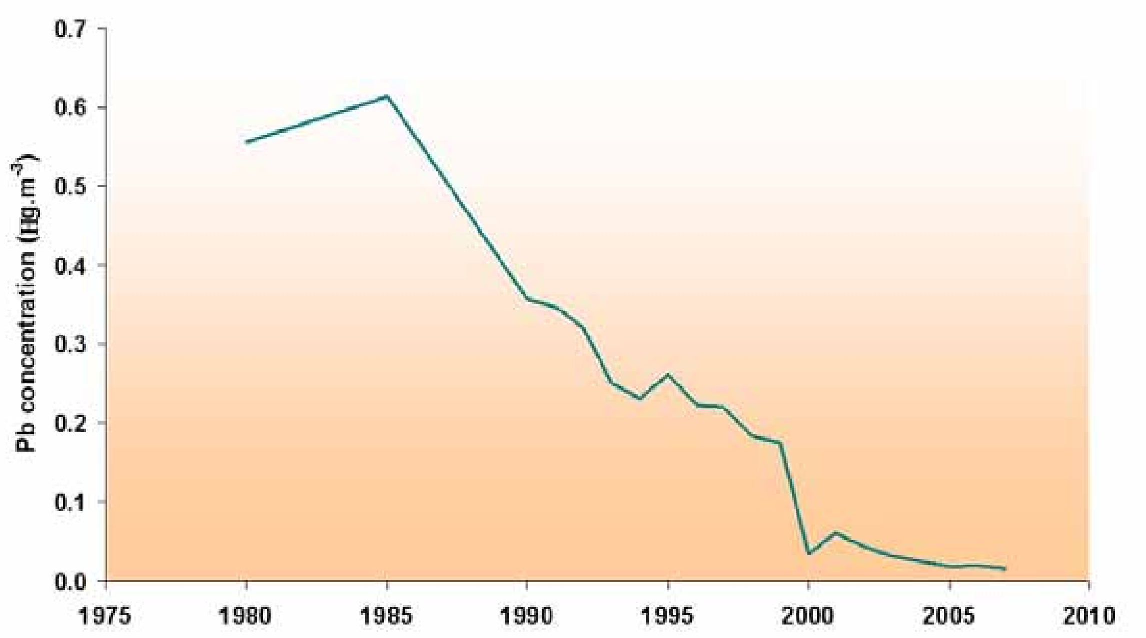


Figure 6.10. Trends in concentrations of lead between 1980 and 2007

UK nickel concentrations (figure 6.9) are heavily influenced by two industrial sites, which exhibit levels an order of magnitude higher than at any other network locations. Therefore any fluctuations in those sites can have a massive impact on the annual averages.

During 1996, one of the London monitoring sites recorded very high levels of nickel, accompanied by high levels of cadmium - this can be seen clearly in Figure 6.9. It is believed that a metal source was temporarily present in the location of the monitoring equipment at some point during the year, as no other London sites exhibited the same trend.

6.7 The future for heavy metal monitoring

Since lead was removed from petrol, urban and rural background sites in the UK have consistently shown very low levels of airborne metals, only a few nanograms per cubic metre. Some 'hot spots' of metal concentrations remain in the UK, although these tend to cluster around industrial point sources. For this reason, the UK network has embarked on a programme of expansion, to target areas of high metals emissions, particularly around industrial sites.

In February 2007, the UK carried out a comprehensive assessment of sites monitoring heavy metals against the requirements of the European Directives. For the purpose of the assessment, the UK was divided into 15 zones and 28 urban agglomerations. Several recommendations were made, to close, move or add extra sites to the Network; these are detailed in Table 6.2. At the beginning of 2007, the UK Heavy Metals Network consisted of 17 sites (see map in Figure 6.11); it is intended that this will be increased to 24 rural, urban and industrial sites by the end of 2008.

Table 6.2. Recent site changes implemented by the UK to ensure compliance with European Legislation.

Sites closed in 2007/2008	Sites opened in 2007/2008
Swansea (INCO)	Swansea (Coedgwilym)
London Brent	Swansea (Morriston)
Leeds Centre	Belfast
Newcastle	Sheffield
Glasgow	Port Talbot
	Cardiff
	Redcar (2 sites)
	Thames Estuary (2 sites)
	Scunthorpe (2 sites)

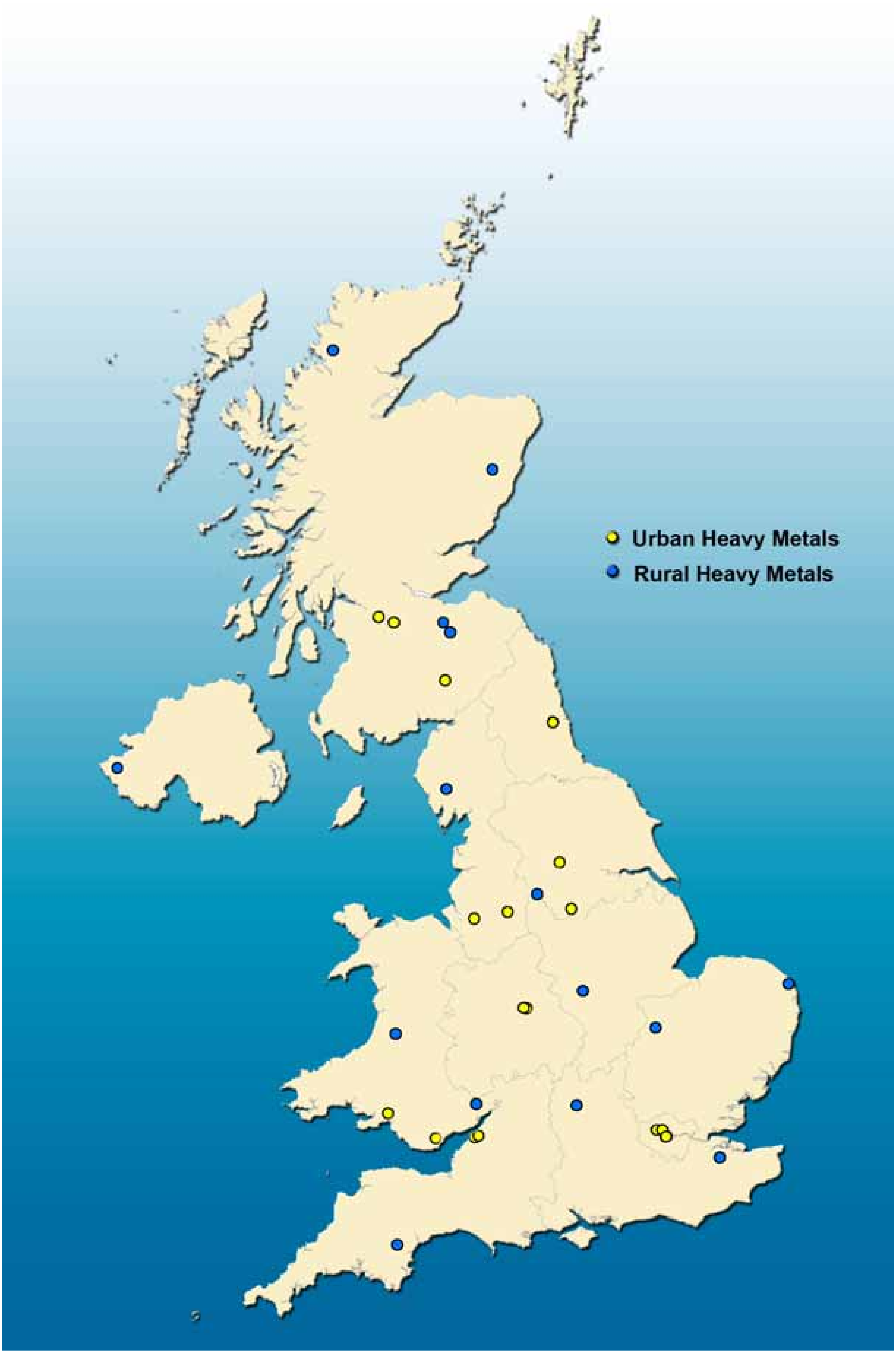


Figure 6.11. UK Heavy Metals Monitoring Network sites.

7 How UK Air Pollution has changed over time

Is air pollution in the UK getting better or worse over time? Here we investigate, but the answers are not always clearcut

7.1 Introduction

The ambient concentrations of different pollutants can vary markedly over different time scales. Concentrations of primary pollutants (those directly emitted into the atmosphere) – such as sulphur dioxide – can fluctuate considerably in the short term; these changes depend primarily on the size, timing and distribution of their emission sources. Secondary pollutants (those that are created in the atmosphere), such as ozone, typically vary more slowly over time as the chemical reactions that control their formation vary.

Increased air pollution concentrations can have important negative human health effects, as well as impacts on the health of crops and vegetation. In the short-term, air pollution episodes can trigger asthma attacks or exacerbate respiratory conditions in sensitive individuals. In the long-term, exposure to air pollution affects our quality of life and overall life expectancy.

This section focuses on the UK 'pollution climate', examining long-term trends in UK air quality and illustrating how our overall exposure to harmful air pollutants is changing over time, in an effort to answer the question "*to what extent is air quality in the UK improving or declining?*" This is not an easy question to answer, given the marked variation in measured pollutant concentrations as meteorological conditions change. For example, ozone concentrations are directly related to photochemical activity driven by the sun, whilst PM_{10} concentrations may decline with precipitation throughout the year. Moreover, levels of all pollutants tend to fall as wind speeds rise and increase their rate of dispersion.

As a result of the close relationship between pollution levels and weather, it can sometimes be difficult to determine whether variations in pollution measurements are the result of changes in emissions, policy measures or associated with changing meteorological conditions. Despite these difficulties, assessing long-term changes in pollution is an important step in:

- Gauging the effectiveness of current regulations and legislative controls on emissions and -
- Deciding whether new or additional regulatory, planning, fiscal or emission control measures are needed at a local, national or international level.

Historically, attention focussed on long-term changes in Black Smoke and SO_2, emitted primarily from domestic and industrial coal burning. As we have seen from previous reports, (and in Section 3 this year), levels of both of these pollutants have declined markedly throughout the UK, both in response to changing emissions patterns and the success of policies to regulate and control their sources. As UK concentrations of these pollutants have declined, however, attention has increasingly focussed on assessing trends and impacts of secondary pollutants, particles and traffic-related species.

Increased monitoring over time (see Section 3) has made it possible to examine these trends in great detail. This section considers these long-term changes in pollution levels in the context of:

- The UK Government's air quality indicators (see Section 2)

- Compliance with specific objectives set out in the UK Air Quality Strategy (discussed in Section 2)

It should be noted that the Devolved Administrations in Scotland, Wales and Northern Ireland are increasingly setting their own air quality indicators and targets. For example, in Wales the 'Environment Strategy for Wales' sets out specific outcomes for air quality that are supported by a series of indicators; these are reported on annually as part of the state of the environment report for Wales. While both the outcomes and indicators are similar at present to those in the rest of the UK, these may diverge in future. Similarly, Scotland has set more stringent targets for some pollutants than England, in particular for PM_{10} and $PM_{2.5.}$

7.2 Pollution indicator 1: PM_{10} & ozone (O_3)

The Government's Sustainable Development indicators for Air Quality provide two significant measures of how the air quality has changed since 1990. The first of these indicators is graphed in Figure 7.1. This statistic, first introduced in 2005, shows trends in two specific pollutants: daily maximum running 8-hour ozone concentrations and annual mean particulate matter (PM_{10}) concentrations. This indicator illustrates the special prominence of these two pollutants, which are believed to pose the most significant threats to public health through long-term exposure.

Figure 7.1 clearly shows that ozone concentrations have been rising more rapidly at urban background locations than at rural sites over the last decade; this has reduced the historic gap between urban and rural environments, which is primarily due to ozone 'scavenging' by traffic-related NO_X emissions in urban areas.

Measured ozone concentrations in 2003 and in 2006 were comparatively high; this resulted primarily from extended periods of hot, sunny weather, promoting photochemical reactions in the atmosphere that generate this secondary pollutant. Extensive analyses of these episodes, together with assessments of their potential health impacts are available for download from the UK Air Quality Archive (www.airquality.co.uk).

As discussed in Section 4, there were no significant heat wave events during the summer of 2007, and much of the UK suffered from serious flooding. As a result, Fig 7.1 shows falling ozone indicator levels at both urban and rural locations throughout the UK.

Concentrations of PM_{10} at background and roadside sites fell steadily at a similar rate until about 2000, and have since levelled off. Again, 2003 and 2006 stand out in these trends, suggesting that the hot summer weather during these years also affected overall PM_{10} indicator levels. This is certainly consistent with the expected photochemical generation of fine secondary particle aerosols during 'summer smog' events.

PM_{10} concentrations in the UK in 2006 are known to have been influenced by long-range transport; this may be due to Saharan dust storms or biomass burning on the Continent. In last year's report, we discussed one such episode.

The observed decline in the PM_{10} concentration from 2006 to 2007 clearly owes much to the hot, sunny summer of 2006 being followed by a cool wet summer during 2007. Photochemical activity constrained by the lack of sunshine in 2007 resulted in fewer fine particles in the form of aerosols, whilst coarse particles were increasingly washed out by precipitation; moreover, re-suspension of coarse dust fractions was less prevalent in 2007's wet weather.

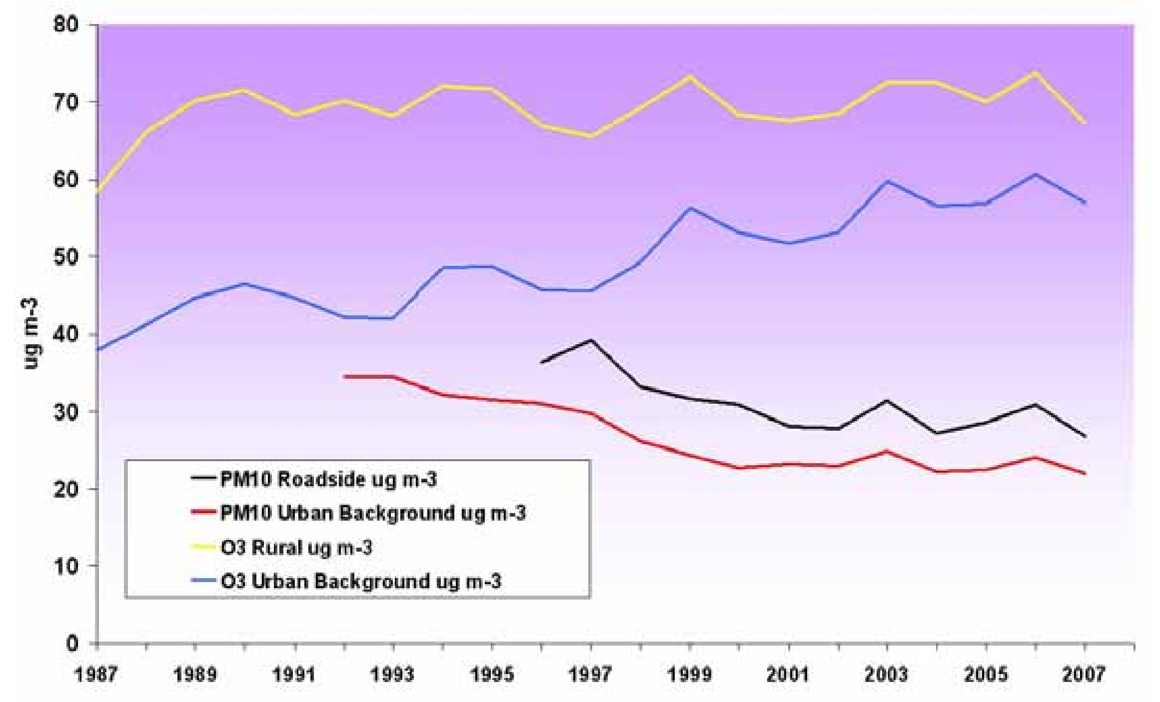


Figure 7.1 – Trends in Air Pollution Indicator 1 from 1987: gravimetric PM_{10} annual mean and ozone annual mean of the daily maximum running 8-hr mean

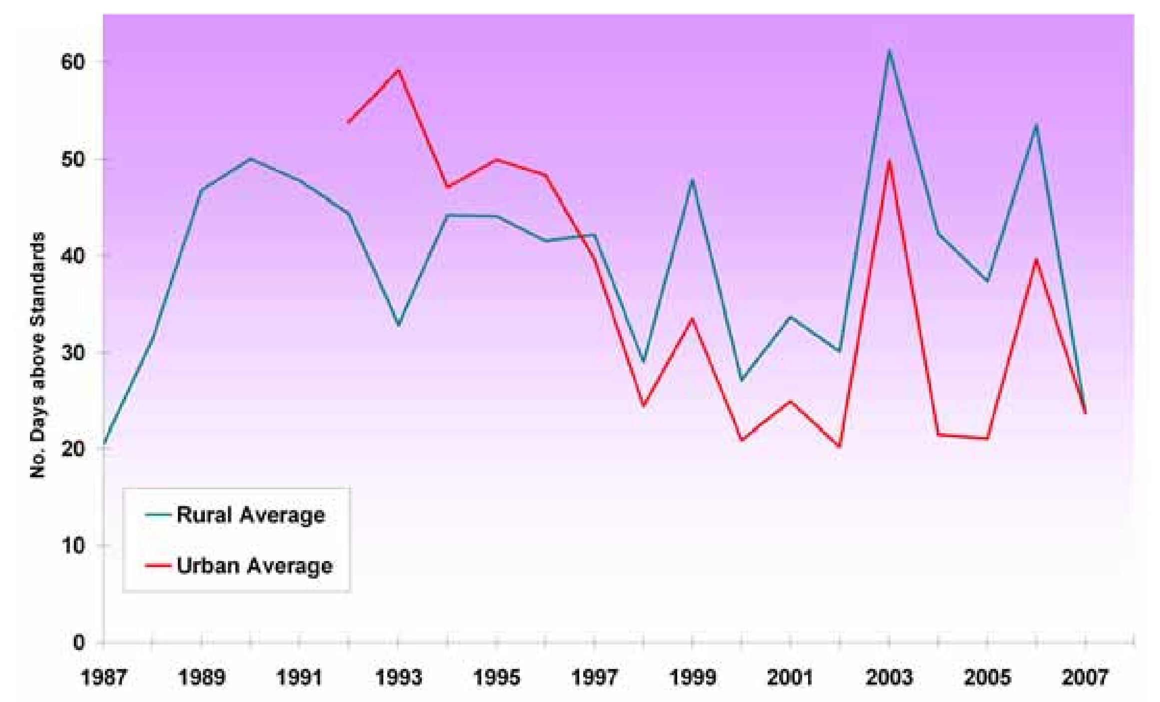


Fig 7.2 Trends in air Pollution Indicator 2 from 1987 to 2006: number of days exceeding 'moderate' air quality band

7.3 Pollution indicator 2: number of moderate or higher air pollution days

The second of the UK Government's Sustainable Development air quality indicators has been established for several years and analysed in earlier reports in this series. This is based on the average number of days per site on which pollution levels exceed the UK's 'moderate' air quality band. These bands represent defined concentrations associated with different levels of health risk. When pollution is 'moderate', sensitive people may notice mild effects, but these are unlikely to require action. When levels enter the 'high' band, sensitive people may notice significant effects and may need to take action.

Figure 7.2 shows how the number of moderate or higher air pollution days in the UK has changed since 1987. Unlike the first indicator discussed, this indicator is based on data for five different pollutants - PM_{10} particles, ozone, sulphur dioxide, carbon monoxide and nitrogen dioxide.

The 'heat-wave' associated peaks for 2003 and 2006, discussed previously, are even more apparent in Figure 7.2. Other interesting trends also become apparent. For example, there appears to be a marked decline in the number of moderate or higher days at urban sites (the red line) from 2000. Since then, the trend has levelled off with the exception of the noted peaks in 2003 and 2006.

No clear trend is apparent for the corresponding UK rural sites (the blue line); however, this does show considerable year-on-year variability. This may be because the dominant pollutant in rural areas is ozone which, being a secondary pollutant, is created in the atmosphere from precursor emissions and is also present naturally.

Concentrations of this pollutant are therefore heavily dependent on a range of factors including the weather and long-range transport. The transboundary nature of ozone transport and formation, combined with its strong dependence on meteorology, make it a difficult pollutant to regulate or control. UK Government is working at an international level to reduce the emissions of precursor pollutant species that react in the atmosphere to form ozone.

7.4 Comparison with UK objectives

Each year, a comprehensive analysis is undertaken of how UK-wide air quality measurements from the national networks compare with the Air Quality Strategy Objectives – both those established in Regulation (summarised in Section 2) and those not in Regulation. Results from the analysis carried out for 2007 are summarised in Figures 7.3 and 7.4.

As in previous reports, Figure 7.3 is presented as a 'box and whisker' plot showing mean compliance statistics averaged across all measurement sites in the AURN, normalised and expressed as a percentage of the Air Quality Strategy Objective. To provide additional information, the maximum site statistic is also graphed. The height of each bar in the figure represents the average statistic across the whole network compared with the relevant national objective, while the blue lines show how the 'worst' site compares with that objective; this is important information, since a single site above the level of the Objective constitutes an exceedence even where the network average falls below the Objective level. The methodology used to produce Figure 7.3 is discussed in greater detail in Appendix A6.

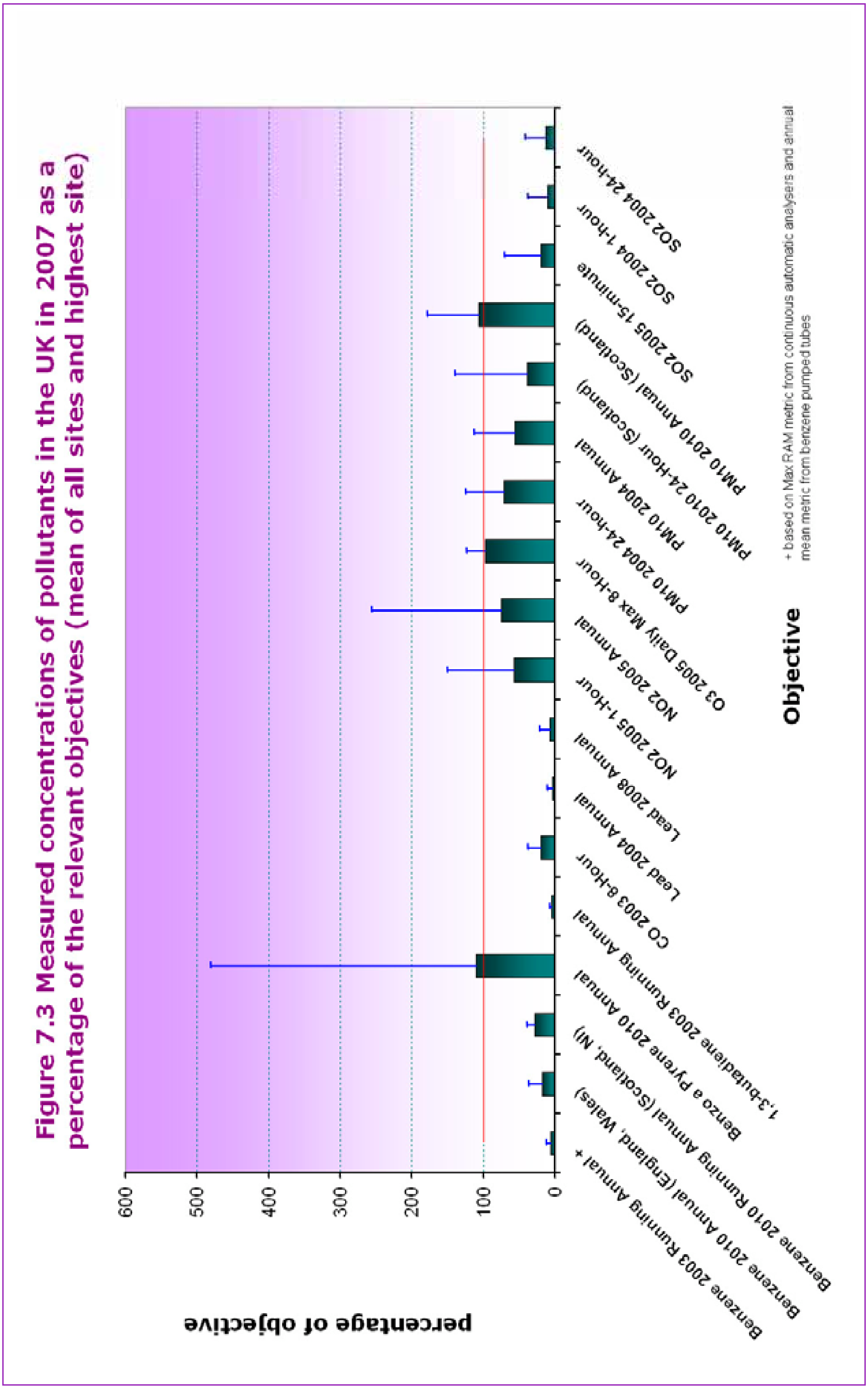


Figure 7.3 Measured concentrations of pollutants in the UK in 2007 as a percentage of the relevant objectives (mean of all sites and highest site)

Figure 7.3 shows clearly that some pollutants - notably benzene, carbon monoxide and sulphur dioxide - are largely under control. By contrast, levels of other pollutants – Benzo[a]pyrene [BaP], NO_2, ozone and PM_{10} – currently exceed their respective objectives at some locations. Ratified data for 2007 show a continuation of the trends seen over recent years – BaP, NO_2, ozone and PM_{10} all exceed the objective at the most highly polluted sites. Of particular concern is PM_{10}, for which the network average - rather than just the highest concentrations measured - exceeds its defined objective.

Additional information is provided in Figure 7.4. This presents time series analyses for specific examples of pollutant objectives including BaP, NO_2, ozone and PM_{10}. The average and maximum concentrations are presented in $\mu g\ m^{-3}$, rather than as percentages of the objective value (shown in Figure 7.3). These graphs show how levels are changing over time in relation to each objective.

Figure 7.4a demonstrates that BaP concentrations are, on average, close to the relevant objective. They also exhibit a slight downward trend. This downward trend is more marked for the maximum concentration, although this remains shallow and the maximum measured concentrations for BaP remain significantly above the objective value. The highest BaP concentration in 2007 was recorded at Scunthorpe, which is historically the highest recorded site in the network, where industrial emissions are known to make a substantial contribution.

Encouragingly, network average NO_2 concentrations have been steadily declining over the last two decades and have been below the objective value since 2000 (Figure 7.4b); this trend looks set to continue. However, the highest concentrations of NO_2 measured by the network appear to have been actually increasing over time at several of the busiest roadside monitoring sites. While this increase may have levelled off since 2003, concentrations at the most polluted traffic-influenced UK sites remain well above the objective level.

Both maximum and average ozone concentrations (Figure 7.4c) have risen slightly over the last decade and it is likely that both these will exceed the objective value within the next few years. Trends in ozone concentrations can be influenced by a number of factors including the weather, baseline or background levels, the magnitude of the precursor emissions and reactions with local NOx emission in urban areas[G1]. Analysis of hemispheric baseline ozone concentrations suggests that concentrations increased over the period from 1995 to a peak in 1999 and subsequently remained roughly constant [G2].

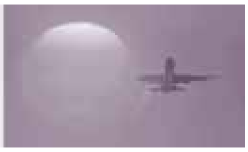
It should be noted that the increase in average ozone concentration measured across the network also reflects the corresponding changes observed in urban areas as a result of tighter control of NO_X emissions; a trend that is further illustrated in the urban background and rural ozone lines in Figure 7.1. Measured ozone concentrations fell markedly from 2006 to 2007 due to 2007's wet summer, as discussed previously.

Figure 7.4d shows corresponding trends in average and maximum PM_{10} levels when compared against the daily objective. It shows a slight decline in average levels in the long-term, although concentrations in recent years appear to have levelled off. The highest levels remain above the objective and have not decreased significantly in recent years. As with ozone, measured PM_{10} concentrations fell from 2006 to 2007.

Both the time series plots for ozone and PM_{10} (Figures 7.4c and 7.4d) clearly show the unusually high concentrations of these pollutants measured during the 'heat wave' year of 2003 and, for ozone, 2006.

Figure 7.4 a) to d) Trends from 1997 to 2007 in mean and maximum measured concentrations for four selected pollutants against their corresponding UK Air Quality Strategy Objectives

8 A broader perspective on UK Air Pollution



How does air pollution in the UK compare with other parts of the world? This is a topic we examined for the first time in last year's report. Here we extend that initial assessment, focussing on our European neighbours.

8.1 Introduction

Previous sections in this report, and all the previous reports in this long-running series, have focussed exclusively on UK-based air pollution issues and measurements. However, it is reasonable to ask how pollution levels here compare with those in other parts of the world - in fact, we get asked this quite often!

This is not altogether a straightforward question to answer, however. There are differences in national climates, measurement techniques, siting criteria and other factors, which all complicate the comparisons.

The best way of obtaining meaningful comparisons is to use data from countries that are broadly comparable in terms of measurement methodology, siting philosophy and measurement quality. The European Union's Air Quality Framework and Daughter Directives (discussed at length in Section 2.1) have substantially improved the degree of harmonisation and comparability between air quality measurements made in different Member States of the EU.

We have chosen, therefore, in this section to compare current UK levels of key pollutants - PM_{10} particles, ozone and (for the first time) nitrogen dioxide - with corresponding measurements throughout Europe. We also compare UK trends in air quality since 1997 with corresponding changes throughout the European Union.

The indicator statistics for these pollutants are precisely those presented and analysed in the previous section:

- Gravimetric PM_{10} annual mean
- Ozone annual mean of the daily maximum running 8-hour mean
- NO_2 annual mean

Why have we selected these pollutants in particular? This is primarily because long-term exposure to PM_{10} and O_3 are now believed to pose the most significant threats to public health in UK and throughout Europe. NO_2 levels are strongly connected with those for ozone. Moreover, as we have seen in the previous section, levels of this pollutant appear to be rising steadily at near-road locations, and remain well above objective.

For these comparisons, data have been obtained from AirBase, the public air quality database system of the European Environment Agency; this currently contains air quality information contributed by participating countries throughout Europe, extending up to 2005. Airbase can be found at http://air-climate.eionet.europa.eu/databases/airbase/; data can be freely retrieved using AirView, a web-based system enabling interactive access and download of information from a wide range of EU states and EEA participants: http://air-climate.eionet.europa.eu/databases/airbase/airview/index_html

It is important to note, however, that the datasets for some Member States are more complete than others.

Despite the degree of caution necessary in interpreting these early analyses, we hope that you will find the results of interest.

8.2 Particulate Matter (PM_{10}) Levels

Particles are a key threat to human health in Europe and many parts of the world. We have therefore separately analysed Gravimetric PM_{10} annual means at two key location types where population exposure is at a maximum: Roadside and Urban Background stations. Our findings are presented in Figures 8.1 to 8.4.

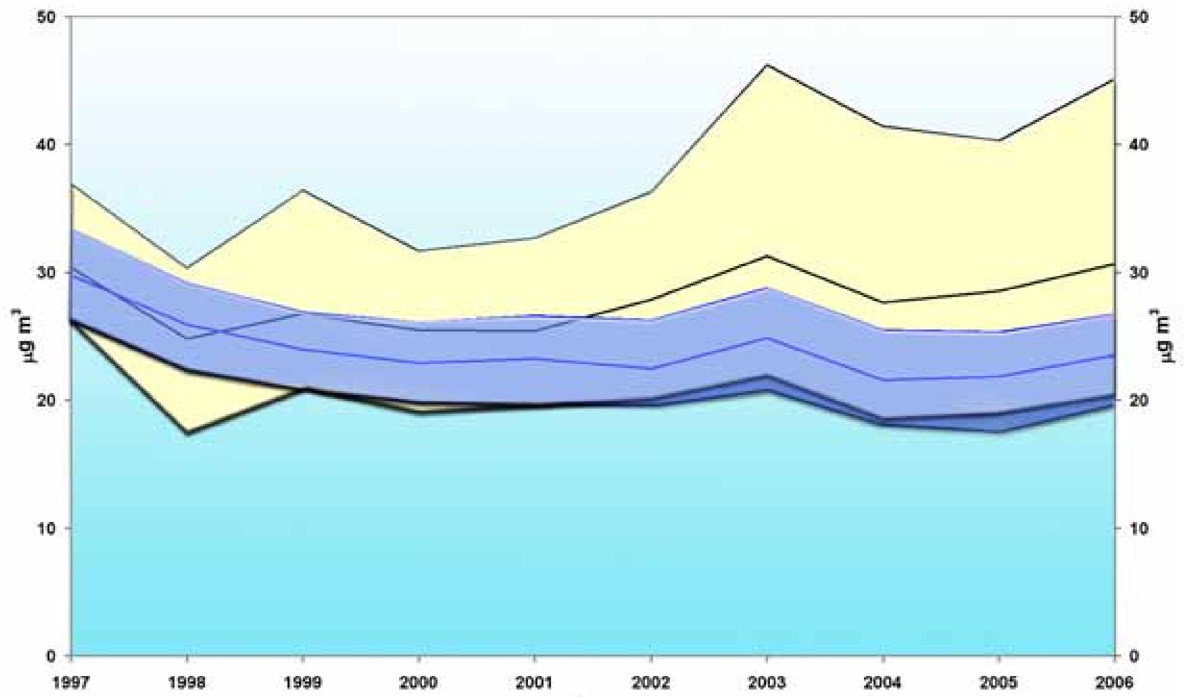


Figure 8.1 Comparison of UK urban background PM_{10} levels (blue line and shaded area) with European averages (yellow): 1997 to 2006. Ranges shown from 10th to 90th percentile values. EU average shown by black line.

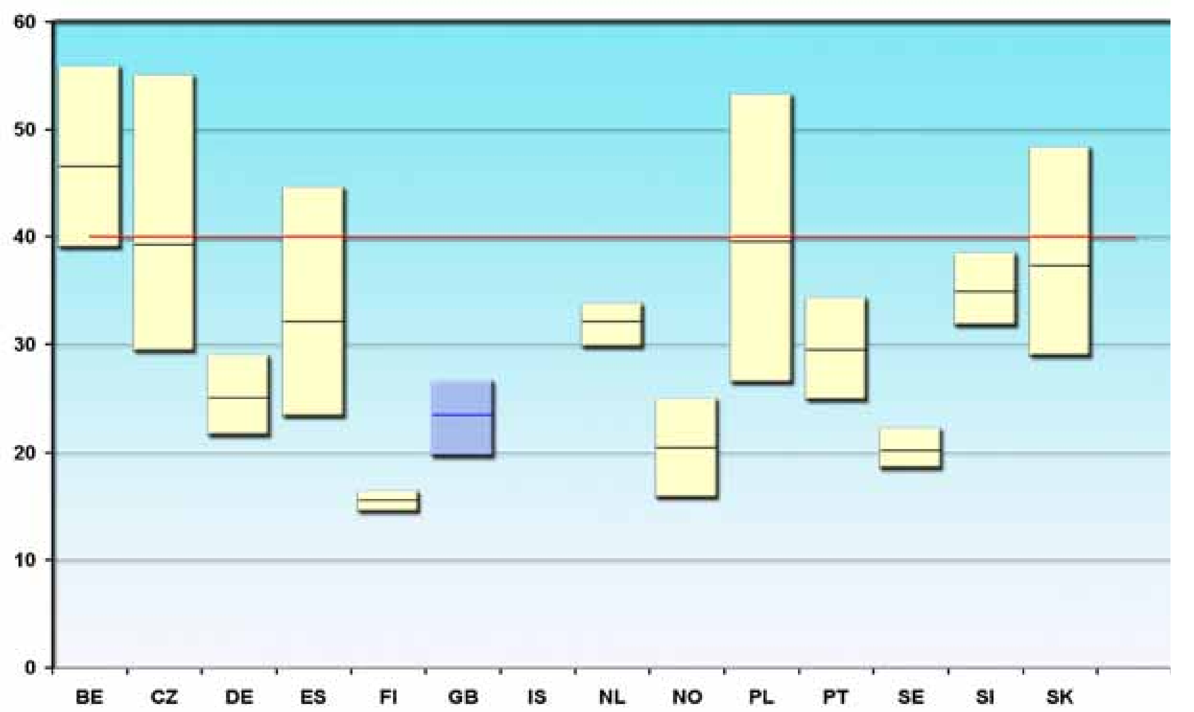


Figure 8.2 Comparison of UK urban background PM_{10} levels (blue) with other European Nations (yellow) for 2006. Ranges shown from 10th to 90th percentile values.

In Figure 8.1, we examine annual mean PM_{10} levels across urban background stations in the UK from 1997 to 2006: 90^{th} percentile, mean and 10th percentile levels are graphed in blue. By way of comparison, the corresponding EU-wide statistics (15 Member States, 2700 sites) are shown in yellow. The blue and yellow shaded areas therefore broadly represent the range of measured PM_{10} annual average levels in urban background areas across the UK and throughout Europe (in the Member States analysed) over the last eight years.

Figure 8.1 clearly shows that current annual means for PM_{10} across urban background stations in the UK tend to lie well below the EU average. It was not always so: in 1997 and 1998, UK and EU levels appeared broadly similar. Since then, however, the 90^{th} percentile of UK measurements (that is, the level exceeded by only the top 10% of measurements) has been around or below the mean of corresponding EU data.

Note also from Fig 8.1 the peak in all data in 2003 and 2006; as highlighted in this and previous annual reports, elevated levels of a range of pollutants were seen throughout UK and Europe during the unusual 'heat wave' summers of those years.

Figure 8.2 provides another way of looking at things; it compares UK background PM_{10} concentrations with those of individual European countries for the latest year of measurements available in AirBase - 2006. UK data are shown in blue, with upper and lower ranges denoting the 10^{th} and 90^{th} percentile measurements respectively, and the middle line showing the mean.

This figure re-enforces the observations summarised in Figure 8.1. It shows that the UK levels that year were broadly similar to those in other countries like Denmark and Norway, but markedly lower than those in most of other countries, including the Netherlands, Czech Republic, Poland, Portugal and Spain.

How can this be explained? A number of factors may be involved:

- Differing particle measurement techniques in UK and Member States of the European Union.
- Our milder, wetter climate; this tends to lead to less dusty conditions and less re-suspension of particles than – say – the relatively hotter and drier southern and Mediterranean countries.
- The fact that UK urban background measurements are often made in relatively green city park areas; such urban background environments are relatively less common in some EU states.

The corresponding PM_{10} data for roadside environments, shown in Figures 8.3 and 8.4, show interesting differences from those for urban background sites. This might be expected; after all, roadside environments are more homogenous throughout Europe than corresponding urban background areas.

Figure 8.3 shows very little systematic long-term trend over time in levels throughout UK or Europe (15 states, 1500 sites). More significantly, however, UK and EU-wide mean PM_{10} measurements at roadside sites are similar; this is markedly different from corresponding observations for urban background locations. This observation lends support to the possibility than UK urban background measurement sites may be representative of different generic location types from those in other EU Member States and other European States.

Figure 8.4 tells a similar story; UK roadside PM_{10} levels are broadly similar to those in many European countries. Clear differences are apparent for some Central/Eastern states however - Poland in particular – where older, comparatively 'dirtier' vehicle fleets and industrial emissions from older plants appear responsible for the markedly higher particle measurements.

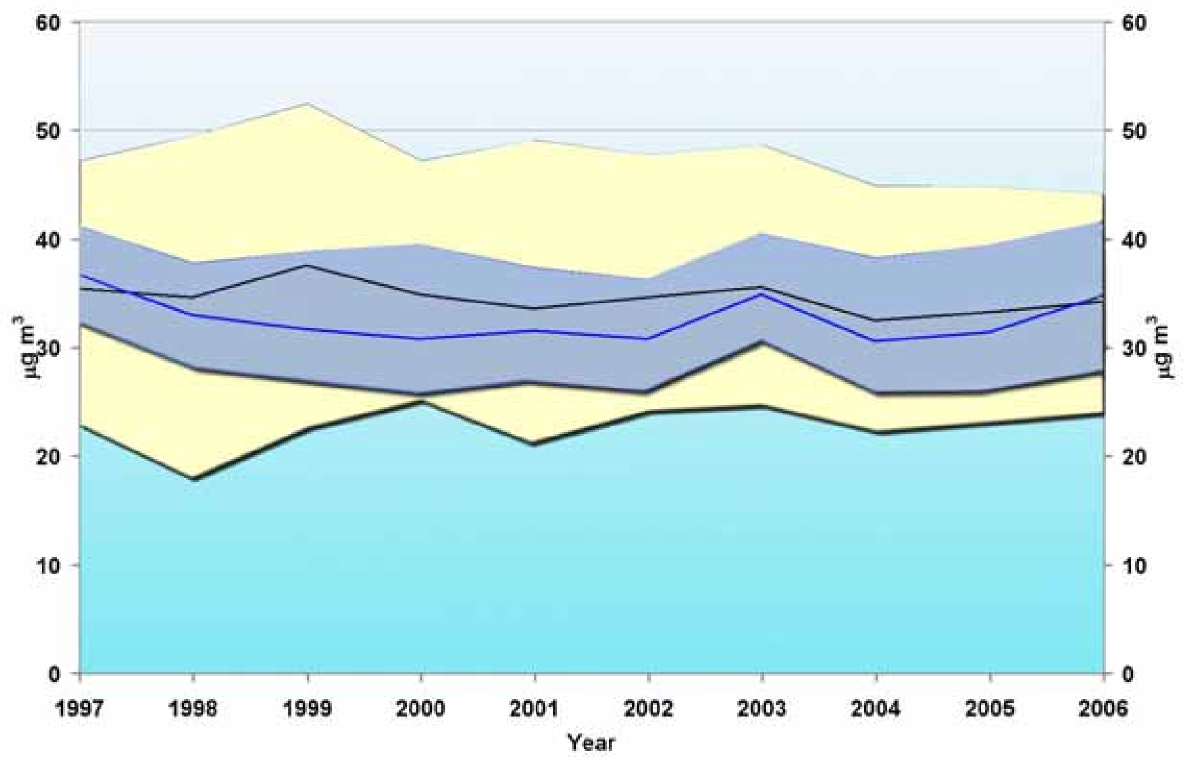


Figure 8.3 Comparison of UK roadside PM_{10} levels (blue line and shaded area) with European Averages (yellow): 1997 to 2006

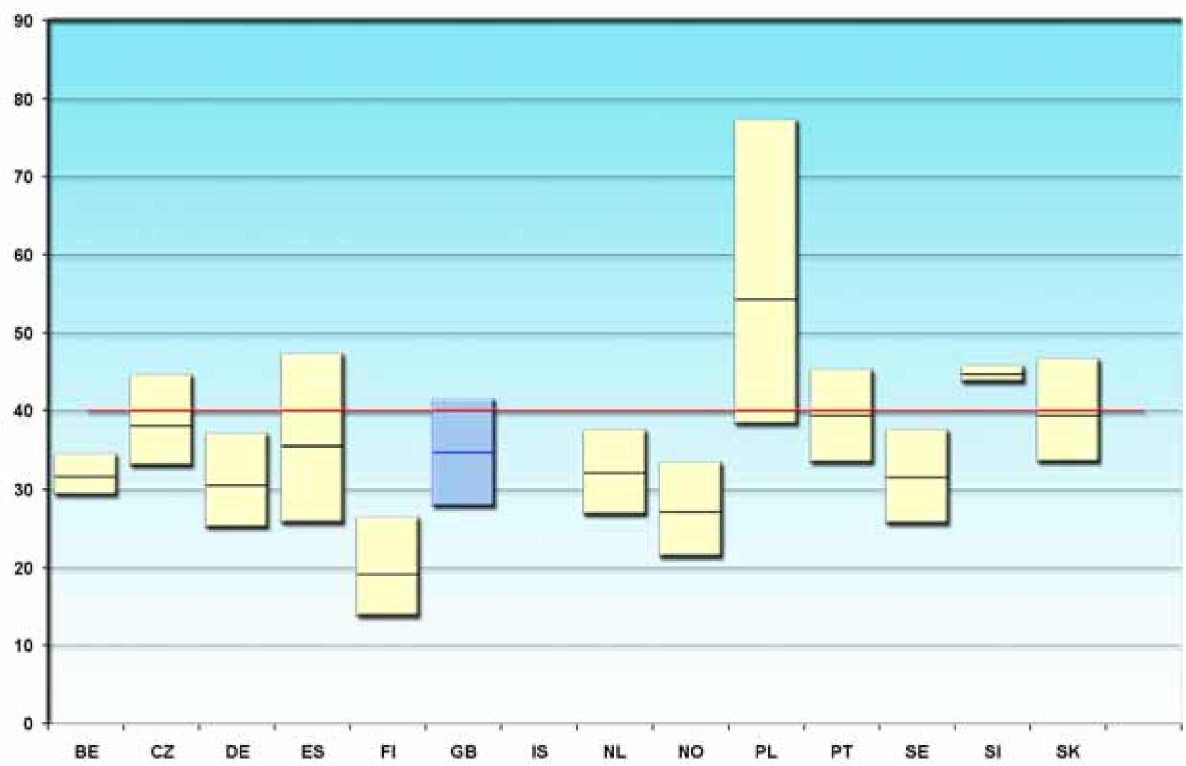


Figure 8.4 Comparison of UK roadside PM_{10} levels (blue) with other European Nations (yellow) for 2006

8.3 Ozone (O_3) levels

We have repeated the analyses of the previous section for another key pollutant- ozone; this has major potential impacts on both human health and our ecosystems. Ozone levels have been examined for both urban background and rural environment types. The annual mean of the daily maximum running 8-hour mean has been used here as a convenient indicator.

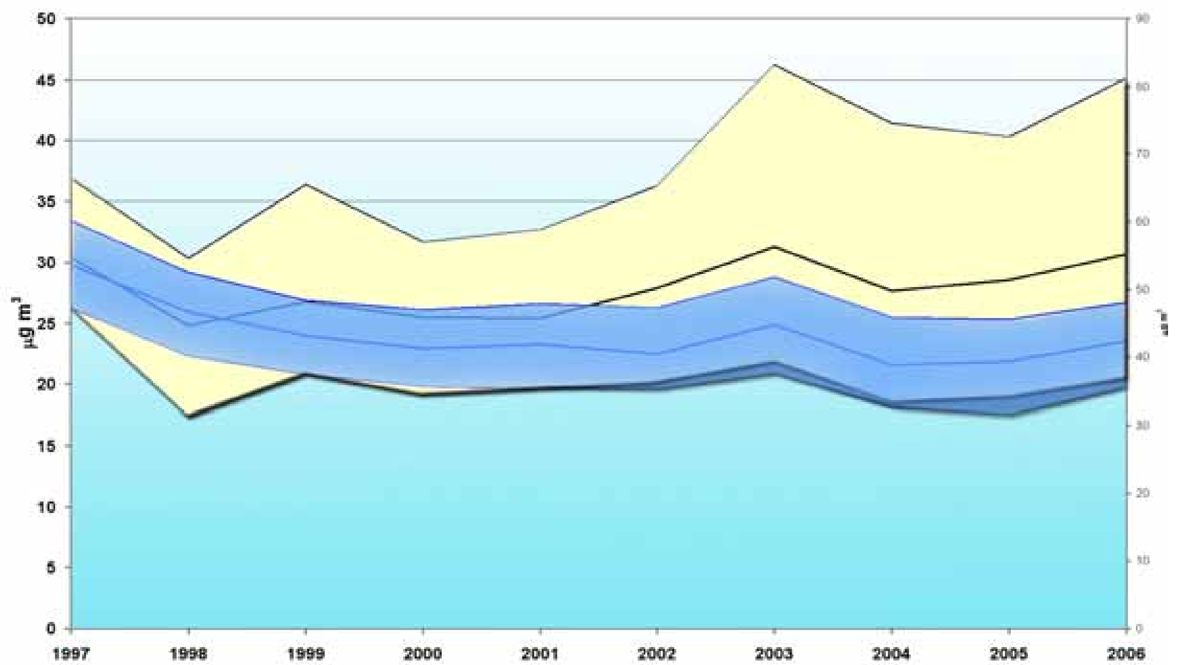


Figure 8.5 Comparison of UK urban background ozone levels (blue line and shaded area) with European Averages (yellow): 1997 to 2006

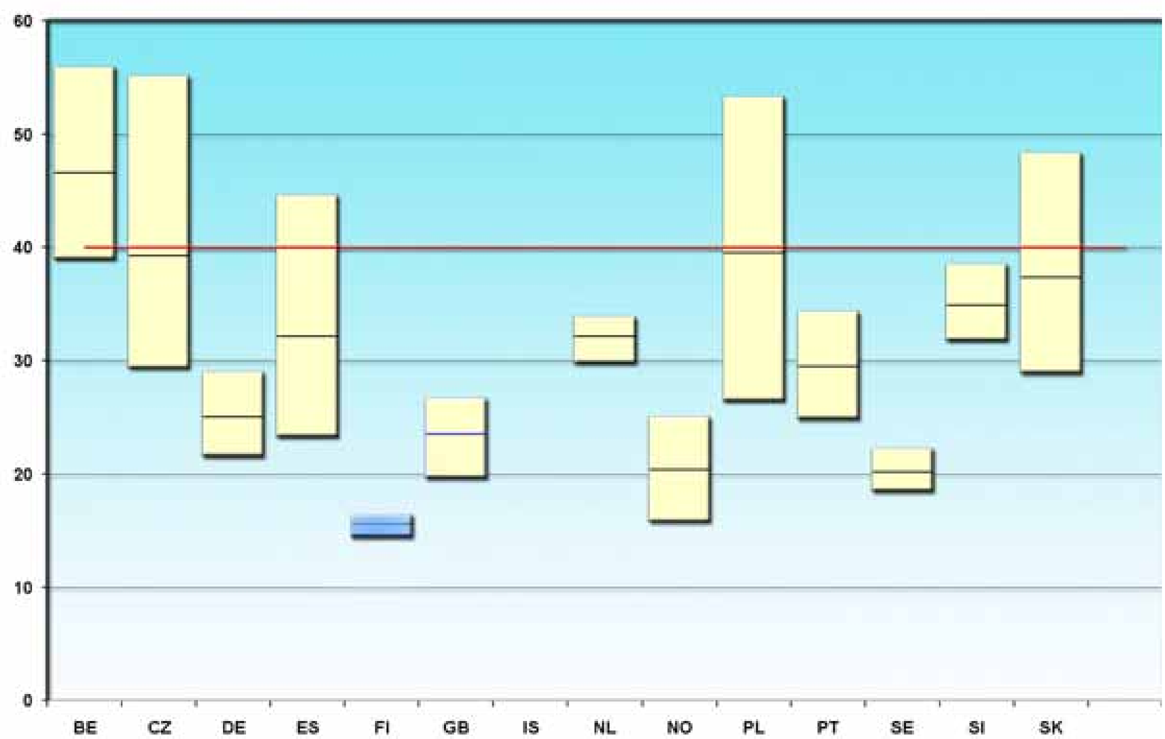


Figure 8.6 Comparison of UK urban background ozone (blue) with other European Nations (yellow) for 2006

Figure 8.5 shows 10th percentile, mean and 90th percentile ozone levels at UK urban background monitoring stations to be consistently below those throughout Europe. There is also evidence of a rising trend in levels at European- but not UK - locations from 1997. Not surprisingly, the notable 2003 'heat wave' summer peak is strongly evidenced once again.

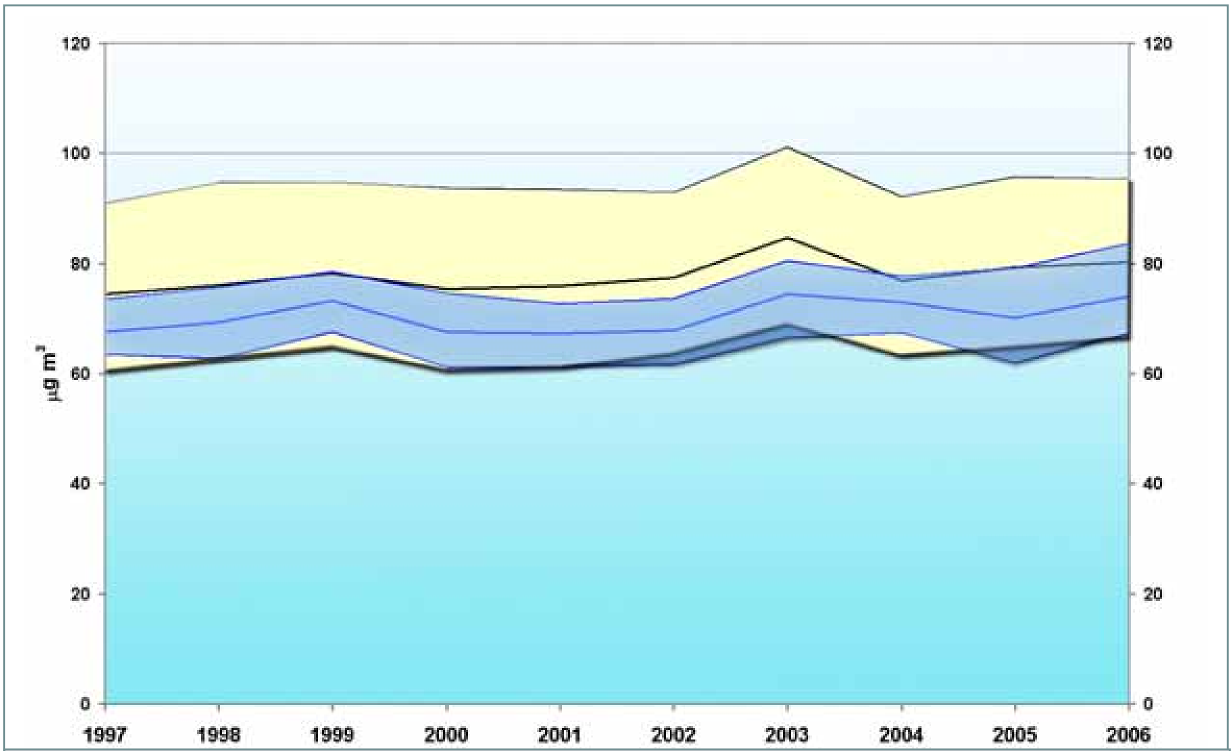


Figure 8.7 Comparison of UK rural ozone levels (blue line and shaded area) with European Averages (yellow): 1997 to 2006

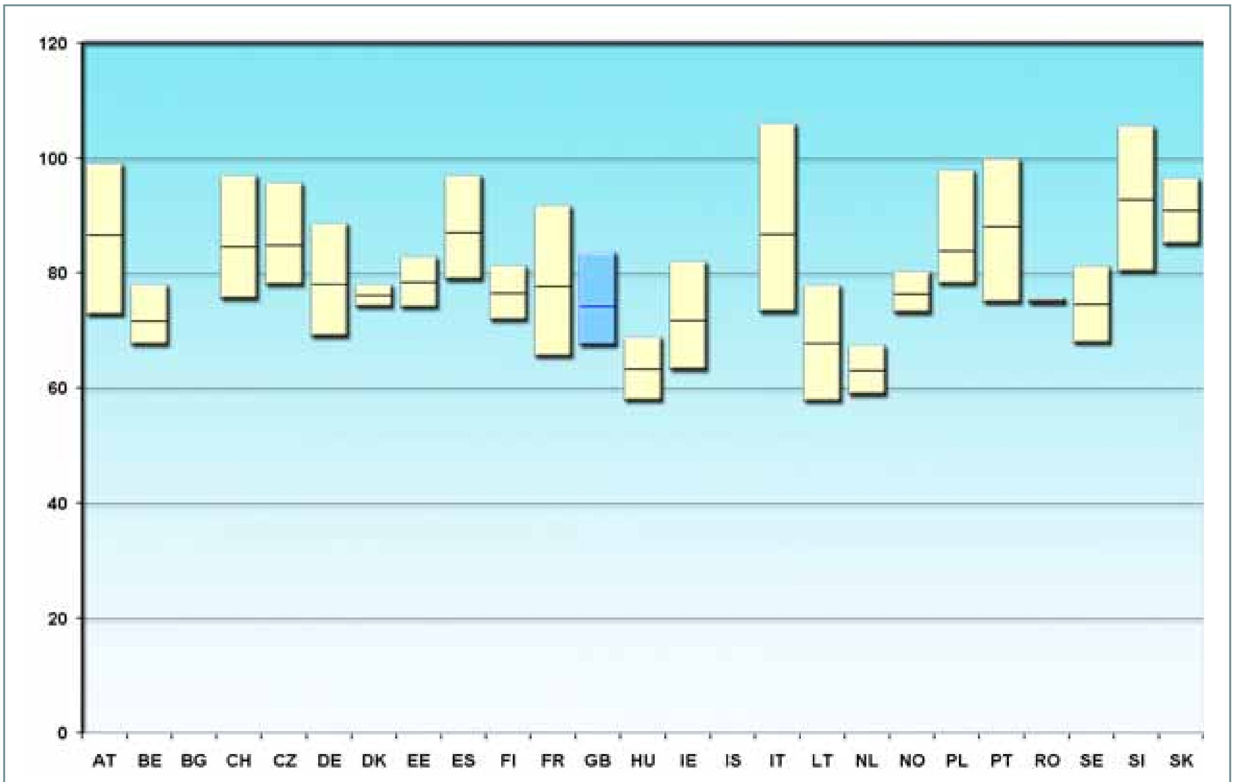


Figure 8.8 Comparison of UK rural ozone (blue) with other European Nations (yellow) for 2006

Examining 2006 measurements in greater detail (Figure 8.6) shows UK urban ozone levels to be similar to those in NW European/Baltic states such as the Netherlands, Belgium and Latvia, but considerably lower than in most EU states including France, Spain, Italy and Portugal.

Geographical location, climate (sunshine and temperature in particular) and altitude can all have a significant impact on ozone levels. In this context, it is interesting to note the similarities between the UK and neighbouring countries such as Belgium and the Netherlands. Conversely, it is not really surprising to see the highest urban ozone levels in relatively hot, sunny Mediterranean countries such as Greece, Italy, Spain and Portugal.

Turning our focus to rural ozone levels (Figures 8.7 and 8.8), we again see UK levels to be consistently lower than the EU average. Comparing Figures 8.7 and 8.5 shows an interesting difference, however; urban background ozone levels throughout Europe are rising, whilst corresponding rural levels of this pollutant are broadly stable.

In fact, this is readily understandable. The ozone statistics analysed here are not strongly affected by peak episodes, but more a measure of baseline average tendency. Background urban ozone levels are, indeed, rising throughout Europe. This is because corresponding NO_x emissions from traffic are being increasingly effectively controlled by a range of EU-wide directives and initiatives, bringing about enforced changes to vehicle engines, fuels and control technologies.

8.4 Nitrogen dioxide (NO_2) levels

We have repeated the analyses of the previous section for another key pollutant- nitrogen dioxide; this is the first time we have analysed levels of this pollutant in a broader European context.

We here examine NO_2 levels for both urban background and rural environment types. The annual mean of the 1-hour means has been used here as an indicator.

Figure 8.9 indicates that, up to 2003, rural NO_2 levels across the UK were very similar to the European average. However, in recent years (2004 – 2006), they appear to have been slightly lower than the EU average, remaining so in 2006 (Figure 8.10). Moreover, the rate of decline in UK levels appears to have changed in 2003. This is difficult to understand fully at this time. However, the introduction of a number of remote rural NO_x to the UK networks in 2003 may be influencing these data trends.

However, as shown in Figures 8.11 and 8.12, NO_2 concentrations at urban background sites exhibit markedly different trends. At sites of this type in the UK, mean NO_2 concentrations are *higher* than the EU averages, by approximately 5 μgm^{-3}. Both UK and European datasets show a slow, continuous decline over the years.

Similarly, at roadside sites, mean UK NO_2 concentrations are higher than the EU roadside averages, by approximately 10 μgm^{-3} (Figures 8.13 and 8.14).

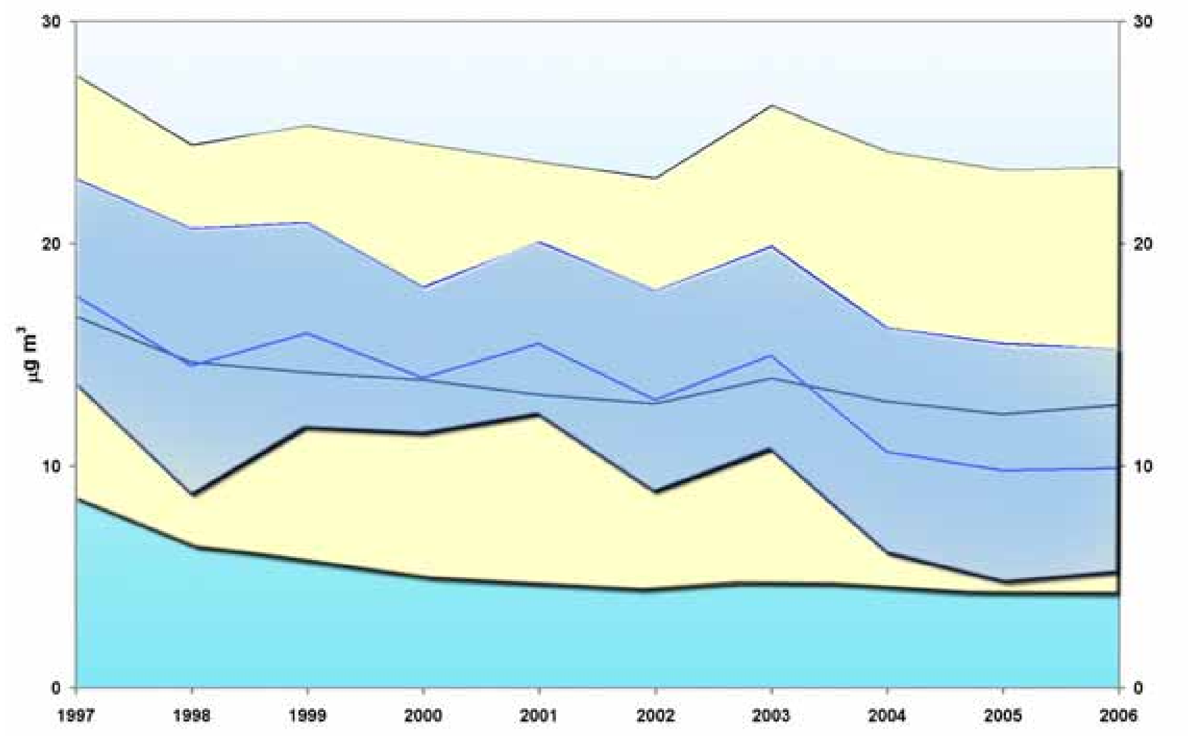


Figure 8.9 Comparison of UK rural NO_2 levels (blue line and shaded area) with European averages (yellow): 1997 to 2006

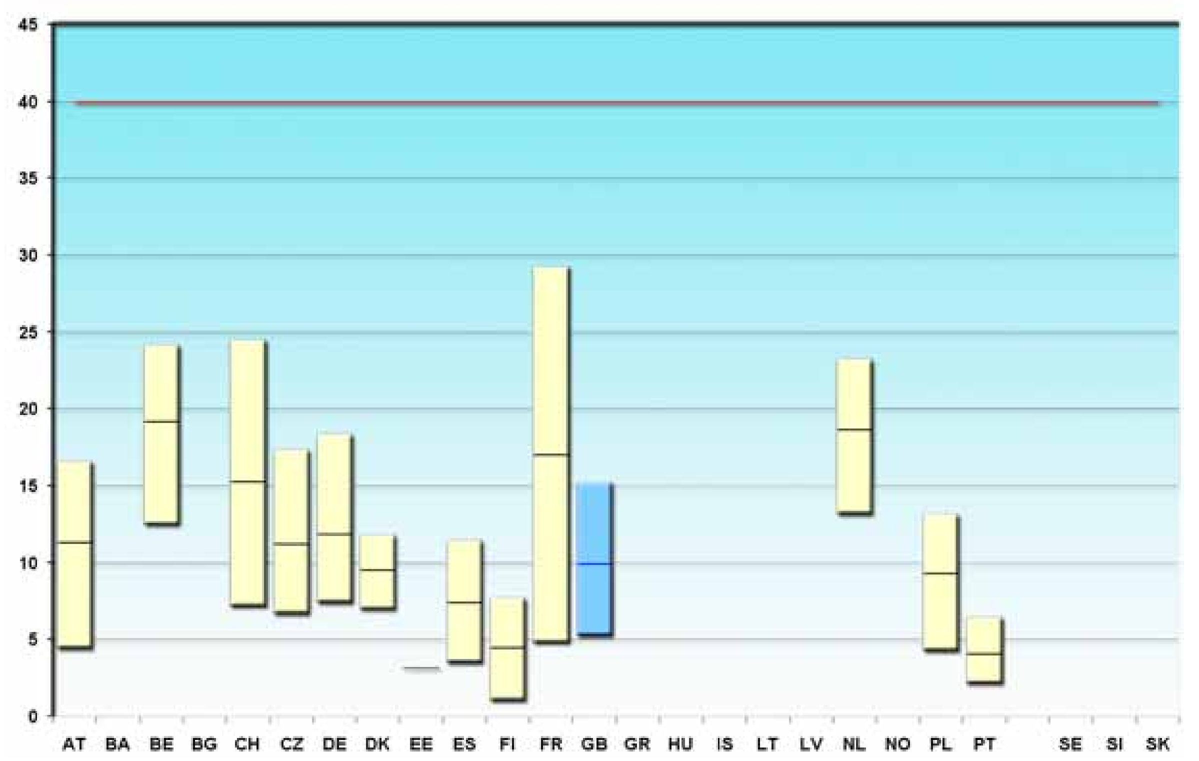


Figure 8.10 Comparison of UK rural NO_2 (blue) with other European Nations (yellow) for 2006

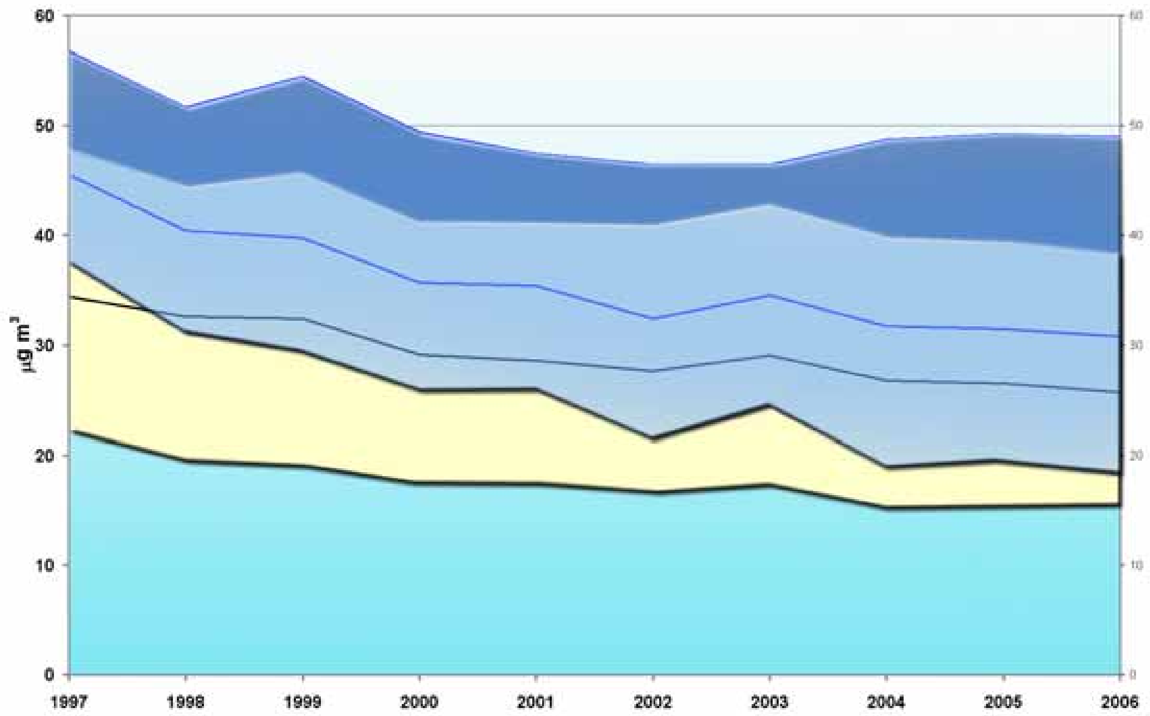


Figure 8.11 Comparison of UK urban background NO_2 levels (blue line and shaded area) with European averages (yellow): 1997 to 2006

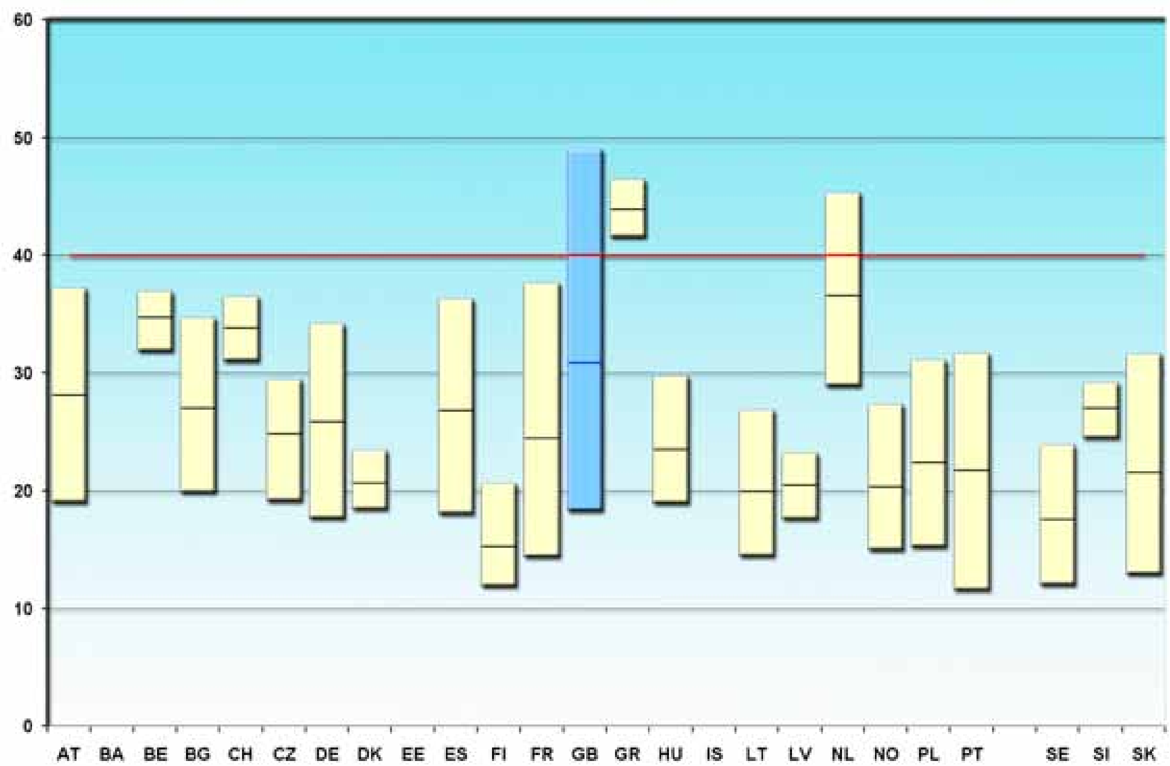


Figure 8.12 Comparison of UK urban background NO_2 (blue) with other European Nations (yellow) for 2006

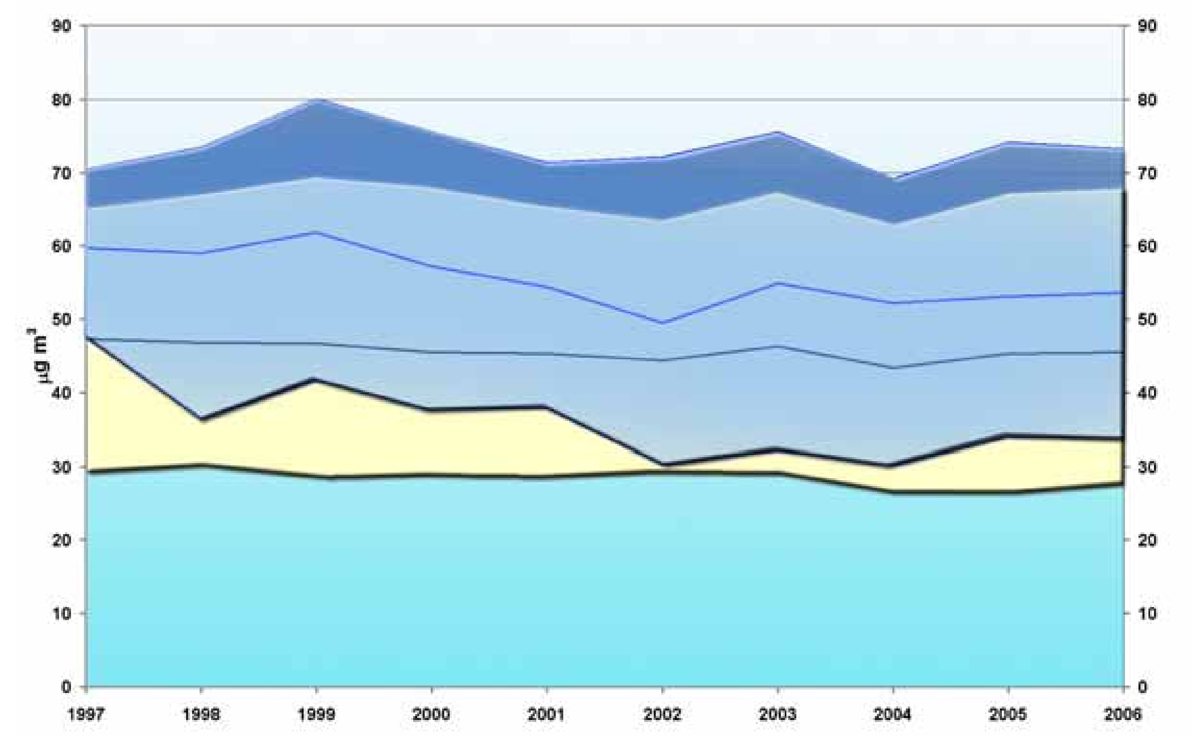


Figure 8.13 Comparison of UK roadside NO_2 levels (blue line and shaded area) with European averages (yellow): 1997 to 2006

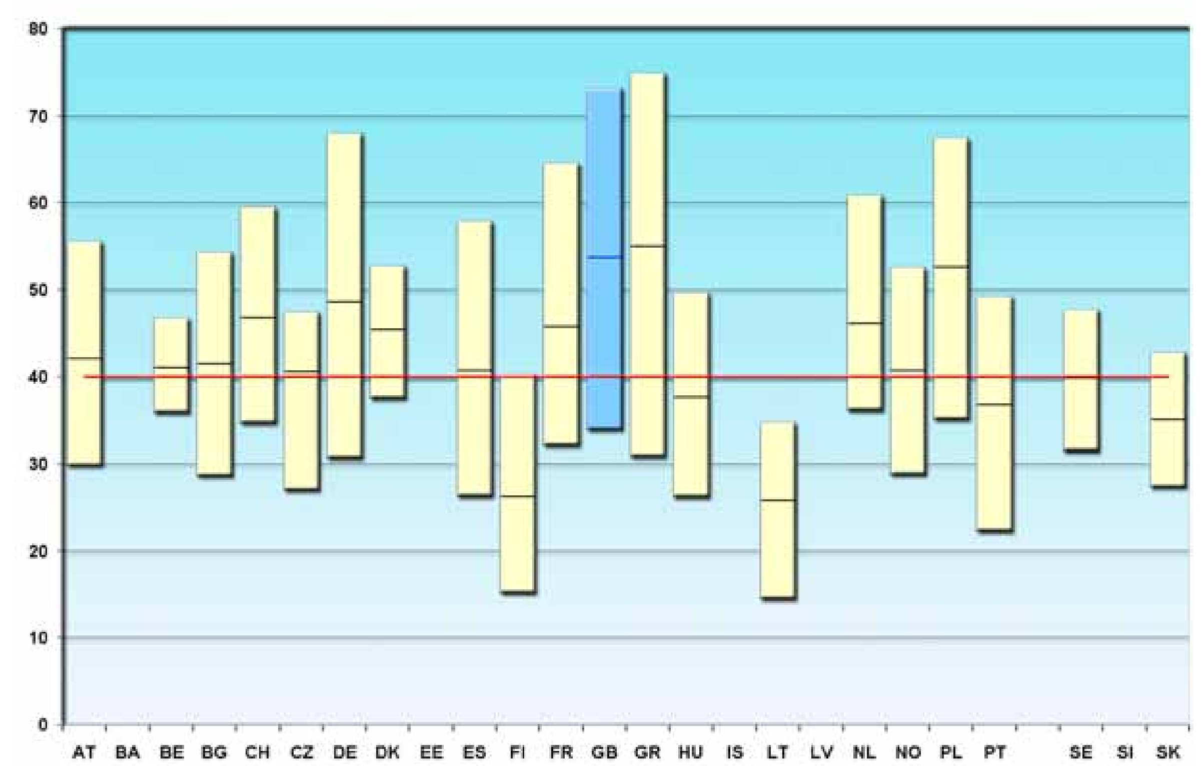


Figure 8.14 Comparison of UK roadside NO_2 (blue) with other European Nations (yellow) for 2006

9 How do I find out more?

Here we provide details of a wide range of sources of further information on the UK's air quality. These include a range of media and web-based resources. Presentation and visualisation methodologies for air quality data are developing very rapidly, so we also provide details of some new ways of examining and nationally reporting UK's pollution levels.

9.1 Current UK air quality reporting systems

As we have seen in previous sections, the UK's air monitoring programmes produce very large amounts of data. However, in isolation, these raw data are of very limited utility. We first need to ensure that the data are accurate and reliable; this is a major quality control task, as highlighted earlier in Section 3.5. Once this key task has been completed, the validated data are archived; useful information can then be derived and communicated to government, technical, local authority and public users in timescales and formats meeting their needs. This high-level process of turning raw data into useful information, depicted in Figure 9.1, is vital to the success of the UK monitoring networks.

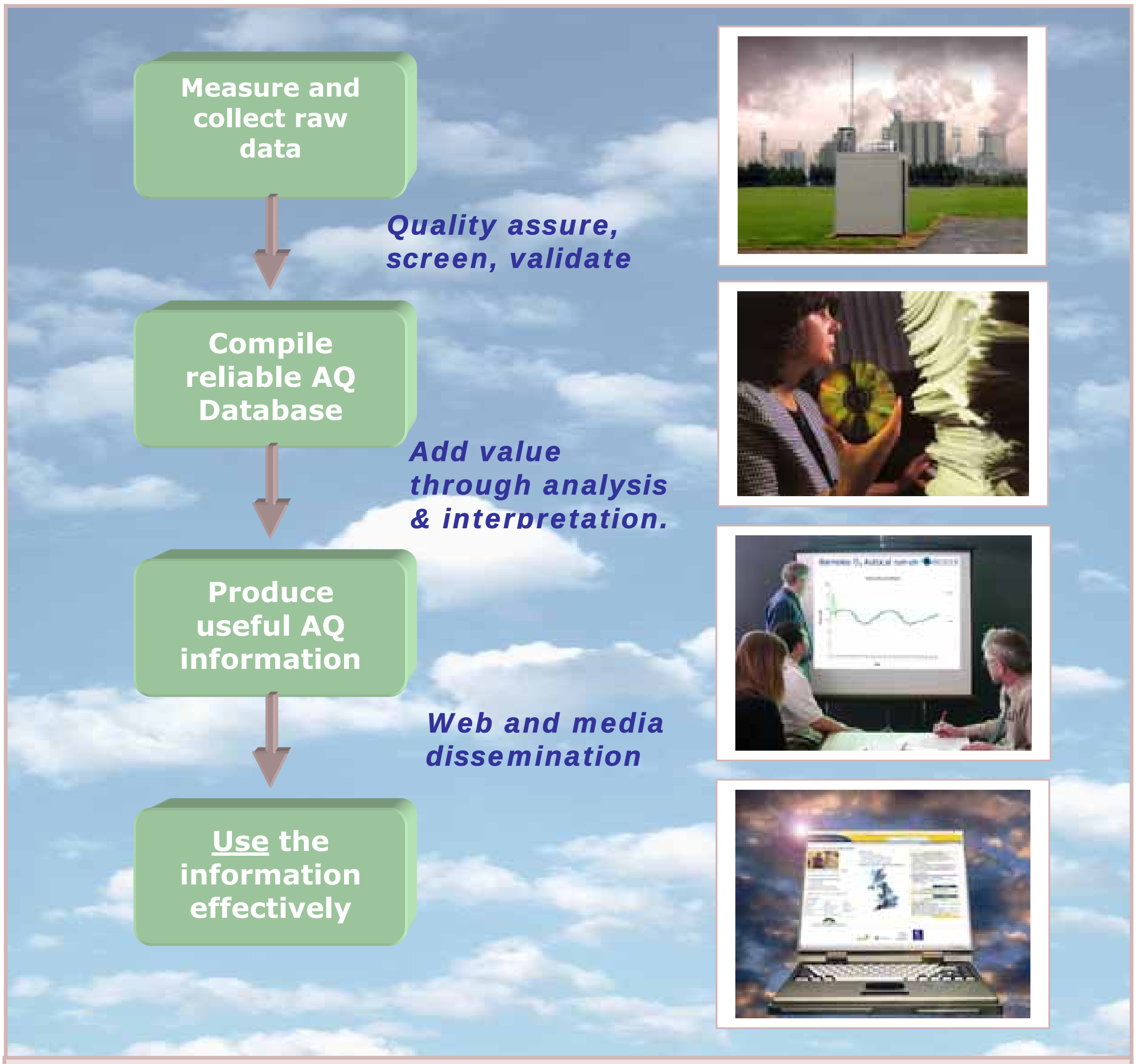


Figure 9.1 This report, as well as the UK Air Quality websites, is a key end-product of the process of turning large quantities of raw air quality data into user-friendly information

The UK's **Air Quality Archives** and **Air Quality Information Service** are our key tools enabling the widest access and use of air quality information in the UK.

The main functions of these systems are:

1. To inform citizens about the quality of the air we all breathe
2. To provide information to Local Government, for the purpose of planning and Local Air Quality Management (see Section 2.3)
3. To provide public warnings in the event of extreme conditions, as required by a number of EC Directives and Decisions
4. To raise awareness, inform and educate
5. To provide a comprehensive data and information resource to scientists, doctors and epidemiologists, both in UK and worldwide.

The UK's air quality archives and associated information services have evolved over many years to serve this wide diversity of end-user communities and objectives.

As noted in the introduction to this report, a primary objective of the UK's air quality monitoring networks is to provide rapid and reliable air quality information to the public. The Air Quality Information Services provide the main link between the networks and the public at large (Figure 9.1, Box 9.1). Data from all the UK's automatic monitoring stations are automatically collected every hour and uploaded to the UK's Air Quality Archive. Corresponding data from sampler measurements programmes are also collected and merged with the archive. The resulting archive contains over 200 million measurement and statistical records, making it one of the largest publicly accessible online databases in the world.

The UK's Air Quality Archive is also the national repository for historical ambient air quality measurements and emissions data. It contains measurements from automatic measurement programmes dating back to 1972, together with sampler measurements dating back to the 1960s. The Archive brings together into one coherent database both data and information from all the UK's measurement networks, as well as corresponding detailed emission data from the National Atmospheric Emissions Inventory (NAEI).

All data and information stored in the UK's Air Quality Archive are freely available at www.airquality.co.uk The website provides user-friendly but comprehensive access to information on all air pollutant concentrations and emissions, together with up-to-date bulletins and measurements from the UK national monitoring networks. It also provides a twice-daily air quality forecast, which is further disseminated via TV Teletext, newspapers and a free telephone service (0800 556677). Finally, the website offers many pages of background information and advice on air quality, together with links to other UK and international information resources. See Box 9.2 for further details of information available from the website. Three areas of this website provide more detailed access to additional information for both public and technical end-users of the website:

1) The external links page at www.airquality.co.uk/archive/related_sites.php
2) The UK research reports database at www.airquality.co.uk/archive/reports/list.php
3) Newly introduced - access to downloadable previous UK annual reports at www.airquality.co.uk/archive/annualreport/

Box 9.3 provides details of a matching information resource that has recently introduced specifically to meet the needs of Local Government at www.laqmsupport.org.uk.

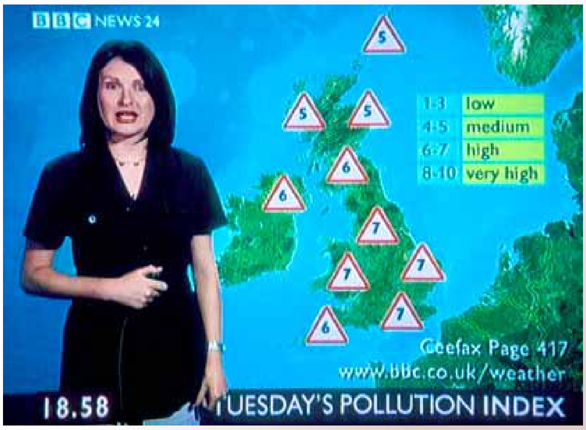
The UK's national air quality web site records over 4,000 hits each day and over 1.5 million every year. It also responds rapidly in providing data and reassurance during major pollution events. The Archive has become a key resource for education and research. It has received wide praise, both within the UK and internationally. A major re-design in 2006 made further improvements to the navigation, user-friendliness and overall usability of the site, as well as enhancing its accessibility to all communities.

The success of the UK Archive has led to the development of similar national archives for Scotland, Wales and Northern Ireland. In 2004, a new air quality archive was established for Wales. Publicly available through its website at www.welshairquality.org.uk, this mirrors many of the services and functions of the UK National Archive.

Fig 9.2 The UK Air Quality Information Service

This utilises a wide variety of media, web and electronic resources to disseminate the latest air quality data and forecasts:

TV Weather Bulletins



TV Teletext

The UK Air Quality Website

Twice daily web forecasts

A series of brochures & reports

Freephone 0800 556677

The UK Archive provides a comprehensive one-stop resource for data and analyses covering all aspects of air quality in the country. The site also includes measurements from a range of monitoring sites subject to QA/QC review comparable to that employed in the national networks. Major developments to the website, introducing new functionalities and further improving its user interface, have been completed in 2007.

With the Northern Ireland Archive www.airqualityni.co.uk going live in 2006 and the Scottish Archive www.scottishairquality.co.uk early in 2007, the family of UK Air Quality websites is now complete (Figure 9.3).

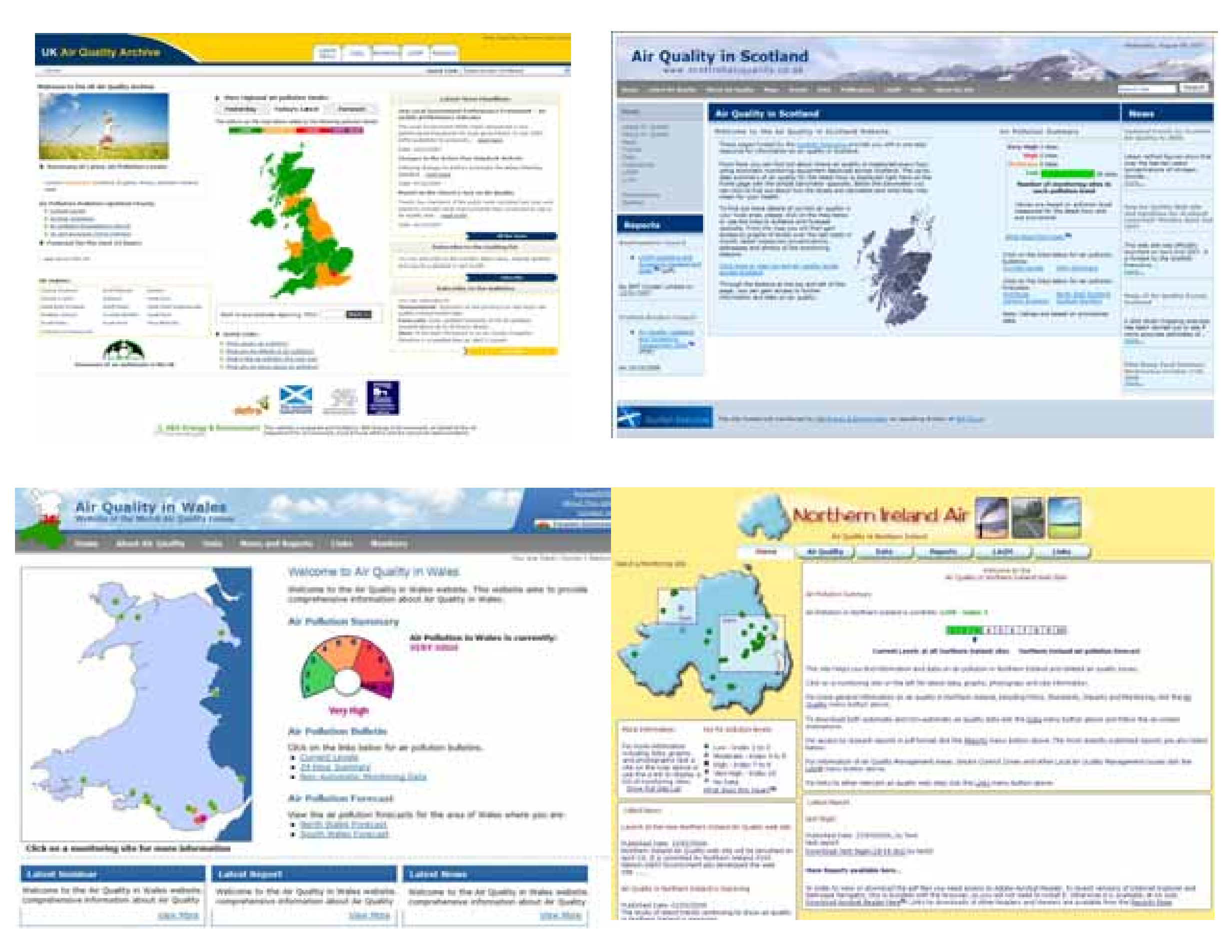


Figure 9.3 The family of UK, Scottish, Welsh and Northern Ireland websites was completed early in 2007

The evolution and development of UK Air Quality websites continue apace.

Under UK Government's Transformational Government Website Rationalisation, it is proposed to improve the quality of service by producing a more centralised and streamlined system of government websites.

At present, the plans are still in the proposal stage. For the time being, there will be no change to the service offered by www.airquality.co.uk. Whatever the outcome of this process, Government and its contractors remain totally committed to maintaining the very highest level of service to its many users in the UK and worldwide.

At present, there are no plans for this rationalisation process to apply to the corresponding Scottish, Welsh and Northern Ireland websites.

9.2 New approaches to air quality reporting

1) Google Earth™ and Google Maps™

The UK and Devolved Administration air quality websites are designed to disseminate information in a direct, user-friendly and intuitive manner. Recent developments to web data presentation and visualisation techniques are now providing ever more powerful ways of doing this.

A real time Google Earth™ interface was developed and implemented for the UK Archive in 2007. This allows users, after downloading and installing Google Earth and a simple data file, to directly access a real-time map of UK-wide pollution levels, as well as detailed information from over 130 automatic monitoring stations throughout the UK. Web users can simply click on any site icon to obtain graphs, current pollution levels, site pictures and other useful information (see Figure 9.4 below). Similar systems are under development for other Devolved Administration and Local Government websites.

We hope this will be the first of many developments to the UK national air quality archives, exploiting new Geographical Information Systems (GIS) and mapping technologies such as Google Earth™ and Google Maps™ in order to more effectively convey information to our many public and technical end-users. Further developments are planned for 2008.

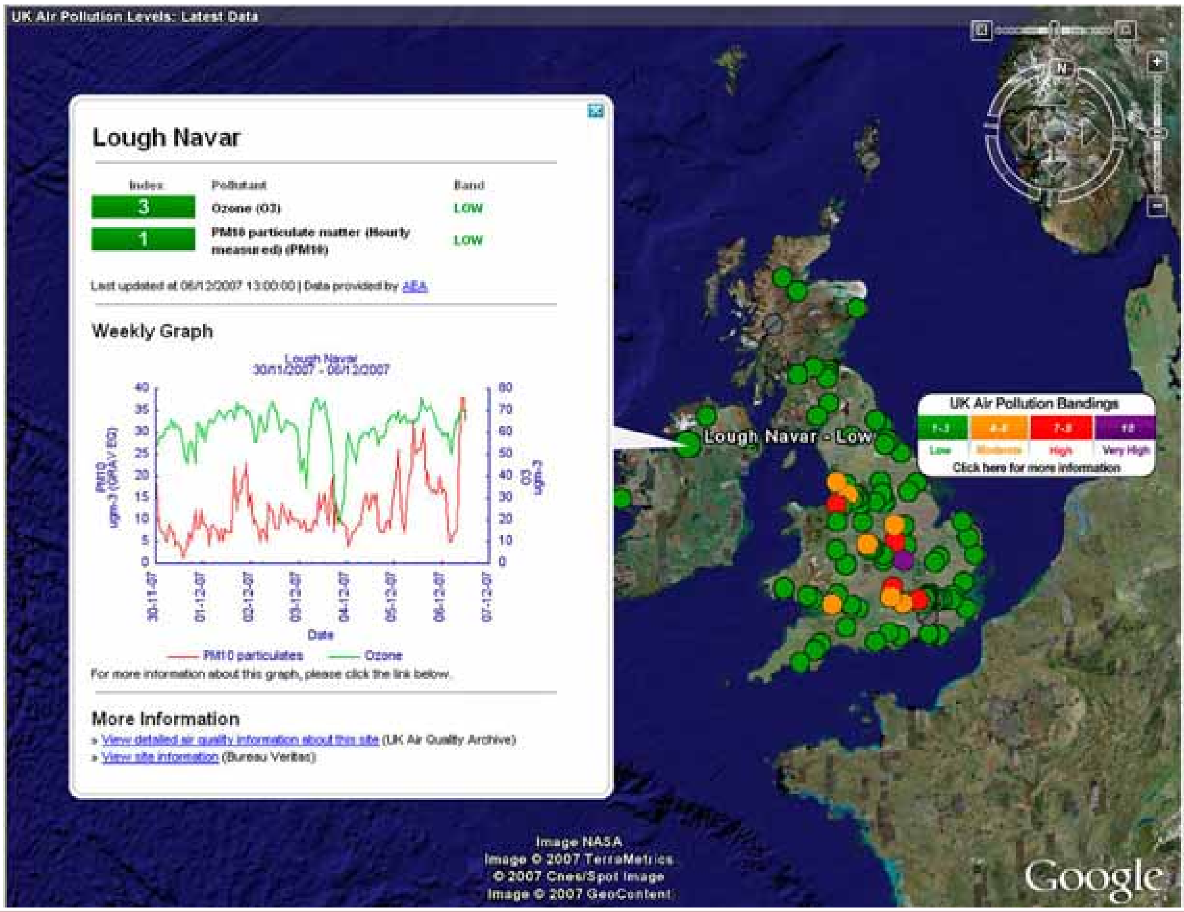


Figure 9.4 Google EarthTM and similar GIS technologies are now making possible more powerful and immersive ways of presenting air quality data

2) Strictly kid's stuff…web resources for children

User-friendliness and accessibility are key design features of all of the UK's national air quality websites.

Taking this idea a step further is an exciting add-on to the existing Northern Ireland website at www.airqualityni.co.uk (Fig 9.5). This new content, labelled 'Kids' Corner' is designed to meet the emerging curricular needs of schoolchildren, as well as raising awareness of air pollution in the coming generations.

Designed in colourful and attention-grabbing cartoon form, it contains useful information for children on all aspects of air pollution and climate change, as well as including an interactive quiz to see how much they have learnt. Above all, it's intended to be fun as well as informative.

It is hoped in future to roll out similar content to other UK air quality websites.

Figure 9.5 New types of web resource are aimed at raising children's awareness of air pollution in the UK

3) New Media Services- Sky TV

Air quality and forecast data have been routinely provided to the BBC for many years, together with hourly data for ITV's TELETEXT service (Figure 9.6). This ongoing service enables serious pollution episodes – such as the photochemical smogs of 2003 – to receive wide media and public attention.

In the latest development, AEA is providing Sky News with detailed information on local and national air quality, together with matching data analyses and comprehensive regional forecasts for the next 24 hours. This information, broadcast twice-daily, is the first of its type to be disseminating on digital satellite television (Figure 9.6)

Figure 9.6 Air quality data and forecasts are now broadcast twice daily on Sky News (courtesy BSkyB Corporation and Sky News- and thanks to Lucy Verasamy!) ©Andi Southam

4) State of the Environment websites

Over the last few years, the web has become an increasingly important and powerful way of reporting air quality to the public, media and technical end-user communities**.** However, such information need not always be disseminated through dedicated air quality websites. As an example, a revolutionary new State of the Environment Website, developed for the Thames Region of the Environment Agency, went live in late 2007 at www.ea-soe.co.uk (Fig 9.7).

Unlike the dedicated air quality websites that have been developed for Defra and the Devolved Administrations, this state-of-the-art interactive website reports - in a wide range of compact and user-friendly formats – the latest information about environmental quality throughout the Thames Region.

The website uses a wide range of indicators to measure the overall health of the environment and to assess trends. There are 35 indicators in all; these are grouped into seven broad media areas covering: air quality, inland and coastal water quality, waste management, water resources, flood risk, climate change, biodiversity and land quality. For all these parameters, the website provides comprehensive information on current environmental quality, trends, targets, pressures and regulations. As well as offering synoptic information, full download of datasets is possible for more advanced user communities.

The website has been designed from the outset to provide customised and user-friendly information appropriate to the needs of the general public, as well addressing the specific needs of designated user communities such as home owners, sports and leisure, students and so on. It provides the public at large with a 'one-stop-shop' for accessing information on the quality of the environment in their Region, and what they can do to improve it over time.

Figure 9.7 The new Environment Agency (Thames Region) State of the Environment website provides a one-stop source of many types of environmental data

Box 9.1 Key Online and Media Information Resources on UK Air Pollution

1) How to obtain up-to date air quality information and forecasts for your area

- The Air Pollution Information Service on freephone 0800 556677
- The UK Air Quality Archive on www.airquality.co.uk
- The Welsh Air Quality Archive at www.welshairquality.org.uk
- The Northern Ireland Archive at www.airqualityni.co.uk
- The Scottish Air quality Archive at www.scottishairquality.co.uk
- Latest forecasts, issued twice daily, at http://www.airquality.co.uk/archive/uk_forecasting/apfuk_home.php
- The National Atmospheric Emissions Inventory on www.naei.org.uk
- The Defra air quality information web resource on http://www.defra.gov.uk/environment/airquality/index.htm
- The Scottish Government Air Quality pages on http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561
- The Welsh Assembly Government Environment link at http://www.wales.gov.uk/subienvironment/index.htm
- The Northern Ireland DoE Environmental Policy Division website at http://www.doeni.gov.uk/epd
- Teletext page 156

2) Useful sources of background information

A colourful brochure 'Air Pollution in the UK', suitable for educational or public use, is available from Defra Publications at: defra@cambertown.com or 08459 556000. This can also be downloaded from the UK Archive website.

A corresponding brochure 'Air Pollution in Wales' may be downloaded from the Welsh Archive website, as detailed above.

A brochure and report on Air Pollution in Northern Ireland is available from the DoE NI website at http://www.doeni.gov.uk/foi/search/

A comprehensive range of air quality research reports is available from http://www.airquality.co.uk/archive/reports/list.php

3) Health effects of air pollution

A concise brochure entitled ***'Air Pollution, what it means for your health'*** is available to download from the Defra air quality information web resource listed above or free of charge from Defra publications or via Freephone.

4) Local air quality issues

For further information on air quality issues in your area, please contact the Environmental Health Department at your local Council office.

Further information on Local Air Quality Management may also be found at:
http://www.defra.gov.uk/environment/airquality/laqm.htm and
http://www.airquality.co.uk/archive/laqm/laqm.php
http://www.scotland.gov.uk
http://www.airqualityni.co.uk/laqm_sca.php

Box 9.2 Information available from the UK Air Quality Archive at www.airquality.co.uk (and corresponding URLs)

- Historic measurements from all national sampler and automatic air monitoring programmes
- A one-stop-shop describing the UK's air monitoring programmes and linking to many websites for the different networks
- Current measurements from automatic networks, speedily available for all UK countries, regions and urban areas
- Detailed air pollution statistics derived from all current and historic data and available via interactive selections
- Twice-daily regional forecasts of air quality
- Maps, photographs and descriptions of all automatic network stations
- Information on causes and effects of the major air pollutants
- Details of UK and international efforts taken to tackle air pollution
- A database of Frequently Asked Questions (FAQs) and answers related to air pollution
- Search-driven information and access to reports covering a wide range of Air Pollution issues
- Background information on a range of Local Air Quality Management (LAQM) issues including:
    - Air Quality Management Areas
    - LAQM tools
    - Helplines
    - Reports and FAQs
- Links to the National Atmospheric Emissions Inventory (NAEI) site which offers:
    - Information on how the inventory has been prepared
    - A data warehouse of emission factors and inventory tools
    - UK–wide maps of emissions of the major pollutants (1km resolution)
    - Mapped emissions for different source types - industrial, transport etc
    - A powerful search facility for finding local emissions by postcode input
    - Information on a broad range of climate change issues
- A range of useful links to air pollution data resources, organisations and information in the UK, Europe and worldwide

Box 9.3 Information for local government at www.laqmsupport.org.uk

This new site, provided on behalf of Defra and the Devolved Administrations, provides Local Authorities with access to advice and information on air quality monitoring, air quality modelling, and emissions inventories. It offers:

- Downloadable tools and guidance to assist with the entire Local Air Quality Management process
- The latest updates to Defra's Technical Guidance
- Guidance on use of NO_2 diffusion tubes, and a link to the NO_2 Web-Based Data Entry System, which provides Local Authorities with a convenient and reliable way of storing and sharing their diffusion tube data.
- Frequently Asked Questions
- Links to other useful websites, such as the Action Plan Appraisal Helpdesk and the Review and Assessment Helpdesk.

The Local Authority Air Quality Support Helpdesk can also be contacted by telephone on 0870 190 6050 and by e-mail on lasupport@aeat.co.uk.

Air Pollution in the UK: 2007

Part 2

In this statistical part of the report, we provide a detailed summary of the measurements made for each pollutant at every monitoring site in the Automatic Urban and Rural Network (AURN) and Automatic Hydrocarbon Network.

We also include information on measurement techniques, data quality requirements and relevant limit values and objectives within the UK and throughout Europe.

We devote one section to each pollutant. A map shows the locations of the monitoring stations. This is followed by graphs showing variations in pollutant concentrations throughout the day and over the year as a whole, as well as trend plots showing long-term changes in concentrations over many years.

Finally, we include table summarising measurements and exceedences of the UK Air Quality objectives during 2007.

In all data tables, the following abbreviations are used to denote various types of monitoring site locations:

KS = kerbside	RS = roadside	UC = urban centre
UB = urban background	UI = urban industrial	S = suburban
RU = rural	RE = remote	A = airport

10. Benzene-Measurement Sites, Instrumentation and Statistics

10.1 Measurement Method

Benzene is measured using automated Gas Chromatograph or BTEX monitors; these measure concentrations of benzene, toluene, ethylbenzene and xylene isomers as well as 1,3-butadiene. This type of instrument uses an adsorption tube for sample collection.

10.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Environnement VOC 71M
- Perkin Elmer OPA

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

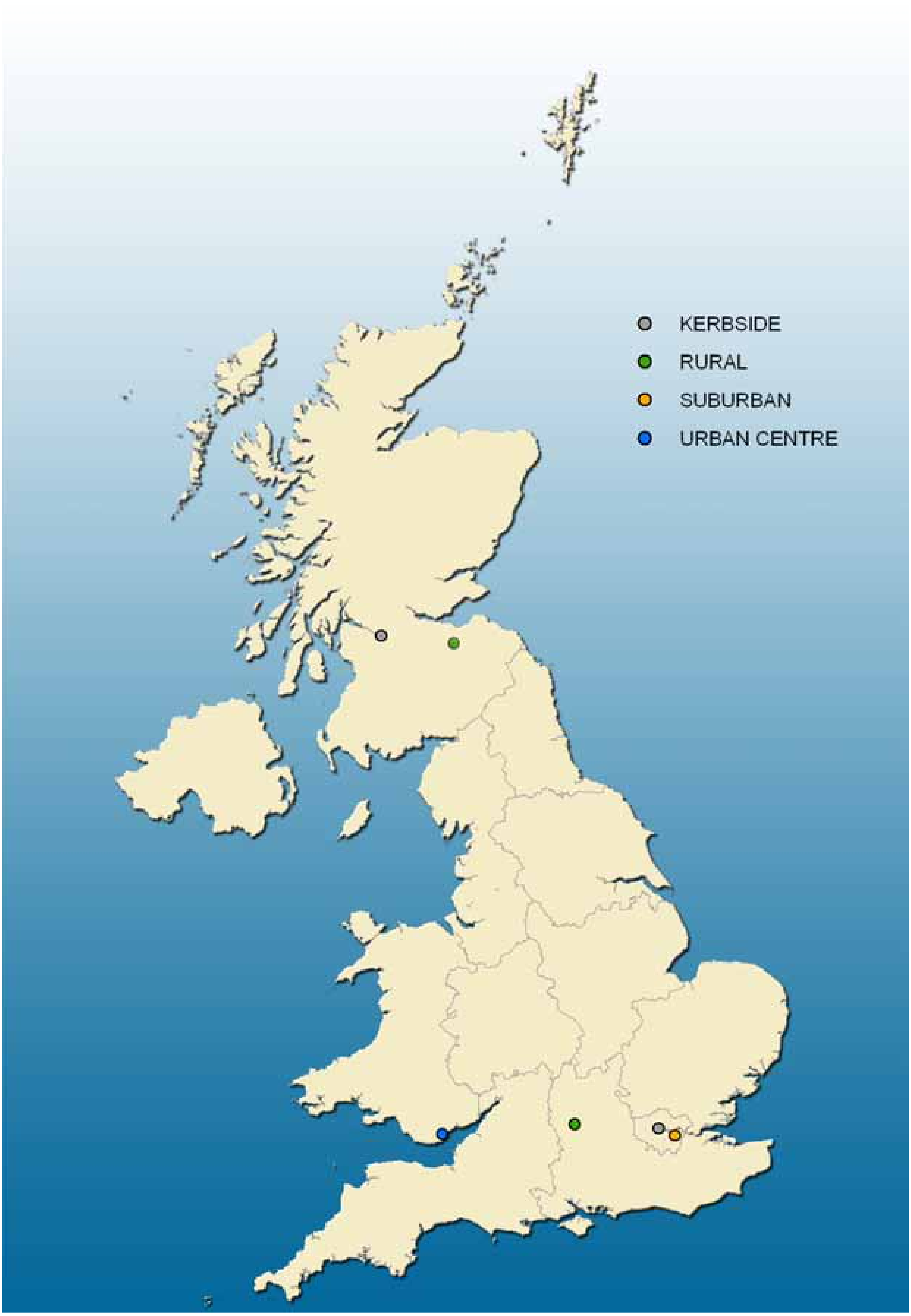
10.3 Data Quality Requirements of EC Directive 2008/50/EC for Benzene

Uncertainty 15%
Minimum data capture 90%

10.4 Objectives and Bandings

Summary of objectives of Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Benzene	16.25 µg m^3	Running Annual Mean	31 December 2003
England and Wales only	5 µg m^{-3}	Annual Mean	31 December 2010
Scotland and Northern Ireland only	3.25 µg m^{-3}	Maximum Running Annual Mean	31 December 2010

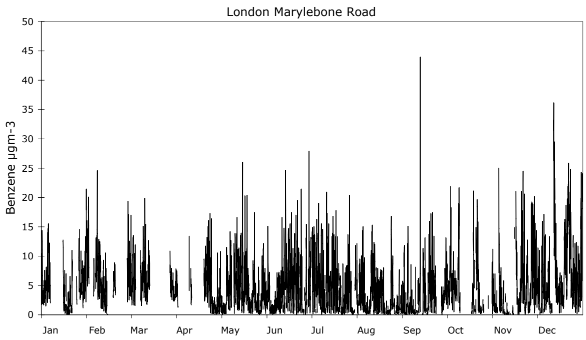
No bandings are set for benzene, as there are no known short-term health effects for this pollutant.



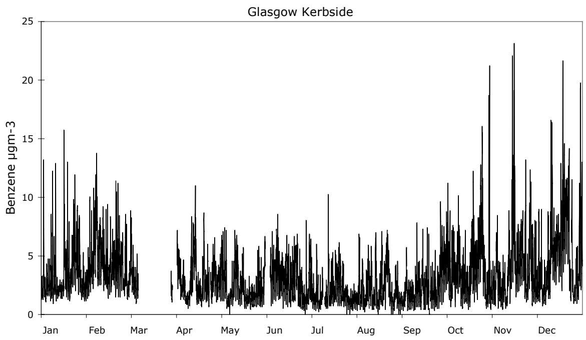
UK Automatic Benzene Monitoring Sites 2007

10.5 Hourly Average Concentrations

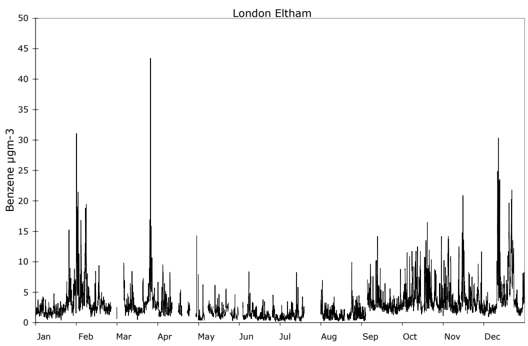
These figures show time series graphs of hourly average benzene concentrations at four monitoring sites of different types, for 2007.



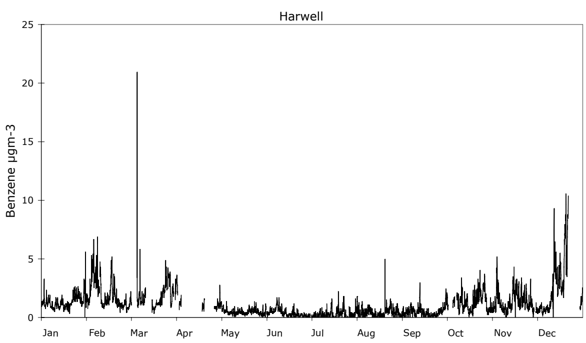
Kerbside Site
(London Marylebone Road)



Kerbside Site
(Glasgow Kerbside)



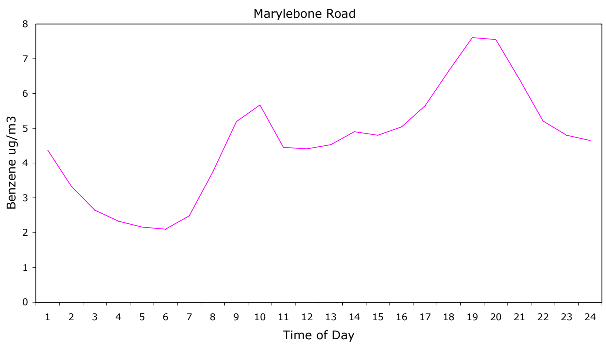
Suburban Site
(*London Eltham*)



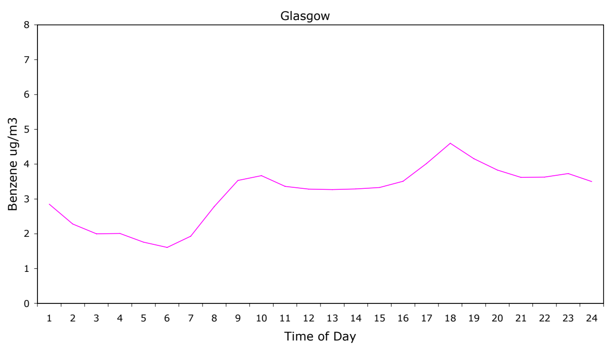
Rural Site
(*Harwell)*

10.6 Diurnal Variations

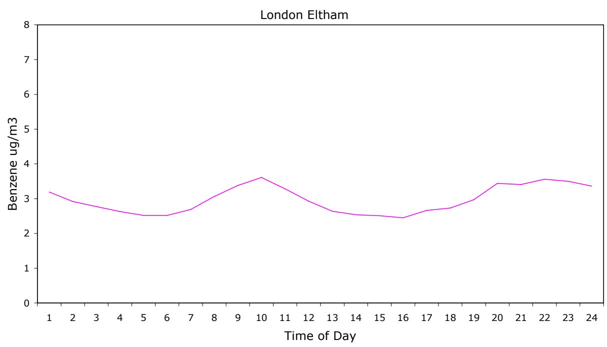
These figures show how benzene concentrations varied on average for each hour of day during 2007, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



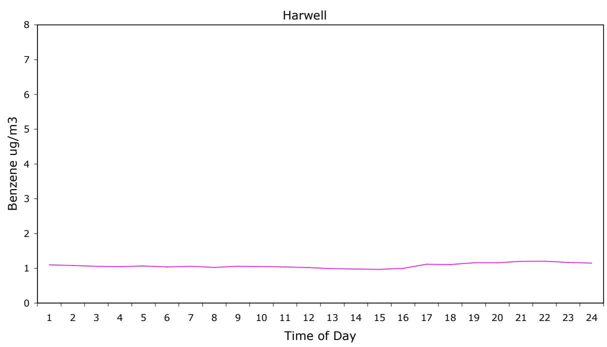
Kerbside Site
(London Marylebone Road)



Kerbside Site
(Glasgow Kerbside)



Suburban Site
(*London Eltham*)

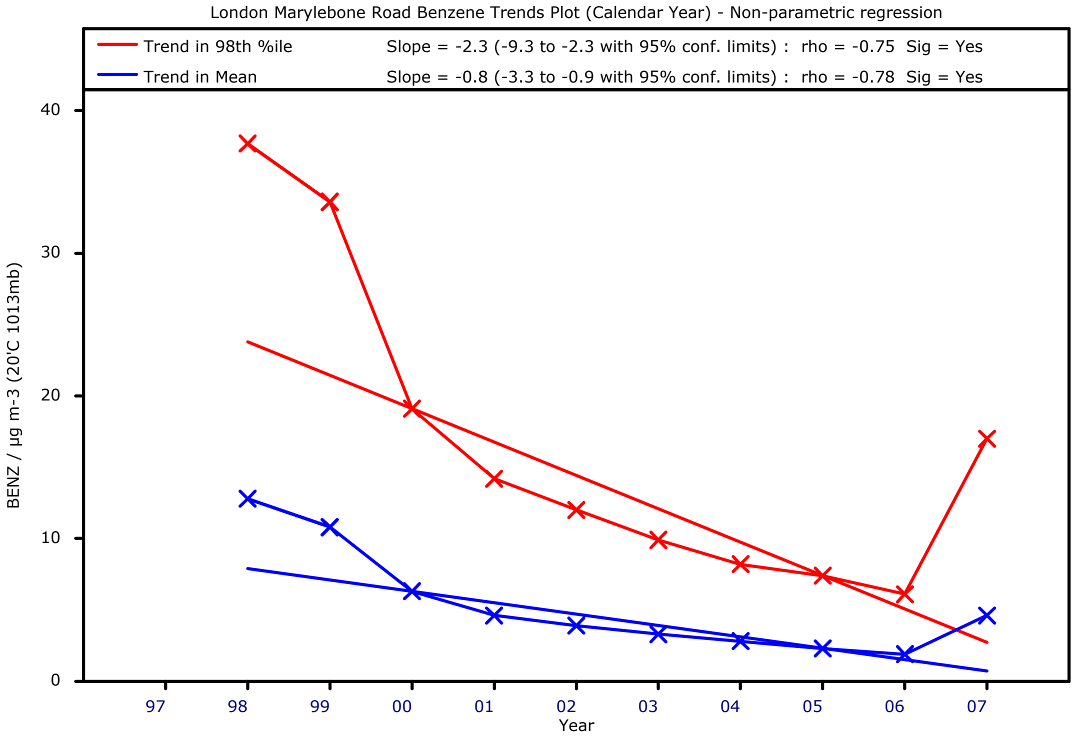


Rural Site
(*Harwell)*

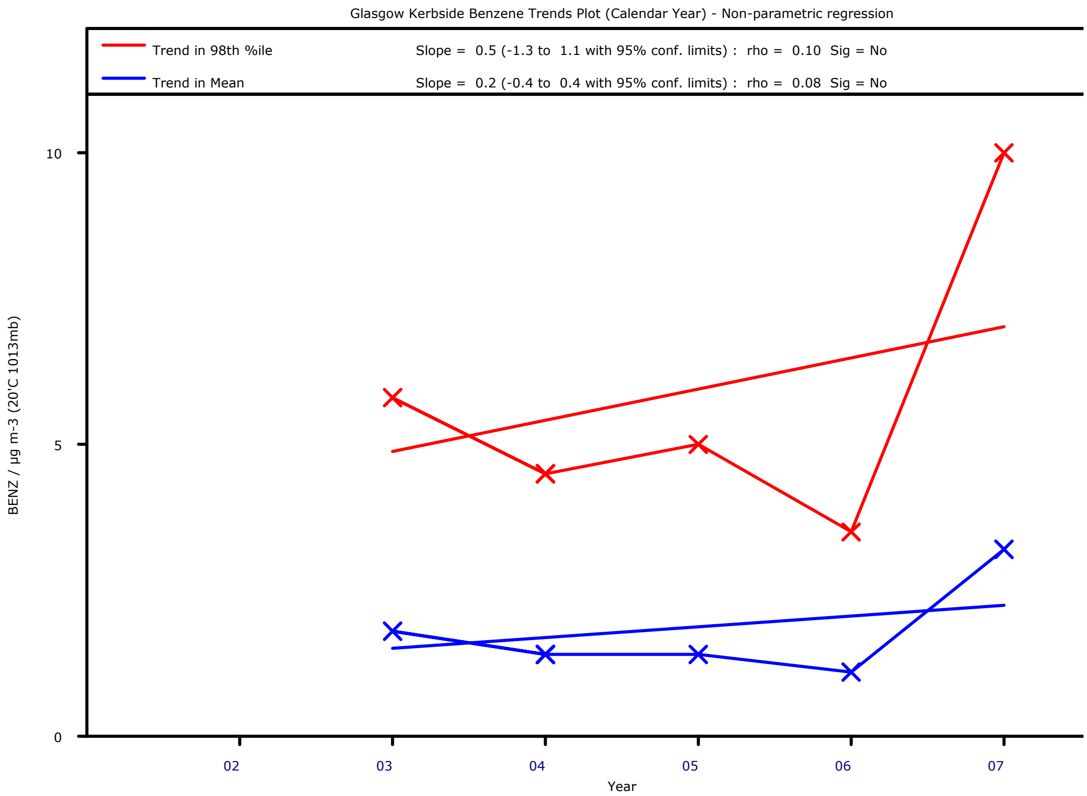
10.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

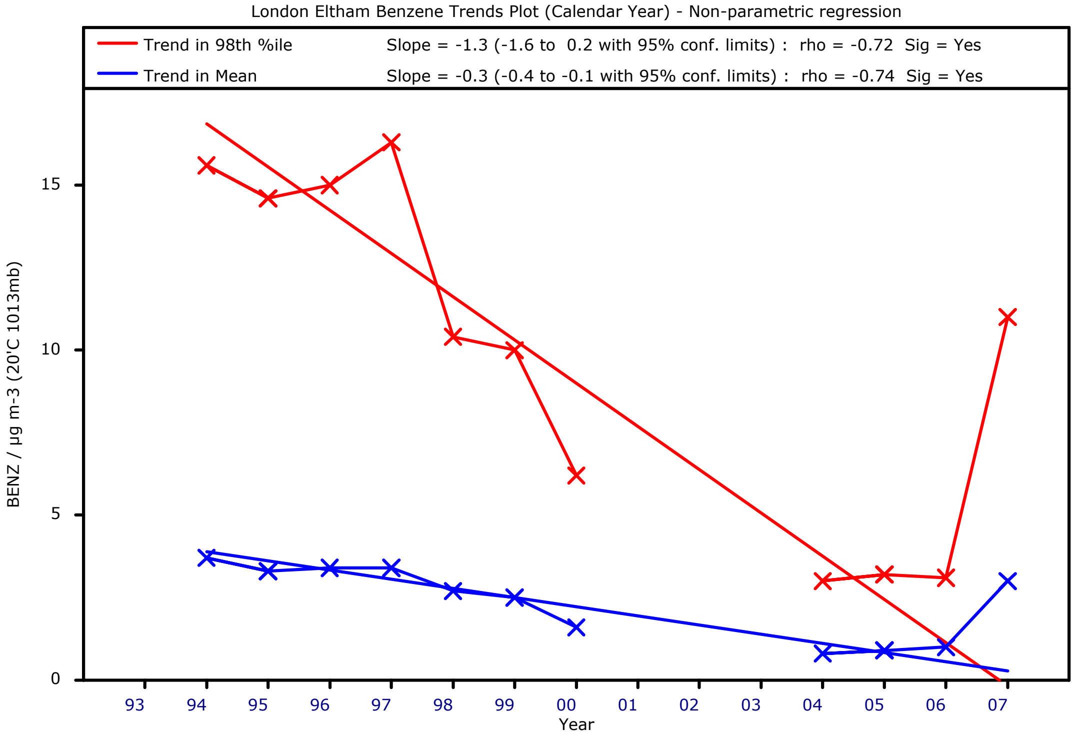
London Marylebone Road Benzene Trends Plot – Non-parametric regression



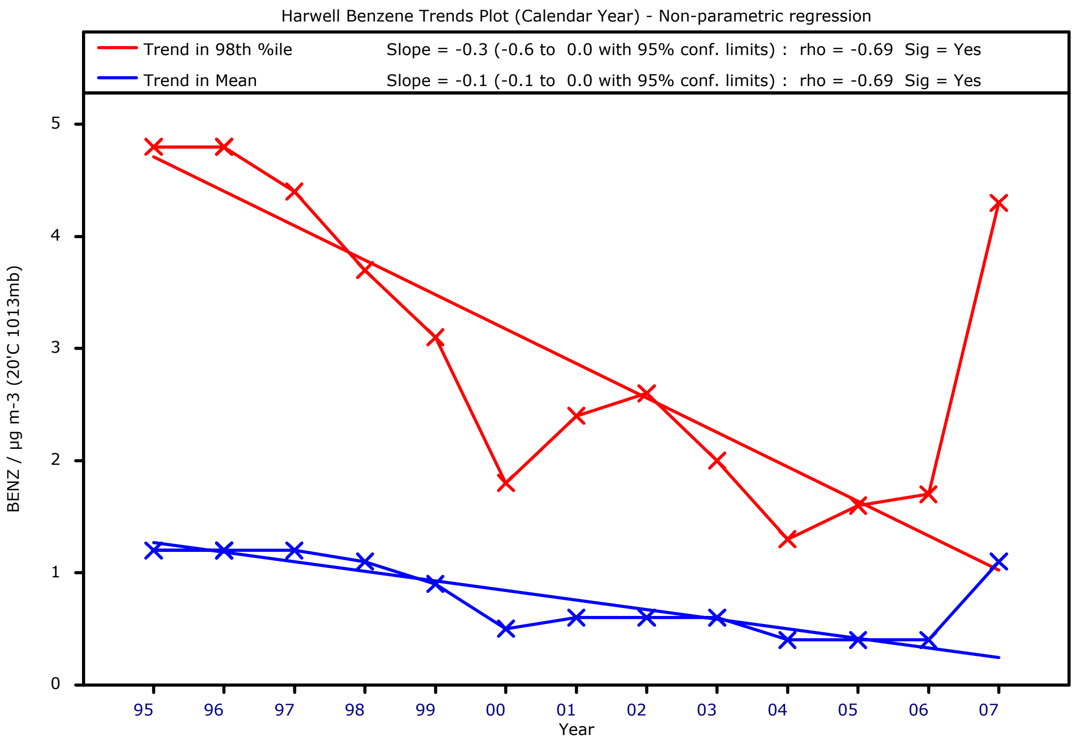
Glasgow Kerbside benzene Trends plot – Non-parametric regression



London Eltham Benzene Trends Plot – Non-parametric regression



Harwell Benzene Trends Plot – Non-parametric regression



10.8 Benzene Statistical Summary 2007

i) Benzene Annual Statistics

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England				
Harwell	RU	1.08	84.3	20.93
London Eltham	S	2.97	84.3	46.80
London Marylebone Road	KS	4.61	67.3	43.94
Scotland				
Auchencorth Moss	RU	---	0.0	---
Glasgow Kerbside	KS	3.15	90.5	23.14
Wales				
Cardiff Centre	UC	1.62	66.0	25.68

ii) Benzene Exceedence Statistics

Site	Air Quality Standard > 16.3 µg m^{-3}	Days	EC Directive and Air Quality Standard (England and Wales) > 5 µg m^{-3}	Annual Mean Standard (Scotland) > 3.3 µg m^{-3}
England				
Harwell	0	0	0	0
London Eltham	0	0	0	0
London Marylebone Road	0	0	0	**1 ***
Scotland				
Glasgow Kerbside	0	0	0	0
Auchencorth Moss	-	-	-	-
Wales				
Cardiff Centre	0	0	0	0

* Not applicable, as this site is not in Scotland.

11. 1,3-Butadiene- Measurement Sites, Instrumentation and Statistics

11.1 Measurement Method

1,3-Butadiene is measured using automated GC or BTEX monitors; these measure concentrations of benzene, toluene, ethylbenzene and xylene isomers as well as 1,3-butadiene. This type of instrument uses an adsorption tube for sample collection.

11.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Environnement VOC 71M
- Perkin Elmer OPA

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

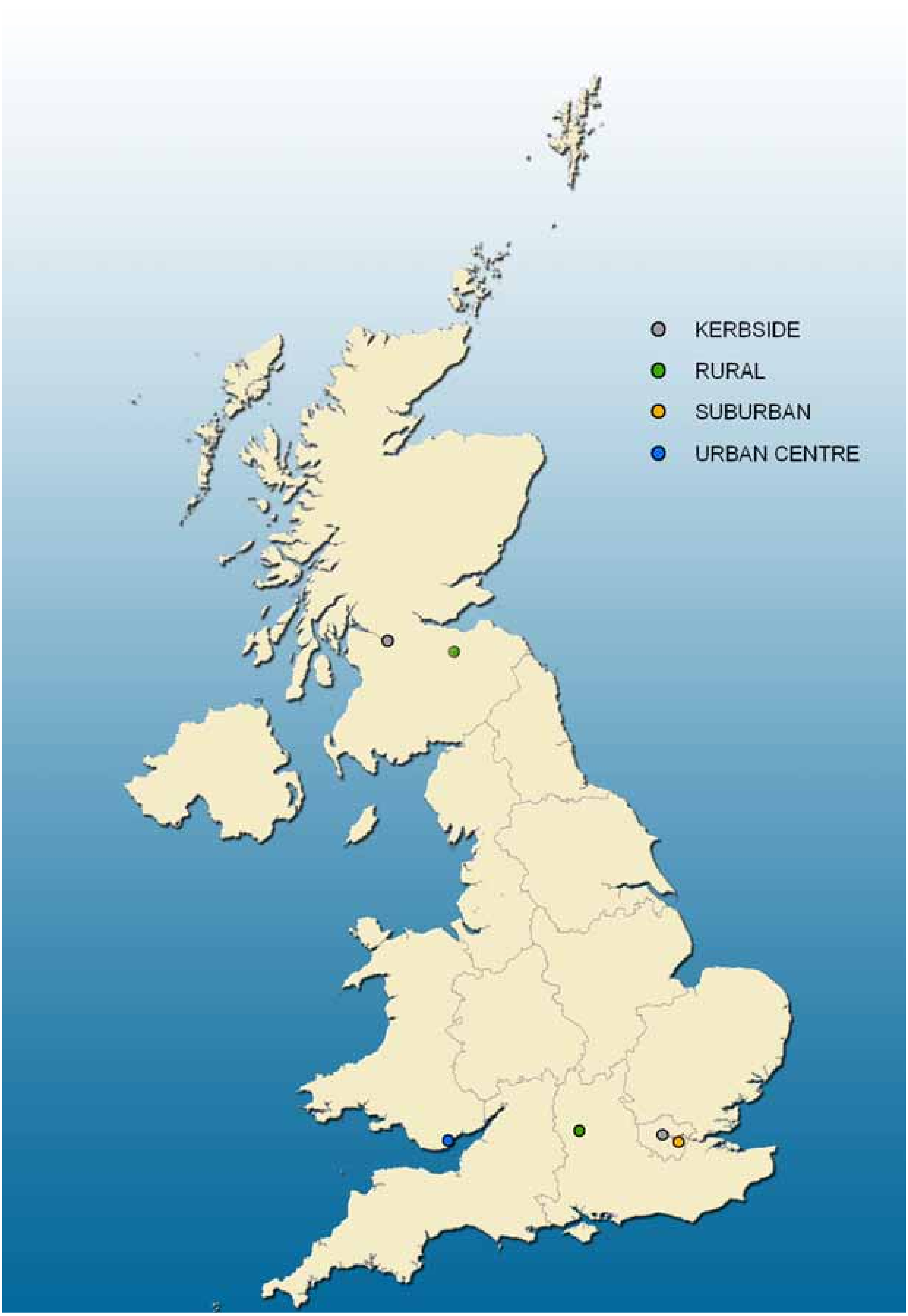
11.3 Data Quality Requirements of EC Directive 2008/50/EC for Benzene

Uncertainty 15%
Minimum data capture 90%

11.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
1,3-Butadiene	2.25 µg m^{-3}	Maximum Running Annual Mean	31 December 2003

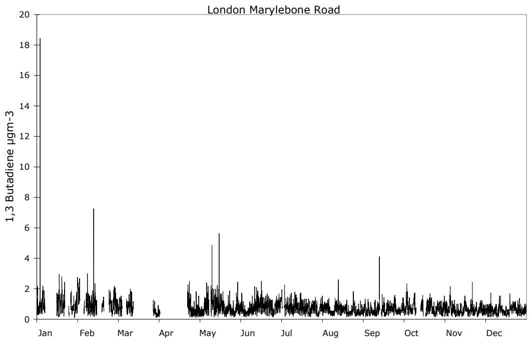
No bandings are set for 1,3-Butadiene, as there are no known short-term effects of this pollutant.



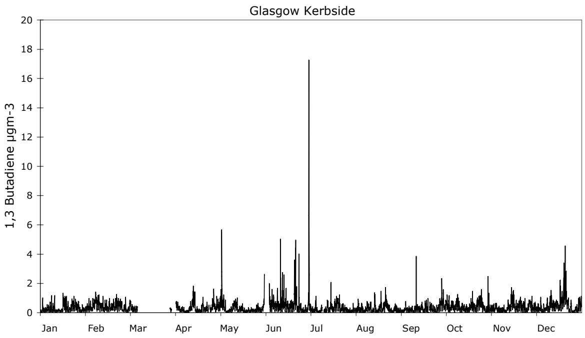
UK Automatic 1,3-Butadiene Monitoring Sites 2007

11.5 Hourly Average Concentrations

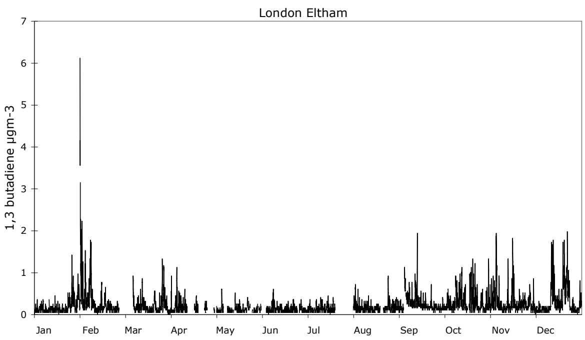
These figures show time series graphs of hourly average 1,3-Butadiene concentrations at four monitoring sites of different types, for 2007.



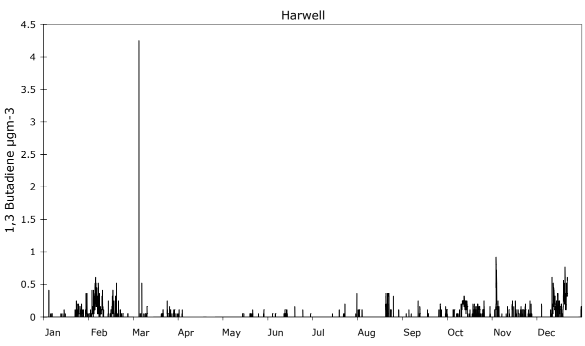
Kerbside Site
(London Marylebone Road)



Kerbside Site
(Glasgow Kerbside)



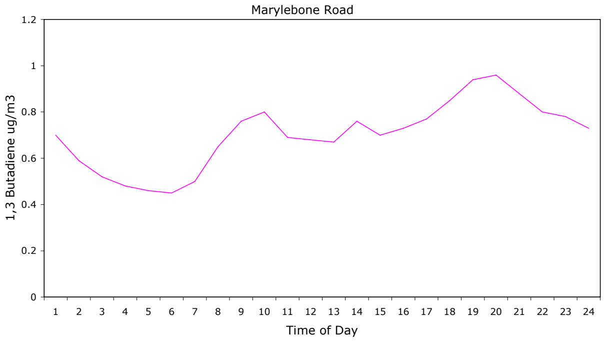
Suburban Site
(*London Eltham*)



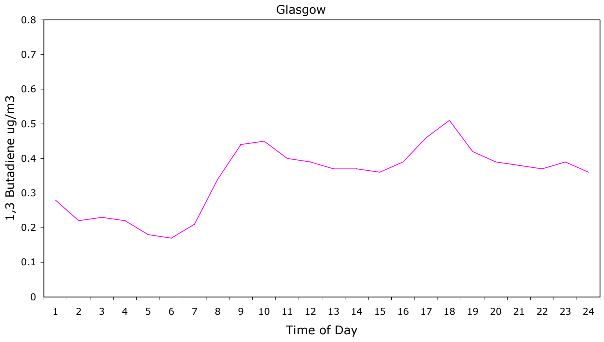
Rural Site
(*Harwell)*

11.6 Diurnal Variations

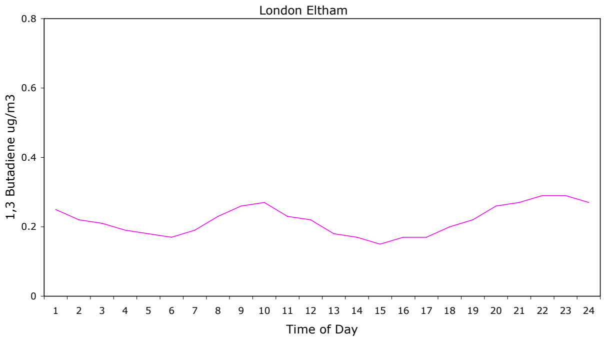
These figures show how 1,3-Butadiene concentrations varied on average for each hour of day during 2007, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



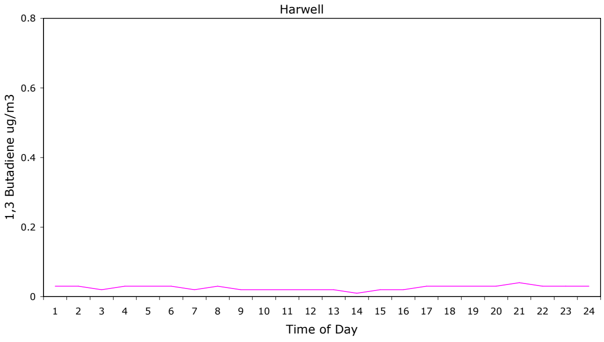
Kerbside Site
(London Marylebone Road)



Kerbside Site
(Glasgow Kerbside)



Suburban Site
(*London Eltham*)

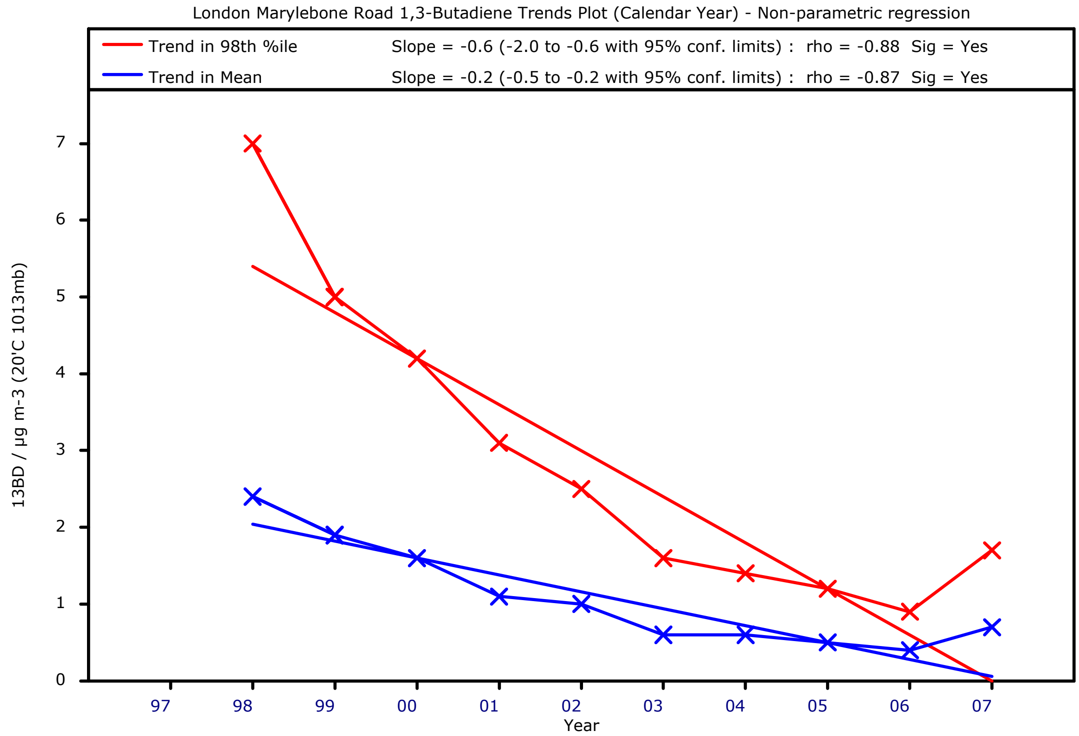


Rural Site
(*Harwell)*

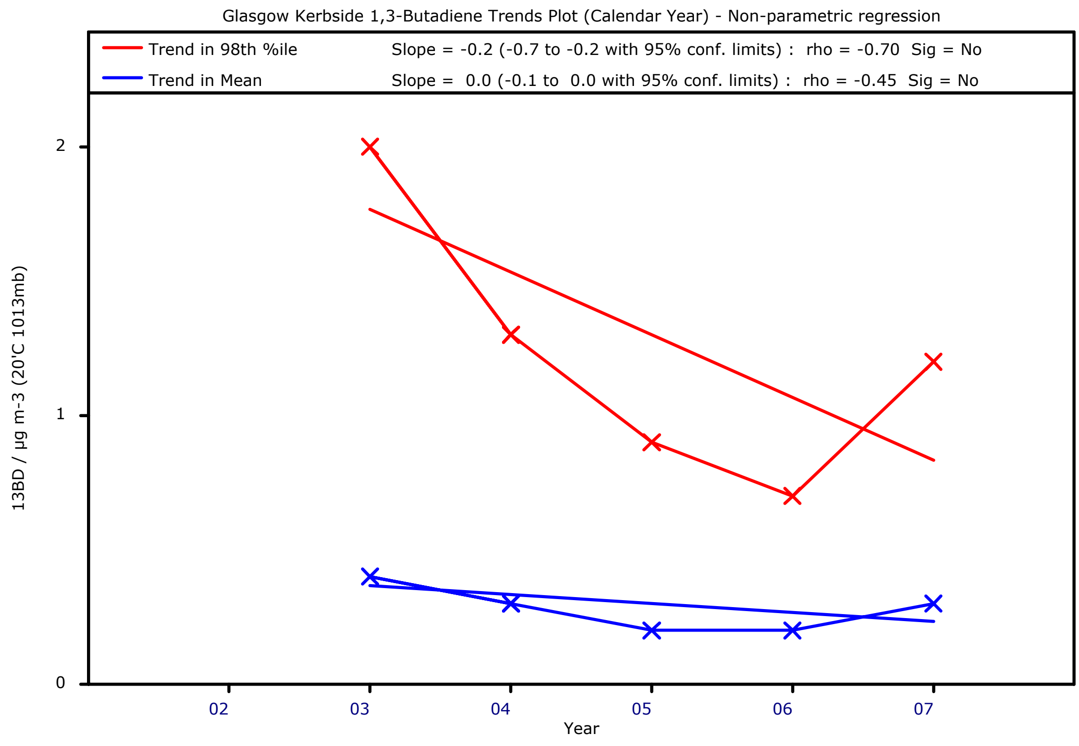
11.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

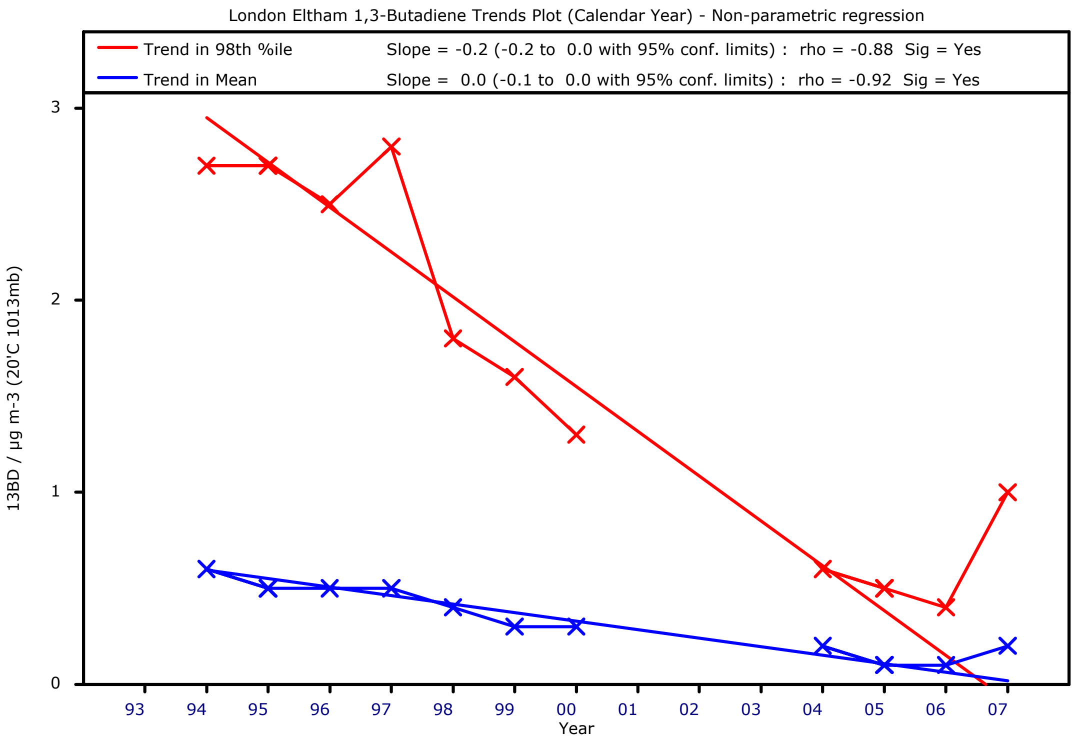
London Marylebone Road 1,3-Butadiene Trends Plot – Non-parametric regression



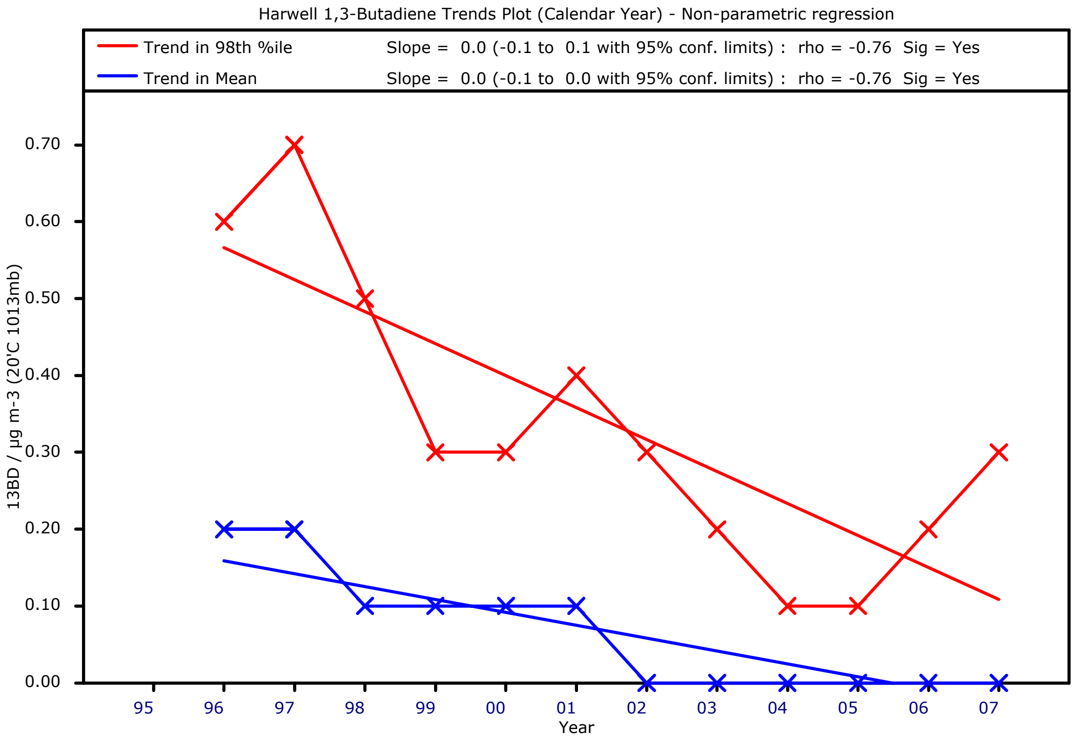
Glasgow Kerbside 1,3-Butadiene Trends plot – Non-parametric regression



London Eltham 1,3-Butadiene Trends Plot – Non-parametric regression



Harwell 1,3-Butadiene Trend Plot - Non-parametric regression



11.8 1,3-Butadiene Statistical Summary 2007

i) 1,3-Butadiene Annual Statistics

Site	Site Type	Annual Average of hourly means	Annual data capture of hourly means %	Maximum hourly mean
England				
Harwell	RU	0.03	84.3	4.25
London Eltham	S	0.22	82.6	6.12
London Marylebone Road	KS	0.70	77.8	18.43
Scotland				
Auchencorth Moss	RU	0.03	62.0	0.65
Glasgow Kerbside	KS	0.34	90.5	17.26
Wales				
Cardiff Centre	UC	0.10	66.9	4.61

ii) 1,3-Butadiene Exceedence Statistics

Site	Air Quality Standard > 2.3 µg m^{-3}	Days
England		
Harwell	0	0
London Eltham	0	0
London Marylebone Road	0	0
Scotland		
Auchencorth Moss	0	0
Glasgow Kerbside	0	0
Wales		
Cardiff Centre	---	---

12. CO - Measurement Sites, Instrumentation and Statistics

12.1 Measurement Method

CO concentrations in ambient air are measured by the absorption of infrared radiation at 4.5 to 4.9 μm wavelength. A reference detection system is used to alternately measure absorption due to CO in the sampled air stream and absorption by interfering species. An infrared detector and amplification system produces output voltages proportional to the CO concentration.

12.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak CO
- API M300
- Environnement SA 11M
- Horiba APMA 350E
- Horiba APMA 360
- Monitor Labs 9830
- Rotork 416
- Thermo Electron 48

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

12.3 Data Quality Requirements of EC Directive 2008/50/EC for CO

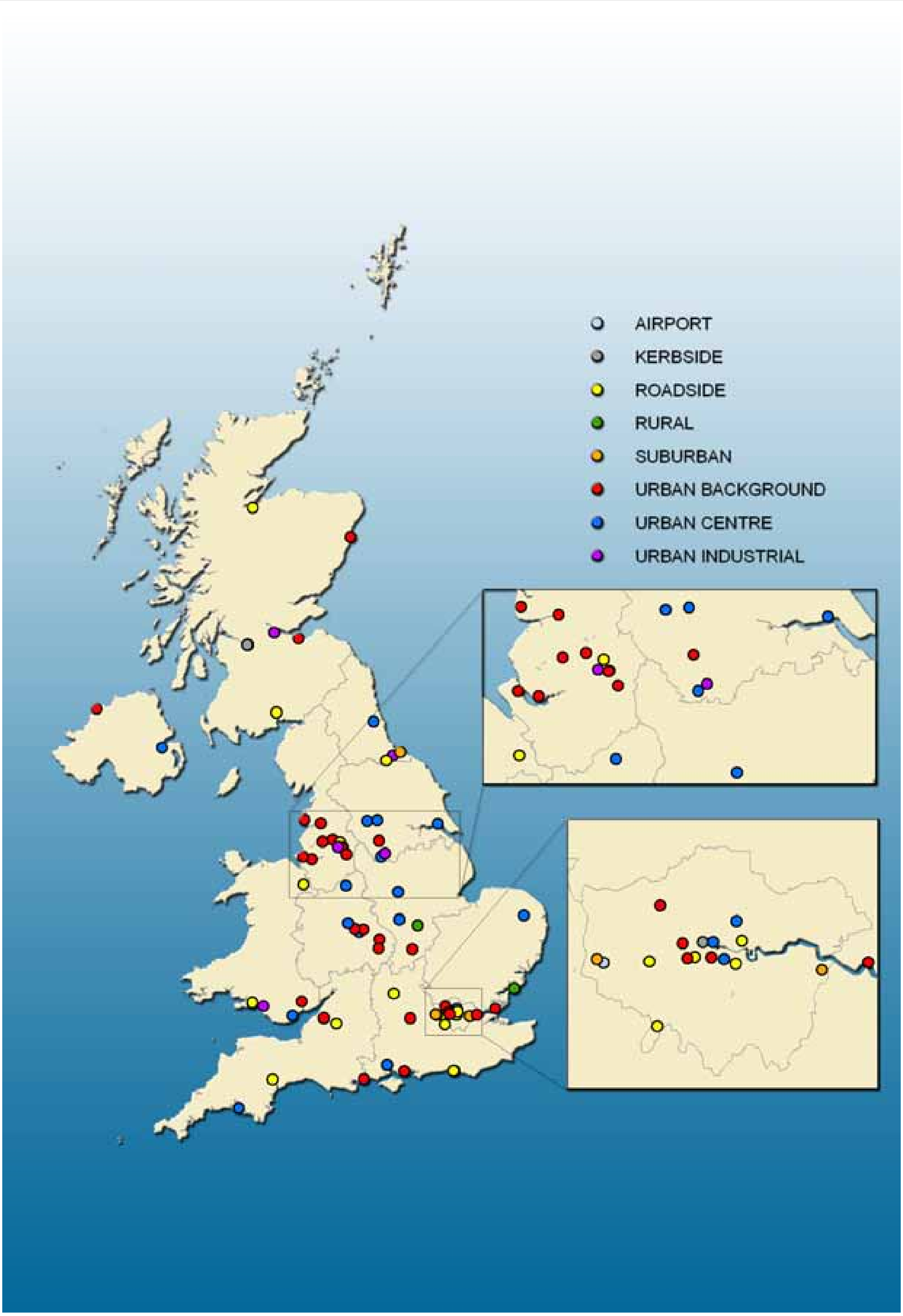
Uncertainty 15%
Minimum data capture 90%

12.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Carbon Monoxide England and Wales	10.0 mg m^{-3}	Maximum daily running 8 Hour Mean	31 December 2003
Scotland only	10.0 mg m^{-3}	Running 8 Hour Mean[a]	31 December 2003
Northern Ireland only	10.0 mg m^{-3}	Maximum daily running 8 Hour Mean	1 January 2005

a. The Quality Objective in Scotland has been defined in Regulations as the running 8-hour mean, in practice this is equivalent to the maximum daily running 8-hour mean

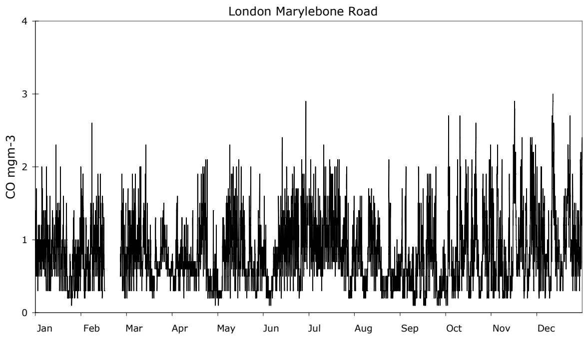
Air Quality Bands and Index Values		
Band	**Index**	**Carbon Monoxide mg m^{-3}**
Low	1	0-3.8
	2	3.9-7.6
	3	7.7-11.5
Moderate	4	11.6-13.4
	5	13.5-15.4
	6	15.5-17.3
High	7	17.4-19.2
	8	19.3-21.2
	9	21.3-23.1
Very High	10	23.2 or more



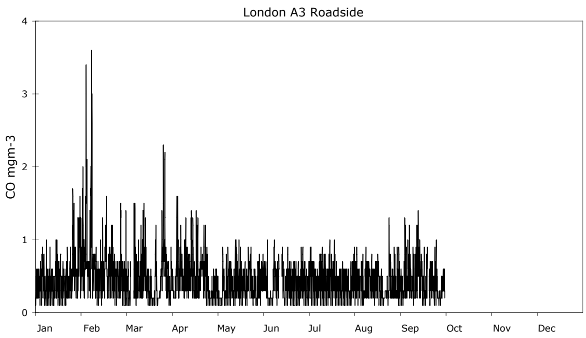
UK Automatic Carbon Monoxide Monitoring Sites 2007

12.5 Hourly Average Concentrations

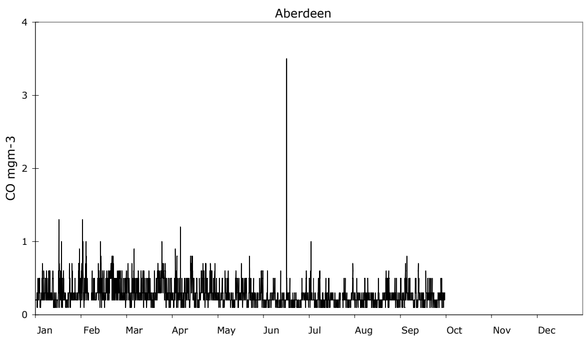
These figures show time series graphs of hourly average carbon monoxide concentrations at four monitoring sites of different types, for 2007.



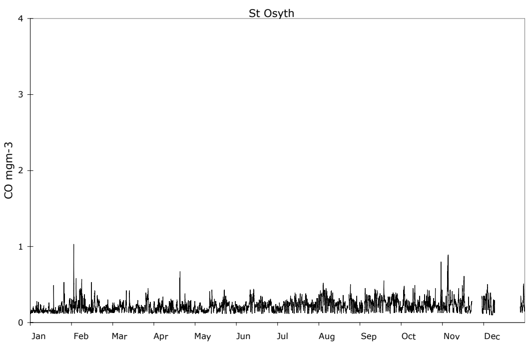
Kerbside Site
(London Marylebone Road)



Roadside Site
(London A3)



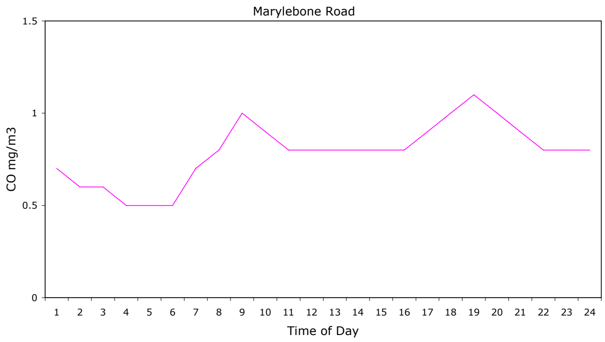
Urban Background Site
(Aberdeen)



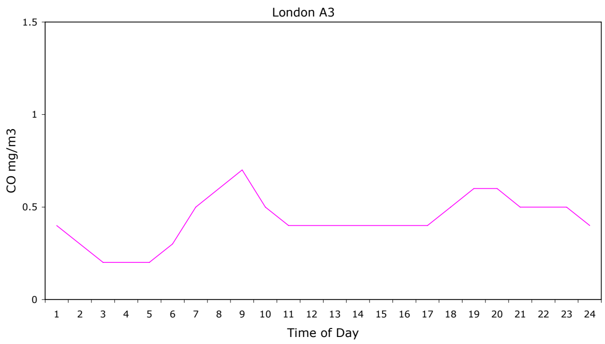
Rural Site
(St.Osyth)

12.6 Diurnal Variations

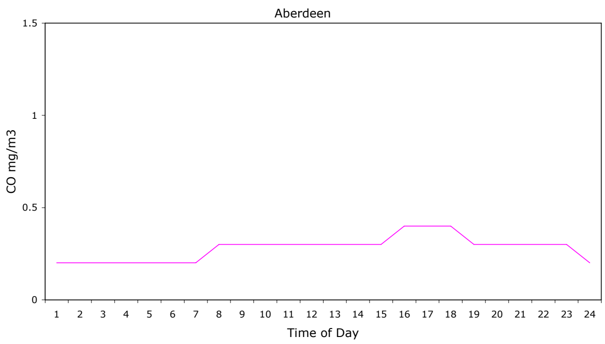
These figures show how carbon monoxide concentrations varied on average for each hour of day during 2007, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



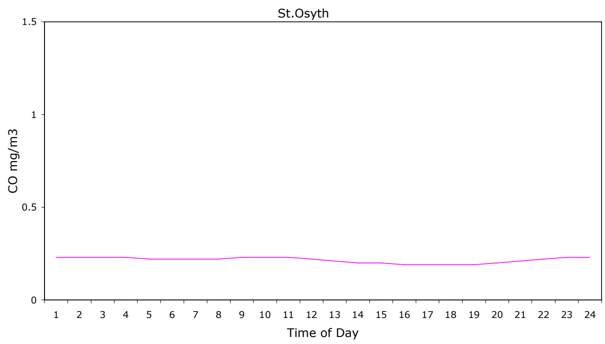
Kerbside Site
(London Marylebone Road)



Roadside Site
(London A3)



Urban Background Site
(Aberdeen)

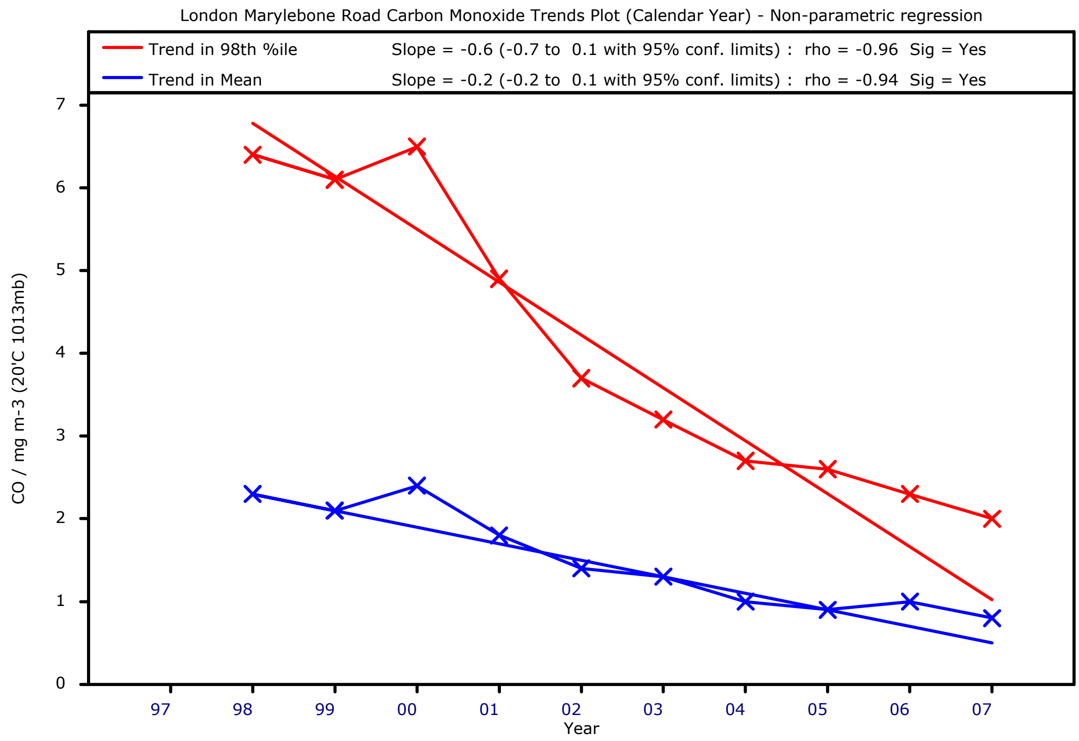


Rural Site
(St.Osyth)

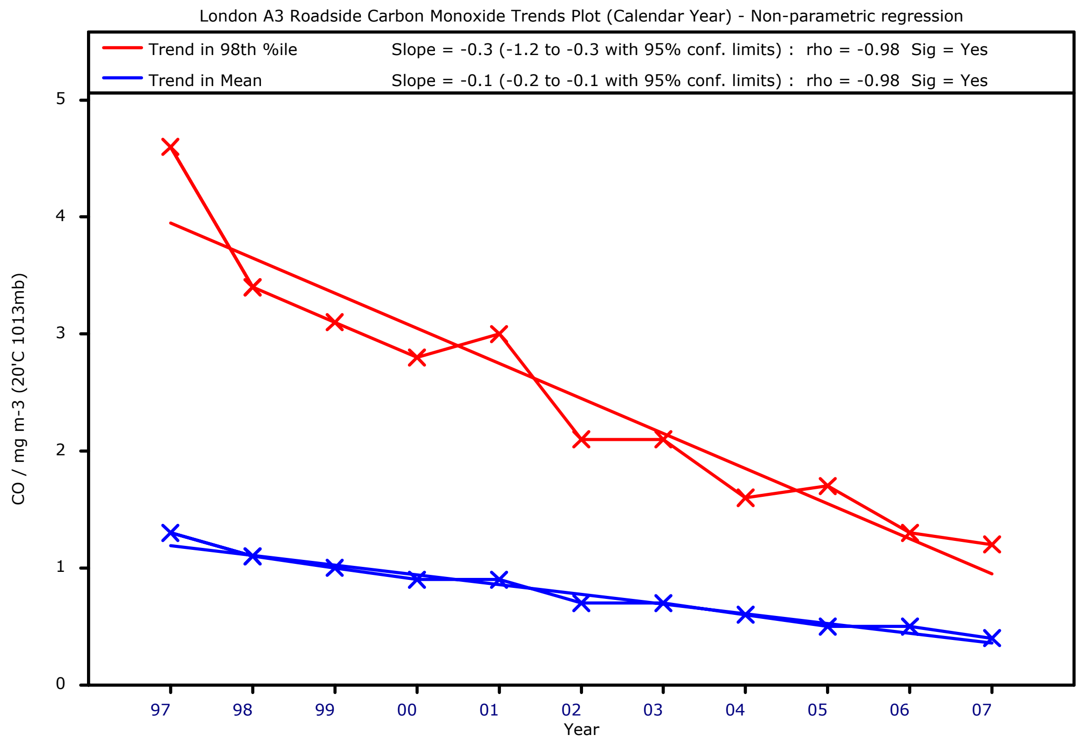
12.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

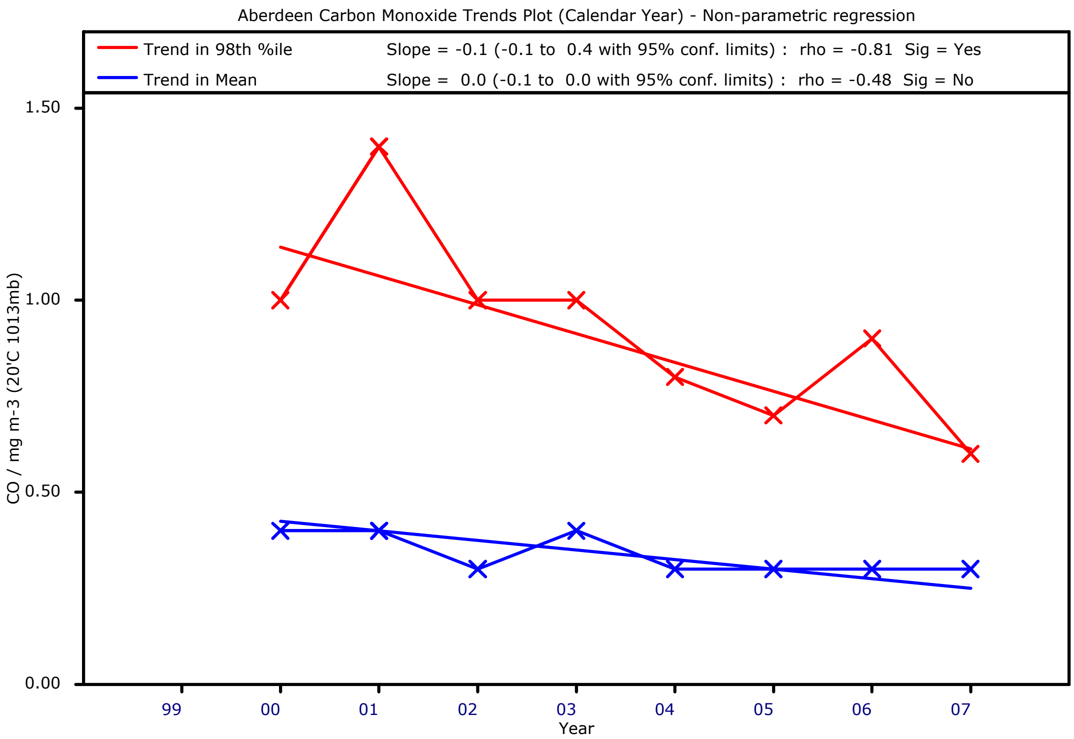
London Marylebone Road Carbon Monoxide Trends – Non-parametric regression



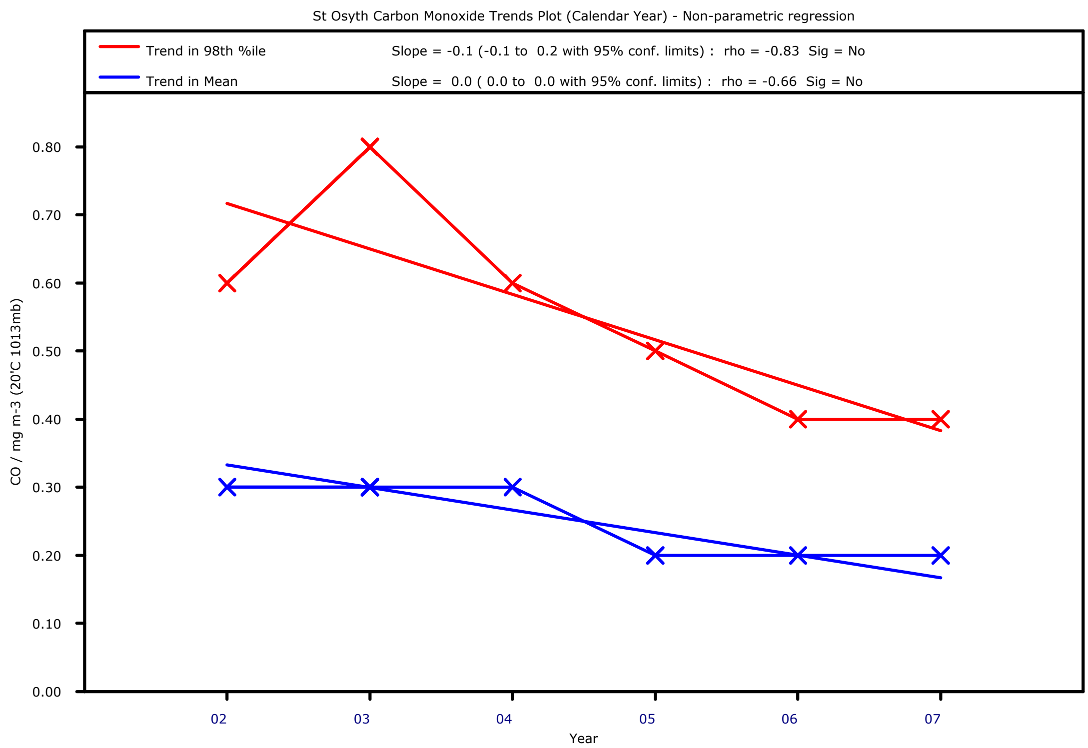
London A3 Carbon Monoxide Trends plot – Non-parametric regression



Aberdeen Carbon Monoxide Trend Plot – Non-parametric regression



St Osyth Carbon Monoxide Trend Plot – Non-parametric regression



12.8 Carbon Monoxide Statistical Summary 2007

i) CO annual statistics I

Site	Site Type	Annual average of hourly means mg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean mg m^{-3}	Maximum running 8-hour mean mg m^{-3}	Date of maximum running 8-hour mean
England						
Barnsley Gawber	UB	0.2	69.0	1.0	0.9	04/02/2007
Bath Roadside	RS	0.5	70.4	3.5	2.2	29/01/2007
Birmingham Centre	UC	0.3	72.9	1.7	1.4	04/02/2007
Birmingham Tyburn	UB	0.2	70.9	2.7	2.2	04/02/2007
Blackpool Marton	UB	0.2	71.7	1.7	1.1	07/02/2007
Bolton	UB	0.2	54.5	2.6	1.6	04/02/2007
Bournemouth	UB	0.3	73.4	1.3	0.8	09/02/2007
Bradford Centre	UC	0.2	70.3	1.4	1.0	08/02/2007
Brentford Roadside	RS	0.5	51.8	3.4	2.8	07/02/2007
Brighton Roadside	RS	0.3	73.5	1.7	1.1	30/01/2007
Bristol Old Market	RS	0.4	98.6	4.2	2.4	06/02/2007
Bristol St Paul's	UB	0.3	97.5	6.3	3.8	15/09/2007
Bury Roadside	RS	0.3	82.4	2.9	2.1	04/02/2007
Coventry Memorial Park	UB	0.2	73.8	1.6	1.2	04/02/2007
Exeter Roadside	RS	0.4	74.1	2.8	1.8	17/02/2007
Hove Roadside	RS	0.3	74.1	2.0	1.2	29/01/2007
Hull Freetown	UC	0.2	91.8	6.3	2.9	11/12/2007
Leamington Spa	UB	0.2	71.5	2.8	1.5	05/02/2007
Leeds Centre	UC	0.2	98.9	3.4	2.3	11/12/2007
Leicester Centre	UC	0.2	99.1	2.6	1.6	04/02/2007
Liverpool Speke	UB	0.2	70.4	1.6	1.2	04/02/2007
London A3 Roadside	RS	0.4	72.6	3.6	2.3	04/02/2007
London Bexley	S	0.3	97.3	3.2	2.0	04/02/2007
London Bloomsbury	UC	0.3	84.1	2.7	2.5	12/12/2007
London Brent	UB	0.2	73.6	3.2	1.8	07/02/2007
London Cromwell Road 2	RS	0.5	95.9	4.4	2.3	22/12/2007
London Hackney	UC	0.2	74.4	2.9	1.5	07/02/2007
London Harlington	A	0.3	96.5	4.2	3.3	17/11/2007
London Hillingdon	S	0.4	69.0	1.9	1.4	04/02/2007
London Marylebone Road	KS	0.8	95.9	3.0	2.7	16/11/2007
London N. Kensington	UB	0.3	97.8	3.6	2.5	12/12/2007
London Southwark	UC	0.3	63.1	2.2	1.6	07/02/2007
London Westminster	UB	0.2	91.8	2.2	1.8	16/11/2007
Manchester Piccadilly	UC	0.3	71.0	4.3	2.4	16/03/2007
Manchester Town Hall	UB	0.3	64.8	1.7	1.5	04/02/2007
Market Harborough	RU	0.2	96.3	0.7	0.6	13/12/2007
Middlesbrough	UI	0.2	95.7	2.1	1.4	20/12/2007
Newcastle Centre	UC	0.2	97.6	1.6	0.8	14/11/2007
Northampton	UB	0.2	73.9	2.4	1.1	07/02/2007
Norwich Centre	UC	0.2	74.1	1.9	0.9	04/02/2007
Nottingham Centre	UC	0.2	73.0	2.1	1.7	04/02/2007
Oxford Centre Roadside	RS	0.1	60.3	1.7	1.4	04/02/2007
Plymouth Centre	UC	0.2	55.1	1.0	0.6	30/09/2007
Portsmouth	UB	0.2	73.9	1.9	0.8	30/01/2007
Preston	UB	0.3	68.9	2.0	1.0	05/02/2007
Reading New Town	UB	0.2	70.2	2.8	1.6	04/02/2007
Redcar	S	---	41.5	2.7	0.9	02/03/2007
Salford Eccles	UI	0.1	94.6	2.3	1.5	04/11/2007
Sandwell West Bromwich	UB	0.2	71.4	1.7	1.3	06/02/2007
Sheffield Centre	UC	0.3	95.4	2.2	1.6	11/12/2007
Sheffield Tinsley	UI	0.3	73.2	1.9	1.5	04/02/2007
Southampton Centre	UC	0.2	96.9	4.3	2.8	11/12/2007
Southend-on-Sea	UB	0.2	73.8	2.4	1.1	07/02/2007
Southwark Roadside	RS	---	0.0	---	---	---
St Osyth	RU	0.22	91.6	1.03	0.70	05/11/2007
Stockport Shaw Heath	UB	0.2	71.8	2.3	1.5	04/02/2007
Stockton-on-Tees Yarm	RS	0.3	73.3	2.7	1.4	16/01/2007
Stoke-on-Trent Centre	UC	0.4	73.1	2.7	1.6	06/02/2007

ii) CO exceedence statistics I

Site	Mod. band	Days	High band	Days	Very High band	Days	EC LV & AQS Obj.	Days	AQS Obj. (Scotland)	Days
England										
Barnsley Gawber	0	0	0	0	0	0	0	0	0	0
Bath Roadside	0	0	0	0	0	0	0	0	0	0
Birmingham Centre	0	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	0	0	0
Blackpool Marton	0	0	0	0	0	0	0	0	0	0
Bolton	0	0	0	0	0	0	0	0	0	0
Bournemouth	0	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0	0
Brentford Roadside	0	0	0	0	0	0	0	0	0	0
Brighton Roadside	0	0	0	0	0	0	0	0	0	0
Bristol Old Market	0	0	0	0	0	0	0	0	0	0
Bristol St Paul's	0	0	0	0	0	0	0	0	0	0
Bury Roadside	0	0	0	0	0	0	0	0	0	0
Coventry Memorial Park	0	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	0	0	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	0	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0	0
London A3 Roadside	0	0	0	0	0	0	0	0	0	0
London Bexley	0	0	0	0	0	0	0	0	0	0
London Bloomsbury	0	0	0	0	0	0	0	0	0	0
London Brent	0	0	0	0	0	0	0	0	0	0
London Cromwell Road 2	0	0	0	0	0	0	0	0	0	0
London Hackney	0	0	0	0	0	0	0	0	0	0
London Harlington	0	0	0	0	0	0	0	0	0	0
London Hillingdon	0	0	0	0	0	0	0	0	0	0
London Marylebone Road	0	0	0	0	0	0	0	0	0	0
London N. Kensington	0	0	0	0	0	0	0	0	0	0
London Southwark	0	0	0	0	0	0	0	0	0	0
London Westminster	0	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	0	0	0	0
Manchester Town Hall	0	0	0	0	0	0	0	0	0	0
Market Harborough	0	0	0	0	0	0	0	0	0	0
Middlesbrough	0	0	0	0	0	0	0	0	0	0
Newcastle Centre	0	0	0	0	0	0	0	0	0	0
Northampton	0	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0	0
Nottingham Centre	0	0	0	0	0	0	0	0	0	0
Oxford Centre Roadside	0	0	0	0	0	0	0	0	0	0
Plymouth Centre	0	0	0	0	0	0	0	0	0	0
Portsmouth	0	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	0	0	0
Redcar	0	0	0	0	0	0	0	0	0	0
Salford Eccles	0	0	0	0	0	0	0	0	0	0
Sandwell West Bromwich	0	0	0	0	0	0	0	0	0	0
Sheffield Centre	0	0	0	0	0	0	0	0	0	0
Sheffield Tinsley	0	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0	0
Southwark Roadside	---	---	---	---	---	---	---	---	---	---
St Osyth	0	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0	0
Stockton-on-Tees Yarm	0	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0	0

iii) CO annual statistics II

Site	Site Type	Annual average of hourly means mg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean mg m^{-3}	Maximum running 8-hour mean mg m^{-3}	Date of maximum running 8-hour mean
England - *continued*						
Thurrock	UB	0.2	67.5	2.6	1.8	04/02/2007
Tower Hamlets Roadside	RS	0.5	84.7	1.7	1.5	28/09/2007
West London	UB	0.4	66.6	2.4	2.0	04/02/2007
Wigan Centre	UB	0.2	73.2	1.7	1.3	07/02/2007
Wirral Tranmere	UB	0.2	68.2	2.3	1.2	07/02/2007
Wolverhampton Centre	UC	0.3	68.0	1.6	1.2	16/02/2007
N Ireland						
Belfast Centre	UC	0.2	94.9	2.2	1.7	15/11/2007
Derry	UB	0.2	69.2	1.3	1.0	03/02/2007
Scotland						
Aberdeen	UB	0.3	73.8	3.5	0.9	16/01/2007
Dumfries	RS	0.4	66.9	3.7	1.5	17/02/2007
Edinburgh St Leonards	UB	0.3	97.4	1.5	1.2	18/12/2007
Glasgow Centre	UC	0.3	98.4	2.7	1.2	18/12/2007
Glasgow City Chambers	UB	0.3	74.0	1.4	1.0	06/02/2007
Glasgow Kerbside	KS	0.4	73.7	1.6	1.1	07/02/2007
Grangemouth	UI	0.2	72.9	1.9	1.0	07/02/2007
Inverness	RS	0.3	73.6	2.8	1.2	18/01/2007
Wales						
Cardiff Centre	UC	0.3	96.9	2.9	2.2	12/12/2007
Cwmbran	UB	0.2	60.7	1.5	1.2	06/01/2007
Swansea Roadside	RS	0.2	73.3	2.2	1.0	03/02/2007
Wrexham	RS	0.3	70.5	3.9	1.9	07/02/2007

iv) CO exceedence statistics II

Site	Mod. band	Days	High band	Days	Very High band	Days	EC LV & AQS Obj.	Days	AQS Obj. (Scotland)	Days
England *- continued*										
Thurrock	0	0	0	0	0	0	0	0	0	0
Tower Hamlets Roadside	0	0	0	0	0	0	0	0	0	0
West London	0	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0	0
Wirral Tranmere	0	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	0	0	0	0	0	0	0	0	0	0
N Ireland										
Belfast Centre	0	0	0	0	0	0	0	0	0	0
Derry	0	0	0	0	0	0	0	0	0	0
Scotland										
Aberdeen	0	0	0	0	0	0	0	0	0	0
Dumfries	0	0	0	0	0	0	0	0	0	0
Edinburgh St Leonards	0	0	0	0	0	0	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	0	0	0
Glasgow City Chambers	0	0	0	0	0	0	0	0	0	0
Glasgow Kerbside	0	0	0	0	0	0	0	0	0	0
Grangemouth	0	0	0	0	0	0	0	0	0	0
Inverness	0	0	0	0	0	0	0	0	0	0
Wales										
Cardiff Centre	0	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0	0
Swansea Roadside	0	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0	0

13. NO_2 - Measurement Sites, Instrumentation and Statistics

13.1 Measurement Method

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide (NO_2).

13.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak NO_2
- API M200
- Environnement AC 31M
- Horiba APNA 360
- Monitor Labs 9841
- Rotork 447
- Thermo Electron 42

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

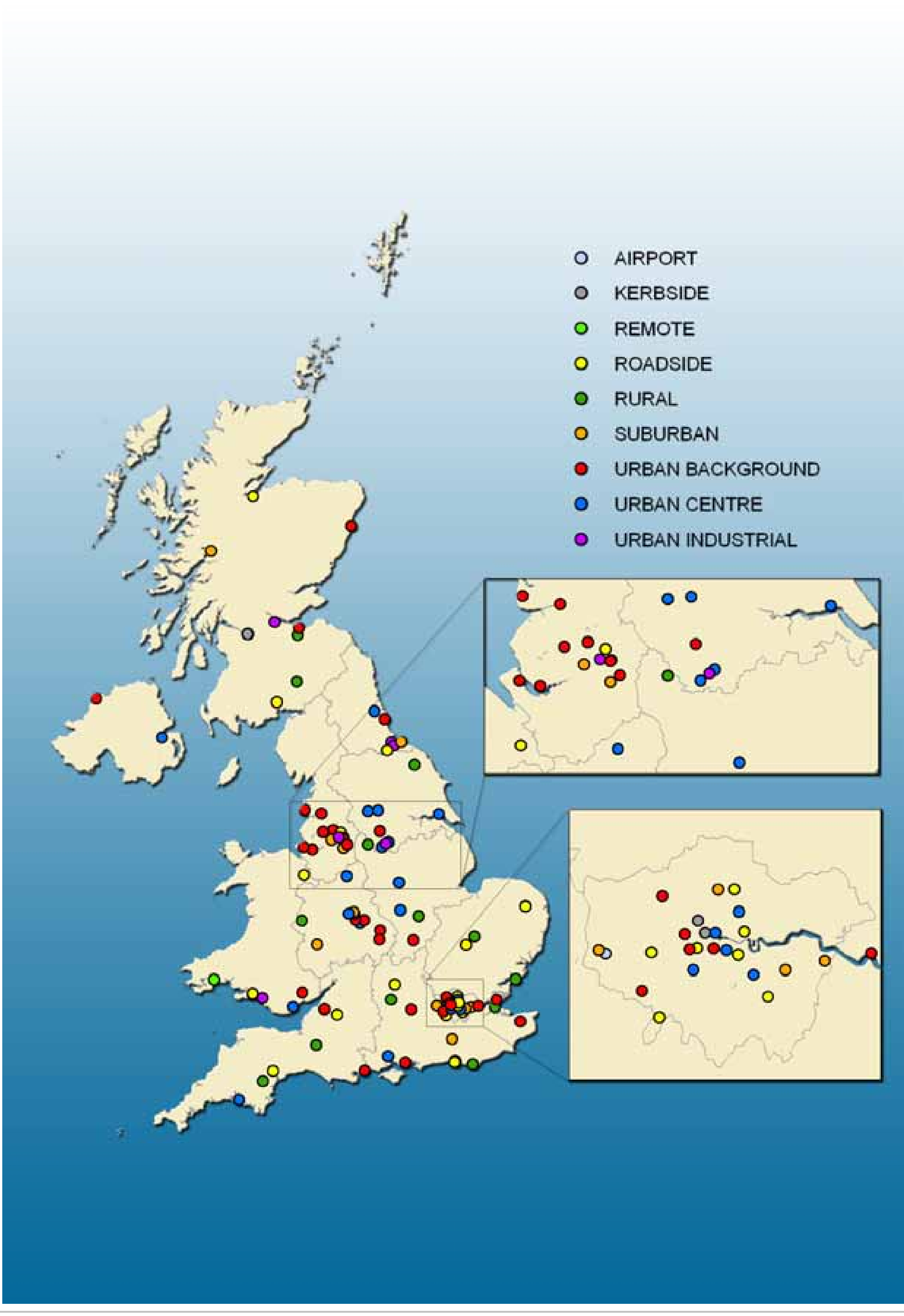
13.3 Data Quality Requirements of EC Directive 2008/50/EC

Uncertainty 15%
Minimum data capture 90%

13.4 Objectives and Bandings

Summary of Objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Nitrogen Dioxide	200 µg m^{-3} Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 µg m^{-3}	Annual Mean	31 December 2005

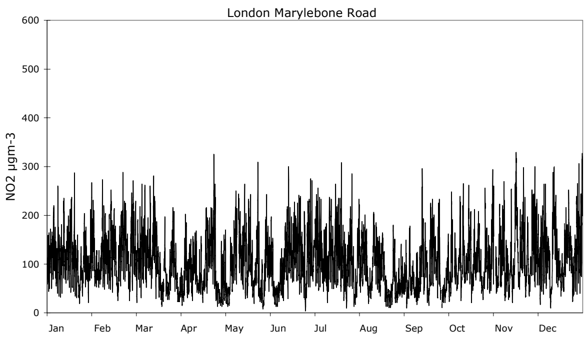
Air Quality Bands and Index Values		
Band	**Index**	**Nitrogen Dioxide µg m^{-3}**
Low	1	0-95
	2	96-190
	3	191-286
Moderate	4	287-381
	5	382-477
	6	478-572
High	7	573-635
	8	363-700
	9	701-763
Very High	10	764 or more



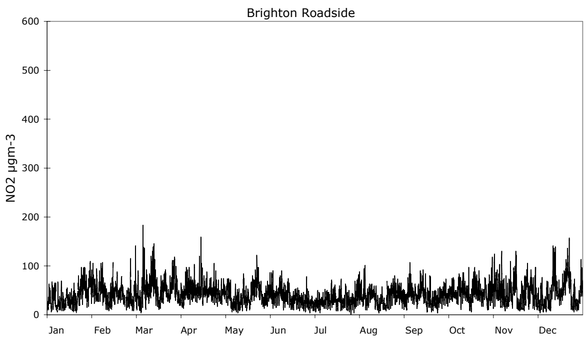
UK Automatic Nitrogen Dioxide Monitoring Sites 2007

13.5 Hourly Average Concentrations

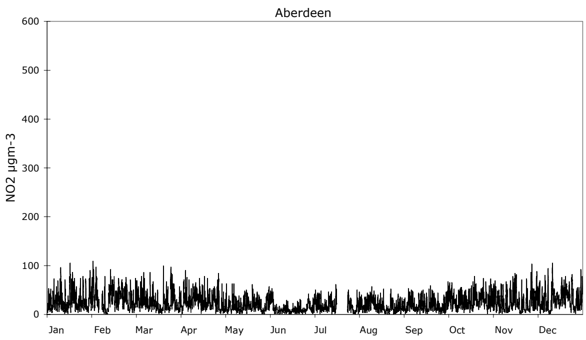
These figures show time series graphs of hourly average nitrogen dioxide concentrations at four monitoring sites of different types, for 2007.



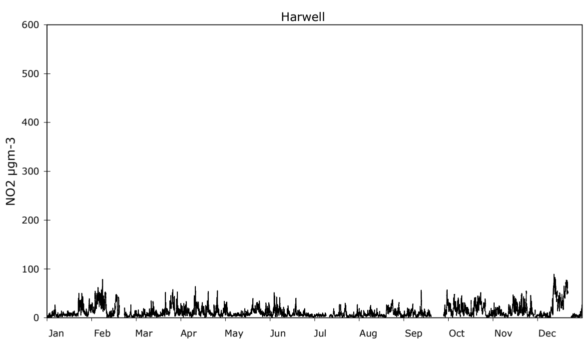
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Brighton Roadside)*



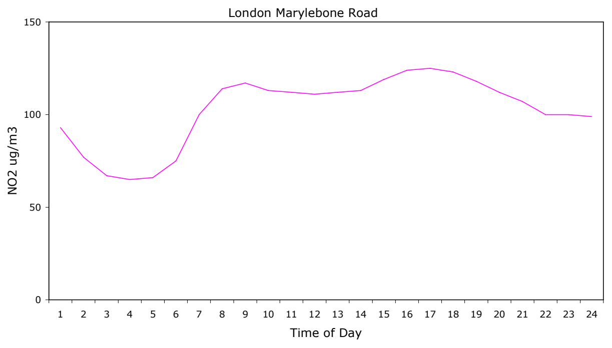
Urban Background Site
(Aberdeen)



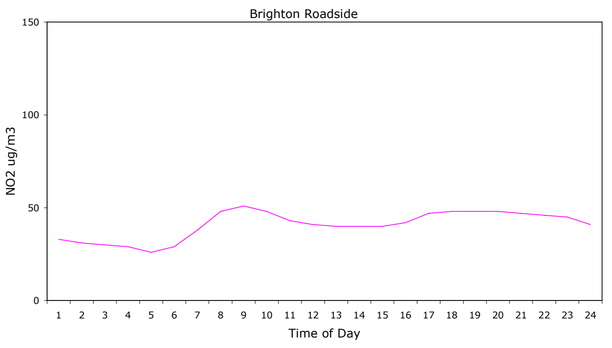
Rural Site
(Harwell)

13.6 Diurnal Variations

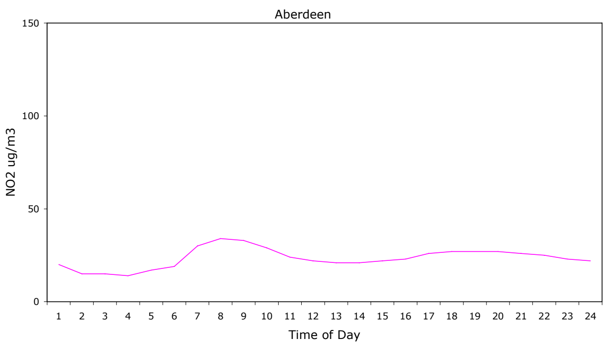
These figures show how nitrogen dioxide concentrations varied on average for each hour of day during 2007, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



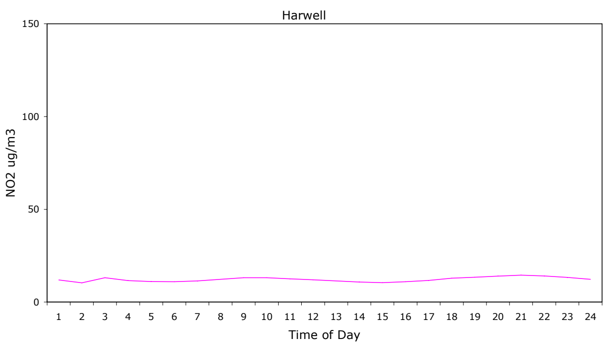
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Brighton Roadside)*



Urban Background Site
(Aberdeen)

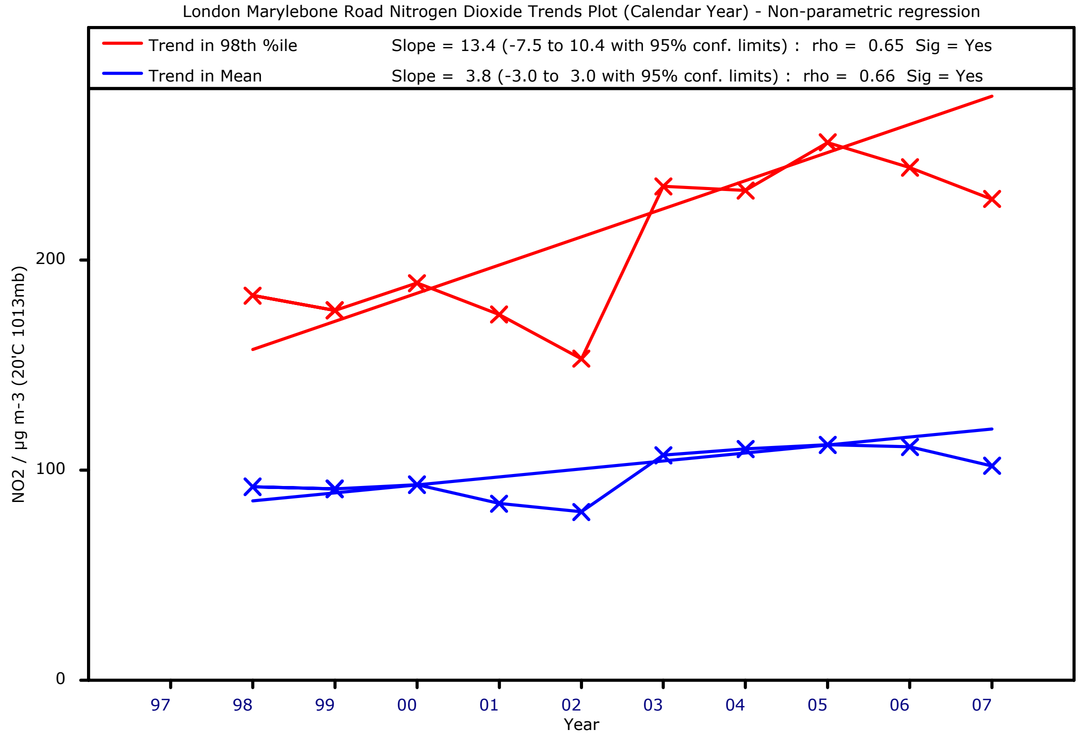


Rural Site
(Harwell)

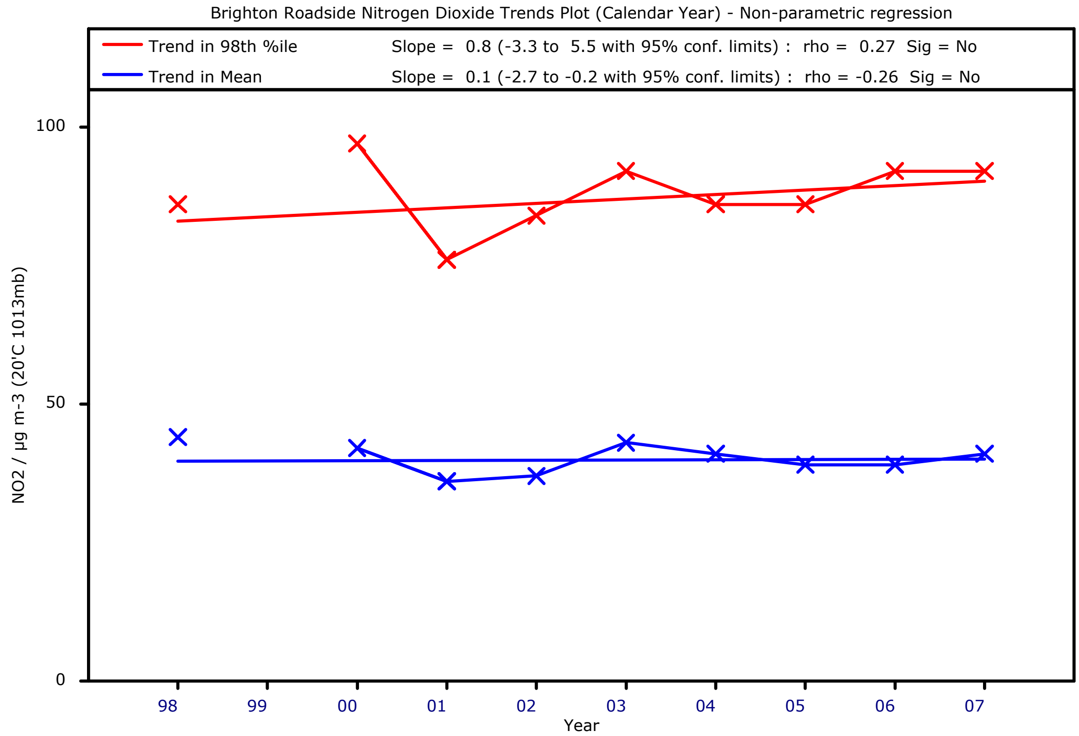
13.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

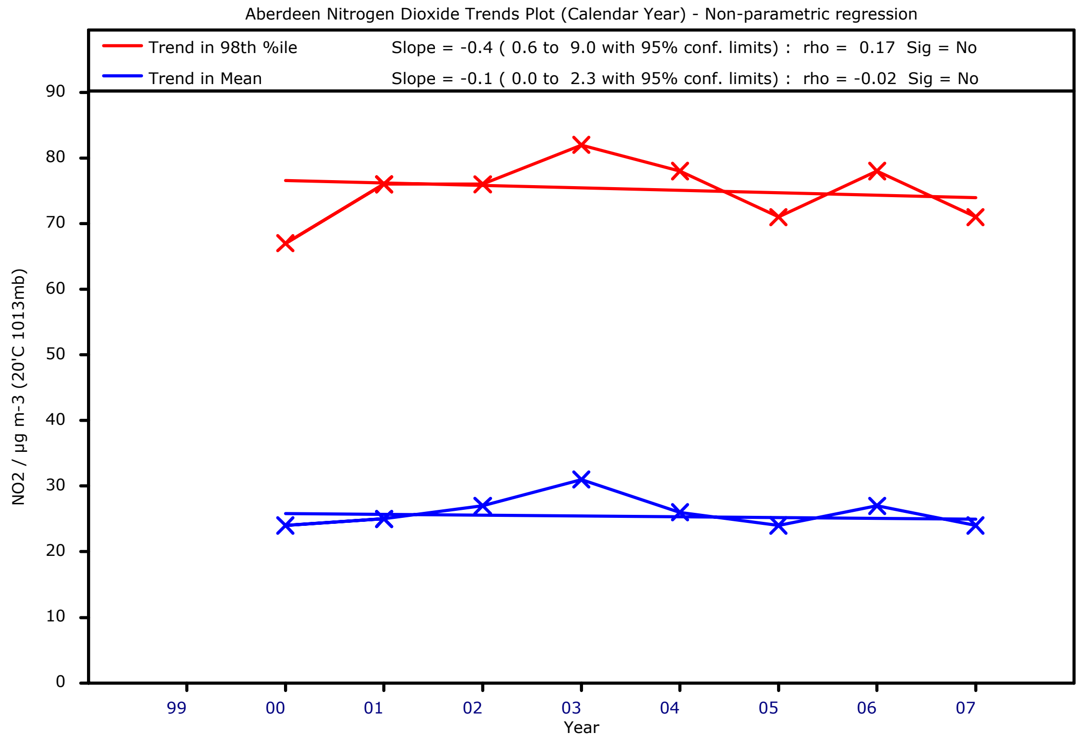
London Marylebone Road Nitrogen Dioxide Trends Plot – Non-parametric regression



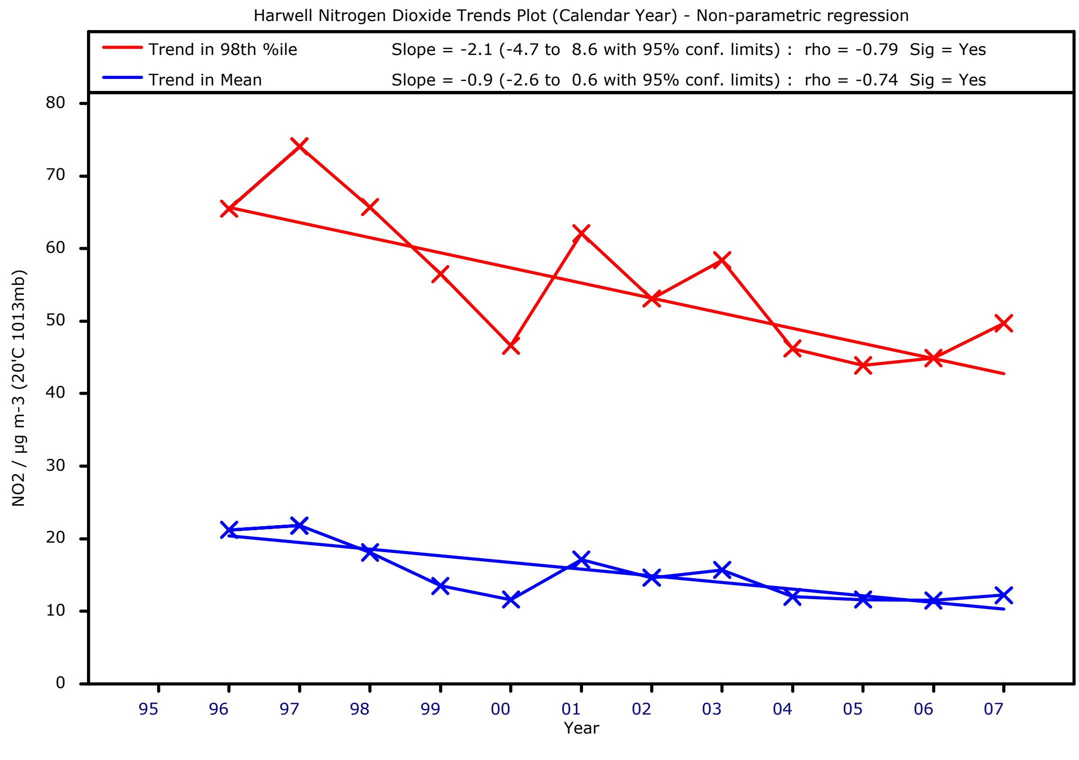
Brighton Roadside Nitrogen Dioxide Trends Plot – Non-parametric regression



Aberdeen Nitrogen Dioxide Trends Plot – Non-parametric



Harwell Nitrogen Dioxide Trends Plot – Non-parametric regression



13.8 Nitrogen Dioxide Statistical Summary 2007

i) NO_2 annual statistics I

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	99.8%ile of hourly means µg m^{-3}
England					
Barnsley Gawber	UB	18	91.1	134	88
Bath Roadside	RS	63	98.4	220	172
Billingham	UI	28	96.4	506	157
Birmingham Centre	UC	34	85.4	174	107
Birmingham Tyburn	UB	33	98.6	166	117
Blackpool Marton	UB	16	97.0	118	78
Bolton	UB	---	0.0	---	---
Bournemouth	UB	16	93.7	103	82
Bradford Centre	UC	22	59.1	107	74
Brentford Roadside	RS	60	73.6	233	193
Brighton Preston Park	UB	22	96.7	128	99
Brighton Roadside	RS	41	98.4	183	130
Bristol Old Market	RS	61	97.8	235	183
Bristol St Paul's	UB	31	93.1	180	111
Bury Roadside	RS	65	81.1	244	176
Cambridge Roadside	RS	41	97.2	160	107
Camden Kerbside	KS	77	97.3	390	264
Canterbury	UB	18	98.9	159	88
Coventry Memorial Park	UB	19	98.9	130	96
Exeter Roadside	RS	39	99.0	170	128
Glazebury	S	18.3	97.1	145.4	92.6
Haringey Roadside	RS	42	96.0	327	212
Harwell	RU	12.2	90.7	89.2	73.2
High Muffles	RU	6.4	97.8	70.7	58.3
Horley	S	---	11.0	115	---
Hove Roadside	RS	30	71.6	126	103
Hull Freetown	UC	25	94.7	180	96
Ladybower	RU	8.9	73.3	91.7	65.5
Leamington Spa	UB	25	71.2	193	101
Leeds Centre	UC	37	99.0	136	107
Leicester Centre	UC	32	99.1	223	124
Leominster	S	13	94.0	84	63
Liverpool Speke	UB	24	96.1	122	96
London A3 Roadside	RS	61	72.2	283	199
London Bexley	S	34	95.5	187	134
London Bloomsbury	UC	61	78.4	300	166
London Brent	UB	26	70.8	136	101
London Bromley	RS	44	71.9	269	134
London Cromwell Road 2	RS	72	95.5	235	166
London Eltham	S	30	96.5	149	117
London Hackney	UC	44	74.4	239	157
London Haringey	UC	---	9.0	220	---
London Harlington	A	37	93.9	222	157
London Hillingdon	S	45	97.9	271	164
London Lewisham	UC	52	69.1	298	170
London Marylebone Road	KS	102	98.0	329	300
London N. Kensington	UB	39	99.0	401	201
London Southwark	UC	39	73.9	172	138
London Teddington	UB	28.4	94.8	159.7	137.7
London Wandsworth	UC	50	69.1	189	166
London Westminster	UB	37	77.3	134	111
Lullington Heath	RU	10.4	94.3	73.0	60.9
Manchester Piccadilly	UC	44	96.2	189	147
Manchester South	S	21	85.5	120	88
Manchester Town Hall	UB	37	71.6	145	120
Market Harborough	RU	11.6	98.2	91.1	69.1
Middlesbrough	UI	21	98.8	138	96
Newcastle Centre	UC	29	86.4	139	96
Northampton	UB	21	97.4	124	92
Norwich Centre	UC	22	99.1	109	84
Norwich Forum Roadside	RS	31	71.5	117	84

ii) NO_2 exceedence statistics I

Site	Mod. band	Days	High band	Days	Very High band	Days	Annual Mean > 40 µg m^{-3}?	No. of hours > 200 µg m^{-3}	Days
England									
Barnsley Gawber	0	0	0	0	0	0	0	0	0
Bath Roadside	0	0	0	0	0	0	**1**	**7**	**7**
Billingham	5	4	0	0	0	0	0	**8**	**7**
Birmingham Centre	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	0	0
Blackpool Marton	0	0	0	0	0	0	0	0	0
Bolton	---	---	---	---	---	---	---	---	---
Bournemouth	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0
Brentford Roadside	0	0	0	0	0	0	**1**	**7**	**4**
Brighton Preston Park	0	0	0	0	0	0	0	0	0
Brighton Roadside	0	0	0	0	0	0	**1**	0	0
Bristol Old Market	0	0	0	0	0	0	**1**	**8**	**4**
Bristol St Paul's	0	0	0	0	0	0	0	0	0
Bury Roadside	0	0	0	0	0	0	**1**	**3**	**3**
Cambridge Roadside	0	0	0	0	0	0	**1**	0	0
Camden Kerbside	10	4	0	0	0	0	**1**	**114**	**32**
Canterbury	0	0	0	0	0	0	0	0	0
Coventry Memorial Park	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	0	0	0
Glazebury	0	0	0	0	0	0	0	0	0
Haringey Roadside	4	2	0	0	0	0	**1**	**21**	**4**
Harwell	0	0	0	0	0	0	0	0	0
High Muffles	0	0	0	0	0	0	0	0	0
Horley	0	0	0	0	0	0	---	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0
Ladybower	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	**2**	**1**
Leominster	0	0	0	0	0	0	0	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0
London A3 Roadside	0	0	0	0	0	0	**1**	**13**	**4**
London Bexley	0	0	0	0	0	0	0	0	0
London Bloomsbury	2	1	0	0	0	0	**1**	**6**	**2**
London Brent	0	0	0	0	0	0	0	0	0
London Bromley	0	0	0	0	0	0	**1**	**2**	**2**
London Cromwell Road 2	0	0	0	0	0	0	**1**	**2**	**2**
London Eltham	0	0	0	0	0	0	0	0	0
London Hackney	0	0	0	0	0	0	**1**	**3**	**2**
London Haringey	0	0	0	0	0	0	---	**3**	**1**
London Harlington	0	0	0	0	0	0	0	**4**	**2**
London Hillingdon	0	0	0	0	0	0	**1**	**8**	**3**
London Lewisham	1	1	0	0	0	0	**1**	**7**	**3**
London Marylebone Road	30	15	0	0	0	0	**1**	**458**	**121**
London N. Kensington	3	1	0	0	0	0	0	**18**	**5**
London Southwark	0	0	0	0	0	0	0	0	0
London Teddington	0	0	0	0	0	0	0	0	0
London Wandsworth	0	0	0	0	0	0	**1**	0	0
London Westminster	0	0	0	0	0	0	0	0	0
Lullington Heath	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	**1**	0	0
Manchester South	0	0	0	0	0	0	0	0	0
Manchester Town Hall	0	0	0	0	0	0	0	0	0
Market Harborough	0	0	0	0	0	0	0	0	0
Middlesbrough	0	0	0	0	0	0	0	0	0
Newcastle Centre	0	0	0	0	0	0	0	0	0
Northampton	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0
Norwich Forum Roadside	0	0	0	0	0	0	0	0	0

iii) NO_2 annual statistics II

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	99.8%ile of hourly means µg m^{-3}
England- (continued					
Nottingham Centre	UC	33	96.7	183	113
Oxford Centre Roadside	RS	57	95.2	265	195
Plymouth Centre	UC	23	84.6	101	84
Portsmouth	UB	23	99.0	178	101
Preston	UB	23	95.8	101	88
Reading New Town	UB	23	95.8	214	128
Redcar	S	17	65.1	115	69
Rochester Stoke	RU	18.4	97.4	113.3	85.8
Rotherham Centre	UC	32	67.1	162	113
Salford Eccles	UI	34	91.0	147	115
Sandwell West Bromwich	UB	29	98.8	199	115
Sheffield Centre	UC	34	94.5	145	107
Sheffield Tinsley	UI	35	69.0	162	134
Somerton	RU	8.4	93.1	71.8	57.7
Southampton Centre	UC	34	77.6	160	115
Southend-on-Sea	UB	25	98.9	168	115
Southwark Roadside	RS	---	0.0	---	---
St Osyth	RU	12.4	92.3	94.4	72.6
Stockport Shaw Heath	UB	28	59.3	107	90
Stockton-on-Tees Yarm	RS	39	99.3	153	128
Stoke-on-Trent Centre	UC	26	96.5	151	109
Sunderland Silksworth	UB	15	87.5	101	76
Thurrock	UB	34	87.3	264	139
Tower Hamlets Roadside	RS	67	84.7	300	235
Walsall Alumwell	UB	36	72.7	139	124
Walsall Willenhall	S	26	94.7	160	101
West London	UB	46	73.1	189	139
Wicken Fen	RU	10.1	86.0	70.5	59.0
Wigan Centre	UB	22	96.1	109	82
Wirral Tranmere	UB	19	96.9	136	96
Wolverhampton Centre	UC	24	72.8	101	92
Yarner Wood	RU	5.6	90.9	69.5	59.6
N Ireland					
Belfast Centre	UC	32	91.0	160	126
Derry	UB	13	89.2	80	63
Scotland					
Aberdeen	UB	24	95.4	109	92
Bush Estate	RU	9.1	90.5	81.9	55.4
Dumfries	RS	38	98.7	216	145
Edinburgh St Leonards	UB	27	97.2	120	99
Eskdalemuir	RU	5.0	78.2	44.1	35.0
Fort William	S	9	84.8	74	53
Glasgow Centre	UC	31	92.0	151	109
Glasgow City Chambers	UB	47	97.3	222	143
Glasgow Kerbside	KS	70	91.9	262	201
Grangemouth	UI	16	98.2	130	88
Inverness	RS	22	98.0	164	118
Wales					
Aston Hill	RU	13.0	91.8	94.0	67.8
Cardiff Centre	UC	31	98.2	151	101
Cwmbran	UB	14	82.4	73	63
Narberth	RE	5.4	89.4	61.5	55.6
Port Talbot	UI	18	54.6	97	76
Port Talbot Margam	UI	---	41.5	94	---
Swansea Roadside	RS	31	98.4	164	115
Wrexham	RS	20	91.9	115	92

iv) NO_2 exceedence statistics II

Site	Mod. band	Days	High band	Days	Very High band	Days	Annual Mean > 40 µg m^{-3}?	No. of hours > 200 µg m^{-3}	Days
England									
Nottingham Centre	0	0	0	0	0	0	0	0	0
Oxford Centre Roadside	0	0	0	0	0	0	**1**	**11**	**4**
Plymouth Centre	0	0	0	0	0	0	0	0	0
Portsmouth	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	**2**	**2**
Redcar	0	0	0	0	0	0	0	0	0
Rochester Stoke	0	0	0	0	0	0	0	0	0
Rotherham Centre	0	0	0	0	0	0	0	0	0
Salford Eccles	0	0	0	0	0	0	0	0	0
Sandwell West Bromwich	0	0	0	0	0	0	0	0	0
Sheffield Centre	0	0	0	0	0	0	0	0	0
Sheffield Tinsley	0	0	0	0	0	0	0	0	0
Somerton	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0
Southwark Roadside	---	---	---	---	---	---	---	---	---
St Osyth	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0
Stockton-on-Tees Yarm	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0
Sunderland Silksworth	0	0	0	0	0	0	0	0	0
Thurrock	0	0	0	0	0	0	0	**3**	**1**
Tower Hamlets Roadside	4	2	0	0	0	0	**1**	**38**	**9**
Walsall Alumwell	0	0	0	0	0	0	0	0	0
Walsall Willenhall	0	0	0	0	0	0	0	0	0
West London	0	0	0	0	0	0	**1**	0	0
Wicken Fen	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0
Wirral Tranmere	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	0	0	0	0	0	0	0	0	0
Yarner Wood	0	0	0	0	0	0	0	0	0
N Ireland									
Belfast Centre	0	0	0	0	0	0	0	0	0
Derry	0	0	0	0	0	0	0	0	0
Scotland									
Aberdeen	0	0	0	0	0	0	0	0	0
Bush Estate	0	0	0	0	0	0	0	0	0
Dumfries	0	0	0	0	0	0	0	**5**	**5**
Edinburgh St Leonards	0	0	0	0	0	0	0	0	0
Eskdalemuir	0	0	0	0	0	0	0	0	0
Fort William	0	0	0	0	0	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	0	0
Glasgow City Chambers	0	0	0	0	0	0	**1**	**2**	**2**
Glasgow Kerbside	0	0	0	0	0	0	**1**	**21**	**13**
Grangemouth	0	0	0	0	0	0	0	0	0
Inverness	0	0	0	0	0	0	0	0	0
Wales									
Aston Hill	0	0	0	0	0	0	0	0	0
Cardiff Centre	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0
Narberth	0	0	0	0	0	0	0	0	0
Port Talbot	0	0	0	0	0	0	0	0	0
Port Talbot Margam	0	0	0	0	0	0	---	0	0
Swansea Roadside	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0

14. NO_x- Measurement Sites, Instrumentation and Statistics

14.1 Measurement Method

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide (NO_2).

14.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak NO_2
- API M200
- Environnement AC 31M
- Horiba APNA 360
- Monitor Labs 9841
- Rotork 447
- Thermo Electron 42

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

14.3 Data Quality Requirements of EC Directive 2008/50/EC

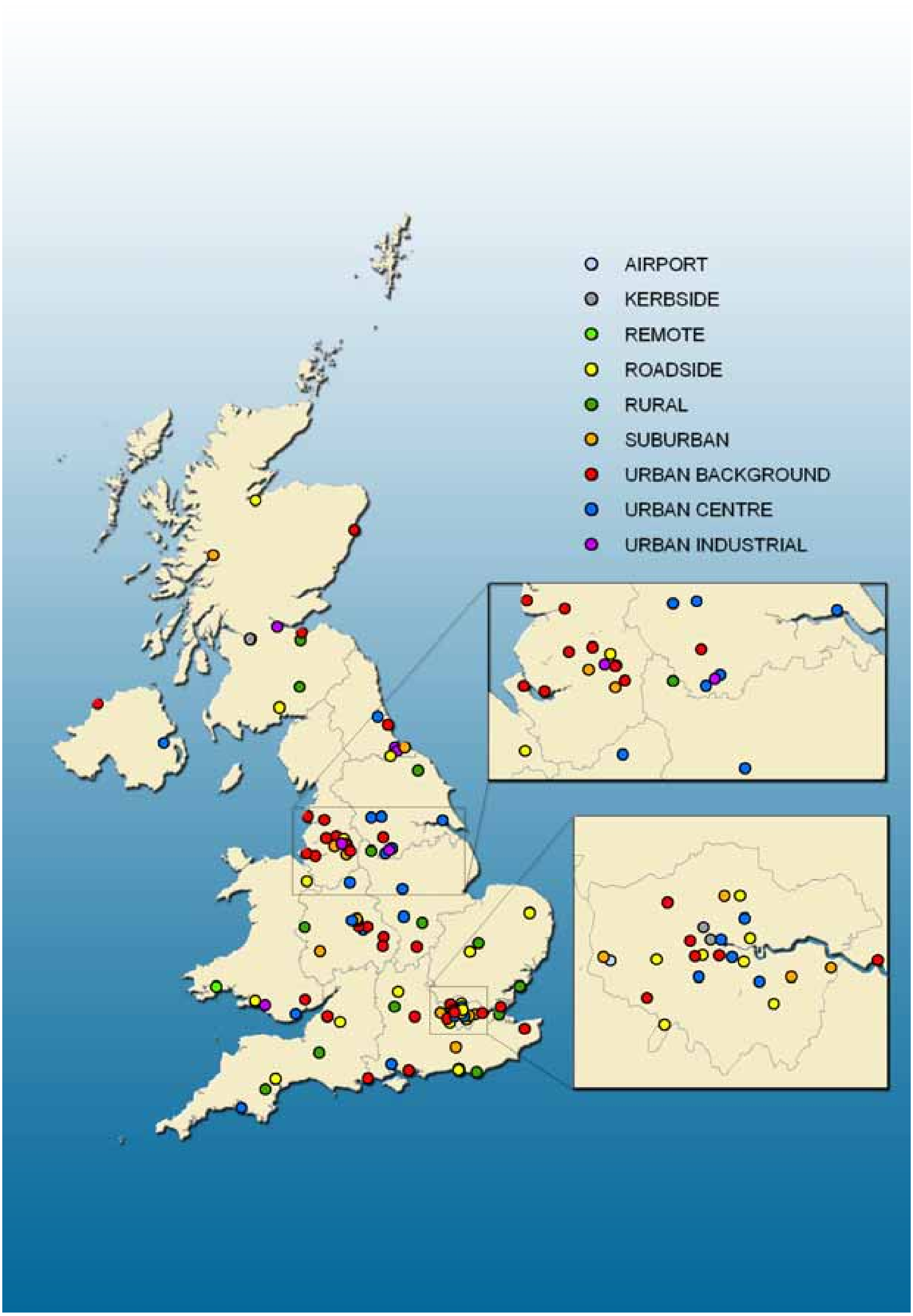
Uncertainty 15%
Minimum data capture 90%

14.4 Objectives and Bandings

Summary of objectives of the National Air Quality Strategy			
	Objective*	**Measured as**	**To be achieved by**
NO_x	30 µg m^{-3}	Annual Mean	31 December 2000

Assuming NO_x is taken as NO_2. Also note this objective is for the protection of vegetation and ecosystems, **so it is only applicable at rural and remote sites. The tables show exceedence statistics for all sites, but those where this objective is applicable (i.e. rural and remote sites) are highlighted in **bold text**.*

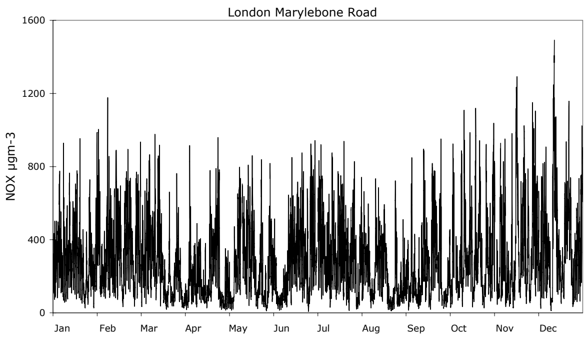
No bandings are set for total oxides of nitrogen, as the short-term effects of total NO_x will depend on the proportions of NO_2 and NO.



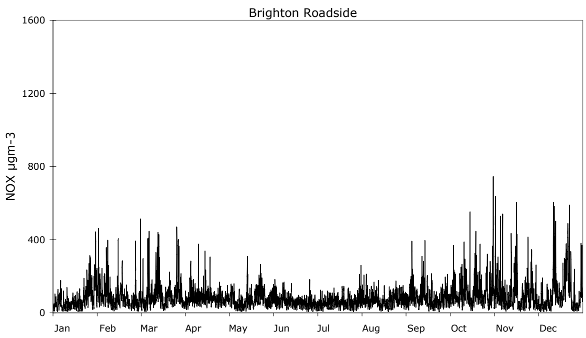
UK Automatic Nitrogen Oxides Monitoring Sites 2007

14.5 Hourly Average Concentrations

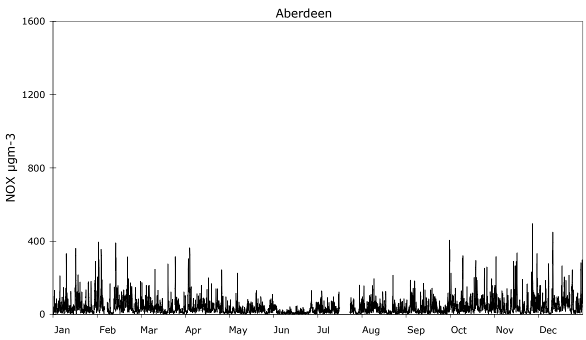
These figures show time series graphs of hourly average nitrogen oxides concentrations at four monitoring sites of different types for 2007.



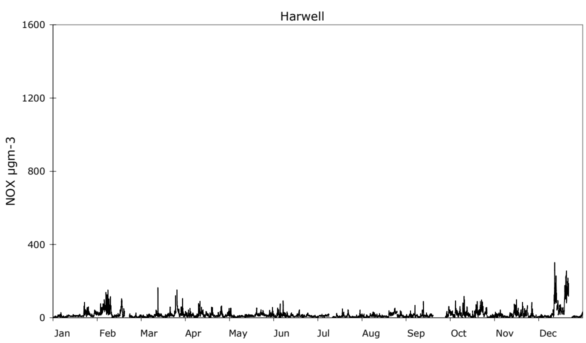
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Brighton Roadside)*



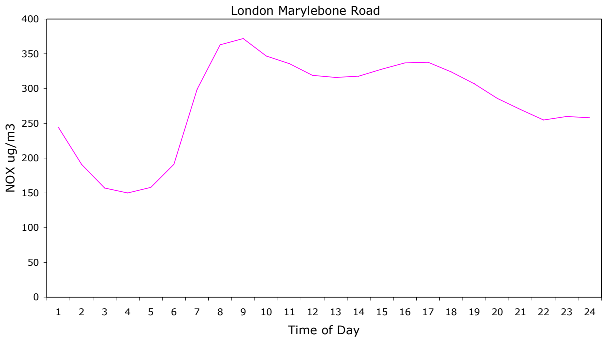
Urban Background Site
(Aberdeen)



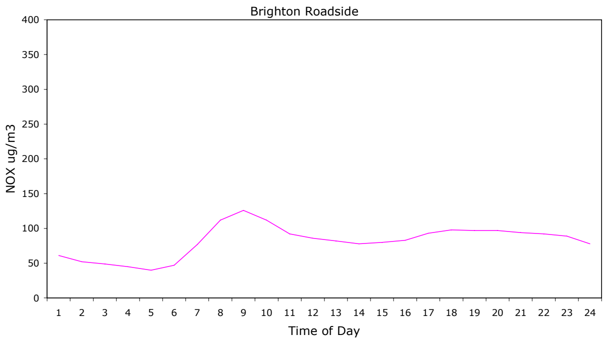
Rural Site
(Harwell)

14.6 Diurnal Variations

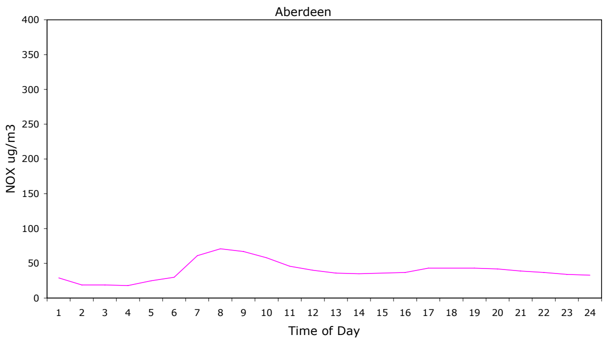
These figures show how NOx concentrations varied on average for each hour of day during the year, at the same four sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



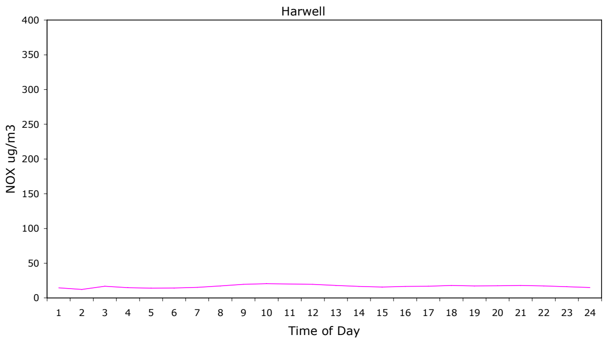
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Brighton Roadside)*



Urban Background Site
(Aberdeen)

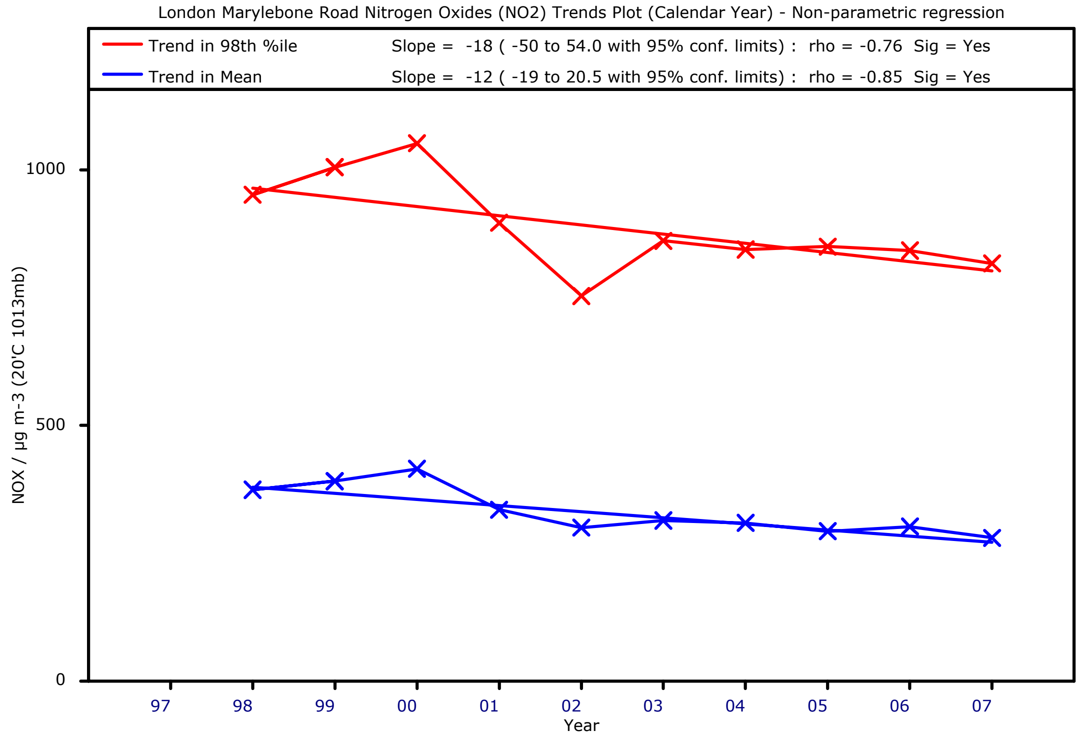


Rural Site
(Harwell)

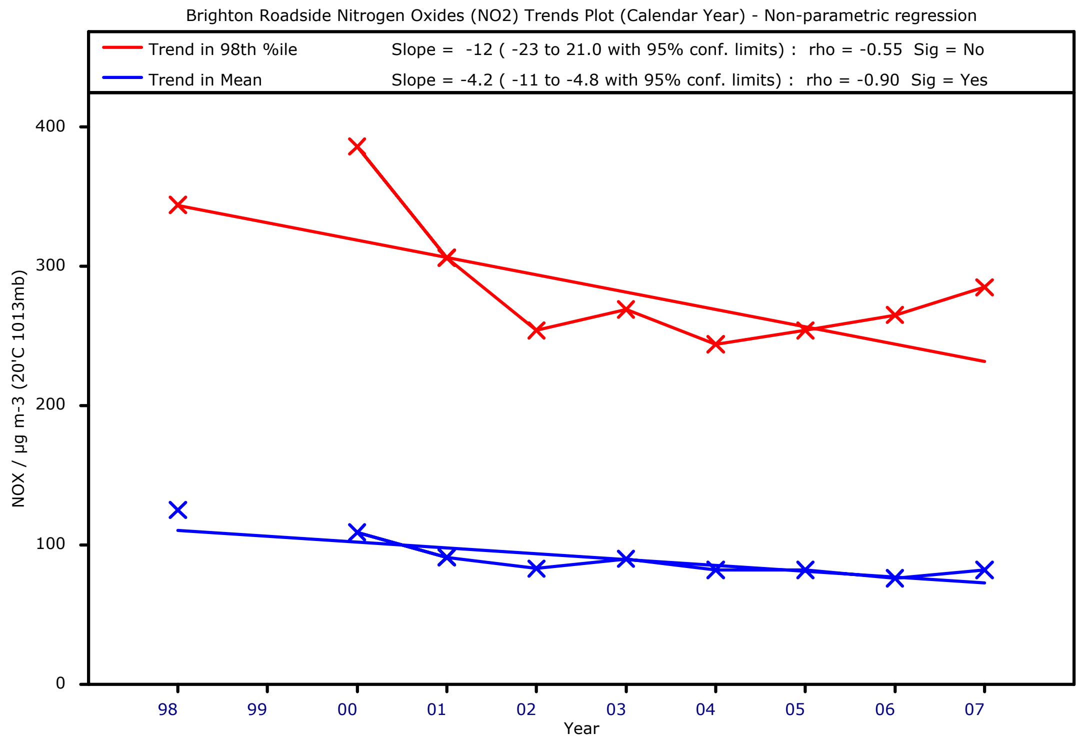
14.7 Trends in annual concentrations

Trends in concentration are shown for sites with at least 5 years of measurement.

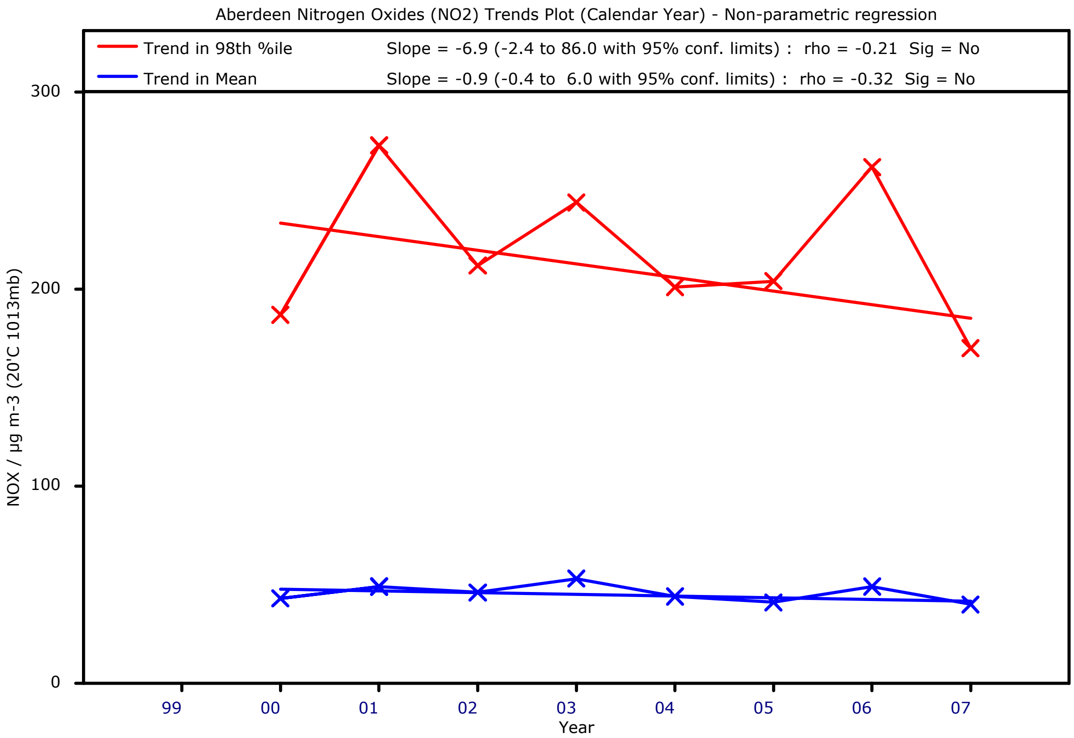
London Marylebone Road Nitrogen Oxides Trends Plot – Non-parametric regression



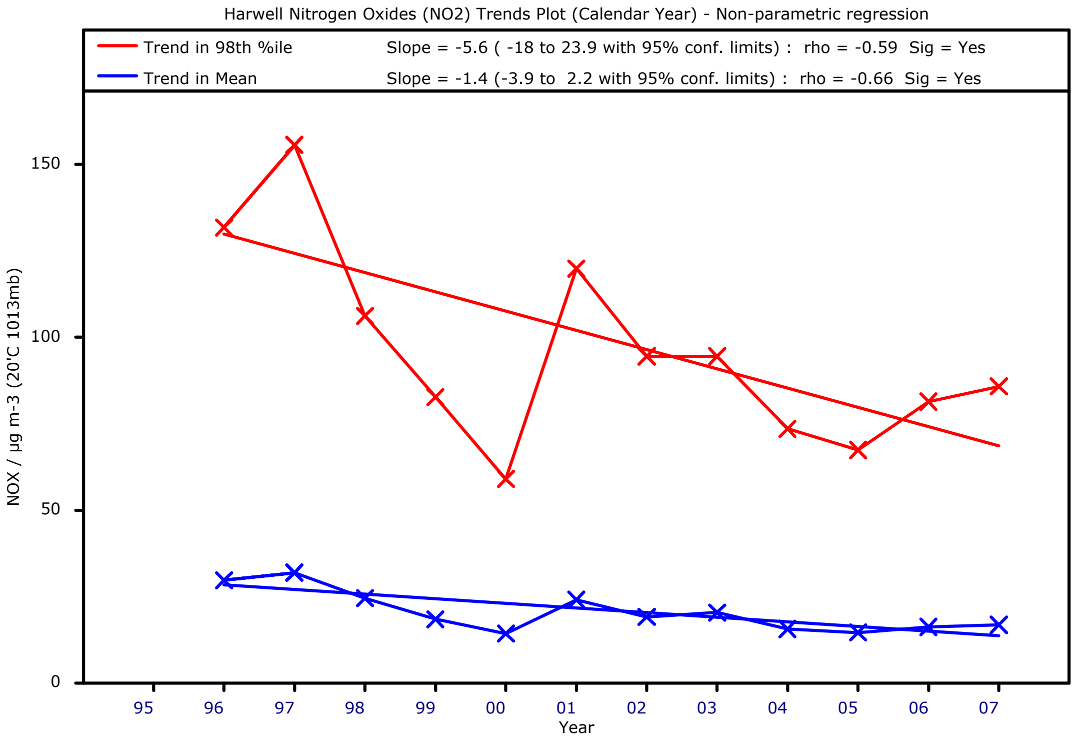
Brighton Roadside Nitrogen Oxides Trends Plot – Non-parametric regression



Aberdeen Nitrogen Oxides Trends Plot – Non-parametric regression



Harwell Nitrogen Oxides Trends Plot – Non-parametric regression



14.8 Nitrogen Oxides Statistical Summary 2007

i) NOx annual statistics I (Rural/Remote sites in bold)

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England				
Barnsley Gawber	UB	29	91.1	688
Bath Roadside	RS	176	98.4	1051
Billingham	UI	51	96.4	1247
Birmingham Centre	UC	57	85.4	947
Birmingham Tyburn	UB	69	98.6	1341
Blackpool Marton	UB	26	97.0	434
Bolton	UB	---	0.0	---
Bournemouth	UB	24	93.7	437
Bradford Centre	UC	32	59.1	472
Brentford Roadside	RS	146	73.6	1169
Brighton Preston Park	UB	34	96.7	594
Brighton Roadside	RS	82	98.4	745
Bristol Old Market	RS	160	97.8	1222
Bristol St Paul's	UB	55	93.1	1005
Bury Roadside	RS	188	81.1	1339
Cambridge Roadside	RS	101	97.2	716
Camden Kerbside	KS	194	97.3	1641
Canterbury	UB	31	98.9	760
Coventry Memorial Park	UB	31	98.9	647
Exeter Roadside	RS	111	99.0	1043
Glazebury	S	33.0	97.1	677.1
Haringey Roadside	RS	89	96.0	1518
Harwell	**RU**	16.8	90.7	300.8
High Muffles	**RU**	8.0	97.8	173.6
Horley	S	---	11.0	802
Hove Roadside	RS	55	71.6	573
Hull Freetown	UC	42	94.7	924
Ladybower	**RU**	11.7	73.3	273.3
Leamington Spa	UB	37	71.2	615
Leeds Centre	UC	71	99.0	770
Leicester Centre	UC	59	99.1	1127
Leominster	S	20	94.0	506
Liverpool Speke	UB	38	96.1	651
London A3 Roadside	RS	137	72.2	1404
London Bexley	S	65	95.5	1402
London Bloomsbury	UC	117	78.4	1406
London Brent	UB	38	70.8	829
London Bromley	RS	76	71.9	963
London Cromwell Road 2	RS	160	95.5	1070
London Eltham	S	50	96.5	965
London Hackney	UC	75	74.4	860
London Haringey	UC	---	9.0	1175
London Harlington	A	77	93.9	1331
London Hillingdon	S	105	97.9	1524
London Lewisham	UC	95	69.1	1142
London Marylebone Road	KS	280	98.0	1492
London N. Kensington	UB	65	99.0	1681
London Southwark	UC	65	73.9	781
London Teddington	UB	48.7	94.8	804.7
London Wandsworth	UC	101	69.1	829
London Westminster	UB	73	77.3	982
Lullington Heath	**RU**	13.0	94.3	199.8
Manchester Piccadilly	UC	83	96.2	968
Manchester South	S	40	85.5	546
Manchester Town Hall	UB	54	71.6	688
Market Harborough	**RU**	13.7	98.2	238.6
Middlesbrough	UI	30	98.8	733
Newcastle Centre	UC	52	86.4	722
Northampton	UB	35	97.4	491
Norwich Centre	UC	36	99.1	972
Norwich Forum Roadside	RS	58	71.5	506

ii) NOx exceedence statistics I (Rural/Remote sites in bold)

Site	EC and AQS Ecosystem Air Quality Objective (Annual Mean) > 30 µg m^{-3}
England	
Barnsley Gawber	0
Bath Roadside	1
Billingham	1
Birmingham Centre	1
Birmingham Tyburn	1
Blackpool Marton	0
Bolton	---
Bournemouth	0
Bradford Centre	1
Brentford Roadside	1
Brighton Preston Park	1
Brighton Roadside	1
Bristol Old Market	1
Bristol St Paul's	1
Bury Roadside	1
Cambridge Roadside	1
Camden Kerbside	1
Canterbury	1
Coventry Memorial Park	1
Exeter Roadside	1
Glazebury	1
Haringey Roadside	1
Harwell	**0**
High Muffles	**0**
Horley	---
Hove Roadside	1
Hull Freetown	1
Ladybower	**0**
Leamington Spa	1
Leeds Centre	1
Leicester Centre	1
Leominster	0
Liverpool Speke	1
London A3 Roadside	1
London Bexley	1
London Bloomsbury	1
London Brent	1
London Bromley	1
London Cromwell Road 2	1
London Eltham	1
London Hackney	1
London Haringey	---
London Harlington	1
London Hillingdon	1
London Lewisham	1
London Marylebone Road	1
London N. Kensington	1
London Southwark	1
London Teddington	1
London Wandsworth	1
London Westminster	1
Lullington Heath	**0**
Manchester Piccadilly	1
Manchester South	1
Manchester Town Hall	1
Market Harborough	**0**
Middlesbrough	0
Newcastle Centre	1
Northampton	1
Norwich Centre	1
Norwich Forum Roadside	1

iii) NOx annual statistics II (Rural/Remote sites in bold)

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England - *continued*				
Nottingham Centre	UC	64	96.7	947
Oxford Centre Roadside	RS	168	95.2	1324
Plymouth Centre	UC	37	84.6	487
Portsmouth	UB	36	99.0	1230
Preston	UB	39	95.8	640
Reading New Town	UB	45	95.8	1318
Redcar	S	22	65.1	290
Rochester Stoke	**RU**	27.8	97.4	466.6
Rotherham Centre	UC	56	67.1	800
Salford Eccles	UI	61	91.0	852
Sandwell West Bromwich	UB	47	98.8	1295
Sheffield Centre	UC	68	94.5	816
Sheffield Tinsley	UI	69	69.0	968
Somerton	**RU**	10.7	93.1	231.9
Southampton Centre	UC	67	77.6	858
Southend-on-Sea	UB	37	98.9	817
Southwark Roadside	RS	---	0.0	---
St Osyth	**RU**	15.6	92.3	273.1
Stockport Shaw Heath	UB	41	59.3	344
Stockton-on-Tees Yarm	RS	116	99.3	1022
Stoke-on-Trent Centre	UC	50	96.5	888
Sunderland Silksworth	UB	23	87.5	552
Thurrock	UB	65	87.3	1517
Tower Hamlets Roadside	RS	173	84.7	1784
Walsall Alumwell	UB	66	72.7	949
Walsall Willenhall	S	43	94.7	1047
West London	UB	72	73.1	921
Wicken Fen	**RU**	14.6	86.0	234.5
Wigan Centre	UB	40	96.1	712
Wirral Tranmere	UB	28	96.9	462
Wolverhampton Centre	UC	41	72.8	372
Yarner Wood	RU	7.2	90.9	122.2
N Ireland				
Belfast Centre	UC	55	91.0	905
Derry	UB	18	89.2	401
Scotland				
Aberdeen	UB	40	95.4	495
Bush Estate	**RU**	13.0	90.5	158.9
Dumfries	RS	95	98.7	957
Edinburgh St Leonards	UB	41	97.2	414
Eskdalemuir	**RU**	6.7	78.2	46.0
Fort William	S	14	84.8	271
Glasgow Centre	UC	57	92.0	884
Glasgow City Chambers	UB	91	97.3	1045
Glasgow Kerbside	KS	241	91.9	1568
Grangemouth	UI	28	98.2	902
Inverness	RS	45	98.0	932
Wales				
Aston Hill	**RU**	15.7	91.8	246.2
Cardiff Centre	UC	50	98.2	753
Cwmbran	UB	24	82.4	672
Narberth	**RE**	7.4	89.4	110.0
Port Talbot	UI	28	54.6	388
Port Talbot Margam	UI	---	41.5	409
Swansea Roadside	RS	63	98.4	844
Wrexham	RS	39	91.9	541

iv) NOx exceedence statistics II (Rural/Remote sites in bold)

Site	EC and AQS Ecosystem Air Quality Objective (Annual Mean) > 30 µg m^{-3}
England - *continued*	
Nottingham Centre	1
Oxford Centre Roadside	1
Plymouth Centre	1
Portsmouth	1
Preston	1
Reading New Town	1
Redcar	0
Rochester Stoke	**0**
Rotherham Centre	1
Salford Eccles	1
Sandwell West Bromwich	1
Sheffield Centre	1
Sheffield Tinsley	1
Somerton	**0**
Southampton Centre	1
Southend-on-Sea	1
Southwark Roadside	---
St Osyth	**0**
Stockport Shaw Heath	1
Stockton-on-Tees Yarm	1
Stoke-on-Trent Centre	1
Sunderland Silksworth	0
Thurrock	1
Tower Hamlets Roadside	1
Walsall Alumwell	1
Walsall Willenhall	1
West London	1
Wicken Fen	**0**
Wigan Centre	1
Wirral Tranmere	0
Wolverhampton Centre	1
Yarner Wood	**0**
N Ireland	
Belfast Centre	1
Derry	0
Scotland	
Aberdeen	1
Bush Estate	**0**
Dumfries	1
Edinburgh St Leonards	1
Eskdalemuir	**0**
Fort William	0
Glasgow Centre	1
Glasgow City Chambers	1
Glasgow Kerbside	1
Grangemouth	0
Inverness	1
Wales	
Aston Hill	**0**
Cardiff Centre	1
Cwmbran	0
Narberth	**0**
Port Talbot	0
Port Talbot Margam	---
Swansea Roadside	1
Wrexham	1

15. PM_{10} - Measurement Sites, Instrumentation and Statistics

15.1 Measurement Methods

The tapered element oscillating microbalance (**TEOM**) system determines particulate concentration by continuously weighing particles deposited on a filter. The **beta-attenuation monitor** (BAM) consists of a paper band filter located between a source of beta rays and a radiation detector. A pump draws ambient air through the filter and the reduction in intensity of beta-radiation measured at the detector is proportional to the mass of particulate deposited on the filter. The **Partisol** is a gravimetric sampler that collects daily samples onto a filter for subsequent weighing to determine the PM10 concentration.

15.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- R&P TEOM 1400
- R&P TEOM 1400 AB with 8500 FDMS
- R&P Partisol
- Met One Beta-Attenuation Monitor (BAM) 1020

Please also see detailed information on particle measurements and conversion factors used in this report (Appendix 6).

15.3 Data Quality Requirements of EC Directive 2008/50/EC

Uncertainty 25%, minimum data capture 90%

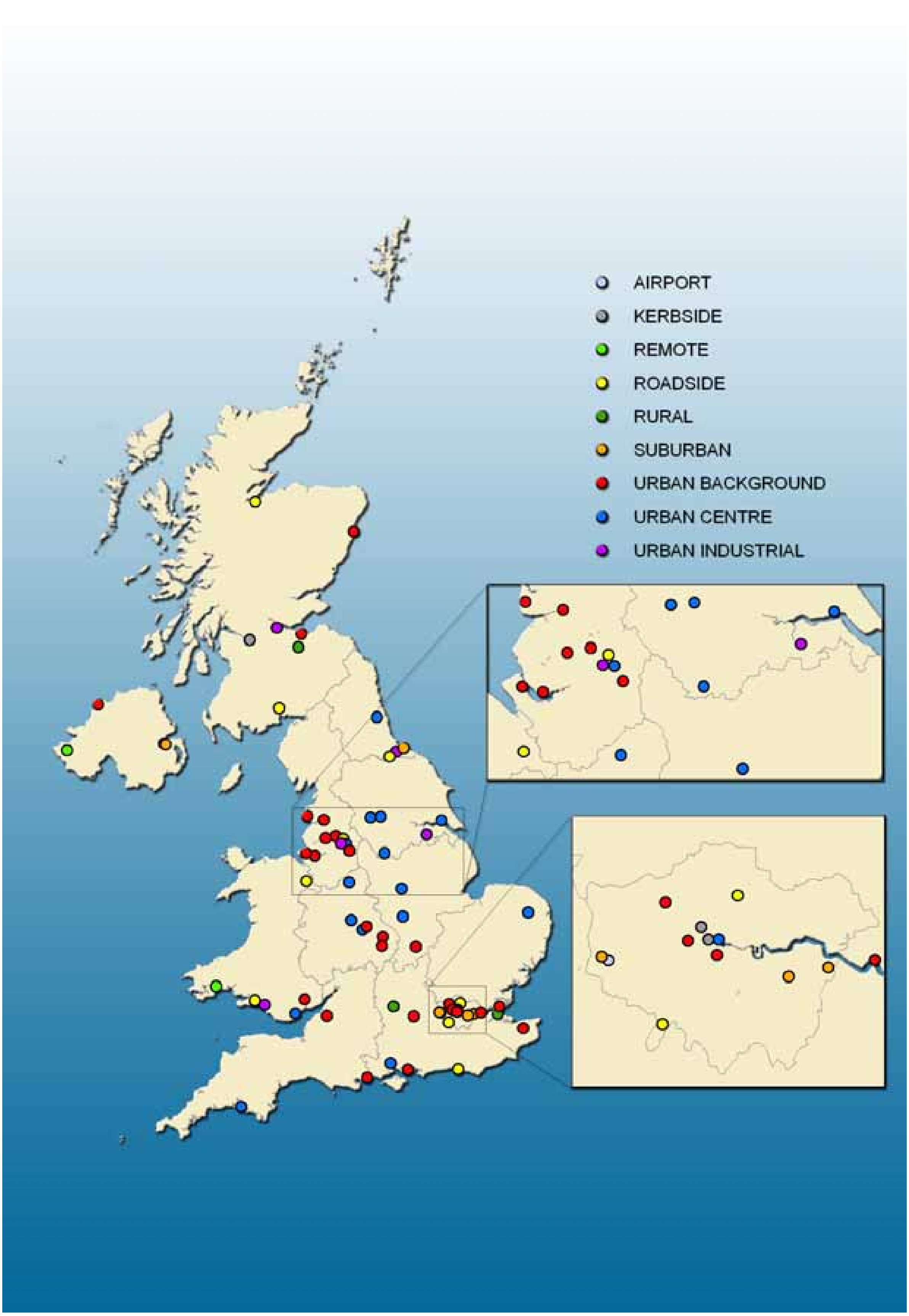
15.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy

	Objective	Measured as	To be achieved by
Particles (PM_{10}) (gravimetric) All authorities	50 µg m^{-3} Not to be exceeded more than 35 times per year	Daily Mean	31 December 2005
	40 µg m^{-3}	Annual Mean	31 December 2005
Particles (PM_{10}) Authorities in Scotland only	50 µg m^{-3} Not to be exceeded more than 7 times per year	Daily Mean	31 December 2010
	18 µg m^{-3}	Annual Mean	31 December 2010

Air Quality Bands and Index Values

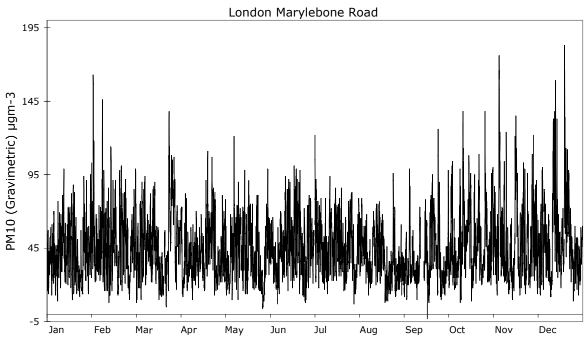
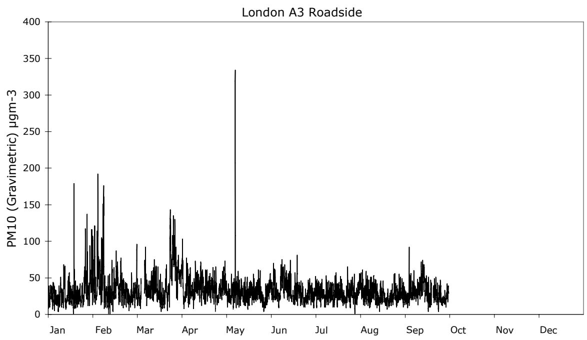
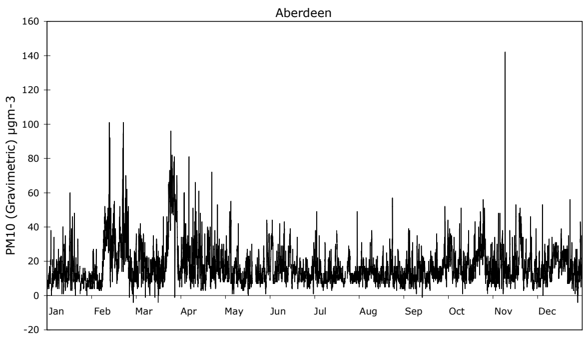
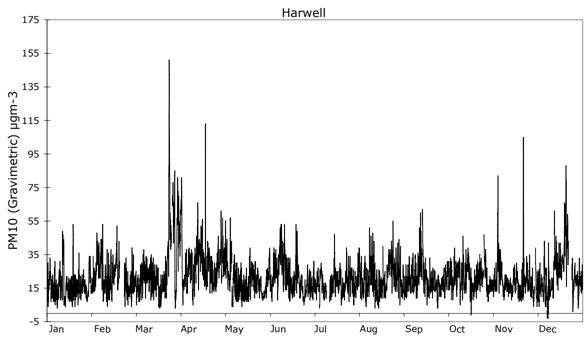
Band	Index	PM_{10} µg m^{-3} (Gravimetric)
Low	1	0-16
	2	17-32
	3	33-49
Moderate	4	50-57
	5	58-66
	6	67-74
High	7	75-82
	8	83-91
	9	92-99
Very High	10	100 or more



UK Automatic PM_{10} Particles Monitoring Sites 2007

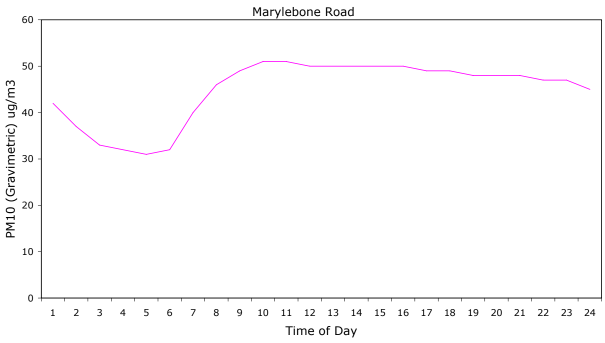
15.5 Hourly Average Concentrations

These figures show time series graphs of hourly average PM_{10} concentrations (gravimetric equivalent) at four monitoring sites of different types for 2007.

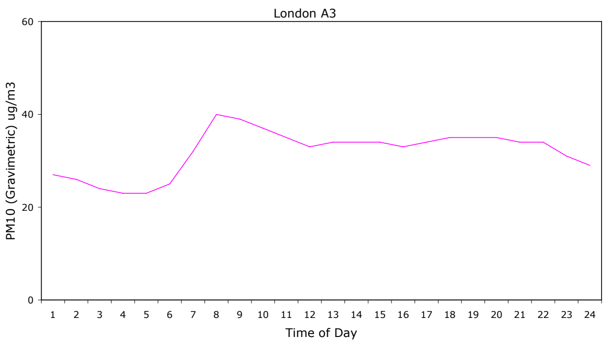
	**Kerbside Site** *(London Marylebone Road)*
	**Roadside Site** (*London A3)*
	**Urban Background Site** *(Aberdeen)*
	**Rural Site** *(Harwell)*

15.6 Diurnal Variations

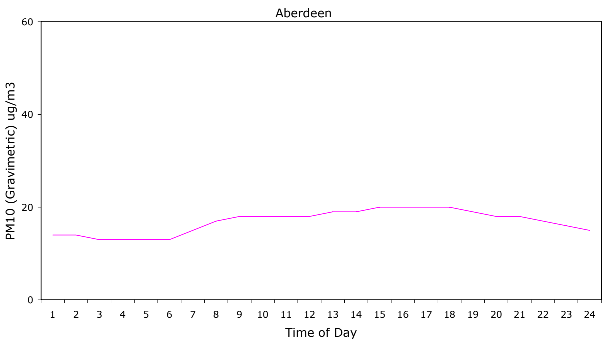
These figures show how PM_{10} concentrations varied on average for each hour of day during the year, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



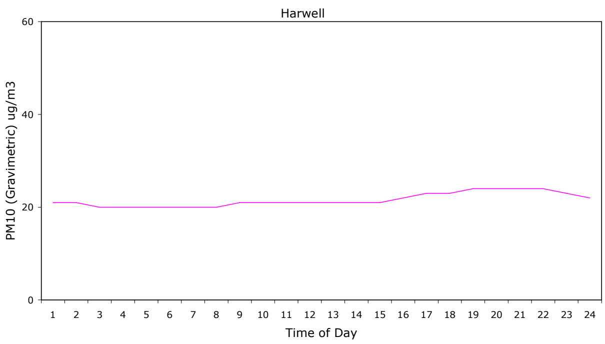
Kerbside Site
(London Marylebone Road)



Roadside Site
(London A3)



Urban Background Site
(Aberdeen)

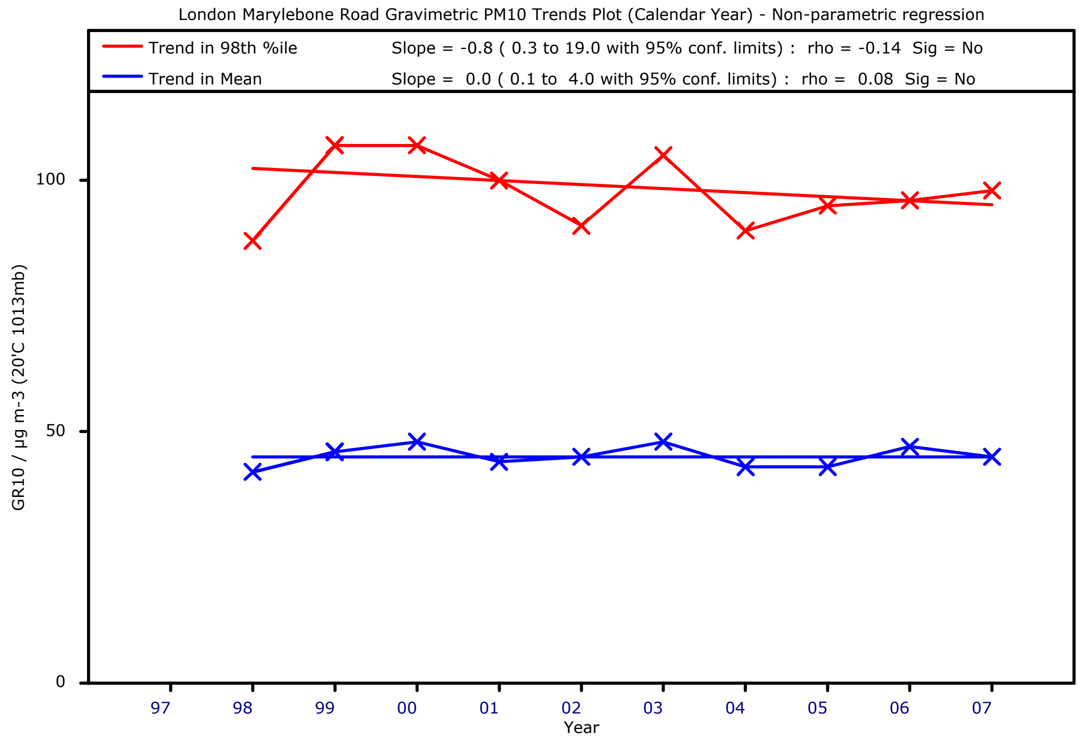


Rural Site
(Harwell)

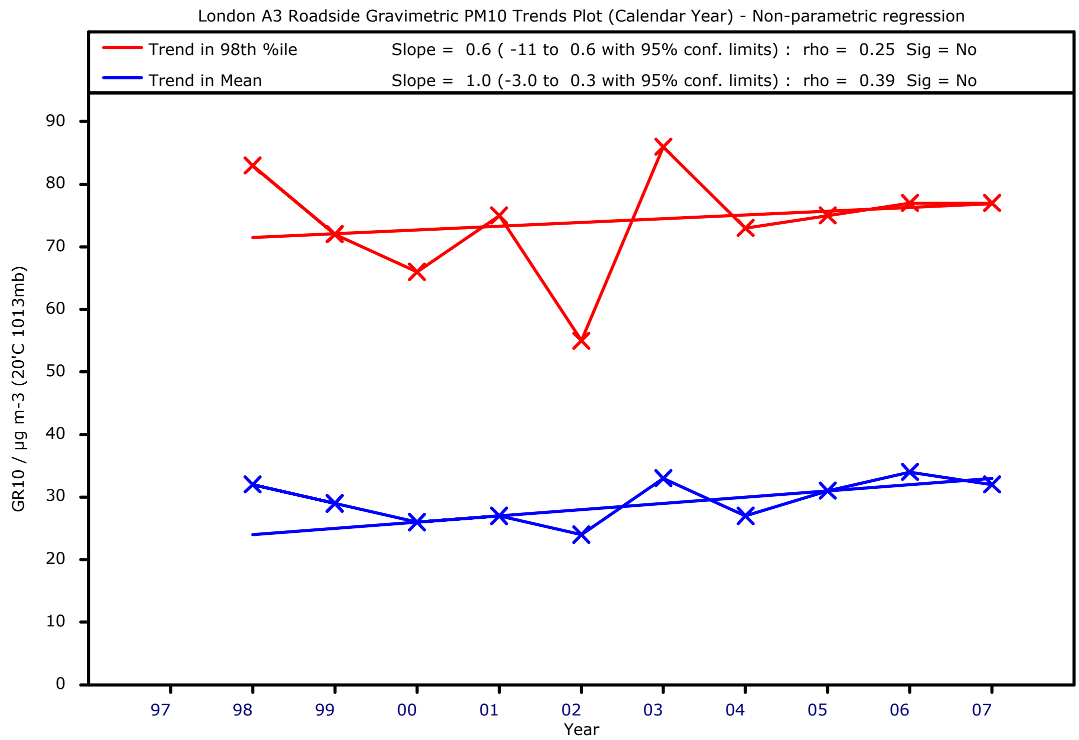
15.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

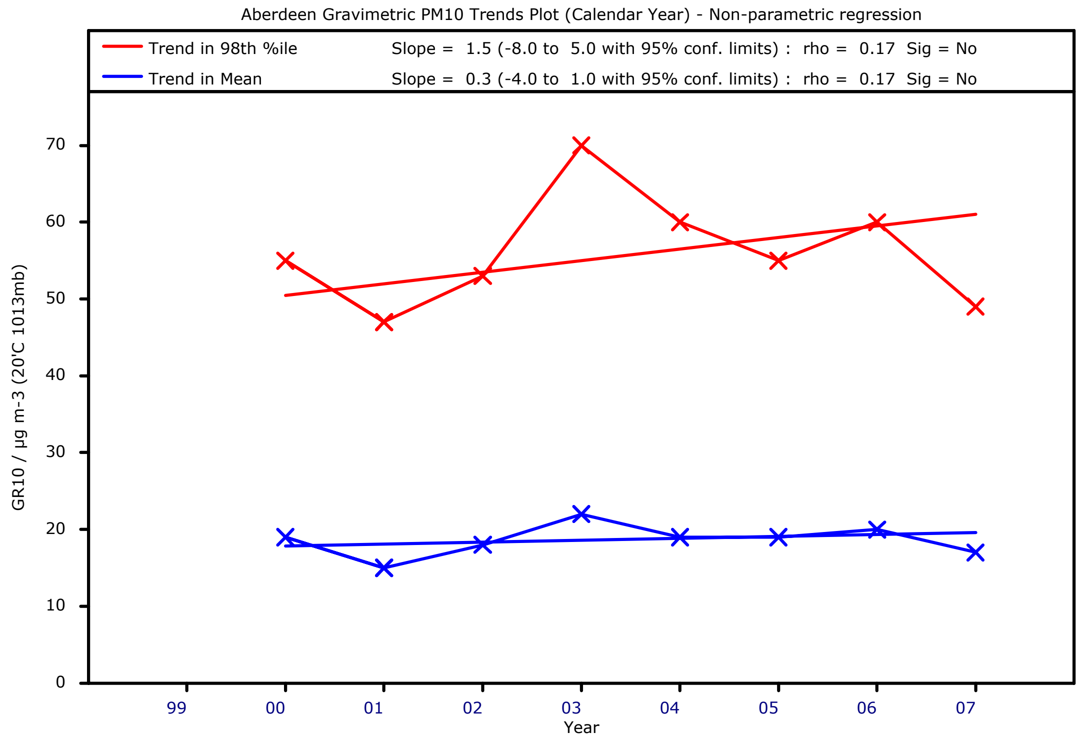
London Marylebone Road Gravimetric PM10 Trends Plot – Non-parametric regression



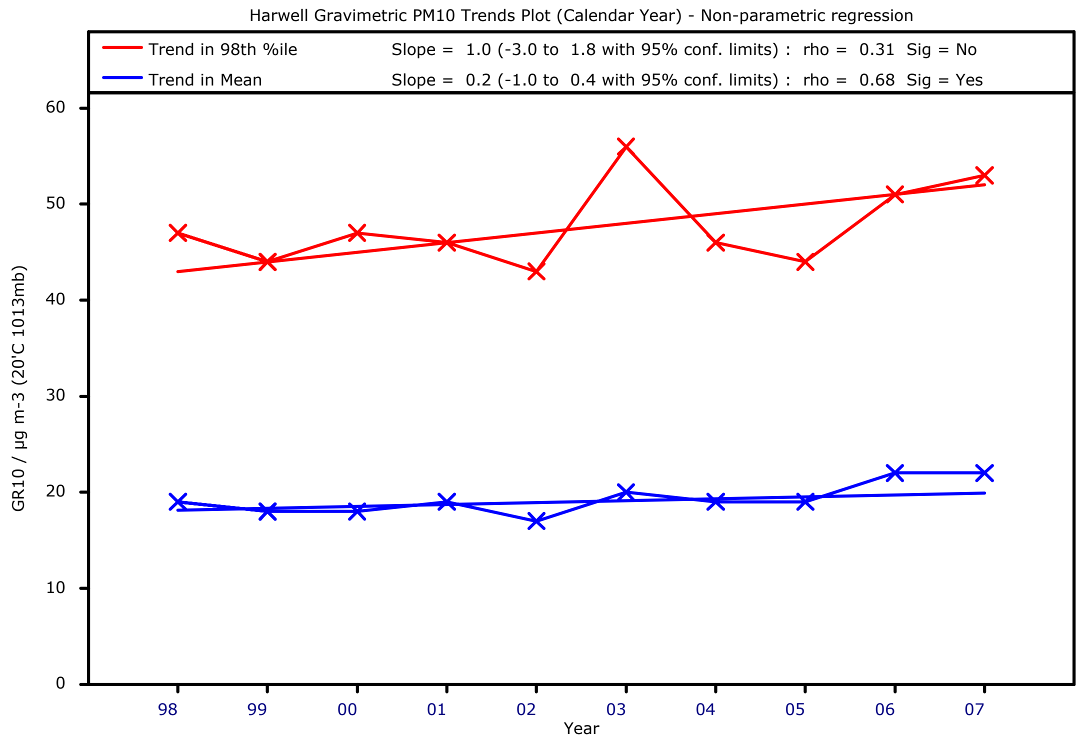
London A3 Roadside Gravimetric PM10 Trends Plot – Non-parametric regression



Aberdeen Gravimetric PM10 Trends Plot – Non-parametric regression



Harwell Gravimetric PM10 Trends Plot – Non-parametric regression



15.8 PM_{10} Statistical Summary 2007

i) PM_{10} annual statistics I

Site	Site Type	Annual average µg m-3	Annual data capture of hourly means % (for Partisol, capture of daily means)	Maximum hourly mean µg m-3	Maximum running 24-hour mean µg m-3	Date of maximum running 24-hour mean	90%ile of daily means µg m-3	98%ile of daily means µg m-3
England								
Birmingham Centre	UC	19	98.0	231	117	04/11/2007	36	61
Birmingham Tyburn	UB	25	98.0	1934	151	09/06/2007	39	62
Blackpool Marton	UB	21	95.4	122	78	28/03/2007	36	53
Bolton	UB	21	79.2	213	102	04/11/2007	33	50
Bournemouth *	UB	29	96.4	---	---	---	43	67
Bradford Centre	UC	24	70.4	125	68	30/03/2007	35	44
Brighton Roadside PM10*	RS	36	93.7	---	---	---	52	71
Bristol St Paul's	UB	20	97.4	438	122	15/09/2007	37	56
Bury Roadside	RS	28	77.7	287	131	04/11/2007	42	65
Camden Kerbside	KS	35	99.4	235	106	12/12/2007	53	77
Canterbury	UB	22	73.8	187	94	25/03/2007	32	56
Coventry Memorial Park	UB	18	99.0	145	104	28/03/2007	34	59
Haringey Roadside	RS	29	74.6	244	105	05/11/2007	41	66
Harwell	RU	22	96.7	151	89	25/03/2007	31	45
Hull Freetown	UC	19	98.4	283	93	05/11/2007	32	55
Leamington Spa	UB	21	97.2	313	87	25/03/2007	32	52
Leeds Centre	UC	25	99.2	213	92	04/11/2007	39	58
Leicester Centre	UC	21	74.3	287	145	04/11/2007	37	54
Liverpool Speke	UB	18	98.2	230	127	04/11/2007	34	66
London A3 Roadside	RS	32	73.3	334	100	25/03/2007	44	68
London Bexley	S	25	98.2	189	97	25/03/2007	39	61
London Bloomsbury	UC	29	89.7	481	97	25/03/2007	41	59
London Brent	UB	19	71.9	135	83	25/03/2007	27	46
London Eltham	S	20	52.8	285	97	01/02/2007	29	36
London Harlington	A	25	77.2	209	80	27/03/2007	36	56
London Hillingdon	S	26	73.1	211	94	25/03/2007	36	50
London Marylebone Road	KS	45	97.8	183	119	05/11/2007	62	79
London N. Kensington	UB	25	98.4	173	96	25/03/2007	36	58
London Westminster *	UB	34	91.5	---	---	---	50	71
Manchester Piccadilly	UC	24	98.4	429	218	04/11/2007	40	78
Middlesbrough	UI	21	97.4	264	99	29/03/2007	31	62
Newcastle Centre	UC	15	87.3	114	84	29/03/2007	26	48
Northampton	UB	21	78.1	140	72	25/03/2007	30	46
Northampton PM10 *	UB	25	63.0	---	---	---	39	58
Norwich Centre	UC	22	98.1	192	79	25/03/2007	30	55
Nottingham Centre	UC	22	95.3	201	137	04/11/2007	39	60
Plymouth Centre	UC	21	86.9	149	95	14/04/2007	36	57
Portsmouth	UB	23	97.7	274	111	25/03/2007	34	46
Preston	UB	20	98.6	214	78	04/11/2007	33	46
Reading New Town	UB	24	94.1	152	103	29/03/2007	40	72
Redcar	S	20	63.1	160	53	16/04/2007	32	42
Rochester Stoke	RU	23	98.3	166	88	25/03/2007	30	51
Salford Eccles	UI	21	90.1	343	155	04/11/2007	32	56
Scunthorpe Town	UI	25	98.0	270	99	05/11/2007	40	59
Sheffield Centre	UC	23	98.6	316	98	04/11/2007	41	60
Southampton Centre	UC	23	98.3	173	106	25/03/2007	39	55
Southend-on-Sea	UB	21	94.9	177	89	25/03/2007	35	57
Stockport Shaw Heath	UB	20	73.4	364	85	25/03/2007	30	51
Stockton-on-Tees Yarm	RS	26	97.6	222	106	27/03/2007	39	65
Stoke-on-Trent Centre	UC	23	97.6	339	150	04/11/2007	39	59
Thurrock	UB	23	99.2	215	86	25/03/2007	34	54
Wigan Centre	UB	21	73.8	178	91	25/03/2007	34	53

* Measurements made using the Partisol gravimetric sampler– these provide daily averages only

ii) PM_{10} exceedence statistics I

Site	Mod. band	Days	High band	Days	Very High band	Days	EC Dir. Limit Value Daily Mean & Air Quality Standard	Days	EC Dir. Value Annual Mean and Air Quality Std.	Annual Mean Standard (Scotland)
England										
Birmingham Centre	139	10	**51**	**6**	0	0	**13**	**13**	0	**1**
Birmingham Tyburn	124	12	**17**	**1**	**24**	**2**	**19**	**19**	0	**1**
Blackpool Marton	69	7	0	0	0	0	**9**	**9**	0	**1**
Bolton	89	6	**5**	**1**	0	0	**6**	**6**	0	**1**
Bournemouth	207	13	**17**	**3**	0	0	**19**	**19**	0	**1**
Bradford Centre	18	2	0	0	0	0	**3**	**3**	0	**1**
Brighton R'side PM10	294	18	**33**	**4**	0	0	**40**	**40**	0	**1**
Bristol St Paul's	85	12	**50**	**4**	0	0	**13**	**13**	0	**1**
Bury Roadside	152	13	**18**	**2**	**2**	**1**	**18**	**18**	0	**1**
Camden Kerbside	341	25	**24**	**4**	0	0	**40**	**40**	0	**1**
Canterbury	68	5	0	0	0	0	**7**	**7**	0	**1**
Coventry Memorial Park	113	11	**27**	**3**	0	0	**11**	**11**	0	0
Haringey Roadside	139	13	**13**	**1**	0	0	**16**	**16**	0	**1**
Harwell	27	3	0	0	0	0	**5**	**5**	0	**1**
Hull Freetown	141	7	0	0	0	0	**11**	**11**	0	**1**
Leamington Spa	58	6	0	0	0	0	**10**	**10**	0	**1**
Leeds Centre	161	12	0	0	0	0	**9**	**9**	0	**1**
Leicester Centre	71	8	**18**	**2**	**7**	**2**	**8**	**8**	0	**1**
Liverpool Speke	136	13	**49**	**4**	0	0	**11**	**11**	0	0
London A3 Roadside	176	13	**5**	**1**	0	0	**17**	**17**	0	**1**
London Bexley	133	8	**1**	**1**	0	0	**14**	**14**	0	**1**
London Bloomsbury	164	13	**2**	**1**	0	0	**14**	**14**	0	**1**
London Brent	28	4	0	0	0	0	**3**	**3**	0	**1**
London Eltham	23	2	**1**	**1**	0	0	**2**	**2**	0	**1**
London Harlington	102	8	0	0	0	0	**12**	**12**	0	**1**
London Hillingdon	75	5	0	0	0	0	**5**	**5**	0	**1**
London Marylebone	584	50	**48**	**6**	0	0	**119**	**119**	**1**	**1**
London N. Kensington	145	12	0	0	0	0	**13**	**13**	0	**1**
London Westminster	236	18	**38**	**6**	0	0	**31**	**31**	0	**1**
Manchester Piccadilly	149	12	**51**	**6**	**34**	**2**	**18**	**18**	0	**1**
Middlesbrough	155	11	**6**	**1**	0	0	**11**	**11**	0	**1**
Newcastle Centre	100	5	0	0	0	0	**6**	**6**	0	0
Northampton	14	2	0	0	0	0	**4**	**4**	0	**1**
Northampton PM10	76	7	**18**	**2**	0	0	**8**	**8**	0	**1**
Norwich Centre	34	4	0	0	0	0	**11**	**11**	0	**1**
Nottingham Centre	125	12	**52**	**6**	**9**	**2**	**14**	**14**	0	**1**
Plymouth Centre	111	8	**1**	**1**	0	0	**9**	**9**	0	**1**
Portsmouth	31	4	**14**	**2**	0	0	**5**	**5**	0	**1**
Preston	70	6	0	0	0	0	**7**	**7**	0	**1**
Reading New Town	239	20	**19**	**2**	0	0	**19**	**19**	0	**1**
Redcar	0	0	0	0	0	0	0	0	0	**1**
Rochester Stoke	42	5	0	0	0	0	**8**	**8**	0	**1**
Salford Eccles	77	6	**10**	**2**	**16**	**1**	**9**	**9**	0	**1**
Scunthorpe Town	116	9	**9**	**2**	0	0	**18**	**18**	0	**1**
Sheffield Centre	145	12	**4**	**1**	0	0	**13**	**13**	0	**1**
Southampton Centre	110	9	**10**	**2**	0	0	**13**	**13**	0	**1**
Southend-on-Sea	127	8	0	0	0	0	**17**	**17**	0	**1**
Stockport Shaw Heath	63	5	0	0	0	0	**6**	**6**	0	**1**
Stockton-on-Tees Yarm	136	12	**22**	**2**	0	0	**12**	**12**	0	**1**
Stoke-on-Trent Centre	78	8	**26**	**4**	**13**	**1**	**12**	**12**	0	**1**
Thurrock	112	9	0	0	0	0	**10**	**10**	0	**1**
Wigan Centre	85	4	0	0	0	0	**7**	**7**	0	**1**

* Measurements made using the Partisol gravimetric sampler– these provide daily averages only

iii) PM_{10} annual statistics II

Site	Site Type	Annual average µg m^{-3}	Annual data capture of hourly means % (for Partisol, capture of daily means)	Maximum hourly mean µg m^{-3}	Maximum running 24-hour mean µg m^{-3}	Date of maximum running 24-hour mean	90%ile of daily means µg m^{-3}	98%ile of daily means µg m^{-3}
England								
Wirral Tranmere	UB	17	97.4	190	92	04/11/2007	32	47
Wolverhampton Centre	UC	19	72.9	144	89	25/03/2007	33	52
N Ireland								
Belfast Centre	UC	19	94.6	163	91	28/03/2007	32	44
Belfast Clara St	S	21	74.3	134	86	28/03/2007	33	53
Derry	UB	21	96.6	160	68	28/03/2007	32	45
Lough Navar	RE	13	97.7	101	53	26/03/2007	20	30
Scotland								
Aberdeen	UB	17	98.7	142	64	27/03/2007	27	40
Auchencorth Moss *	RU	---	35.6	---	---	---	---	---
Auchencorth Moss PM	RU	7	96.9	82	52	27/03/2007	14	27
Dumfries *	RS	24	95.3	---	---	---	39	57
Edinburgh St Leonards	UB	19	75.5	95	68	28/03/2007	29	54
Glasgow Centre	UC	20	98.0	339	75	28/03/2007	32	45
Glasgow Kerbside	KS	32	94.5	183	106	28/03/2007	51	70
Grangemouth	UI	16	98.3	112	57	27/03/2007	25	38
Inverness *	RS	19	87.7	---	---	---	29	38
Inverness PM10	RS	10	54.9	59	31	05/05/2007	16	23
Wales								
Cardiff Centre	UC	22	89.7	148	104	28/03/2007	38	63
Cwmbran	UB	18	74.0	159	87	25/03/2007	29	44
Narberth	RE	18	89.0	179	97	26/03/2007	26	40
Port Talbot	UI	31	53.7	321	110	14/04/2007	61	86
Port Talbot Margam	UI	---	42.7	306	103	30/11/2007	---	---
Swansea Roadside	RS	18	82.4	240	83	14/04/2007	32	51
Wrexham *	RS	24	95.1	---	---	---	43	63
Wrexham PM10	RS	19	73.0	162	115	28/03/2007	35	55

* Measurements made using the Partisol gravimetric sampler– these provide daily averages only

iv) PM_{10} exceedence statistics - II

Site	Mod. band	Days	High band	Days	Very High band	Days	EC Dir. Limit Value Daily Mean & Air Quality Standard	Days	EC Dir. Value Annual Mean and Air Quality Std.	Annual Mean Standard (Scotland)
England - continued										
Wirral Tranmere	57	6	0	0	0	0	**5**	**5**	0	0
Wolverhampton Centre	60	4	0	0	0	0	**6**	**6**	0	**1**
N Ireland										
Belfast Centre	30	2	0	0	0	0	**5**	**5**	0	**1**
Belfast Clara St	54	3	0	0	0	0	**7**	**7**	0	**1**
Derry	9	2	0	0	0	0	**6**	**6**	0	**1**
Lough Navar	0	0	0	0	0	0	0	0	0	0
Scotland										
Aberdeen	0	0	0	0	0	0	**4**	**4**	0	0
Auchencorth Moss *	0	0	0	0	0	0	0	0	---	---
Auchencorth Moss PM	0	0	0	0	0	0	0	0	0	0
Dumfries *	93	10	0	0	0	0	**11**	**11**	0	**1**
Edinburgh St Leonards	32	3	0	0	0	0	**6**	**6**	0	**1**
Glasgow Centre	33	2	0	0	0	0	**3**	**3**	0	**1**
Glasgow Kerbside	264	19	**27**	**3**	0	0	**38**	**38**	0	**1**
Grangemouth	0	0	0	0	0	0	**1**	**1**	0	0
Inverness *	0	0	0	0	0	0	0	0	0	**1**
Inverness PM10	0	0	0	0	0	0	0	0	0	0
Wales										
Cardiff Centre	119	10	**23**	**2**	0	0	**11**	**11**	0	**1**
Cwmbran	23	2	0	0	0	0	**3**	**3**	0	0
Narberth	21	2	**3**	**1**	0	0	**2**	**2**	0	0
Port Talbot	328	32	**57**	**4**	0	0	**31**	**31**	0	**1**
Port Talbot Margam	128	14	**13**	**3**	0	0	**14**	**14**	---	---
Swansea Roadside	102	6	0	0	0	0	**7**	**7**	0	0
Wrexham *	132	9	**38**	**3**	0	0	**21**	**21**	0	**1**
Wrexham PM10	93	7	**24**	**2**	0	0	**8**	**8**	0	**1**

* Measurements made using the Partisol gravimetric sampler– these provide daily averages only

16. $PM_{2.5}$ - Measurement Sites, Instrumentation and Statistics

16.1 Measurement Method

The tapered element oscillating microbalance (TEOM) system determines particulate concentration by continuously weighing particles deposited on a filter.

16.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- R&P TEOM 1400
- R&P TEOM 1400 AB with 8500 FDMS
- R&P Partisol

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

Please also see detailed information on particle measurements and conversion factors used in this report (Appendix 6).

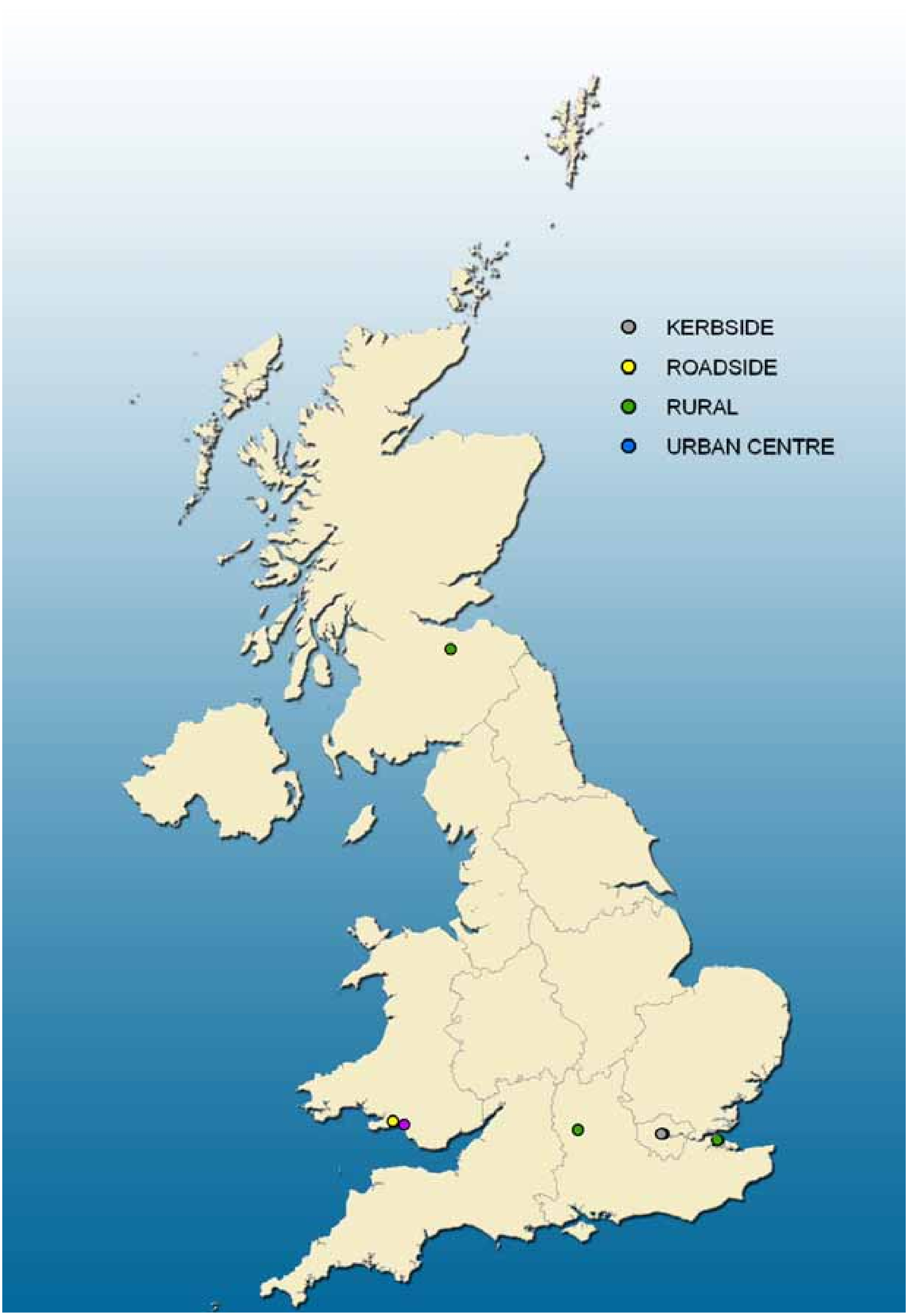
16.3 Data Quality Requirements of EC Directive 2008/50/EC

Uncertainty 25%
Minimum data capture 90%

16.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy

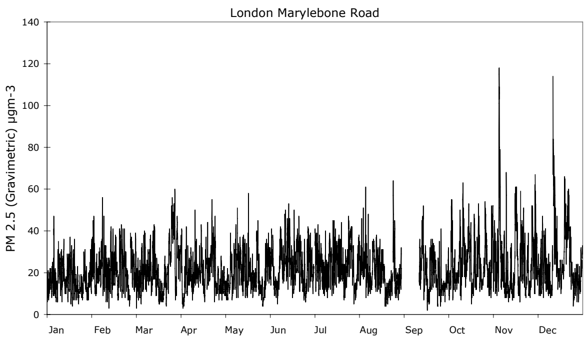
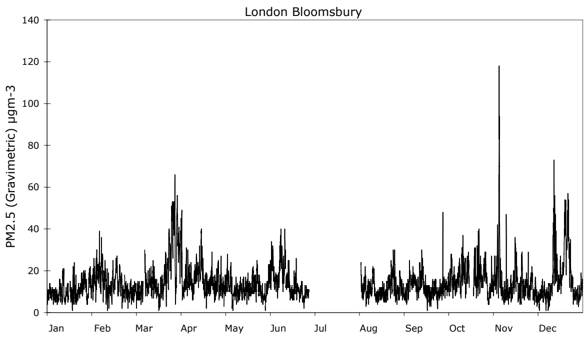
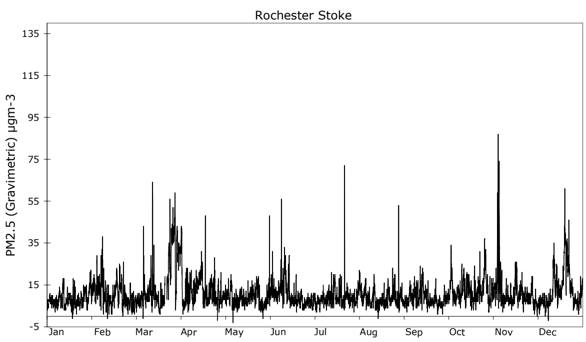
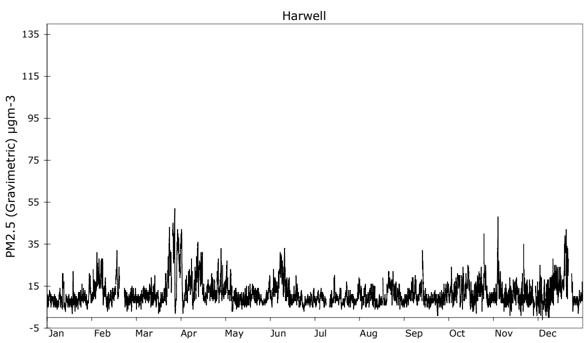
	Objective	Measured as	To be achieved by
Particles ($PM_{2.5}$) (gravimetric) All authorities	25 µg m^{-3}	Annual Mean	2020
	20% reduction in exposure reduction in urban background areas	Annual Mean	2010-2020
Particles ($PM_{2.5}$) Authorities in Scotland only	12 µg m^{-3}	Annual Mean	2020



UK Automatic Gravimetric $PM_{2.5}$ particles Monitoring Sites 2007

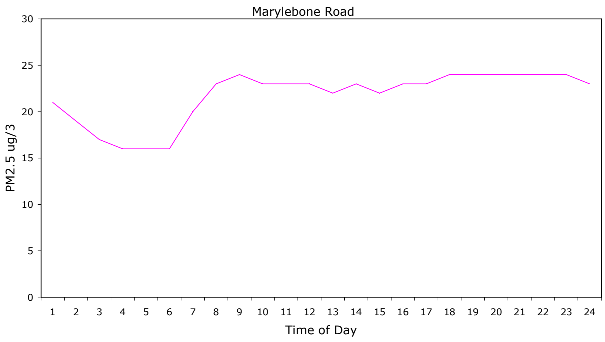
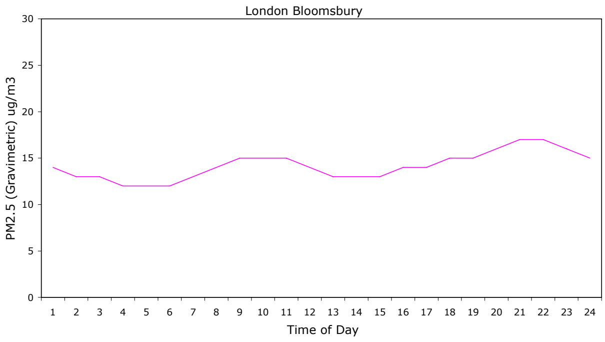
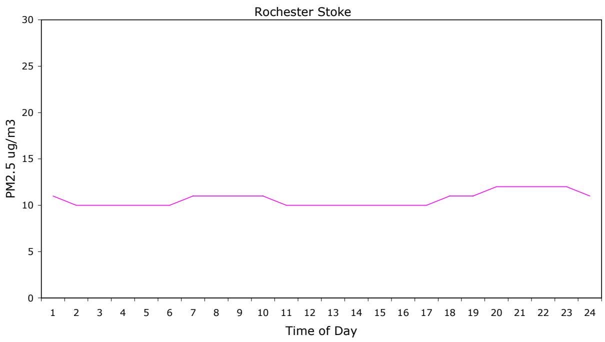
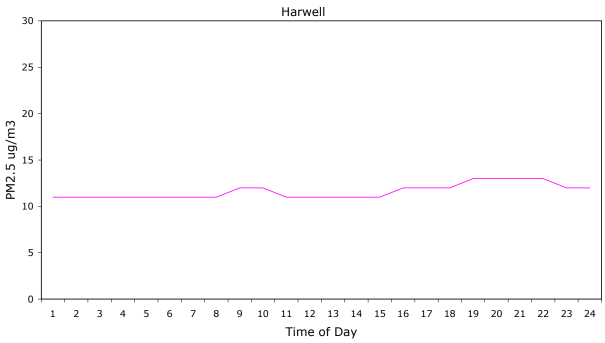
16.5 Hourly Average Concentrations

These figures show time series graphs of hourly average $PM_{2.5}$ concentrations at four monitoring sites of different types, for 2007.

	**Kerbside Site** *(London Marylebone Road)*
	**Urban Centre Site** (*Bloomsbury)*
	**Rural Site** (*Rochester)*
	**Rural Site** *(Harwell)*

16.6 Diurnal Variations

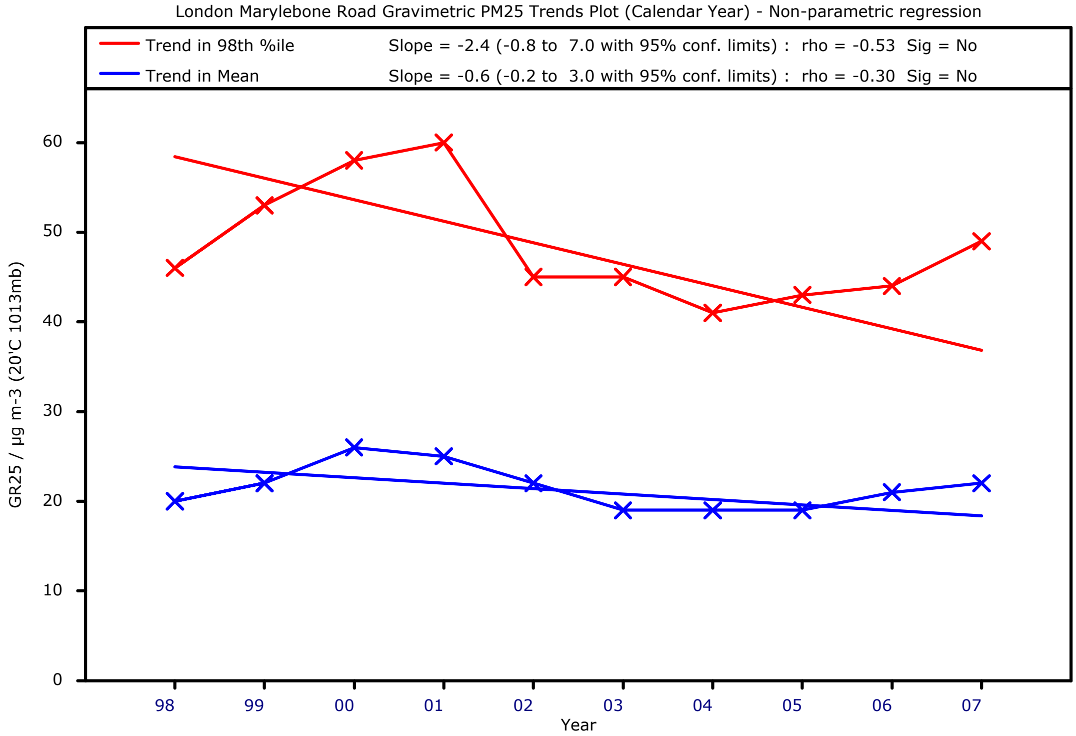
These figures show how $PM_{2.5}$ concentrations varied on average for each hour of day during 2007, at the same four monitoring sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.

	**Kerbside Site** *(London Marylebone Road)*
	**Urban Centre Site** (*Bloomsbury)*
	**Rural Site** (*Rochester)*
	**Rural Site** *(Harwell)*

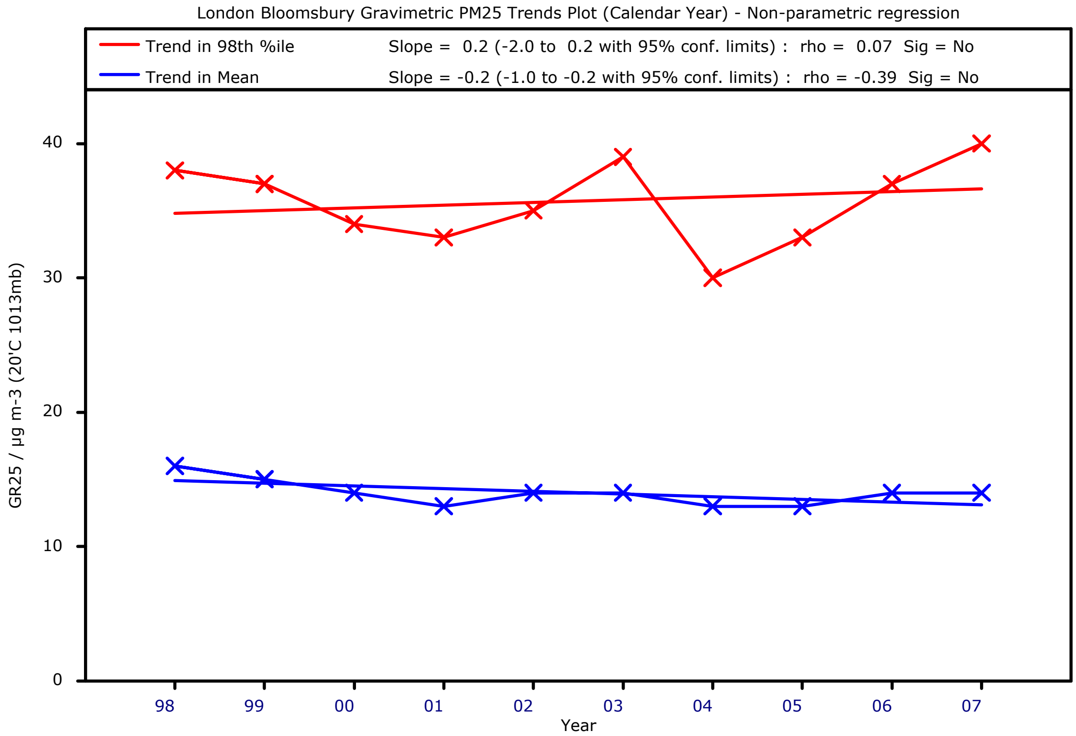
16.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

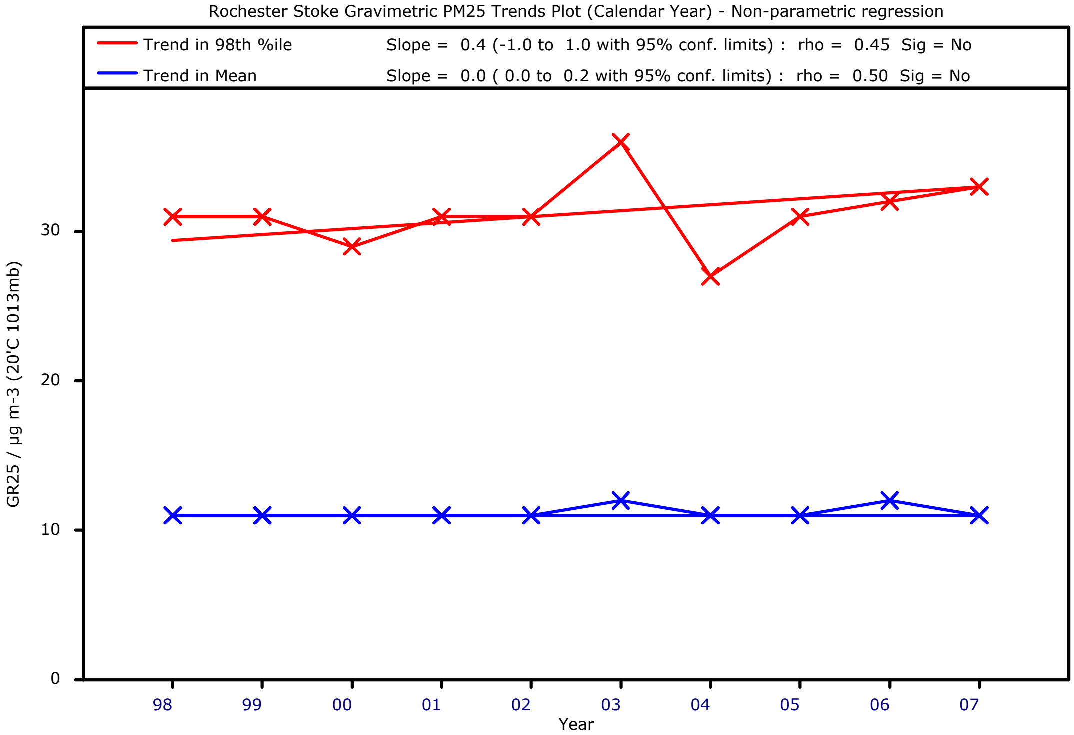
London Marylebone Road $PM_{2.5}$ Particulate Matter Trends Plot –Non-parametric regression



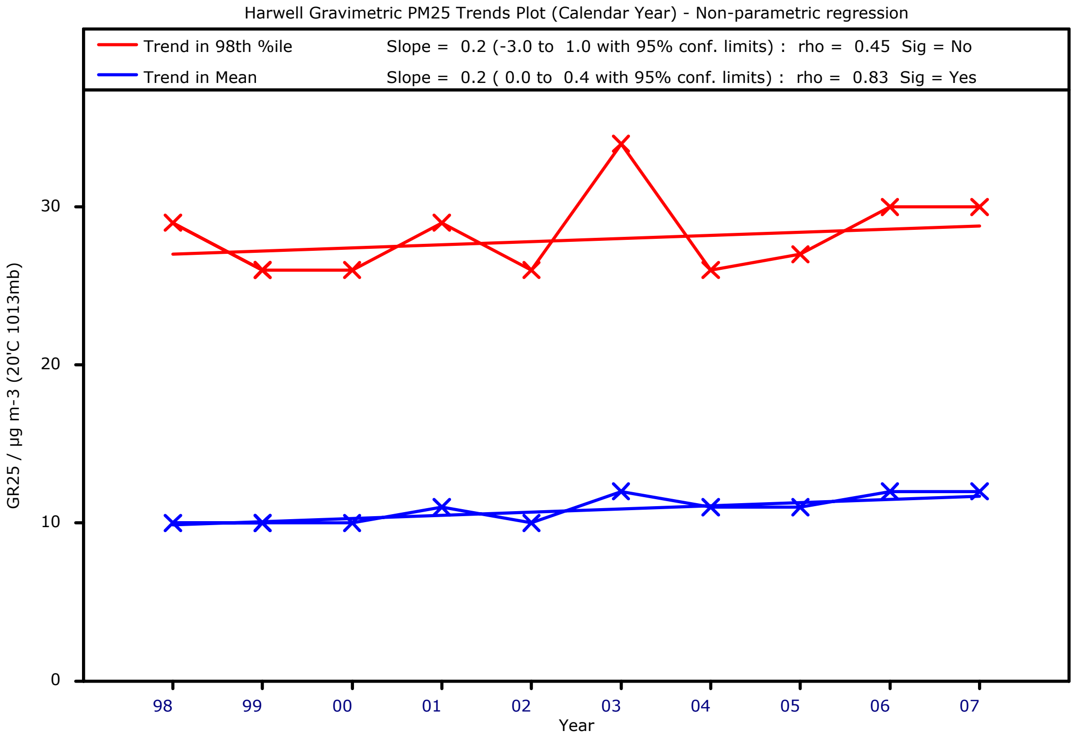
London Bloomsbury $PM_{2.5}$ Particulate Matter Trends Plot – Non-parametric regression



Rochester $PM_{2.5}$ particulate Matter Trends plot – Non-parametric regression



Harwell $PM_{2.5}$ Particulate Matter Trends Plot – Non-parametric regression



16.8 $PM_{2.5}$ Statistical Summary 2007

i) $PM_{2.5}$ Annual statistics

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England				
Harwell	RU	12	96.6	52
London Bloomsbury	UC	14	88.2	118
London Marylebone Road	KS	22	95.7	118
Rochester Stoke	RU	11	99.1	87
Scotland				
Auchencorth Moss *	RU	13	92.3	---
Auchencorth Moss PM	RU	4	96.7	64
Wales				
Swansea Roadside	RS	14	91.7	262

* Measurements made using the Partisol gravimetric sampler– these provide daily averages only

ii) Exceedence Statistics-

There are no exceedence statistics for $PM_{2.5}$ Particulate Matter.

17. SO_2 - Measurement Sites, Instrumentation and Statistics

17.1 Measurement Method

The sulphur dioxide analyser works on the principle of ultra violet (UV) fluorescence. SO_2 molecules are excited to higher energy states by UV radiation. These energy states decay causing an emission of secondary fluorescent radiation with intensity proportional to the concentration of SO_2 in the sample.

17.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak SO_2
- API M100
- Environnement AF 21M
- Horiba APSA 360
- Monitor Labs 9850
- Rotork 477
- Thermo Electron 43

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

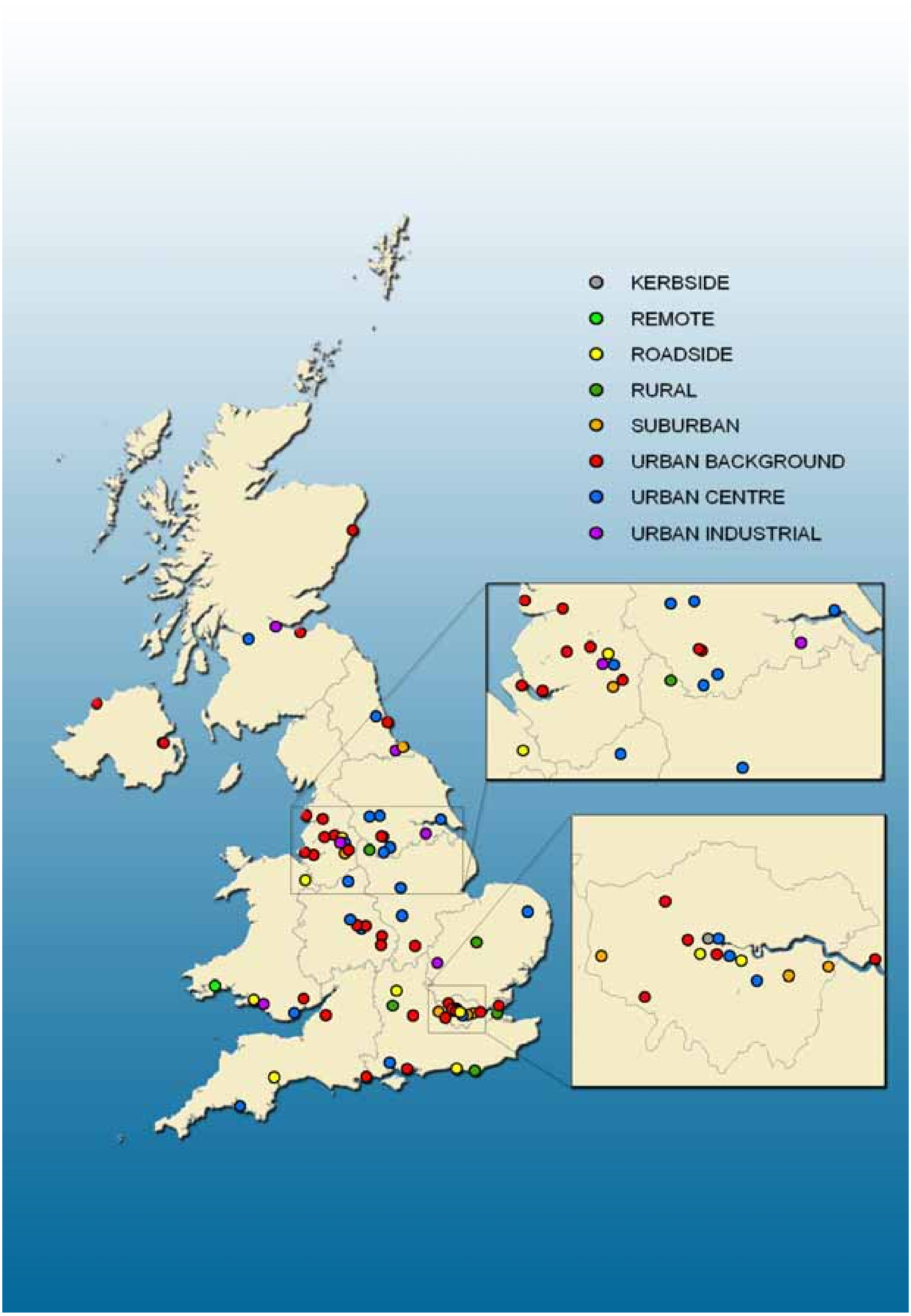
17.3 Data Quality Requirements of EC Directive 2008/50/EC

Uncertainty 15%, minimum data capture 90%

17.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Sulphur Dioxide	266 µg m^{-3} Not to be exceeded more than 35 times per year	15 Minute Mean	31 December 2005
	350 µg m^{-3} Not to be exceeded more than 24 times per year	1 Hour Mean	31 December 2005
	125 µg m^{-3} Not to be exceeded more than 3 times per year	24 Hour Mean	31 December 2005
	(V) 20 µg m^{-3}	Annual Mean	31 December 2000
	(V) 20 µg m^{-3}	Winter Mean (01 October - 31 March)	31 December 2000

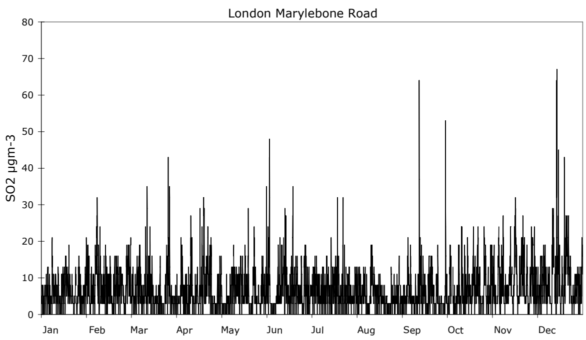
Air Quality Bands and Index Values		
Band	Index	Sulphur Dioxide µg m^{-3}
Low	1	0-88
	2	89-176
	3	177-265
Moderate	4	266-354
	5	355-442
	6	443-531
High	7	532-708
	8	709-886
	9	887-1063
Very High	10	1064 or more



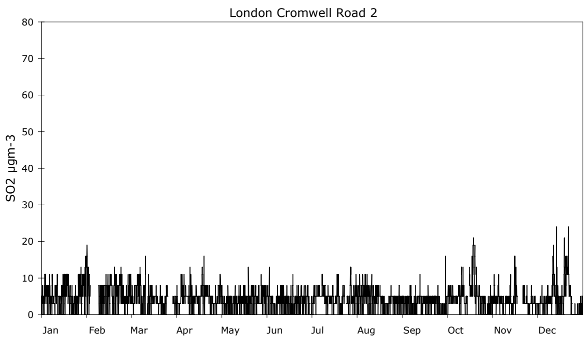
UK Automatic Sulphur Dioxide Monitoring Sites 2007

17.5 Hourly Average Concentrations

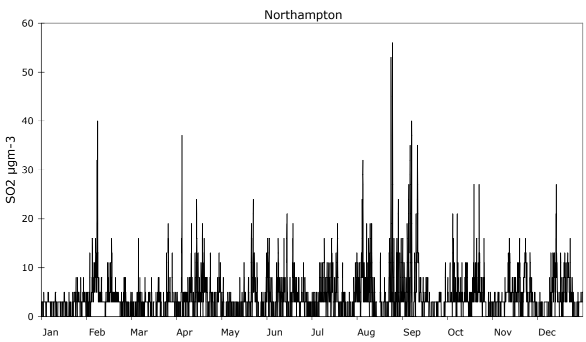
These figures show time series graphs of hourly average sulphur dioxide concentrations at four monitoring sites of different types for 2007.



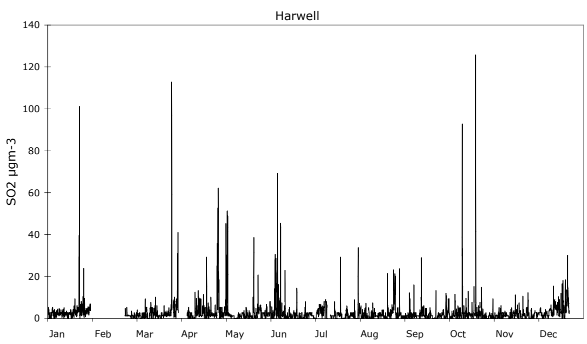
Kerbside Site
(London Marylebone Road)



Roadside Site
(*London Cromwell Road)*



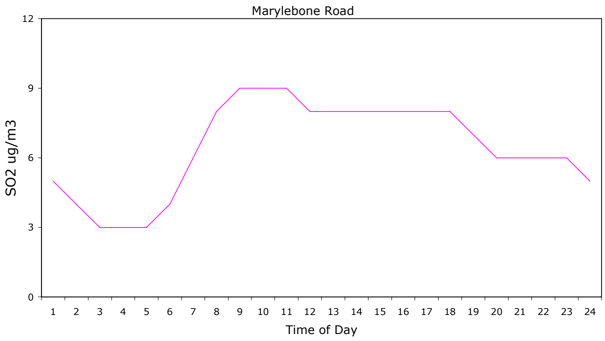
Urban Background Site
(*Northampton)*



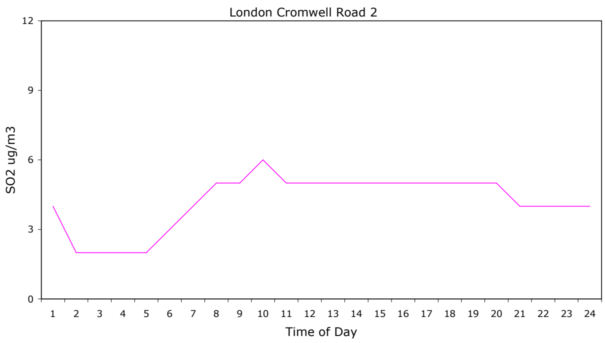
Rural Site
(Harwell)

17.6 Diurnal Variations

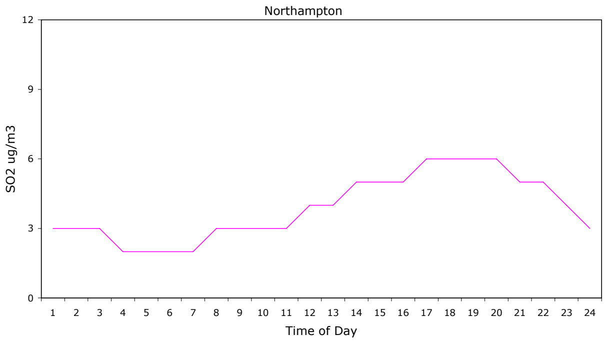
These figures show how sulphur dioxide concentrations varied on average for each hour of day during 2007, at the same four sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



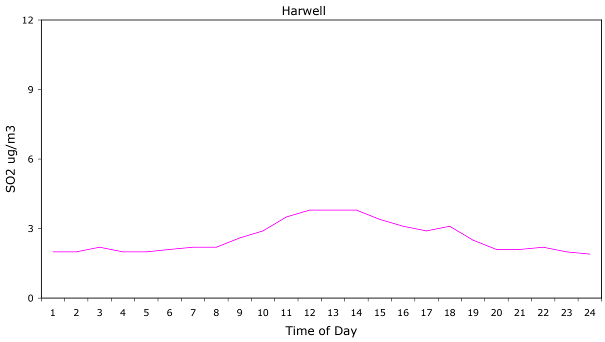
Kerbside Site
(London Marylebone Road)



Roadside Site
(*London Cromwell Road)*



Urban Background Site
(*Northampton)*

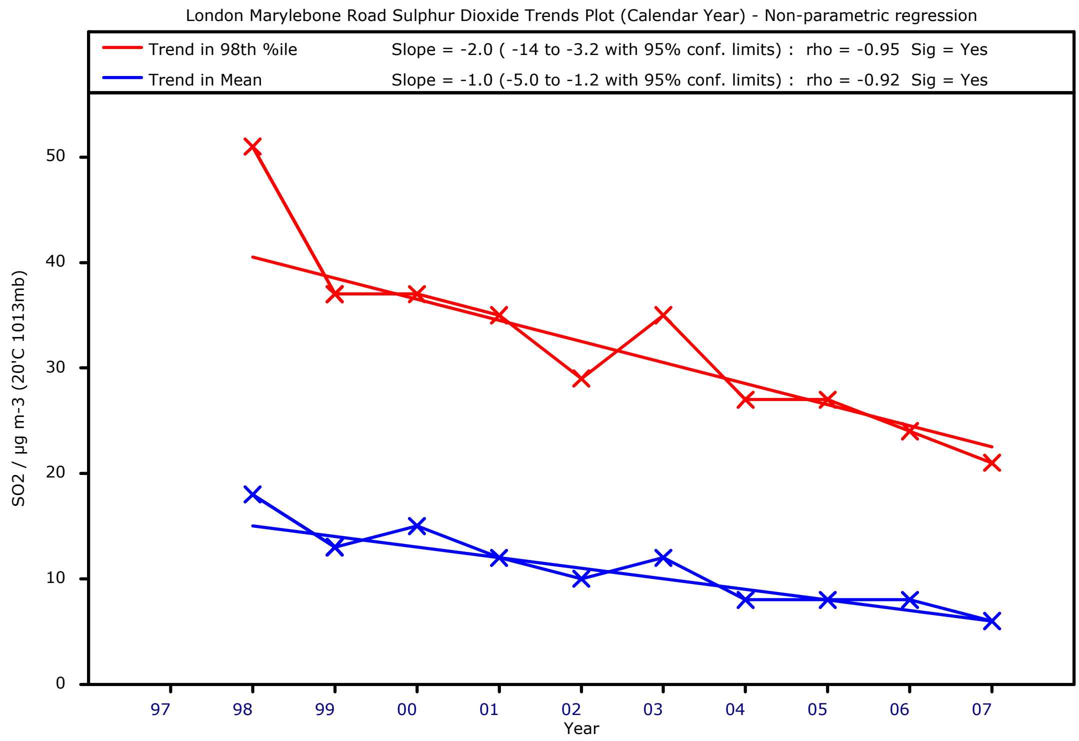


Rural Site
(Harwell)

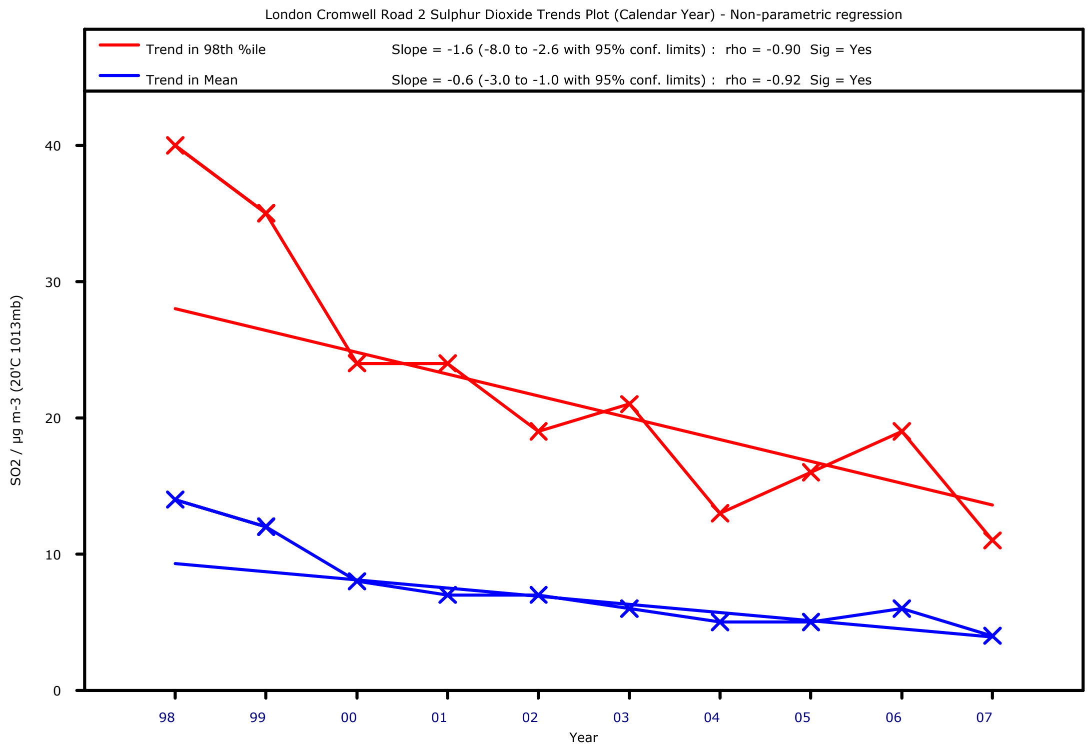
17.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

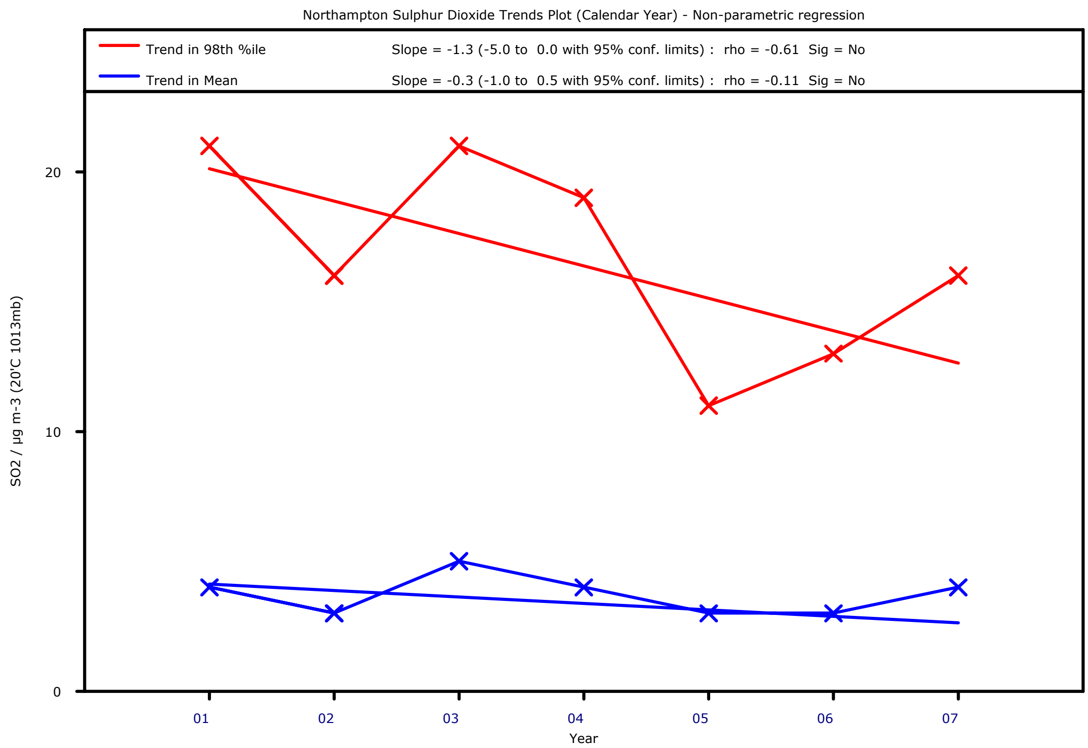
London Marylebone Road Sulphur Dioxide Trends plot – non-parametric regression



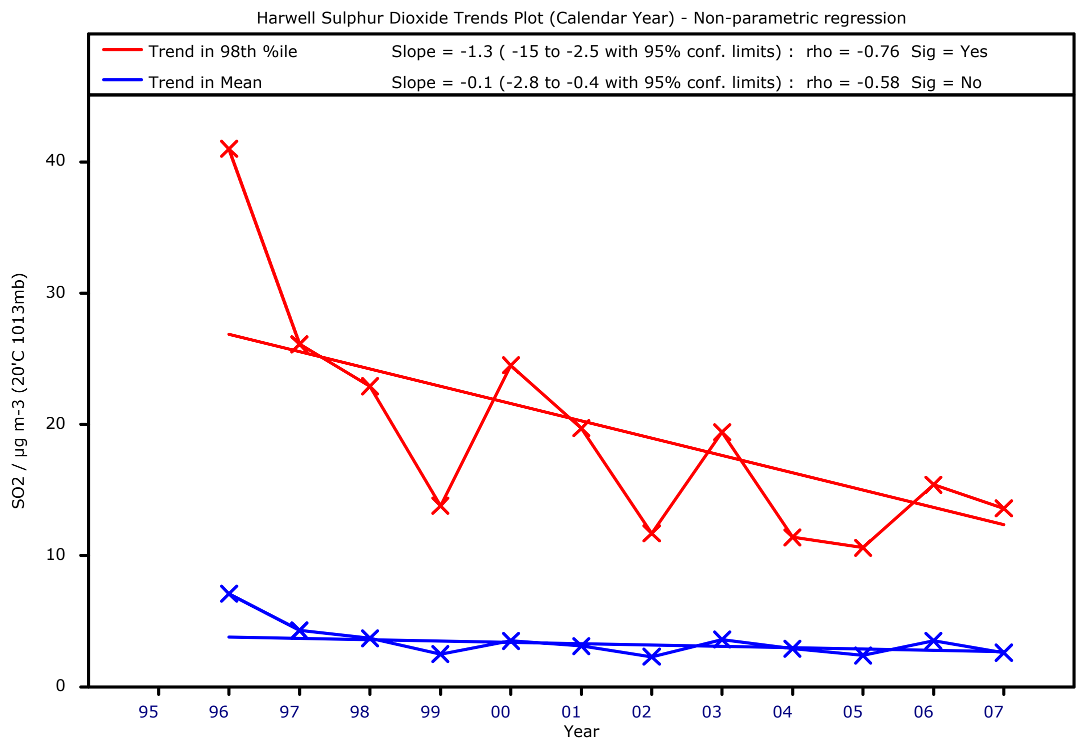
London Cromwell Road Sulphur Dioxide Trends Plot – Non-parametric regression



Northampton Sulphur dioxide Trends Plot – Non-parametric regression



Harwell Sulphur dioxide Trends Plot – Non-parametric regression



17.8 Sulphur Dioxide Statistical Summary 2007

i) SO_2 annual statistics I

Site	Site Type	Annual avg. of hourly means µg m^{-3}	Annual data capture of hourly means %	Max. hourly mean µg m^{-3}	Max. 15-minute mean µg m^{-3}	Date of max. 15-minute mean	99.9 %ile of 15-min means µg m^{-3}	99.7 %ile of hourly means µg m^{-3}	99 %ile of daily means µg m^{-3}
England									
Barnsley 12	UB	8	95.1	82	98	03/05/200	67	56	35
Barnsley Gawber	UB	7	90.1	82	178	14/04/200	56	40	19
Birmingham Centre	UC	3	65.1	51	56	04/06/200	27	19	10
Birmingham Tyburn	UB	2	95.1	53	61	28/03/200	24	19	11
Blackpool Marton	UB	5	67.5	19	27	10/02/200	16	16	10
Bolton	UB	---	40.7	37	61	13/09/200	---	---	---
Bournemouth	UB	1	63.3	61	69	04/02/200	29	19	7
Bradford Centre	UC	10	64.6	45	59	23/07/200	40	32	19
Bristol St Paul's	UB	2	98.2	59	106	05/04/200	29	21	8
Bury Roadside	RS	7	61.4	80	82	06/03/200	56	40	23
Coventry Mem. Park	UB	2	70.4	35	43	14/02/200	24	19	9
Exeter Roadside	RS	1	74.0	11	21	11/04/200	8	5	3
Harwell	RU	2.6	87.5	125.8	167.0	26/03/200	75.5	41.5	15.4
Hove Roadside	RS	2	74.0	32	37	07/02/200	24	16	8
Hull Freetown	UC	3	97.7	109	189	01/04/200	48	32	12
Ladybower	RU	4.1	81.9	85.1	103.7	21/12/200	68.1	39.4	16.5
Leamington Spa	UB	3	96.3	32	37	16/04/200	19	13	7
Leeds Centre	UC	2	99.0	215	242	11/06/200	82	37	13
Leicester Centre	UC	2	99.2	53	80	05/04/200	27	16	10
Liverpool Speke	UB	6	98.2	138	154	09/08/200	72	48	18
London Bexley	S	4	98.6	144	184	20/05/200	82	51	17
London Bloomsbury	UC	5	82.4	85	104	15/12/200	56	35	22
London Brent	UB	2	70.5	48	64	03/06/200	29	21	9
London Cromwell	RS	4	93.8	24	32	14/12/200	21	16	11
London Eltham	S	4	67.4	69	109	20/07/200	51	32	14
London Hillingdon	S	2	72.7	35	56	01/08/200	24	16	6
London Lewisham	UC	3	73.6	85	154	04/02/200	53	35	13
London M'bone Rd	KS	6	98.7	67	98	12/09/200	45	32	17
London N. Kens.	UB	3	96.2	51	59	14/12/200	35	24	12
London Southwark	UC	3	62.6	80	98	30/09/200	32	27	12
London Teddington	UB	3.7	64.7	84.9	118.4	19/07/200	47.3	31.9	14.3
London Westminster	UB	4	91.4	80	88	14/12/200	51	32	17
Lullington Heath	RU	2.6	96.9	61.7	82.7	22/04/200	33.5	23.9	10.9
Manchester	UC	5	70.5	32	51	26/02/200	24	16	8
Manchester South	S	1	72.9	48	56	28/03/200	19	13	7
Middlesbrough	UI	5	98.8	152	200	02/06/200	96	64	22
Newcastle Centre	UC	4	96.9	98	109	02/04/200	56	35	13
Northampton	UB	4	99.1	56	56	24/08/200	43	32	14
Norwich Centre	UC	1	90.8	21	24	16/11/200	16	11	6
Nottingham Centre	UC	3	98.3	45	48	15/10/200	24	19	10
Oxford Centre R'side	RS	2	71.7	21	27	07/02/200	16	13	6
Plymouth Centre	UC	1	62.1	8	21	08/04/200	8	5	3
Portsmouth	UB	3	72.2	51	59	12/04/200	35	21	8
Preston	UB	3	71.1	32	37	14/04/200	21	16	8
Reading New Town	UB	6	68.2	51	53	09/02/200	43	37	25
Redcar	S	7	62.7	149	261	05/04/200	120	80	25
Rochester Stoke	RU	5.8	98.4	156.9	267.6	06/03/200	84.6	54.3	16.1
Rotherham Centre	UC	4	70.4	53	64	03/05/200	43	24	11
Salford Eccles	UI	8	77.1	98	168	11/06/200	61	43	24
Sandwell West	UB	2	98.7	56	69	04/04/200	35	19	9
Scunthorpe Town	UI	6	96.9	162	253	10/02/200	120	85	34
Sheffield Centre	UC	8	94.6	117	122	03/05/200	43	29	16
Southampton Centre	UC	3	98.1	56	82	11/04/200	43	24	10
Southend-on-Sea	UB	4	73.3	88	112	06/03/200	59	32	12
Southwark Roadside	RS	---	0.0	---	---	---	---	---	---

ii) SO_2 exceedence statistics I

Site	Mod. band	Days	High band	Days	Very High band	Days	AQS 15-min obj.	Days	EC Dir. & AQS 1-hr obj.	Days	EC Dir. & AQS daily mean obj.	Days
England												
Barnsley 12	0	0	0	0	0	0	0	0	0	0	0	0
Barnsley Gawber	0	0	0	0	0	0	0	0	0	0	0	0
Birmingham Centre	0	0	0	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	0	0	0	0	0
Blackpool Marton	0	0	0	0	0	0	0	0	0	0	0	0
Bolton	0	0	0	0	0	0	0	0	0	0	0	0
Bournemouth	0	0	0	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0	0	0	0
Bristol St Paul's	0	0	0	0	0	0	0	0	0	0	0	0
Bury Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Coventry Mem. Park	0	0	0	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Harwell	0	0	0	0	0	0	0	0	0	0	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0	0	0	0
Ladybower	0	0	0	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	0	0	0	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0	0	0	0
London Bexley	0	0	0	0	0	0	0	0	0	0	0	0
London Bloomsbury	0	0	0	0	0	0	0	0	0	0	0	0
London Brent	0	0	0	0	0	0	0	0	0	0	0	0
London Cromwell Rd 2	0	0	0	0	0	0	0	0	0	0	0	0
London Eltham	0	0	0	0	0	0	0	0	0	0	0	0
London Hillingdon	0	0	0	0	0	0	0	0	0	0	0	0
London Lewisham	0	0	0	0	0	0	0	0	0	0	0	0
London Marylebone Rd	0	0	0	0	0	0	0	0	0	0	0	0
London N. Kensington	0	0	0	0	0	0	0	0	0	0	0	0
London Southwark	0	0	0	0	0	0	0	0	0	0	0	0
London Teddington	0	0	0	0	0	0	0	0	0	0	0	0
London Westminster	0	0	0	0	0	0	0	0	0	0	0	0
Lullington Heath	0	0	0	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	0	0	0	0	0	0
Manchester South	0	0	0	0	0	0	0	0	0	0	0	0
Middlesbrough	0	0	0	0	0	0	0	0	0	0	0	0
Newcastle Centre	0	0	0	0	0	0	0	0	0	0	0	0
Northampton	0	0	0	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0	0	0	0
Nottingham Centre	0	0	0	0	0	0	0	0	0	0	0	0
Oxford Centre R’side	0	0	0	0	0	0	0	0	0	0	0	0
Plymouth Centre	0	0	0	0	0	0	0	0	0	0	0	0
Portsmouth	0	0	0	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	0	0	0	0	0
Redcar	0	0	0	0	0	0	0	0	0	0	0	0
Rochester Stoke	1	1	0	0	0	0	**1**	**1**	0	0	0	0
Rotherham Centre	0	0	0	0	0	0	0	0	0	0	0	0
Salford Eccles	0	0	0	0	0	0	0	0	0	0	0	0
Sandwell W Bromwich	0	0	0	0	0	0	0	0	0	0	0	0
Scunthorpe Town	0	0	0	0	0	0	0	0	0	0	0	0
Sheffield Centre	0	0	0	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0	0	0	0
Southwark Roadside	---	---	---	---	---	---	---	---	---	---	---	---

iii) SO_2 annual statistics II

Site	Site Type	Annual avg. of hourly means µg m^{-3}	Annual data capture of hourly means %	Max. hourly mean µg m^{-3}	Max. 15-minute mean µg m^{-3}	Date of max. 15-minute mean	99.9 %ile of 15-min means µg m^{-3}	99.7 %ile of hourly means µg m^{-3}	99 %ile of daily means µg m^{-3}
England									
Stewartby	UI	---	9.7	45	82	03/12/200	---	---	---
Stockport Shaw	UB	3	73.9	37	43	28/03/200	24	19	9
Stoke-on-Trent	UC	4	71.2	43	80	10/01/200	27	19	8
Sunderland	UB	2	70.4	24	24	26/02/200	16	11	5
Thurrock	UB	4	97.7	72	101	31/07/200	56	37	15
Wicken Fen	RU	3.8	97.8	24.7	37.5	05/02/200	18.9	12.5	8.3
Wigan Centre	UB	2	72.7	37	45	04/02/200	29	19	9
Wirral Tranmere	UB	4	50.2	93	136	14/04/200	64	45	15
W'hampton Centre	UC	3	73.1	61	82	10/03/200	45	27	10
N Ireland									
Belfast Centre	UC	4	87.9	72	98	03/05/200	40	29	15
Belfast East	UB	3	74.1	45	69	23/03/200	40	29	12
Derry	UB	4	74.3	45	96	24/10/200	24	21	10
Scotland									
Aberdeen	UB	3	72.6	29	56	13/02/200	27	19	7
Edinburgh St L.'s	UB	3	96.9	229	317	03/05/200	114	64	17
Glasgow Centre	UC	2	96.3	53	61	02/05/200	35	21	8
Grangemouth	UI	7	98.3	234	279	14/04/200	186	130	49
Wales									
Cardiff Centre	UC	3	97.2	144	215	24/08/200	61	27	11
Cwmbran	UB	---	35.5	56	77	25/08/200	---	---	---
Narberth	RE	2.0	88.6	33.5	41.8	07/02/200	18.6	12.5	5.0
Port Talbot	UI	9	53.4	120	210	27/02/200	125	80	27
Port Talbot Margam	UI	---	41.6	189	221	20/10/200	---	---	---
Swansea Roadside	RS	4	73.2	64	80	01/06/200	43	29	12
Wrexham	RS	3	95.1	35	48	07/02/200	29	21	11

iv) SO_2 exceedence statistics II

Site	Mod. band	Days	High band	Days	Very High band	Days	AQS 15-min obj.	Days	EC Dir. & AQS 1-hr obj.	Days	EC Dir. & AQS daily mean obj.	Days
England - continued												
Stewartby	0	0	0	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0	0	0	0
Sunderland	0	0	0	0	0	0	0	0	0	0	0	0
Thurrock	0	0	0	0	0	0	0	0	0	0	0	0
Wicken Fen	0	0	0	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0	0	0	0
Wirral Tranmere	0	0	0	0	0	0	0	0	0	0	0	0
W'hampton Centre	0	0	0	0	0	0	0	0	0	0	0	0
N Ireland												
Belfast Centre	0	0	0	0	0	0	0	0	0	0	0	0
Belfast East	0	0	0	0	0	0	0	0	0	0	0	0
Derry	0	0	0	0	0	0	0	0	0	0	0	0
Scotland												
Aberdeen	0	0	0	0	0	0	0	0	0	0	0	0
Edinburgh St Leonards	1	1	0	0	0	0	**1**	**1**	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	0	0	0	0	0
Grangemouth	1	1	0	0	0	0	**1**	**1**	0	0	0	0
Wales												
Cardiff Centre	0	0	0	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0	0	0	0
Narberth	0	0	0	0	0	0	0	0	0	0	0	0
Port Talbot	0	0	0	0	0	0	0	0	0	0	0	0
Port Talbot Margam	0	0	0	0	0	0	0	0	0	0	0	0
Swansea Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0	0	0	0

18. Ozone - Measurement Sites, Instrumentation and Statistics

18.1 Measurement Method

The measurement of ozone is based on the absorption of ultra violet light by ozone. The absorption by an air path with no ozone present is measured to give a reference intensity. The absorption of the ozone-containing sample is then measured. The ozone concentration is calculated using the Beer-Lambert absorption equation.

18.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak O_3
- API M400
- Environnement O341M
- Horiba APOA 360
- Monitor Labs 9850
- Rotork 427
- Thermo Electron 49

** Here and elsewhere in this report, references to commercial names of equipment or products does not constitute a recommendation or endorsement by Defra, the DAs or the report authors.*

18.3 Data Quality Requirements of EC Directive 2008/50/EC

Uncertainty 15%, minimum data capture 90%

18.4 Objectives and Bandings

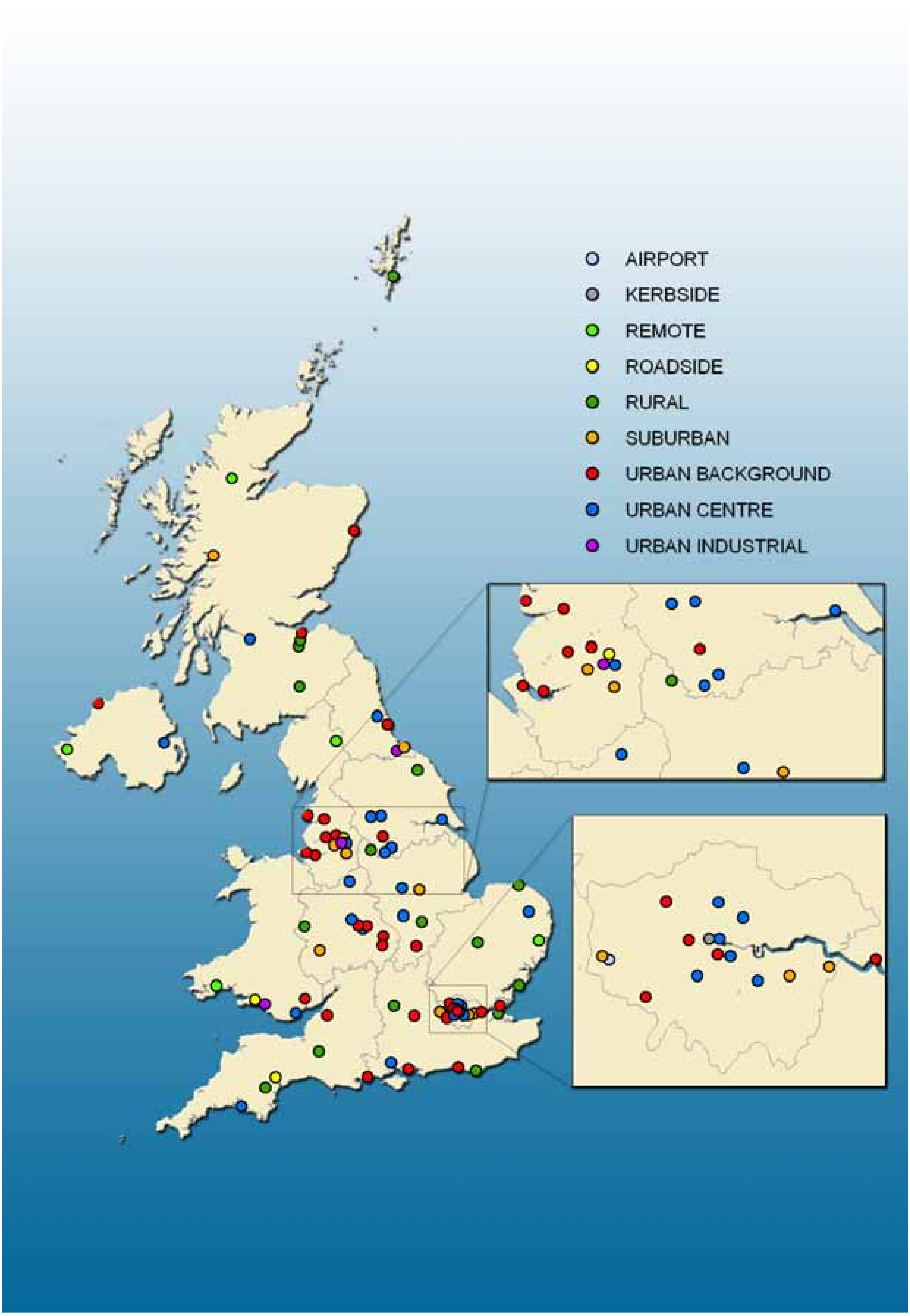
Summary of objectives of the Air Quality Strategy

	Objective*	Measured as	To be achieved by
Ozone	100 µg m^{-3} Not to be exceeded more than 10 times per year	Daily maximum of running 8-hour mean	31 December 2005

*Not included in the Regulations for the purpose of Air Quality Management

Air Quality Bands and Index Values

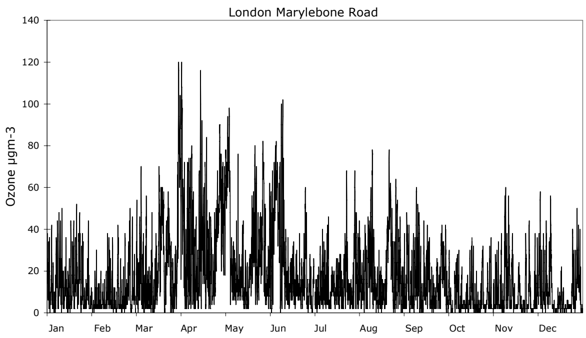
Band	Index	Ozone µgm^{-3}
Low	1	0-33
	2	34-65
	3	66-99
Moderate	4	100-125
	5	126-153
	6	154-179
High	7	180-239
	8	240-299
	9	300-359
Very High	10	360 or more



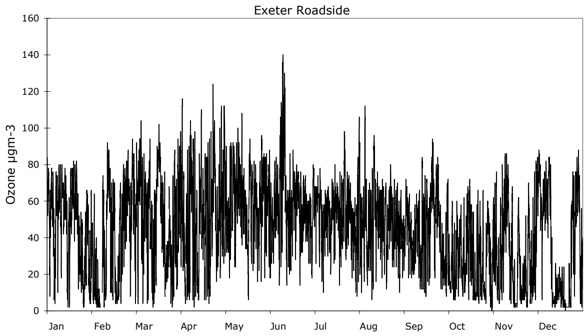
UK Automatic Ozone Monitoring Sites 2007

18.5 Hourly Average Concentrations

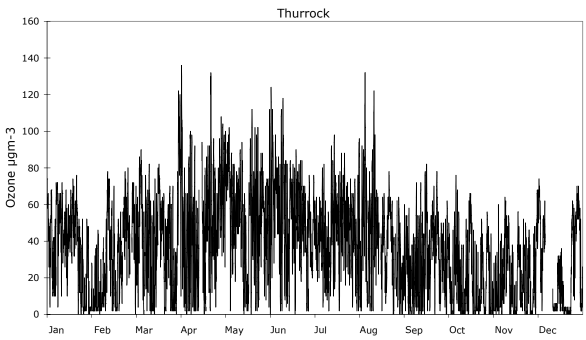
These figures show time series graphs of hourly average ozone concentrations at four monitoring sites of different types, for 2007.



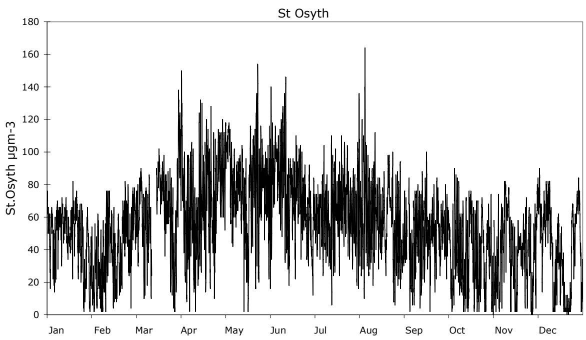
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Exeter Roadside)*



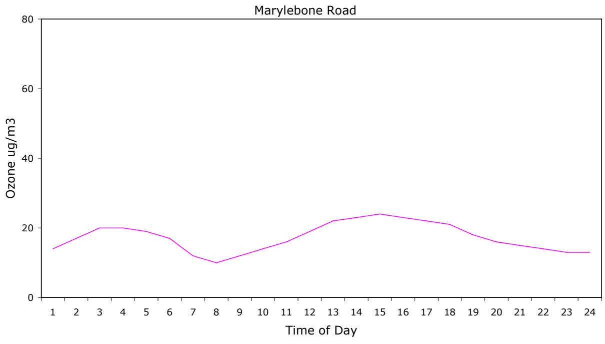
Urban Background Site
(*Thurrock)*



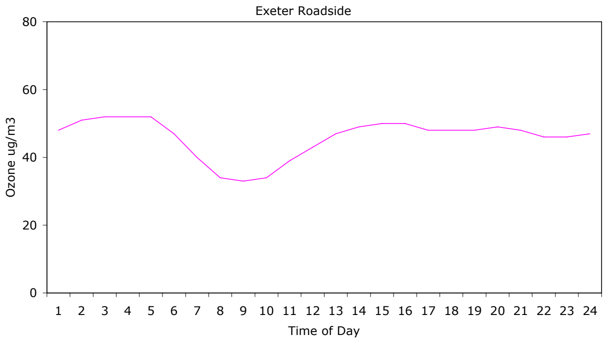
Rural Site
(St Osyth)

18.6 Diurnal Variations

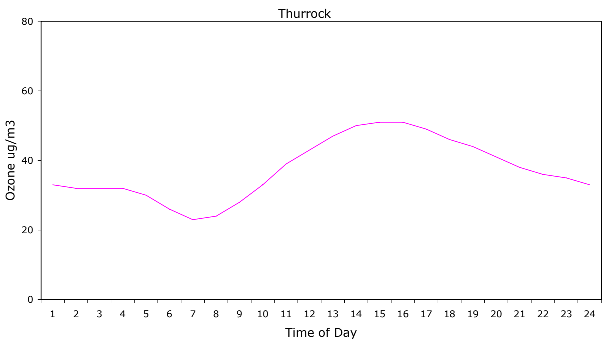
These figures show how ozone concentrations varied on average for each hour of day during the year, at the same four sites. Local time is used, rather than GMT, to more closely reflect the daily cycle of man-made emissions.



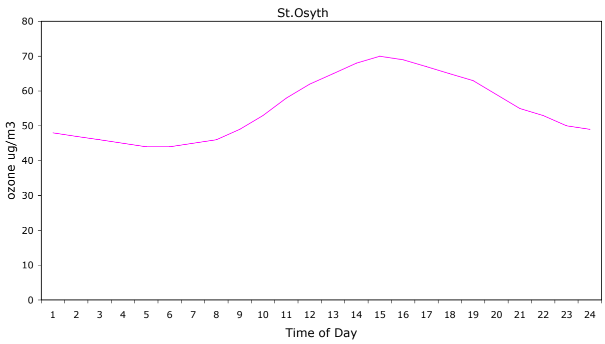
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Exeter Roadside)*



Urban Background Site
(*Thurrock)*

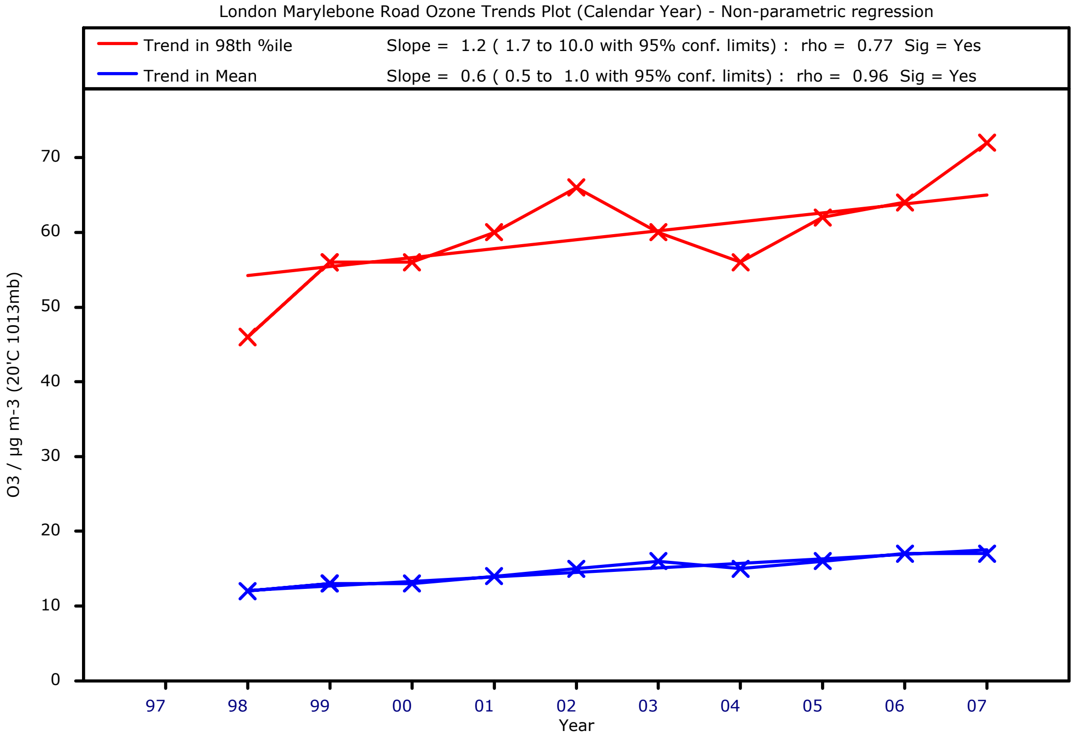


Rural Site
(St Osyth)

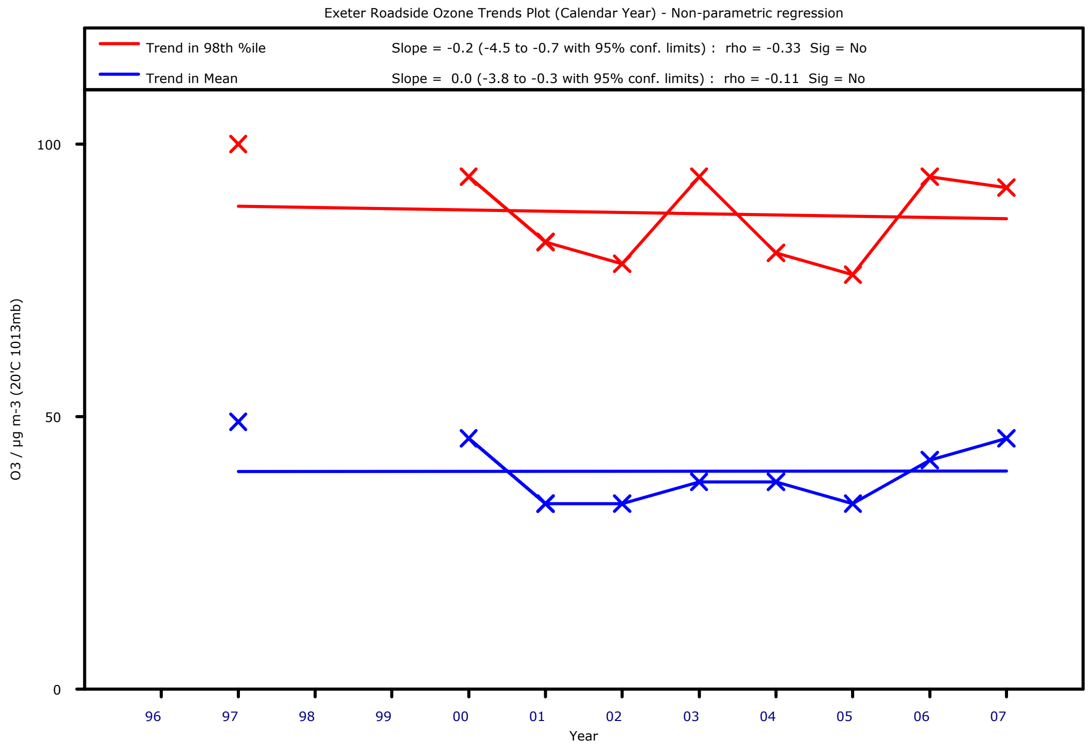
18.7 Trends in annual concentrations

Trends in concentrations are shown for sites with at least 5 years of measurement.

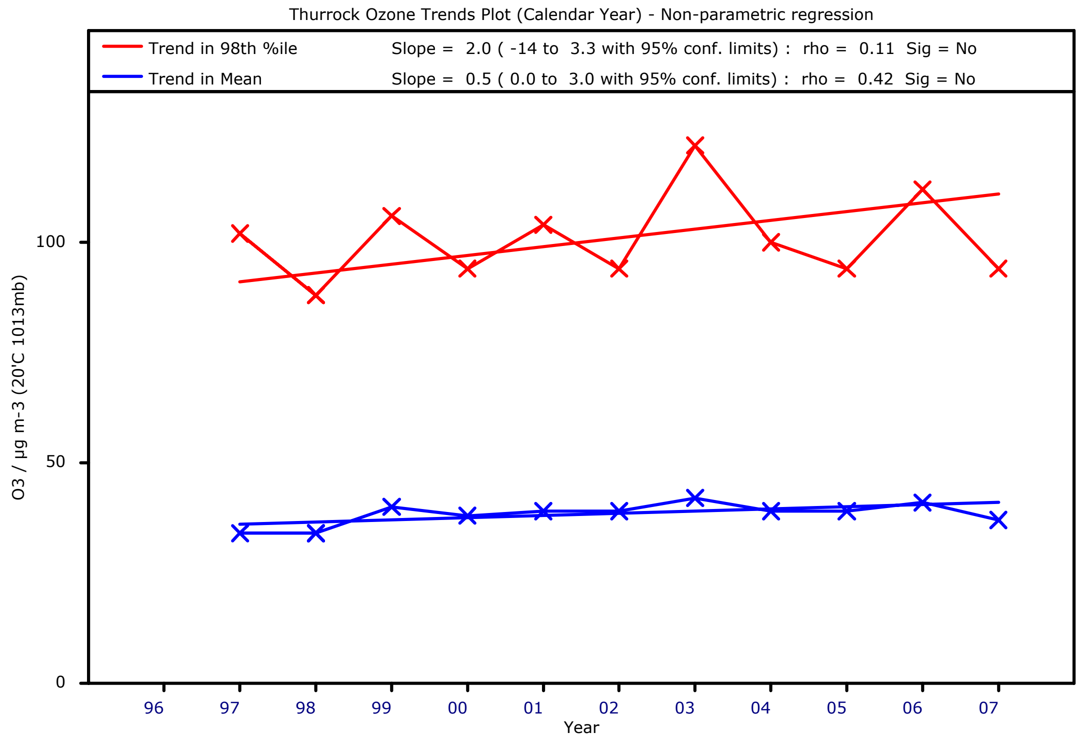
London Marylebone Road Ozone Trends Plot – Non-parametric regression



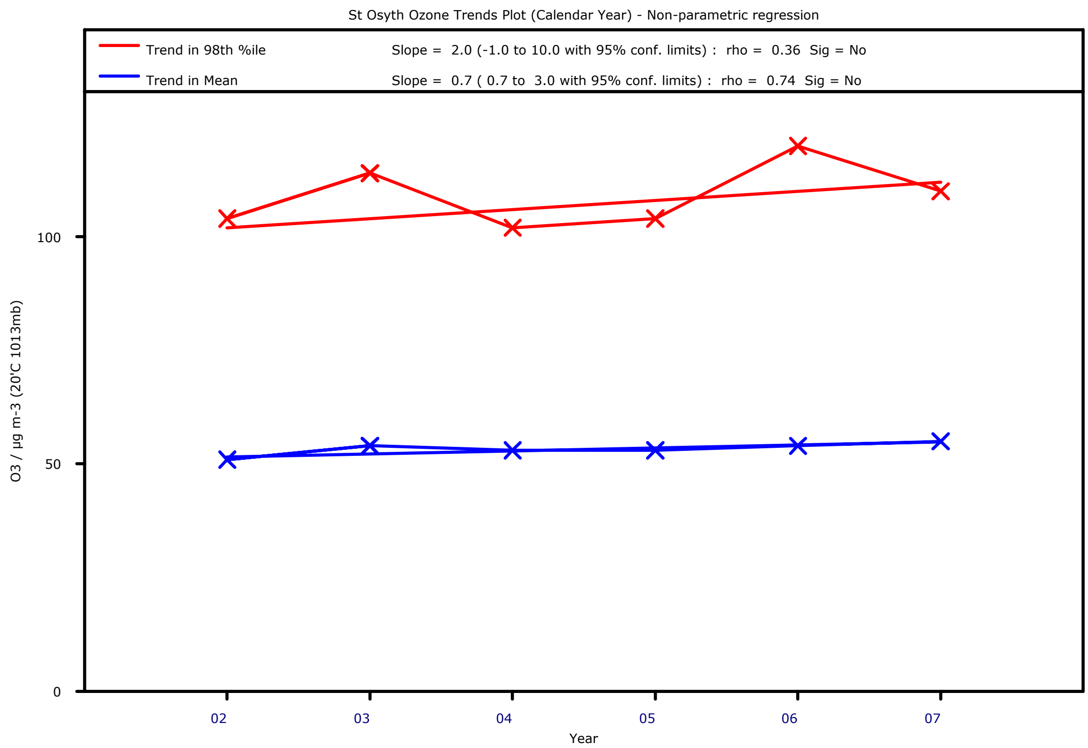
Exeter Roadside Ozone Trends Plot – Non-parametric regression



Thurrock Ozone Trends Plot – Non-parametric regression



St Osyth Ozone Trends Plots – Non-parametric regression



18.8 Ozone Statistical Summary 2007

i) O_3 annual statistics I

Site	Site Type	Annual avg. of 1-hour means µg m^{-3}	Annual data capture of hourly means %	Max. hourly mean µg m^{-3}	Max. running 8-hour mean µg m^{-3}	Date of max. running 8-hour mean	97%ile of daily max run 8hr µg m^{-3}
England							
Barnsley Gawber	UB	44	94.5	126	116	03/06/2007	90
Birmingham Centre	UC	38	96.5	142	132	15/04/2007	86
Birmingham Tyburn	UB	35	98.8	138	126	15/04/2007	92
Blackpool Marton	UB	55	98.0	168	143	11/06/2007	101
Bolton	UB	42	79.7	136	107	02/04/2007	95
Bottesford	S	45	99.5	140	131	05/08/2007	102
Bournemouth	UB	51	98.8	158	137	09/06/2007	106
Bradford Centre	UC	43	71.2	132	111	10/06/2007	90
Brighton Preston Park	UB	50	96.7	154	145	24/04/2007	116
Bristol St Paul's	UB	43	98.2	148	130	09/06/2007	105
Bury Roadside	RS	22	57.1	100	78	15/04/2007	66
Coventry Mem. Park	UB	45	99.3	154	141	15/04/2007	103
Exeter Roadside	RS	46	99.1	140	134	10/06/2007	97
Glazebury	S	41	72.9	136	127	10/06/2007	98
Great Dun Fell	RE	62	86.5	148	135	12/06/2007	105
Harwell	RU	48	82.4	148	132	09/06/2007	97
High Muffles	RU	53	98.5	146	131	03/06/2007	102
Hull Freetown	UC	43	98.2	138	120	03/06/2007	101
Ladybower	RU	53	98.5	148	134	15/04/2007	102
Leamington Spa	UB	39	96.1	140	130	09/06/2007	98
Leeds Centre	UC	37	99.1	128	112	09/06/2007	88
Leicester Centre	UC	38	99.1	140	129	03/06/2007	96
Leominster	S	48	98.8	132	127	09/06/2007	105
Liverpool Speke	UB	44	98.2	140	120	09/06/2007	90
London Bexley	S	45	74.0	146	135	22/04/2007	105
London Bloomsbury	UC	24	85.4	124	117	05/08/2007	77
London Brent	UB	43	73.9	140	133	05/08/2007	111
London Eltham	S	39	98.1	136	129	22/04/2007	103
London Hackney	UC	38	74.4	136	125	22/04/2007	97
London Haringey	UC	39	81.4	136	127	05/08/2007	111
London Harlington	A	32	89.4	138	120	05/08/2007	99
London Hillingdon	S	30	98.3	148	134	15/04/2007	105
London Lewisham	UC	33	74.4	120	103	15/04/2007	89
London Marylebone Rd	KS	17	98.6	120	111	31/03/2007	77
London N Kensington	UB	36	96.8	144	138	05/08/2007	105
London Southwark	UC	36	74.0	118	110	22/04/2007	93
London Teddington	UB	42	96.7	142	130	22/04/2007	114
London Wandsworth	UC	34	74.3	150	134	05/08/2007	87
London Westminster	UB	34	95.6	138	132	22/04/2007	98
Lullington Heath	RU	54	96.3	138	134	24/04/2007	109
Manchester Piccadilly	UC	21	88.0	116	100	09/06/2007	66
Manchester South	S	31	94.8	128	112	09/06/2007	73
Market Harborough	RU	55	96.9	150	139	15/04/2007	112
Middlesbrough	UI	46	98.4	132	128	03/06/2007	94
Newcastle Centre	UC	43	97.8	134	120	15/04/2007	92
Northampton	UB	46	97.2	156	150	05/08/2007	112
Norwich Centre	UC	45	99.1	160	145	05/08/2007	104
Nottingham Centre	UC	34	98.3	118	110	05/08/2007	88
Plymouth Centre	UC	41	87.3	142	124	10/06/2007	88
Portsmouth	UB	47	99.1	146	134	09/06/2007	108
Preston	UB	42	95.7	116	104	02/04/2007	87
Reading New Town	UB	43	96.7	146	133	22/04/2007	105
Redcar	S	53	62.1	138	127	03/06/2007	105
Rochester Stoke	RU	46	98.4	136	130	02/06/2007	103
Rotherham Centre	UC	33	70.2	116	100	05/08/2007	82
Salford Eccles	UI	35	94.2	130	107	09/06/2007	87
Sandwell W Bromwich	UB	42	97.1	154	144	15/04/2007	97

ii) O_3 exceedence statistics I

Site	Mod-erate band	Days	High band	Days	Very High band	Days	AQS Objective (Running 8-hour Mean > 100 µg m^{-3})	Days
England								
Barnsley Gawber	88	11	0	0	0	0	**38**	**9**
Birmingham Centre	48	7	0	0	0	0	**23**	**4**
Birmingham Tyburn	67	13	0	0	0	0	**25**	**5**
Blackpool Marton	157	25	0	0	0	0	**79**	**12**
Bolton	63	12	0	0	0	0	**22**	**4**
Bottesford	131	20	0	0	0	0	**56**	**12**
Bournemouth	279	47	0	0	0	0	**125**	**20**
Bradford Centre	60	12	0	0	0	0	**24**	**5**
Brighton Preston Park	286	45	0	0	0	0	**147**	**24**
Bristol St Paul's	166	25	0	0	0	0	**76**	**13**
Bury Roadside	1	1	0	0	0	0	0	0
Coventry Memorial Park	198	34	0	0	0	0	**89**	**16**
Exeter Roadside	95	19	0	0	0	0	**36**	**6**
Glazebury	93	11	0	0	0	0	**46**	**8**
Great Dun Fell	221	25	0	0	0	0	**127**	**13**
Harwell	106	16	0	0	0	0	**55**	**8**
High Muffles	164	19	0	0	0	0	**84**	**13**
Hull Freetown	165	24	0	0	0	0	**69**	**12**
Ladybower	174	25	0	0	0	0	**85**	**12**
Leamington Spa	121	17	0	0	0	0	**59**	**9**
Leeds Centre	55	9	0	0	0	0	**25**	**5**
Leicester Centre	128	21	0	0	0	0	**58**	**10**
Leominster	167	24	0	0	0	0	**82**	**15**
Liverpool Speke	41	9	0	0	0	0	**11**	**2**
London Bexley	209	40	0	0	0	0	**75**	**14**
London Bloomsbury	37	5	0	0	0	0	**19**	**3**
London Brent	188	29	0	0	0	0	**88**	**16**
London Eltham	180	28	0	0	0	0	**81**	**15**
London Hackney	95	16	0	0	0	0	**42**	**7**
London Haringey	183	29	0	0	0	0	**81**	**15**
London Harlington	120	21	0	0	0	0	**45**	**8**
London Hillingdon	218	31	0	0	0	0	**113**	**17**
London Lewisham	29	7	0	0	0	0	**5**	**2**
London Marylebone Road	31	6	0	0	0	0	**10**	**2**
London N. Kensington	173	31	0	0	0	0	**74**	**16**
London Southwark	60	12	0	0	0	0	**9**	**3**
London Teddington	228	33	0	0	0	0	**106**	**19**
London Wandsworth	53	10	0	0	0	0	**29**	**5**
London Westminster	114	20	0	0	0	0	**47**	**10**
Lullington Heath	224	30	0	0	0	0	**117**	**16**
Manchester Piccadilly	11	4	0	0	0	0	0	0
Manchester South	24	5	0	0	0	0	**8**	**2**
Market Harborough	317	41	0	0	0	0	**167**	**21**
Middlesbrough	73	11	0	0	0	0	**32**	**4**
Newcastle Centre	67	14	0	0	0	0	**34**	**5**
Northampton	191	25	0	0	0	0	**115**	**16**
Norwich Centre	220	41	0	0	0	0	**105**	**16**
Nottingham Centre	54	11	0	0	0	0	**15**	**4**
Plymouth Centre	44	11	0	0	0	0	**22**	**4**
Portsmouth	236	39	0	0	0	0	**106**	**19**
Preston	25	8	0	0	0	0	**4**	**2**
Reading New Town	176	25	0	0	0	0	**90**	**15**
Redcar	165	22	0	0	0	0	**87**	**15**
Rochester Stoke	220	36	0	0	0	0	**90**	**16**
Rotherham Centre	13	5	0	0	0	0	0	0
Salford Eccles	43	7	0	0	0	0	**13**	**4**
Sandwell West Bromwich	112	16	0	0	0	0	**60**	**9**

iii) O_3 annual statistics II

Site	Site Type	Annual avg. of 1-hour means µg m^{-3}	Annual data capture of hourly means %	Max. hourly mean µg m^{-3}	Max. running 8-hour mean µg m^{-3}	Date of max. running 8-hour mean	97%ile of daily max run 8hr µg m^{-3}
England - *continued*							
Sheffield Centre	UC	38	95.6	130	119	05/08/2007	89
Sibton	RE	50	95.4	152	138	05/08/2007	96
Somerton	RU	54	94.5	136	127	10/06/2007	104
Southampton Centre	UC	31	97.3	104	91	01/04/2007	74
Southend-on-Sea	UB	45	98.8	138	120	22/04/2007	101
St Osyth	RU	55	98.4	164	144	05/08/2007	119
Stoke-on-Trent Centre	UC	47	94.6	146	134	09/06/2007	105
Sunderland Silksworth	UB	50	96.3	142	123	03/06/2007	98
Thurrock	UB	37	96.6	136	124	22/04/2007	100
Weybourne	RU	65	98.2	166	151	05/08/2007	123
Wicken Fen	RU	54	74.3	142	139	05/08/2007	115
Wigan Centre	UB	46	98.0	150	134	10/06/2007	106
Wirral Tranmere	UB	47	97.0	128	113	08/06/2007	94
Wolverhampton Centre	UC	46	73.1	130	120	15/04/2007	91
Yarner Wood	RU	59	95.2	142	137	09/06/2007	113
N Ireland							
Belfast Centre	UC	43	95.0	120	110	09/06/2007	91
Derry	UB	48	96.7	104	98	01/05/2007	85
Lough Navar	RE	46	97.9	116	102	11/06/2007	93
Scotland							
Aberdeen	UB	47	98.5	120	112	30/03/2007	96
Auchencorth Moss	RU	58	99.5	118	108	21/04/2007	96
Bush Estate	RU	56	98.7	114	109	31/03/2007	92
Edinburgh St Leonards	UB	48	97.6	116	112	31/03/2007	99
Eskdalemuir	RU	54	98.6	130	118	14/04/2007	100
Fort William	S	54	78.5	118	105	30/03/2007	90
Glasgow Centre	UC	36	98.0	118	108	09/06/2007	85
Lerwick	RU	64	86.9	130	109	05/04/2007	97
Strath Vaich	RE	68	87.9	134	124	05/05/2007	106
Wales							
Aston Hill	RU	63	91.9	138	131	22/04/2007	102

iv) O_3 exceedence statistics II

Site	Mod-erate band	Days	High band	Days	Very High band	Days	AQS Objective (Running 8-hour Mean > 100 µg m^{-3})	Days
England - *continued*								
Sheffield Centre	61	11	0	0	0	0	**21**	**4**
Sibton	98	21	0	0	0	0	**44**	**8**
Somerton	199	31	0	0	0	0	**87**	**15**
Southampton Centre	2	1	0	0	0	0	0	0
Southend-on-Sea	169	36	0	0	0	0	**64**	**12**
St Osyth	569	74	0	0	0	0	**309**	**41**
Stoke-on-Trent Centre	220	31	0	0	0	0	**105**	**16**
Sunderland Silksworth	126	18	0	0	0	0	**63**	**11**
Thurrock	133	22	0	0	0	0	**63**	**11**
Weybourne	764	68	0	0	0	0	**563**	**47**
Wicken Fen	246	36	0	0	0	0	**116**	**20**
Wigan Centre	197	28	0	0	0	0	**90**	**13**
Wirral Tranmere	78	14	0	0	0	0	**28**	**5**
Wolverhampton Centre	70	13	0	0	0	0	**28**	**5**
Yarner Wood	322	43	0	0	0	0	**160**	**26**
N Ireland								
Belfast Centre	49	12	0	0	0	0	**11**	**2**
Derry	6	2	0	0	0	0	0	0
Lough Navar	37	13	0	0	0	0	**3**	**1**
Scotland								
Aberdeen	68	14	0	0	0	0	**15**	**2**
Auchencorth Moss	84	13	0	0	0	0	**31**	**7**
Bush Estate	54	10	0	0	0	0	**22**	**4**
Edinburgh St Leonards	104	16	0	0	0	0	**44**	**9**
Eskdalemuir	118	16	0	0	0	0	**67**	**11**
Fort William	43	10	0	0	0	0	**14**	**2**
Glasgow Centre	18	5	0	0	0	0	**4**	**1**
Lerwick	86	14	0	0	0	0	**33**	**7**
Strath Vaich	256	32	0	0	0	0	**152**	**18**
Wales								
Aston Hill	203	27	0	0	0	0	**125**	**14**

This page has been left intentionally blank

Air Pollution in the UK: 2007

Part 3

In this part of the report, we provide supplementary information in a series of appendices:

A1- The major air pollutants measured in the UK

A2- Regional maps of UK automatic air quality monitoring sites

A3- The UK's automatic and sampler-based air quality monitoring networks

A4- Analysis of statistically significant trends in UK air pollution levels

A5- Current UK, European and WHO Air Quality Criteria

A6- Calculation methods, statistical methods and measurement uncertainty

Appendix A1- The major air pollutants measured in the UK

We describe major sources and effects of these pollutants, together with typical UK-wide patterns of exposure.

The principal air pollutants measured in UK National Air Monitoring networks are:

- Nitrogen oxides, primarily nitrogen dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Ozone (O_3)
- Particles- primarily measured as PM_{10} at the present time
- Benzene (C_6H_6)
- 1,3-butadiene (C_4H_6)
- Lead and heavy metals

The first five of these are measured in the AURN, whilst the two volatile organic compounds- benzene and 1,3-butadiene- are measured in the automatic hydrocarbon network. The various pollutants have different sources and behave very differently once emitted into the atmosphere. As a result, spatial and temporal patterns can differ markedly between the pollutants.

In this appendix, we briefly examine the sources, effects and distributions of these major pollutants. For more detail, please refer to the authoritative series of pollutant-specific analyses and guidelines produced by EPAQS (the UK Expert Panel on Air Quality Standards)[P1-9] and World Health Organisation[P10].

Nitrogen oxides

Nitrogen oxides (NO_x) are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides - nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x - is road traffic. For the UK as a whole, approximately 45% of all oxide of nitrogen emission originates from this source, with most of the remainder arising from power stations and other industrial sources. Since power station and industrial emissions are usually from elevated sources (i.e. high chimneys), motor vehicles represent by far the largest source of low-level NOx emission and therefore make the largest contribution (75% or greater) to long-term ground level concentrations in urban areas.

Nitric oxide is not generally considered to be harmful to health at the concentrations found in the ambient atmosphere. However, once released to the atmosphere, it rapidly oxidises to nitrogen dioxide, which has a variety of environmental and health impacts. Its direct health impact as a respiratory irritant may be significant. Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.

In the presence of sunlight, nitrogen oxides can react with Volatile Organic Compounds (VOCs) to produce photochemical pollutants including ozone. Nitrogen dioxide can also be further oxidised in air to acid gases such as nitric acid, which contribute to the production of acid rain over regional scales.

The highest NOx levels in UK cities are generally observed at kerbside locations. However, since much of the NO_2 is formed from primary emissions of NO by time-dependent oxidation processes in the atmosphere, the relative decline in NO_2 concentration away from the kerbside is slower than for NO.

Modelling and monitoring studies- for example with diffusion tube samplers- have shown that NO_2 concentrations tend to be greatest in central urban areas. However, this cannot always be assumed to be the case, especially where major road systems, industrial areas or other large sources are located away from city centre areas.

Sulphur dioxide

Sulphur dioxide (SO_2) is an acid gas, which acts as an irritant to the respiratory system and may exacerbate or initiate symptoms in asthmatics. Even moderate concentrations of SO_2 may result in a decline in lung function in asthmatics. Tightness in the chest and coughing occur at high levels, and lung function of asthmatics may be impaired to the extent that medical help is required. Sulphur dioxide pollution is considered more harmful when particle and other pollution concentrations are high. This is a good example of combined or *synergistic* effects of air pollutants.

Primary emissions of sulphur dioxide are a major contributor to the formation of acid rain; this can be transported over long distances, with important consequences for terrestrial and aquatic ecosystems, as well as the man-made built environment.

This pollutant is formed by the oxidation of sulphur impurities in fuels during combustion processes. In 2006, a very high proportion (approximately 91%) of UK SO_2 emissions originate from fuel combustion, mainly of solid fuels and fuel oils. As the use of coal for domestic heating has decreased, SO_2 emissions from this source, and ambient concentrations in urban areas, have declined considerably over the last 20-30 years.

Geographically, SO_2 concentrations in the UK are highest in urban areas where there is significant industrial use of coal or oil, or urban areas where coal and oil are still widely used for domestic heating. Historically, this has included Northern Ireland, where there was limited availability of natural gas; however, in recent years ambient concentrations in the region have decreased as natural gas has become more widely available.

Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless but toxic gas produced by incomplete combustion of fossil fuels. At worst-case ambient levels (in congested streets, car-parks or tunnels), exposure may reduce the oxygen-carrying capacity of the blood and impair oxygen delivery to the brain and other organs, particularly affecting adults with angina and diseases of the coronary arteries.

Carbon monoxide in urban areas results almost entirely from vehicle emissions. The emission rate for individual vehicles depends critically on vehicle speed, being higher at low speeds.

Since CO is a primary pollutant, its ambient concentrations closely follow emissions. In urban areas, concentrations are therefore highest at the kerbside and decrease rapidly with increasing distance from the road. Since traffic is by far the most important source of CO, its spatial distribution will follow that of traffic: this will generally result in the highest levels being observed in the city centre, where most congested areas tend to be found.

Ozone

Ozone (O_3) is a highly reactive oxidising agent, with a wide range of material, vegetation and human health impacts. Acute health effects of ozone may include eye/nose irritation, respiratory problems and airway inflammation.

In addition to its serious impacts on human health, ozone is also *phytotoxic* – damaging to many plants and commercial crops. It can also damage or age some man-made materials such as rubbers and elastomers, as well as bleaching paints and fabrics.

A natural background ozone concentration exists in the atmosphere due to mixing of ozone from the stratosphere and its generation in the troposphere. The background concentration depends on latitude and time of year: in the UK, measurements show the resulting annual average background concentration to be about 70 µg/m^3.

Ozone is not emitted directly into the atmosphere in any significant quantity and its presence in the lower atmosphere at concentrations exceeding background results primarily from a complex series of reactions in the atmosphere; these may be summarised as the sunlight-initiated oxidation of volatile organic compounds (VOCs) in the presence of nitrogen oxides (NO_x). The sources of VOCs are similar to those described for NO_x above, but also include other activities such as solvent use, and petrol distribution and handling.

The reactions producing ozone occur in air containing these NO_x and VOC precursors as it moves downwind; ozone formation can occur over a timescale of a few hours to several days. As a result, ozone concentrations are decoupled temporally and spatially from precursor sources and ambient concentrations are strongly dependent on meteorological conditions, together with scavenging and deposition rates. The net result is that ozone concentrations measured at a particular location may have arisen from VOC and NOx emissions many hundreds or even thousands of miles away. Maximum concentrations, therefore, generally occur some distance downwind of the original sources of precursor emissions.

In urban areas, chemical scavenging by NO_x emissions results in ozone concentrations that are generally lower than in rural areas. Moreover, urban ozone concentrations tend to be highly variable over small spatial scales, with concentrations lowest where corresponding levels of other pollutants such as NO are highest. In cities, therefore, ozone concentrations will tend to be lower in central areas and increase in the suburbs, although the spatial variation will be complex and, in open spaces in urban areas, levels of ozone may approach those found in nearby rural areas.

Particulate matter

Particulate Matter (PM) is a generic descriptor covering a wide range of particle size fractions, morphologies and chemical compositions. Although coarse (large) particle size ranges may cause significant local nuisance or soiling impacts, it is the finer (small) fractions that are capable of deep lung/airway penetration. This is why these fractions such as PM_{10} and $PM_{2.5}$ are measured in UK national monitoring networks.

Particles also have a range of important non-biological impacts including:

- Soiling of man-made materials and buildings, resultant loss of amenity
- Reducing visibility (fine particles- aerosol)
- Effects on heterogeneous atmospheric chemistry

Particles are produced from a variety of natural and man-made sources. Natural sources include sea salt, soil blowoff, Saharan dust, forest fires and volcanic activity. Man-made sources include incomplete combustion processes (e.g. coal and diesel smoke), industry and construction activity. Industrial accidents such as the Buncefield 2005 event can also produce large quantities of particles.

Particles may be either directly emitted into the atmosphere (primary particles) or formed there by chemical reactions (secondary particles). Sulphate and nitrate aerosol is a good example of the latter; this can often transported over national or continental distances. Both particle size, usually expressed in terms of its aerodynamic diameter, and chemical composition are greatly influenced by its origin.

The principal source of PM_{10} (the mass fraction of particles collected by a sampler with a 50% inlet cut-off at aerodynamic diameter 10μm) in many cities is road traffic emissions, particularly from diesel vehicles. As well as creating dirt, odour and visibility problems, PM_{10} particles are associated with health effects including increased risk of heart and lung disease. In addition, they may carry surface- absorbed carcinogenic compounds into the lungs. Concern about the potential health impacts of fine particulate matter has increased over recent years. In particular, increasing policy and measurement action – both Europe-wide and within the UK – is now focussing on $PM_{2.5}$.

Existing PM_{10} data show that daily average concentrations are usually highest in the winter months and lowest in the summer. During winter episode periods, PM_{10} levels increase together with other traffic-related pollutants such as oxides of nitrogen. During the spring and summer, the photochemical oxidation of sulphur dioxide and oxides of nitrogen to particulate sulphate and nitrate is another important source.

The new Air Quality Directive 2008/50/EC- as discused at length in Section 2.1 - introduces Limit Values for $PM_{2.5}$ particulate matter, together with an exposure-reduction target. This will require reductions in fine particle concentrations throughout each Member State and a cap on concentrations in the most polluted areas. These developments are likely to have wide-ranging implications for the UK's national monitoring networks measuring particulate matter (see Section 3).

Benzene

Benzene (C_6H_6) is a fat-soluble volatile organic compound (VOC) with a range of potential health effects. Acute exposure to benzene at occupational levels can cause narcotic, anaesthetic or fatal consequences. Benzene is a proven genotoxic carcinogen, and ambient long-term exposure is implicated in the formation of a range of types of leukaemia in the general population. Potential chronic health effects of this pollutant also include central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects.

Benzene has no significant natural sources, so that ambient exposure results primarily from petrol combustion in road transport emissions or evaporation of petrol (which contains benzene) from filling stations. Benzene is naturally broken down by chemical reactions in the atmosphere, although these reactions can take several days. As a result, outdoor benzene concentrations tend to closely follow road networks and traffic density patterns.

1,3-Butadiene

Evidence from occupational human exposure and laboratory studies on animals shows 1,3-butadiene (C_4H_6) to be a carcinogen, exposure to which can cause a range of cancers of the lymphoid system, blood-forming tissues, lymphomas and leukaemias. Potential chronic health effects of this pollutant also include central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects.

This substance is used in some industrial sectors, primarily in the production of synthetic rubber. However, ambient exposure of the general population results primarily from fuel combustion- mainly from petrol-fuelled motor vehicles, but also from other fossil fuels, accidental fires and industrial releases.

Unlike benzene, this is not a constituent of petrol, so evaporative or fugitive emissions are not a significant source. Although 1,3-butadiene is removed by catalytic converters and not produced from diesel engines, spatial and temporal exposure patterns in the UK are dominated by road transport.

Lead

The majority of the UK's lead (Pb) emissions arise from the metallurgical industry, in particular iron and steel manufacturing.

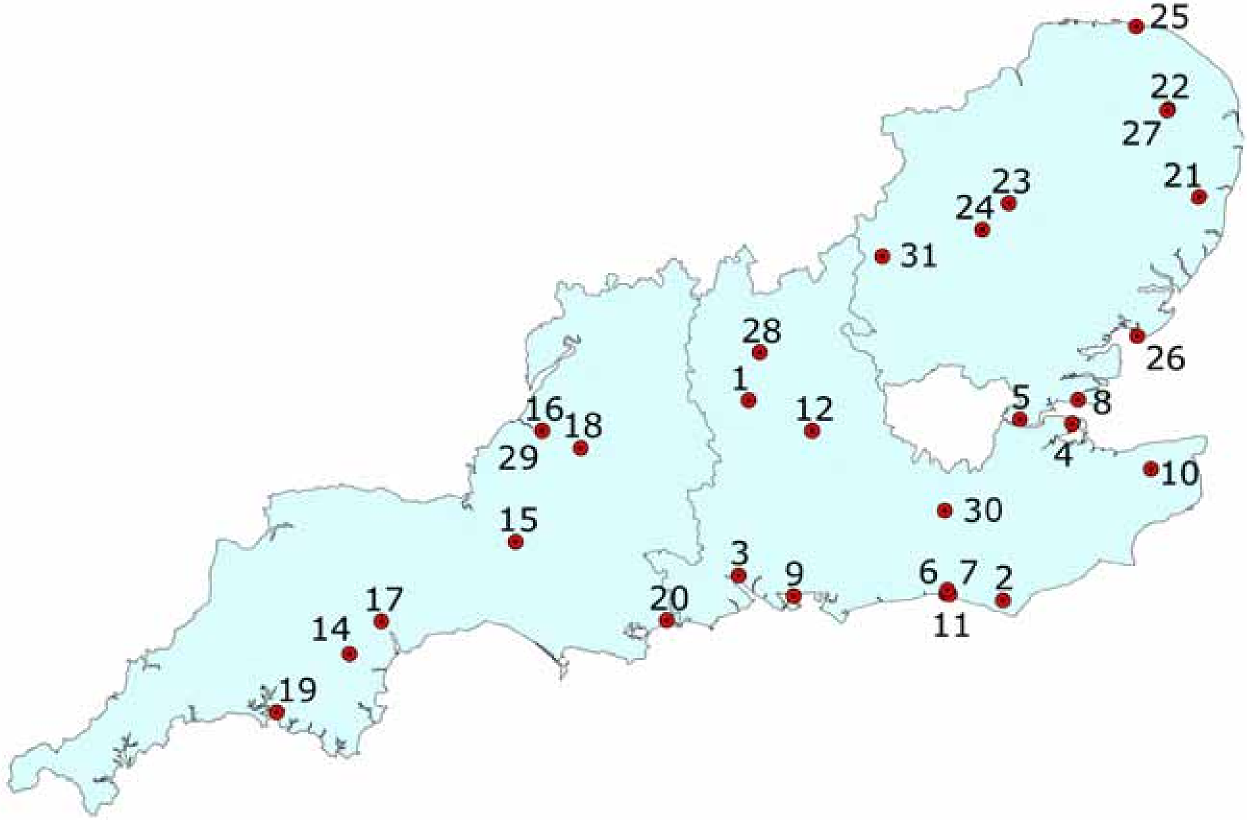
Road vehicles were once a significant source but, due to the progressive reduction in the lead content of leaded petrol during the 1980s, followed by the phasing out of leaded petrol, have become much less significant. The phasing out of leaded petrol, together with other measures such as tighter controls on waste incineration plant and reductions in coal burning by industry, has led to significant reductions in urban lead levels over recent years.

Even small amounts of lead can be harmful, especially to infants and young children. In addition, lead taken in by the mother can interfere with the health of the unborn child. Exposure has also been linked to impaired mental function, visual-motor performance and neurological damage in children, and memory and attention span.

Appendix A2- Regional maps of UK automatic air quality monitoring stations

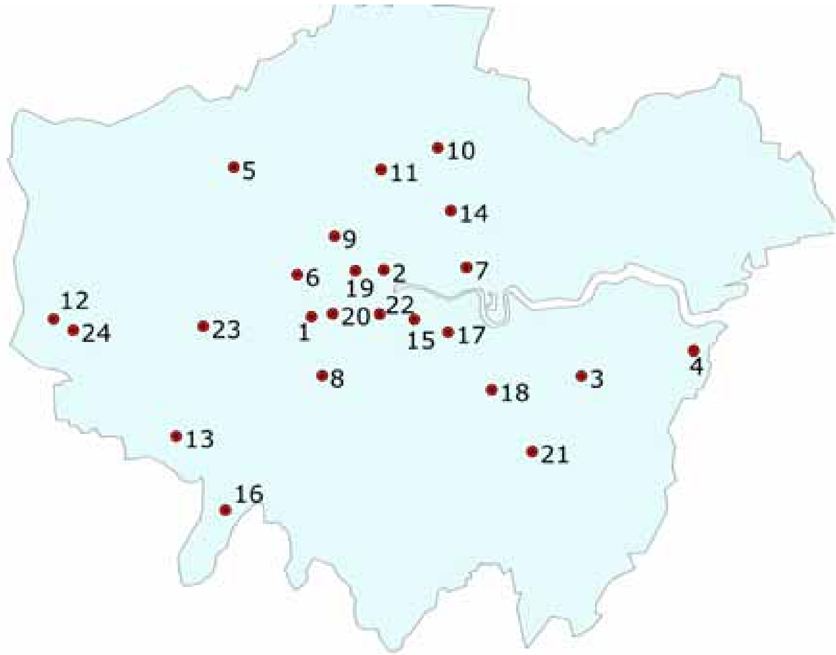
These maps show Automatic Urban and Rural Network (AURN) and Hydrocarbon air monitoring sites in different parts of the UK.

Figure A2.1	**Southern England**
Figure A2.2	**London**
Figure A2.3	**Midlands**
Figure A2.4	**NW England**
Figure A2.5	**NE England**
Figure A2.6	**Wales**
Figure A2.7	**N. Ireland**
Figure A2.8	**Scotland**



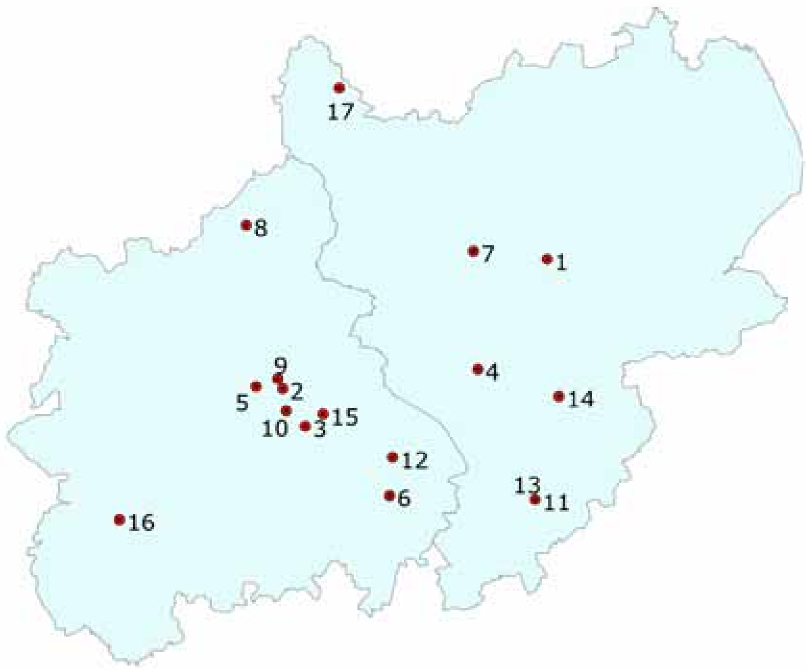
No	Site Name
1	Harwell
2	Lullington Heath
3	Southampton Centre
4	Rochester
5	Thurrock
6	Hove Roadside
7	Brighton Roadside
8	Southend-on-Sea
9	Portsmouth
10	Canterbury
11	Brighton Roadside PM10
12	Reading New Town
13	Brighton Preston Park
14	Yarner Wood
15	Somerton
16	Bristol Old Market
17	Exeter Roadside
18	Bath Roadside
19	Plymouth Centre
20	Bournemouth
21	Sibton
22	Norwich Centre
23	Wicken Fen
24	Cambridge Roadside
25	Weybourne
26	St Osyth
27	Norwich Forum Roadside
28	Oxford Centre Roadside
29	Bristol St Paul's
30	Horley
31	Stewartby

Figure A2.1 Automatic sites, Southern England



No	Site Name
1	West London
2	London Bloomsbury
3	London Eltham
4	London Bexley
5	London Brent
6	London N. Kensington
7	Tower Hamlets Roadside
8	London Wandsworth
9	Camden Kerbside
10	Haringey Roadside
11	London Haringey
12	London Hillingdon
13	London Teddington
14	London Hackney
15	London Southwark
16	London A3 Roadside
17	Southwark Roadside
18	London Lewisham
19	London Marylebone Road
20	London Cromwell Road 2
21	London Bromley
22	London Westminster
23	Brentford Roadside
24	London Harlington

Figure A2.2 Automatic sites, London



No	Site Name
1	Bottesford
2	Walsall Alumwell
3	Birmingham Centre
4	Leicester Centre
5	Wolverhampton Centre
6	Leamington Spa
7	Nottingham Centre
8	Stoke-on-Trent Centre
9	Walsall Willenhall
10	Sandwell West Bromwich
11	Northampton
12	Coventry Memorial Park
13	Northampton PM10
14	Market Harborough
15	Birmingham Tyburn
16	Leominster
17	Ladybower

Figure A2.3 Automatic sites, Midlands

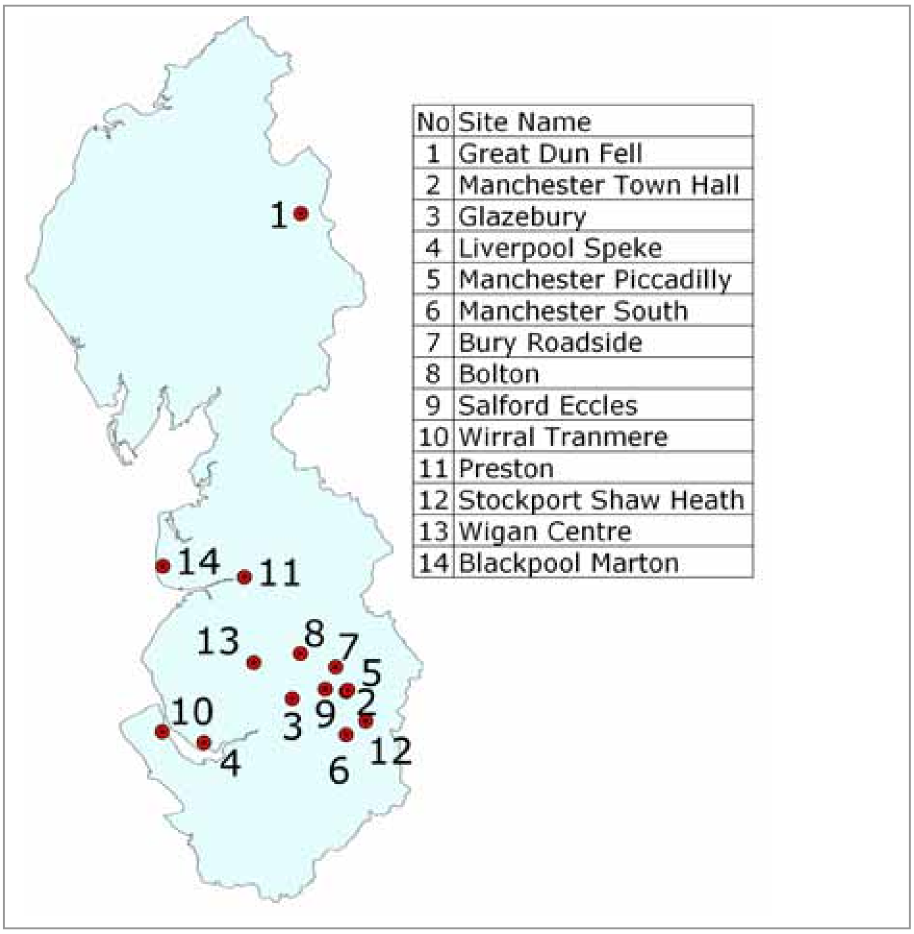


Figure A2.4 Automatic sites, NW England

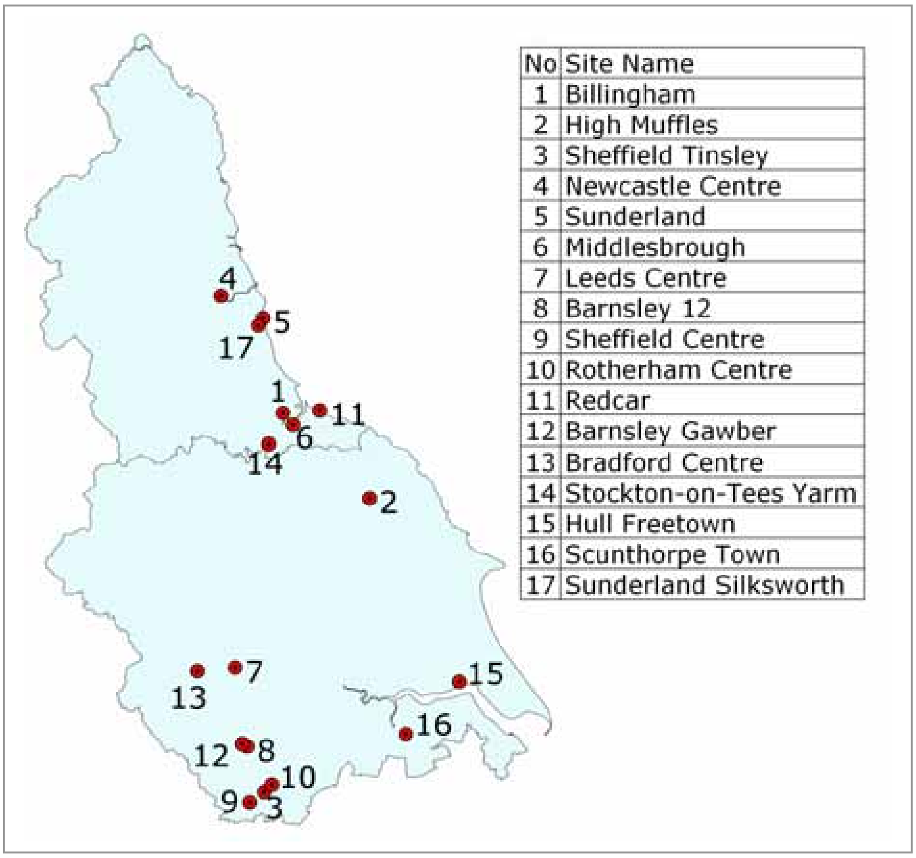


Figure A2.5 Automatic sites, NE England

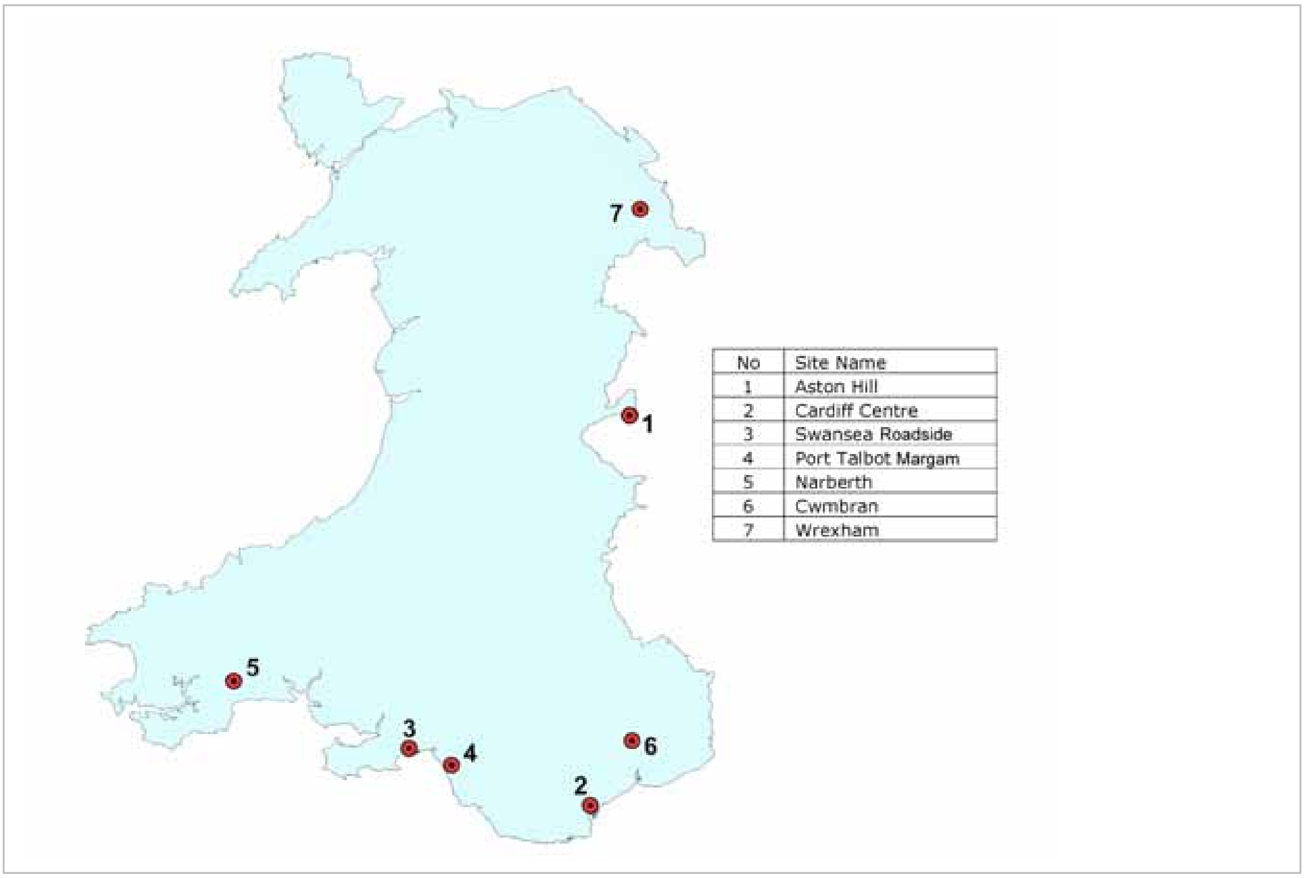


Figure A2.6 Automatic sites, Wales

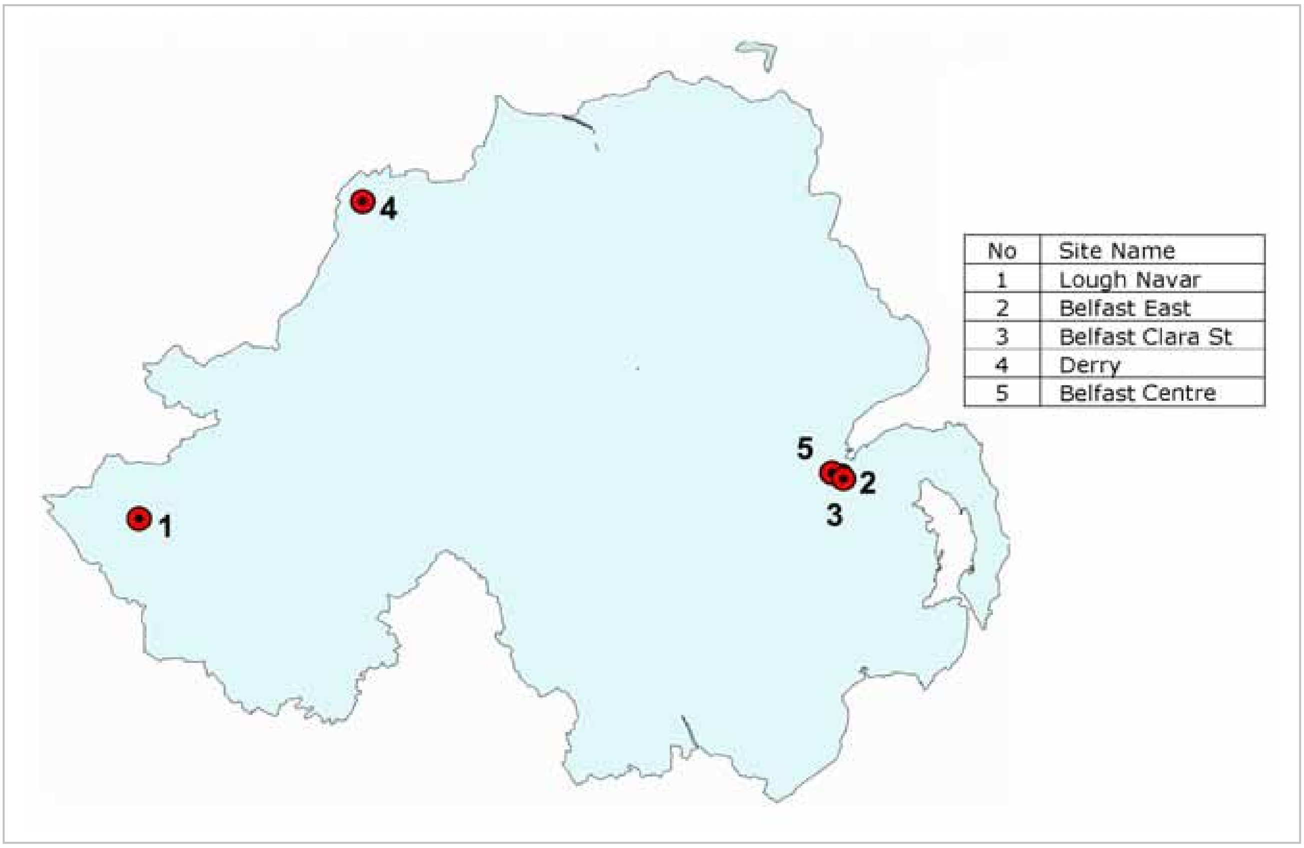
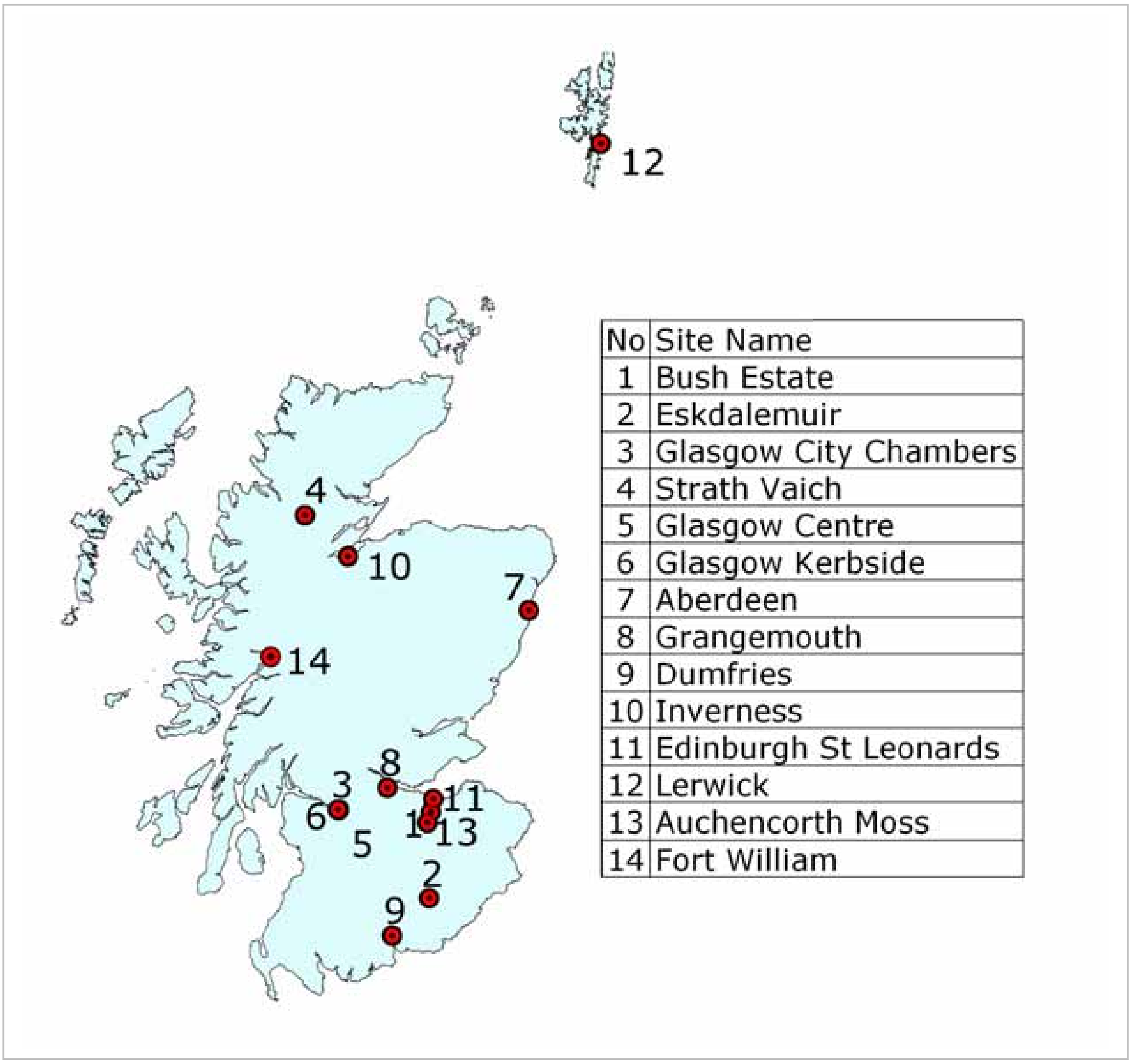


Figure A2.7 Automatic sites, Northern Ireland



No	Site Name
1	Bush Estate
2	Eskdalemuir
3	Glasgow City Chambers
4	Strath Vaich
5	Glasgow Centre
6	Glasgow Kerbside
7	Aberdeen
8	Grangemouth
9	Dumfries
10	Inverness
11	Edinburgh St Leonards
12	Lerwick
13	Auchencorth Moss
14	Fort William

Figure A2.8 Automatic sites, Scotland

Appendix A3- The UK's automatic and sampler-based air quality monitoring networks

Here we provide a concise guide to the different UK air monitoring networks, their objectives and methodologies.

A3.1 The Automatic Urban and Rural Network (AURN)

(Network managed for Defra and the DAs by Bureau Veritas & quality assured by AEA)

The AURN is the UK's largest automatic monitoring programme. It includes automatic air quality monitoring stations measuring oxides of nitrogen (NO_x), sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO) and particles (PM_{10}). These are monitored on an hourly basis at measurement sites throughout the UK.

As of August 2008, the AURN consists of 120 monitoring sites. Of these, 61 are directly funded by Defra and the devolved administrations, whilst a further 59 affiliated sites are owned and operated by local authorities; eight of these sites are also in the London Air Quality Network (LAQN). The network has grown dramatically since it was first established in 1992 (see Figure 3.7 in section 3 of the main report.)

The major objectives of the network are as follows:

- Checking if statutory air quality standards and targets are met (e.g. EC Directives)
- Informing the public about air quality
- Providing information for local air quality review and assessments within the UK Air Quality Strategy
- Identifying long-term trends in air pollution concentrations
- Assessing the effectiveness of policies to control pollution

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 London Air Quality Network (LAQN). AEA undertakes the role of Quality Assurance and Control Unit (QA/QC Unit) for the entire AURN. The responsibility for operating individual monitoring sites is assigned to local organisations, such as local authority Environmental Health Officers with relevant experience in the field. Calibration gases for the network are supplied by Air Liquide Ltd and are provided with a UKAS certificate of calibration by AEA.

The techniques used for monitoring within the AURN are summarised below. These techniques represent the current state-of-the-art for automated monitoring networks and, with the exception of the automatic PM_{10} analysers, are the reference methods of measurement defined in the relevant EU Directives. See Section 3.5 for additional information on recent evaluations of PM_{10} measurement techniques.

AURN Measurement Techniques (considered in greater detail in Part 2)

O_3	UV absorption
NO/NO_x	Chemiluminescence
SO_2	UV fluorescence
CO	IR Absorption
PM_{10}	▶ Tapered Element Oscillating Microbalance ▶ Beta Attenuation monitor ▶ Gravimetric monitor

During 2007, Defra undertook a major review of the AURN, aimed at ensuring that it would continue to meet the UK's compliance monitoring needs in the most cost-effective way. For some pollutants, where ambient concentrations were well within EC Limit Values and AQS Objectives, monitoring was discontinued at some sites. This allowed the resources to be re-directed to locations and pollutants for which the priority was assessed to be higher. The spatial distribution of sites within the UK was also considered and, in some zones and agglomerations, (e.g. London) some sites were closed.

Carbon monoxide monitoring was significantly scaled down, being discontinued at 52 sites: this pollutant is well within EC Limit Values and AQS Objectives throughout the UK. Sulphur dioxide monitoring has also been decreased, with monitoring discontinued at 37 sites. Ozone monitoring was discontinued at 13 sites, PM_{10} particulate monitoring at 10 sites and NO_x and NO_2 monitoring ceased at 19 sites.

In total, 20 AURN sites were discontinued in 2007. In many cases, however, they have not been shut down, but simply been de-affiliated from the AURN and continue to be operated by the relevant Local Authorities.

A 3.2 The Acid Deposition Monitoring Network

(Managed and operated for Defra and the DAs by AEA and CEH)

The Acid Deposition Monitoring network (ADMN) was established in 1986 to monitor the composition of precipitation and hence to provide information on deposition of acidifying compounds in the United Kingdom. Its main emphasis has always been the assessment of potential impacts on UK ecosystems. Other measurements have also been made within the programme - sulphur dioxide, nitrogen dioxide and particulate sulphate - to provide a more complete understanding of precipitation chemistry in the United Kingdom.

This network has evolved substantially over time. It was originally based on two sub-programmes – a ‘primary’ network providing high quality and high frequency data, which could be used to identify trends over time, and a ‘secondary’ network providing information on the spatial distribution of acid deposition in the UK. Originally, there were 9 primary and 59 secondary sampling sites. Subsequent changes made to the programme, including different measurement techniques, altered sampling frequencies and reductions to the number of monitoring sites, have made this distinction less clear cut.

In 1999, seven new sites were established to monitor rainwater composition in ecologically sensitive areas. The UK Nitric Acid Monitoring Network was also introduced to the acid deposition contract in 1999; this provides monthly data on acid gases and particulates. Further changes in 2006 saw the exposure of triplicate nitrogen dioxide diffusion tubes at three sites and the installation of a wet-only daily precipitation collector at one site. In addition, sulphur dioxide measurements undertaken by the ADMN and Rural SO_2 Monitoring Network (part of the Acid Deposition Processes contract) were terminated at the end of 2005, being replaced by measurements made as part of the expanded nitric acid monitoring network.

In 2007, the network covered the following measurements and sites:

The Acid Deposition Monitoring Network - site numbers & measured parameters

Precipitation Composition	– Rainwater sampling using a bulk collector on a ***fortnightly*** basis at 38 sites – Rainwater sampling using a bulk collector on a ***daily*** basis at 1 of the above sites – Additional wet-only measurements on a ***daily*** basis at 1 site
Particulate Sulphate **Nitrogen Dioxide**	– Sampled on a ***daily*** basis at 5 sites – Diffusion tube measurements on a ***monthly*** basis at 24 sites. Of these, 3 sites operate triplicate tubes.
Nitric acid, other acid gases and aerosols	– Denuder (DELTA) measurements on a ***monthly*** basis at 30 sites

A 3.3 The hydrocarbon monitoring networks

i) The Automatic Hydrocarbon Network
(Network managed and quality assured for Defra and the DAs by AEA)

Automatic hourly measurements of speciated hydrocarbons, made using an advanced automatic gas chromatograph (VOCAIR), commenced in the UK in 1991. By 1995, monitoring had expanded considerably with the formation of a 13-site dedicated network measuring 26 species continuously at urban, industrial and rural locations.

The focus in this ground-breaking measurement programme was two-fold: firstly to assess ambient concentrations of a range of Volatile Organic Compounds (VOCs) with significant photochemical oxidant formation potential, and secondly to measure two known genotoxic carcinogens (benzene and 1,3-butadiene) for comparison against emerging UK Air Quality Objectives. Data on these 'air toxics' were also regularly reported to the public.

The automatic hydrocarbon monitoring network, as originally constituted, used state-of-the-art measurement techniques, combined with advanced software techniques for signal processing and validation. It was the first network of its kind in the world. The Automatic Hydrocarbon Network operated successfully for 10 years before the programme was re-focussed, re-designed and simplified in 2002.

By the start of 2007, the UK Automatic Hydrocarbon Network consisted of six sites, located at Cardiff, Glasgow, Harwell, London Eltham, London Marylebone Road and Auchencorth Moss. Three of these sites – Cardiff, Glasgow and Harwell- utilise an Environnment VOC71M analyser configured to measure and report the concentrations of 1,3-butadiene, benzene, toluene, ethylbenzene, (m+p)-xylene and o-xylene.

Benzene data are used for comparison with the UK Air Quality Objectives and are also reported to the European Commission to fulfil requirements of the 2nd Daughter Directive (and the new Directive on ambient air quality and cleaner air for Europe (Directive 2008/50/EC, 21st May 2008), which supersedes it). 1,3-butadiene data were used for comparison with UK AQS Objectives.

Auchencorth Moss and the two London sites - London Eltham and London Marylebone Road - are fitted with automatic Perkin Elmer gas chromatographs measuring a wider range of VOCs, equivalent to that studied under the original measurement programme. These instruments are capable of measuring and reporting at least 27 hydrocarbons. In April 2007, a Perkin Elmer instrument was installed at Harwell as an upgrade to the existing VOC71M instrument.

Measurements from all six sites are reported to the European Commission, satisfying requirements under the Ozone Daughter Directive for monitoring photochemical ozone precursors. Corresponding benzene and the 1,3-butadiene data are used for comparison with the UK Air Quality Objectives, whilst benzene data are reported to the European Commission to fulfil requirements of the 2nd Daughter Directive (and the new Directive 2008/50/EC [B5] on ambient air quality and cleaner air for Europe, which supersedes it).

Hourly benzene and 1,3-butadiene data from all sites continue to be reported to the public at large through a range of web, electronic, text and broadcast media.

During 2007, a strategic review of the UK monitoring networks resulted in the cessation of VOC monitoring at the Cardiff Centre monitoring site.

ii) The Non-Automatic Hydrocarbon Network
(Managed and operated for Defra and the DAs by the National Physical Laboratory)

The UK Non-Automatic Hydrocarbon Network measures ambient benzene concentrations at 35 sites around the United Kingdom. Benzene is monitored to assess compliance with UK Objectives (between 3.25 and 16.25 µgm^{-3} depending on area and compliance date, expressed as a running annual mean), as well as with the corresponding EC Air Quality Directive Limit Value (5 µgm^{-3} annual average).

Until 2007, 1,3-butadiene was also monitored at nine of these locations, in order to assess compliance with the UK Air Quality Strategy Objective (2.25 µg m^{-3} expressed as a running annual mean). However, the network was reviewed in 2007, and in view of the fact that

- 1,3-butadiene levels at all the sites were well below the Objective and
- levels at half of the sites were at or below the detection limit for the method used

- Defra took the decision to discontinue monitoring 1,3-butadiene.

As the Objectives and Limit Values for benzene relate to the annual average concentration, it is not necessary to use a monitoring method with short time resolution. Sampling is therefore undertaken using pumped samplers, with sampling period of two weeks. Ambient air is pumped through sampling tubes containing a proprietary absorbent (Carbopack X), using purpose-built pump units that switch between two tubes to produce two nominally identical samples covering each fortnight. Every fortnight, the tubes are changed, and the instruments checked by Local Site Operators, who send the exposed tubes to the network management unit for analysis.

Currently, all samplers are located at monitoring stations operated within the Automatic Urban and Rural Network (AURN) - discussed separately in Section A3.1. Measurements began over the period December 2001 to August 2002, following the decommissioning of the first generation Automatic Hydrocarbon Network, which provided on-line measurements of hourly data for 26 hydrocarbon species at 13 sites. The data obtained now provide a useful addition to automatic measurements from the six sites comprising the Automatic Hydrocarbon Network (above).

The fortnightly pumped measurement method for benzene was developed specifically for this network; this following the requirement of the 2nd Daughter Directive that, in view of their inherently lower measurement uncertainty, measurements for reporting purposes be made by pumped sampling rather than by diffusive sampling. Previously, pumped sampling for benzene had been geared to short periods of a day or less. The combination of a suitable sorbent material and sound engineering in the pump control box has led to a very successful method.

The EU instructs CEN, the European Committee for Standardisation, to set out standard methods to be used to comply with Directives. The relevant CEN benzene standards (EN 14662, five parts) include the pumped method used in this network.

A3.4 The PAH and TOMPs Networks

(Networks managed and operated for Defra and the DAs by AEA and Lancaster University respectively since April 2004)

2007 was a period of great change in these two networks. At the start of the year, there were 24 sites. 18 of these were operated within the PAHs programme, with a further six sites operated as the TOMPS monitoring network but with samples also analysed for

PAHs under the PAH programme. Both networks used the same type of sampler; the modified Andersen GPS-1 Pesticide sampler.

During the year, the PAH network underwent two major changes; the type of sampler used was changed to comply with the requirements of the 4^{th} Air Quality Daughter Directive: this specified that the particulate size fraction collected should be PM_{10}, and that each sample be taken over a period limited to 24 hours. A number of new sites came into operation, giving 29 locations at the end of the year with a further two sites operating from the early part of 2008. One of the sites in the TOMPs network closed at the end of the year.

i) PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a group of persistent organic compounds, some of which are toxic and/or human carcinogens; they are produced through industrial and combustion processes. There are three major policy drivers and data uses for this programme:

- The UK Air Quality Objective for PAHs, based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS), is for an annual air quality standard of 0.25 ngm^{-3} benzo[a]pyrene to be achieved by 2010.
- The European Community's fourth Air Quality Daughter Directive (2005/107/EC), which includes a target value of 1 ng m^{-3} for the annual mean concentration of benzo[a]pyrene as a representative PAH, to be achieved by 2012.
- The UK's decision to sign, and ratify, the UNECE protocol on Persistent Organic Pollutants (POPs), which includes PAHs.

Under the protocol, there is a requirement for signatories to control emissions of PAHs to measure and assess the long-range transport of four specified PAHs.

All these policy imperatives require sound data on ambient concentrations and trends of PAHs in the environment.

The modified Anderson GPS-1 pesticide samplers captures both gas and particle-phase PAHs on glass fibre and polyurethane filter operating over a 14 day sample period. This instrument has been deployed at all 18 UK network locations since they commenced operation in 1991. Some have been phased out during 2007 to implement standard EN15549 from the beginning of 2008.

The number of UK network locations has also increased to 32 sites in response to the 4^{th} Air Quality Daughter Directive, whilst the network now uses Digitel DH-80 high volume aerosol samplers. Thirty two of the UK Network locations sample particle-phase only PAHs on glass fibre filters while two of these sites include both an additional modified DH-80 high volume sampler; this captures both gas and particle-phase PAHs on glass fibre and polyurethane filers. These two sites will additionally deploy a deposition sampler.

Extraction of the filter and, where relevant, foam media and subsequent analysis by gas chromatography/mass spectroscopy (GC/MS) provides data on 39 PAH species. However, for the filter-only method, the results are only a representation of the PAHs retained by the filter. For some of the more volatile PAH compounds, this represents only a small fraction of the total. The deposition method measures the same list of compounds, but is subject to a high degree of uncertainty.

ii) TOMPs

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

The TOMPs network provides data to inform the public of air quality, and information to support the development of policy to protect the environment. The specific aims of the TOMPs programme are:

- To identify sources of TOMPs in the UK's atmosphere.
- To quantify sources that are regarded as potentially significant.
- To measure concentrations of TOMPs in ambient air in UK cities, in order to assess both human exposure and the relationship between source emissions and levels in the ambient atmosphere.
- The UK's decision to ratify the UNECE protocol on Persistent Organic Pollutants (POPs), which includes PCDD/Fs, PCBs and PAHs. Under the protocol, there is a requirement for signatories to control and assess the long-range transport of these compounds.
- The network is also used to investigate the behaviour of newly identified persistent organic pollutants such as brominated flame retardants and other industrial chemicals.

There were six sites in the TOMPs network during 2007: London Ashdown House, Manchester and Middlesbrough (all urban background sites), together with Hazelrigg, High Muffles and Stoke Ferry (all rural sites). The Stoke Ferry sampler ceased operation at the end of 2007.

The TOMPs network samples are analysed for PCDD/Fs and PCBs. Portions from the extracts of samples are also analysed for PAHs as part of the PAH network. The sampling method is based around the use of a modified Andersen GPS-1 sampler, with subsequent chemical analysis requiring the use of a range of sophisticated chemical analysis techniques. These include:

- Gas chromatography coupled with high-resolution mass spectrometry for the PCDD/Fs and for those PCBs with dioxin-like effects
- Low-resolution mass spectrometry for the other PCBs.

A 3.5 UK Heavy Metals Monitoring Networks

(i) UK urban/industrial network (previously the Lead, Multi-element and Industrial Metals Networks)

(Network managed and operated for Defra and the DAs by the National Physical Laboratory)

This network monitors a range of metallic elements at urban and industrial sites. In 2007, it comprised 17 sites, all of which monitored As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Pt, V and Zn. Additionally, measurements of ambient vapour phase mercury concentrations are made at 13 sites.

Historically, this network grew out of several separate long-term monitoring programmes, funded by the UK Government and latterly responding to specific needs of EC Directives in relation to toxic and industrial metals.

The network originally included:

- Five urban multi-element monitoring sites providing measurements of 9 important trace elements (Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and V)
- Eight sites for the monitoring of ambient lead resulting from lead in petrol (2 rural, 3 urban and 3 kerbside).

- Eight sites operating in three industrial areas monitoring lead - Walsall (IMI and Brookside works) and Newcastle (Elswick works).
- A short-term survey 2000-2001 at 30 industrial site locations across the UK in order to establish the UK's position with respect to the requirements of the 4th Daughter Directive which was then being drafted. Five of these sites continued in operation.

The disparate nature of the historic monitoring networks from which this network was formed resulted in differences in methods and practices, as well as in the range of metals monitored. So, in 2003, all monitoring was rationalised into a single integrated network (with the exception of the Rural Trace Element sites), referred to as the UK Heavy Metals Monitoring Network. In September 2004, the number of elements measured at the old Industrial Metals sites was increased to ensure consistency across the Network.

Sampling is now undertaken for weekly periods at sites, in the PM_{10} fraction of particulates using R&P Partisol 2000 samplers. Analysis of samples occurs with UKAS-accredited ICP-MS analysis, with acid digest techniques, in accordance with European Standard EN 14902:2005. Consistency in approach has been achieved with historical data collection and analyses through thorough equivalence exercises.

The UK Urban Industrial Metals Network now forms the basis of the UK's compliance monitoring for:

- The First Daughter Directive (99/30/EC) which set a Limit Value for lead in air concentrations of 0.5 µg/m^3, expressed as an annual mean to be achieved by 1st January 2005. This limit has been incorporated into the new Directive on ambient air quality and cleaner air for Europe (Directive 2008/50/EC, 21st May 2008, [B5])
- The 4th Daughter Directive (2004/107/EC), which sets 'target values' for arsenic, cadmium, nickel (and polycyclic aromatic hydrocarbons) in the PM_{10} particulate fraction of ambient air. The 4th Daughter Directive also requires monitoring of mercury although no limit or target values are set. This Daughter Directive remains in force: it is envisaged that it will be incorporated into the new Directive 2008/50/EC at some stage in the future.

The agreement reached between the European Parliament and the Environment Council on the Directive on the Quality of Petrol and Diesel Fuels led to the ban of sales of leaded petrol in the UK with effect from 1st January 2000. This has, in turn, led to a dramatic decline in ambient lead levels in many UK environments, which was monitored by this Network and is discussed in greater detail in Section 6 of the main report.

During 2007, as part of Defra's review of the network to ensure it continued to meet compliance monitoring requirements, four of the original "multi-element" sites were closed down (in Newcastle, London Brent, Glasgow and Leeds. Eleven new sites were subsequently established, although these did not begin operation until 2008. Next year's report will contain details of these.

The findings of this network and its predecessors are summarized in a recently published paper [Q1].

(ii) The Rural Heavy Metals and Mercury Network

(Network managed and operated for Defra and the DAs by CEH)

In 2003-4, the Rural Trace Element Monitoring Network was established as 10 primary sites across the UK. The PM_{10} fraction of particulates is collected weekly using Thermo FH95 single or FH95SEQ sequential samplers, together with weekly or 4-weekly collections of precipitation. In addition, a further three secondary sites collect precipitation samples only and two more high elevation sites collect precipitation and cloud water samples.

Concentrations of As, Cd, Cr, Cu, Ni, Pb, Se, V, Zn, Al, Sc, Ti, Mn, Fe, Co, Rb, Sr, Mo, Sn, Sb, Ba and W in particulates, precipitation and cloud water are determined by accredited ICP-MS analysis at CEH Lancaster.

Elemental mercury (Hg^0) makes up over 97% of the total atmospheric mercury burden. The remaining amount consists of reactive gaseous mercury (RGM) and particulate mercury (Hg^P). Speciated measurements of mercury are made at the Auchencorth Site using a state-of-the-art Tekran mercury speciation system, which measures RGM, Hg^P and Hg^0.

As concentrations of these species are so low (of the order of pgm^{-3} for RGM and Hg^p), very sensitive analytical equipment is required. The detector in the Tekran 2537A analyser employs Cold Vapour Atomic Fluorescence Spectroscopy (CVAFS). Elemental mercury is sampled and analysed for one hour, whilst RGM and Hg^P are collected on a KCl-coated denuder and particulate trap, respectively. During the following hour, the collected RGM and HgP are desorbed and analysed. Using this method, Hg^0 is analysed with a temporal resolution of 5 minutes every other hour and hourly averages of RGM and Hg^P concentrations are obtained every other hour.

At the 10 primary sites, newly designed samplers have also been set up to collect Total Gaseous Mercury (TGM) in air (2-weekly) and mercury in precipitation (Monthly). Analysis of Total Gaseous Mercury is based on the system of Two-Stage Gold Amalgamation. Mercury is adsorbed onto gold-coated sand contained within a quartz cartridge and is desorbed by heating the cartridge to 500°C to release the trapped mercury. Desorption is carried out using a custom-built unit that interfaces with a Tekran 2537A analyser, used in off-line mode. Two sampling cartridges are used in series to detect any breakthrough of mercury from the first cartridge, which can be analysed if the capture efficiency of the first cartridge has been reduced.

Mercury in precipitation is analysed using a Cold Vapour Atomic Fluorescence Spectrometer (PSA Ltd) with a Analytical detection limit = 0.8ng l^{-1} (99% confidence, Controlled Reference Material NRCC-ORMS-2.)

A 3.6 The National Ammonia and Nitric Acid Monitoring Networks

(Managed and operated for Defra and the DAs by CEH- Centre for Ecology and Hydrology)

i) The NAMN

Ammonia (NH_3) emissions are estimated to have at least doubled over the last century across Europe. This rise has been primarily due to the intensification of agriculture, together with the increased use of nitrogen-based fertilizers. The main sources of NH_3 in the atmosphere are from the decomposition and volatilisation of animal wastes. Other sources include direct volatilisation from synthetic fertilizers (particularly urea), and a wide range of non-agricultural sources such as sewage, catalytic converters, wild animals and industrial processes. It is recognised that deposition of atmospheric NH_3 contributes to acidification and eutrophication processes, which can cause damage to sensitive ecosystems.

Under the UNECE Gothenburg Protocol and the National Emissions Ceilings Directive of the EU, the target of both these agreements is that NH_3 emissions should not exceed 297 kt as NH_3 by 2010, with a particular focus on reducing the extent of critical loads exceedence for acidification and eutrophication effects. Abatement of NH_3 emissions is also included in EU Integrated Pollution Prevention and Control (IPPC) for the intensive pig and poultry sectors.

In the UK, the Defra-funded National Ammonia Monitoring Network (NAMN, http://www.uk-pollutantdeposition.ceh.ac.uk/networks) was established in 1996 to quantify temporal and spatial changes in air concentrations and deposition in gaseous NH_3 and aerosol NH_4^+ (included since 1999) on a long-term basis. The monitoring provides a baseline in reduced nitrogen (NH_x) species, which is necessary for examining responses to changes in the agricultural sector and to verify compliance with targets set by international agreements. Data from the network are also used to test the performance of an atmospheric chemistry and transport model (FRAME) that was developed at the same time with a special focus on NH_x, and to contribute to national Nitrogen (N) deposition estimates.

There are currently 95 sites in the NAMN (shown in Figure 3.9 in the main document) and the high spatial variability of ammonia concentrations demonstrates that this large number of sites is necessary. At 58 of these sites, where power is available, an active diffusion denuder methodology using the CEH DELTA (DEnuder for Long Term Atmospheric sampling) system is used to provide the main spatial and temporal patterns of NH_3 across the UK. Aerosol NH_4^+, a secondary product is spatially more even and is monitored at a subset of DELTA sites (currently 46).

The DELTA network is complemented by the implementation of a high sensitivity passive diffusion sampler, the ALPHA (Adapted Low-cost Passive High-Absorption) sampler at a further 49 sites to assess regional and local scale variability in air NH_3 concentrations in source regions. In the first phase of the network, the Gradko 3.5 cm membrane diffusion tube was used, but, owing to limitations in the sensitivity of the method (Limit of Detection = approx. 1-2 µg NH_3 m^{-3}), this was replaced by the new ALPHA sampler in the second phase of the network (since 2000). The ALPHA sampler was designed and developed specifically for monitoring ambient concentrations of NH_3, with a detection limit of around 0.02 µg NH_3 m^{-3}. To provide an ongoing validation of the ALPHA sampler, its performance is continuously assessed against the DELTA system at 12 sites within the network.

The DELTA system used in the NAMN also provides a foundation for monitoring of other atmospheric components at a subset of sites, including monthly measurements of gaseous HNO_3, SO_2, HCl and aerosol NO_3^-, SO_4^{2-}, Cl^-, plus base cations Na^+, Ca^{2+} and Mg^{2+}, as part of the UK Nitric Acid Monitoring Network.

Overall, the UK NAMN structure currently consists of the following sites:

Site type	Number
DELTA sites sampling gaseous NH_3	58
DELTA sites also sampling aerosol NH_4^+	46
DELTA sites also sampling gaseous HNO_3, SO_2, HCl and aerosol NO_3^-, SO_4^{2-}, Cl^-, K^+, Ca^{2+}, Mg^{2+} as part of the Nitric Acid Monitoring Network	30
ALPHA sites sampling gaseous NH_3	49
Intercomparison sites with both DELTA & ALPHA samplers	12
Total number of sites	95

ii) The UK Nitric Acid Monitoring Network

The UK Nitric Acid Monitoring Network has been in operation since September 1999, providing data on nitric acid, particulate nitrate and other species as part of the UK Acid Deposition Monitoring Network.

In the first phase of the network, monitoring was implemented at 12 sites using the CEH DELTA system, in an integrated fashion with the UK National Ammonia Monitoring Network (NAMN). An extension of the DELTA system at the NAMN sites was used to additionally sample gaseous HNO_3, SO_2, HCl and particulate NO_3^-, SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+}, in parallel with monthly sampling of NH_3 and NH_4^+ at the NAMN sites.

To improve on the national spatial coverage, the network was increased from 12 to 30 sites in the second phase of the network, starting January 2006 (Figure 3.9 in main document). The new expanded network also replaced measurements of gaseous SO_2 and particulate SO_4^{2-} previously made under the Rural Sulphur Dioxide Monitoring Programme, which terminated at the end of 2005.

Data from the network are reported on the website http://www.uk-pollutantdeposition.ceh.ac.uk/networks. The aims of the network are to provide a long-term dataset of monthly speciated measurements of acid gases and aerosols that will be used to:

- Provide temporal and spatial patterns and trends, and compare results with dispersion models
- Facilitate Pollution Climate mapping and assessment of Acid Deposition Processes
- Contribute to mass closure from the measurements of several components of particulate matter (NO_3^-, SO_4^{2-}, Cl^-, Na^+, Mg^{2+} and Ca^{2+}) together with NH_4^+ from the closely integrated NAMN), which was one of the recommendations in the Department's Air Quality Expert Group's report on Particulate matter
- Calculate national and regional deposition budgets, especially in upland areas that are sensitive to acid deposition.

A3.7 The UK Black Smoke Network

(Network managed and operated for Defra and the DAs by the National Physical Laboratory)

Black Smoke measurements were the earliest systematic measurements of air pollution by particulate matter in the United Kingdom, with records dating back to the 1920s. Air is sampled through a filter and the darkness of the stain, measured by optical reflectance, is converted to a Black Smoke Index, given in units of μgm^{-3}.

In 2005, monitoring of Black Smoke ceased to be a regulatory requirement in the United Kingdom, with particulate matter being regulated as PM_{10} and $PM_{2.5}$. In that year, Defra commissioned an independent review of the UK urban network for measurement of Black Smoke, SO_2 and NO_2. Its recommendations for Black Smoke monitoring included continuing a network of about 20 sites, some of which should be at AURN locations.

The resulting new UK Black Smoke Network commenced operation on 1st September 2006. The design of the Network was planned to incorporate 11 existing Black Smoke sites and 10 Black Smoke samplers in AURN stations. Samplers were installed at the AURN (section A3.1) sites between October 2006 and March 2007.

The design of the Network was planned to incorporate 11 existing Black Smoke sites from the old Smoke and SO_2 Network, and to install 10 Black Smoke samplers in AURN stations. The sites are listed below.

Black Smoke sampling uses the 8-port sampler that has historically been used in the UK network, based on the standard method BS 1747 Part 11, ISO 9835. The principle of the 8-port sampler method involves drawing air at a constant flow rate of around 1.4 l/min through a Whatman Number 1 cellulose filter, so that about 2 m^3 of air (at ambient conditions of temperature and pressure) is sampled for each daily sample. Suspended particulate matter is collected on the filter over an area determined by a choice of clamp – in this case with a one inch diameter - forming a dark stain. The inlet, an upturned funnel, is not specifically designed to be size selective, and has been shown in one study to collect the approximate size fraction $PM_{4.5}$.

Existing Sites	AURN sites
Strabane 2	Edinburgh St Leonard's
Cardiff 12	Glasgow Centre
Halifax 17	Manchester Piccadilly
South Kirkby 1	Belfast Centre
Halesowen 8	Bradford
Sunderland 8	Stoke Centre
Norwich 7	North Kensington
Dunmurry 3	Birmingham Tyburn
Woolwich 9	Nottingham Centre
Bath 6	Folkestone, Kent Network
Marylebone Road	

The 8-port sampler is designed with eight pairs of filter clamps for weekly operation, providing daily sampling from a midnight-to-midnight basis. The timed eight-port valve is set to switch over at midnight to expose a fresh filter paper each day. Weekly visits are made to change filter papers and to record weekly sample volumes and flow rates.

Black smoke concentrations are then estimated by means of a reflectance measurement. The darkness of the stain is measured with an EEL M43D reflectometer, the reflectance being determined relative to a blank filter of the same type. The instrument uses a light bulb to give a broad band source that is reflected back from the smoke stain to a photo-sensitive element and produces a reading between 0% and 100% reflectance. NPL measures the reflectance of all of the filters sampled by the network, whereas, previously, reflectometry measurements were performed by local Councils using their own reflectometers.

The measured reflectance, sampled volume and filter area are used to calculate the concentration of dark particulate matter in the sampled air, as Black Smoke Index, with units of μgm-^{3}, using the relationship given in BS 1747: Part 2:

$$C = \frac{1}{V}\left(91679.22 - 3332.046R + 49.618884R^2 - 0.35329778R^3 + 0.0009863435R^4\right)$$

where:

C = concentration in μg/m^3
V = volume of sampled air in ft^3
R = reflectometer reading (%)

The above relationship is only valid for a one inch diameter filter clamp - an additional factor is required for other clamp sizes. This relationship is also only valid for values of R above 40%, which was true for all samples measured in the Network over recent years.

The results of the first full year of the new Black Smoke Network's operation are compiled in a report [Q2] available on the Air Quality Archive at http://www.airquality.co.uk/archive/reports/cat05/0706141352_2006_Annual_Report_final.pdf

Appendix A4- Analysis of statistically significant trends in UK pollution levels

Here we summarise those measurement sites with over five years of measurements having statistically significant trends.

A4.1 Sites with Significant Trends for Benzene, µg m^{-3} / yr

Benzene µg m^{-3} / yr									
Site	**Environment****	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho***	**No. of years**
Harwell	RU	Annual mean	1995	2007	-0.09	-0.14	0.01	-0.72	13
Harwell	RU	98 %ile	1995	2007	-0.31	-0.6	0	-0.69	13
London Eltham	S	Annual mean	1994	2007	-0.28	-0.38	-0.06	-0.75	11
London Eltham	S	98 %ile	1994	2007	-1.31	-1.57	0.23	-0.72	11
London Marylebone Road	KS	Annual mean	1998	2007	-0.8	-3.25	-0.91	-0.75	10
London Marylebone Road	KS	98 %ile	1998	2007	-2.34	-9.3	-2.3	-0.75	10

A4.2 Sites with Significant Trends for 1,3-Butadiene µg m^{-3} / yr

1,3-Butadiene µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho***	**No. of years**
Harwell	RU	Annual mean	1996	2007	-0.02	-0.02	0	-0.9	12
Harwell	RU	98 %ile	1996	2007	-0.04	-0.1	0.1	-0.76	12
London Eltham	S	Annual mean	1994	2007	-0.04	-0.05	-0.01	-0.94	11
London Eltham	S	98 %ile	1994	2007	-0.23	-0.23	0.03	-0.88	11
London Marylebone Road	KS	Annual mean	1998	2007	-0.24	-0.49	-0.18	-0.88	10
London Marylebone Road	KS	98 %ile	1998	2007	-0.6	-2	-0.59	-0.88	10

** Rho is the Spearman's rank correlation coefficient, a statistical parameter that expresses the correlation between two variables. The relationship between the variables does not have to be linear, and the variables do not have to follow any particular frequency distribution (e.g. normal distribution). The magnitude of rho can be from 0 - 1, and rho can be positive or negative. The closer rho is to 1 (or -1) the more closely the two variables are correlated. If rho = 0 they are not at all correlated. For the more interested reader, further information on the Spearman's rank correlation coefficient can be found on the web-based encyclopaedia "Wikipedia" at: http://en.wikipedia.org/wiki/Spearman%27s_rank_correlation_coefficient*

** Site Environment Types:

RU- Rural
S- Suburban
KS- Kerbside
RS- Roadside
UC- Urban Centre
UB- Urban Background
UI- Urban Industrial
RE- Remote

A4.3 (i) Sites with Significant Trends for Carbon Monoxide, mgm^{-3} / yr

Carbon Monoxide mg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Bath Roadside	RS	Annual mean	1997	2007	-0.1	-0.1	-0.1	-0.99	11
Bath Roadside	RS	98 %ile	1997	2007	-0.3	-0.3	-0.1	-0.99	11
Belfast Centre	UC	Annual mean	1992	2007	-0.1	-0.1	0	-0.93	16
Belfast Centre	UC	98 %ile	1992	2007	-0.3	-0.4	0.2	-0.94	16
Birmingham Centre	UC	Annual mean	1992	2007	0	0	0	-0.88	16
Birmingham Centre	UC	98 %ile	1992	2007	-0.1	-0.8	-0.1	-0.95	16
Bolton	UB	98 %ile	1998	2007	-0.2	-0.5	0.1	-0.89	10
Bradford Centre	UC	Annual mean	1998	2007	0	-0.1	0	-0.88	10
Bradford Centre	UC	98 %ile	1998	2007	-0.2	-0.5	-0.2	-0.95	10
Brighton Roadside	RS	Annual mean	1998	2007	-0.1	-0.1	0	-0.95	10
Brighton Roadside	RS	98 %ile	1998	2007	-0.2	-0.3	-0.2	-0.98	10
Bristol Old Market	RS	Annual mean	1997	2007	-0.1	-0.7	-0.2	-0.91	11
Bristol Old Market	RS	98 %ile	1997	2007	-0.4	-2.6	-0.6	-0.94	11
Bury Roadside	RS	Annual mean	1997	2007	0	-0.2	0	-0.64	10
Bury Roadside	RS	98 %ile	1997	2007	-0.2	-0.5	-0.2	-0.89	10
Cardiff Centre	UC	Annual mean	1992	2007	0	-0.1	0.1	-0.89	16
Cardiff Centre	UC	98 %ile	1992	2007	-0.1	-0.7	-0.1	-0.97	16
Derry	UB	98 %ile	1997	2007	-0.1	-0.2	-0.1	-0.95	11
Exeter Roadside	RS	Annual mean	1997	2007	-0.1	-0.5	-0.1	-0.97	11
Exeter Roadside	RS	98 %ile	1997	2007	-0.4	-2.7	-0.6	-0.99	11
Glasgow Centre	UC	Annual mean	1997	2007	0	-0.1	0	-0.76	11
Glasgow Centre	UC	98 %ile	1997	2007	-0.1	-0.7	-0.1	-0.91	11
Glasgow City Chambers	UB	Annual mean	1990	2007	0	-0.1	0.3	-0.94	18
Glasgow City Chambers	UB	98 %ile	1990	2007	-0.2	-0.6	-0.1	-0.98	18
Glasgow Kerbside	KS	Annual mean	1997	2007	-0.1	-0.3	-0.1	-0.93	11
Glasgow Kerbside	KS	98 %ile	1997	2007	-0.3	-0.8	-0.3	-0.98	11
Hove Roadside	RS	Annual mean	1998	2007	0	-0.1	0.1	-0.93	10
Hove Roadside	RS	98 %ile	1998	2007	-0.2	-0.5	-0.2	-0.98	10
Leamington Spa	UB	98 %ile	1998	2007	-0.1	-0.4	-0.1	-0.88	10
Leeds Centre	UC	Annual mean	1993	2007	0	-0.2	0	-0.82	15
Leeds Centre	UC	98 %ile	1993	2007	-0.2	-0.3	-0.1	-0.88	15
Leicester Centre	UC	Annual mean	1994	2007	-0.1	-0.1	0	-0.76	14
Leicester Centre	UC	98 %ile	1994	2007	-0.1	-0.2	0	-0.96	14
London A3 Roadside	RS	Annual mean	1997	2007	-0.1	-0.2	-0.1	-0.98	11
London A3 Roadside	RS	98 %ile	1997	2007	-0.3	-1.2	-0.3	-0.98	11
London Bexley	S	Annual mean	1994	2007	0	0	0	-0.79	14
London Bexley	S	98 %ile	1994	2007	-0.1	-0.5	0	-0.88	14
London Bloomsbury	UC	Annual mean	1992	2007	0	-0.2	0	-0.79	16
London Bloomsbury	UC	98 %ile	1992	2007	-0.1	-0.7	0.1	-0.84	16
London Brent	UB	Annual mean	1996	2007	0	-0.1	0.1	-0.7	12
London Brent	UB	98 %ile	1996	2007	-0.2	-0.3	1.2	-0.96	12
London Cromwell Road 2	RS	Annual mean	1998	2007	-0.1	-0.1	0	-0.98	10
London Cromwell Road 2	RS	98 %ile	1998	2007	-0.3	-0.4	-0.2	-0.99	10

A4.3 (ii) Sites with Significant Trends for Carbon Monoxide, mgm^{-3}/yr (cont)

Carbon Monoxide mg m^{-3} / yr *- continued*									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
London Hackney	UC	Annual mean	1997	2007	-0.1	0	0.2	-0.76	11
London Hackney	UC	98 %ile	1997	2007	-0.3	-0.2	0.6	-0.95	11
London Hillingdon	S	Annual mean	1997	2007	0	-0.1	-0.1	-0.92	11
London Hillingdon	S	98 %ile	1997	2007	-0.2	-1.8	-0.3	-0.97	11
London Marylebone Road	KS	Annual mean	1998	2007	-0.2	-0.2	0.1	-0.94	10
London Marylebone Road	KS	98 %ile	1998	2007	-0.6	-0.7	0.1	-0.96	10
London N. Kensington	UB	98 %ile	1996	2007	-0.1	-0.5	1	-0.94	12
London Southwark	UC	Annual mean	1997	2007	-0.1	-0.1	0	-0.84	11
London Southwark	UC	98 %ile	1997	2007	-0.2	-1.3	-0.3	-0.94	11
Manchester Piccadilly	UC	Annual mean	1996	2007	0	0	0.1	-0.66	12
Manchester Piccadilly	UC	98 %ile	1996	2007	-0.1	-0.2	0.3	-0.84	12
Manchester Town Hall	UB	Annual mean	1992	2007	0	-0.3	0	-0.71	14
Manchester Town Hall	UB	98 %ile	1992	2007	-0.1	-2.8	-0.3	-0.94	14
Middlesbrough	UI	Annual mean	1995	2007	0	-0.1	0	-0.6	13
Middlesbrough	UI	98 %ile	1995	2007	0	-0.1	0	-0.82	13
Newcastle Centre	UC	Annual mean	1992	2007	-0.1	-0.1	0	-0.94	16
Newcastle Centre	UC	98 %ile	1992	2007	-0.2	-0.4	-0.1	-0.98	16
Norwich Centre	UC	Annual mean	1998	2007	0	0	0.1	-0.78	10
Norwich Centre	UC	98 %ile	1998	2007	-0.1	-0.1	0.1	-0.83	10
Nottingham Centre	UC	Annual mean	1997	2007	0	-0.1	0	-0.81	11
Nottingham Centre	UC	98 %ile	1997	2007	-0.2	-0.6	-0.2	-0.95	11
Oxford Centre Roadside	RS	98 %ile	1998	2007	-0.3	-1	-0.3	-0.89	10
Plymouth Centre	UC	98 %ile	1998	2007	-0.1	-0.2	0	-0.91	10
Salford Eccles	UI	98 %ile	1998	2007	-0.2	-0.7	0	-0.91	10
Sheffield Centre	UC	Annual mean	1996	2007	0	-0.1	0	-0.84	12
Sheffield Centre	UC	98 %ile	1996	2007	-0.1	-0.3	0.3	-0.95	12
Sheffield Tinsley	UI	Annual mean	1992	2007	0	-0.4	0	-0.68	16
Sheffield Tinsley	UI	98 %ile	1992	2007	-0.1	-2.7	-0.3	-0.92	16
Southampton Centre	UC	Annual mean	1994	2007	-0.1	-0.1	0	-0.94	14
Southampton Centre	UC	98 %ile	1994	2007	-0.2	-0.5	-0.1	-0.97	14
Stoke-on-Trent Centre	UC	Annual mean	1997	2007	0	-0.1	0	-0.91	11
Stoke-on-Trent Centre	UC	98 %ile	1997	2007	-0.2	-0.8	-0.2	-0.98	11
Thurrock	UB	Annual mean	1997	2007	0	-0.2	0	-0.8	11
Thurrock	UB	98 %ile	1997	2007	-0.1	-1.3	-0.2	-0.89	11
Tower Hamlets Roadside	RS	Annual mean	1996	2007	-0.1	-0.2	0.1	-0.93	12
Tower Hamlets Roadside	RS	98 %ile	1996	2007	-0.5	-0.6	0.5	-0.98	12
West London	UB	Annual mean	1990	2007	-0.1	-0.3	0.3	-0.73	18
West London	UB	98 %ile	1990	2007	-0.3	-0.6	1.2	-0.95	18
Wolverhampton Centre	UC	Annual mean	1996	2007	0	-0.1	0	-0.81	12
Wolverhampton Centre	UC	98 %ile	1996	2007	-0.1	-0.3	0.2	-0.94	12

A4.4 (i) Sites with Significant Trends for Nitrogen Dioxide, µg m^{-3} / yr

Nitrogen Dioxide µg m^{-3} / yr									
Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
Barnsley Gawber	UB	Annual mean	1998	2007	-1.4	-5	-0.7	-0.95	10
Belfast Centre	UC	Annual mean	1992	2007	-1	-2	-0.6	-0.78	16
Belfast Centre	UC	98 %ile	1992	2007	-1.8	-10.5	-1.5	-0.54	16
Billingham	UI	Annual mean	1987	2007	-0.6	-2.2	-0.5	-0.81	21
Billingham	UI	98 %ile	1987	2007	-0.9	-9	-0.7	-0.59	21
Birmingham Centre	UC	Annual mean	1993	2007	-1.4	-3	-0.5	-0.79	15
Birmingham Centre	UC	98 %ile	1993	2007	-2.9	-3.1	6	-0.71	15
Bradford Centre	UC	Annual mean	1998	2007	-1.8	-3	0.7	-0.88	10
Cardiff Centre	UC	Annual mean	1992	2007	-1.1	-4	-0.9	-0.83	16
Cardiff Centre	UC	98 %ile	1992	2007	-1.4	-8	-1	-0.72	16
Exeter Roadside	RS	98 %ile	1997	2007	2.2	-5	2.4	0.61	11
Glasgow Centre	UC	Annual mean	1997	2007	-1	-2.3	1	-0.92	10
Glasgow City Chambers	UB	Annual mean	1987	2007	-0.3	-4	-0.6	-0.64	21
Haringey Roadside	RS	Annual mean	1996	2007	-1.2	-2	2	-0.9	12
Haringey Roadside	RS	98 %ile	1996	2007	-1.8	-14.5	0	-0.59	12
Harwell	RU	Annual mean	1996	2007	-0.9	-2.6	0.6	-0.74	12
Harwell	RU	98 %ile	1996	2007	-2.1	-4.7	8.6	-0.79	12
Ladybower	RU	Annual mean	1991	2007	-0.7	-3.5	-0.7	-0.89	16
Ladybower	RU	98 %ile	1991	2007	-1.9	-3.3	0.4	-0.82	16
Leamington Spa	UB	Annual mean	1997	2007	-1	-1.3	1	-0.69	11
Leamington Spa	UB	98 %ile	1997	2007	-1.3	-3	1.7	-0.71	11
Leeds Centre	UC	Annual mean	1993	2007	-1.8	-1.9	4	-0.81	15
Leeds Centre	UC	98 %ile	1993	2007	-1.9	-2	11	-0.68	15
Leicester Centre	UC	Annual mean	1994	2007	-1	-1.5	2	-0.9	14
Leicester Centre	UC	98 %ile	1994	2007	-1.7	-2.3	2	-0.62	14
London Bexley	S	Annual mean	1994	2007	-0.7	-1.5	0	-0.74	14
London Bloomsbury	UC	Annual mean	1992	2007	-1	-1.7	0.8	-0.66	15
London Bloomsbury	UC	98 %ile	1992	2007	-3.3	-18	1	-0.69	15
London Brent	UB	Annual mean	1996	2007	-1	-3.5	-0.9	-0.85	12
London Eltham	S	Annual mean	1996	2007	-0.6	-2	2	-0.72	12
London Hackney	UC	Annual mean	1997	2007	-1.7	-4	-1	-0.75	11
London Marylebone Road	KS	Annual mean	1998	2007	3.8	-3	3	0.66	10
London Marylebone Road	KS	98 %ile	1998	2007	13.4	-7.5	10.4	0.65	10
London N. Kensington	UB	Annual mean	1996	2007	-0.8	-1	6	-0.79	12
London Southwark	UC	Annual mean	1997	2007	-1.2	-3	1	-0.79	11
London Teddington	UB	Annual mean	1997	2007	-1.1	-3.5	-0.7	-0.71	11
Lullington Heath	RU	Annual mean	1991	2007	-0.4	-1.5	0.9	-0.87	17
Lullington Heath	RU	98 %ile	1991	2007	-1.5	-4.2	-0.4	-0.88	17
Manchester South	S	Annual mean	1997	2007	-0.6	-2	1	-0.66	10
Manchester Town Hall	UB	Annual mean	1987	2007	-0.8	-3.5	0.8	-0.81	21
Manchester Town Hall	UB	98 %ile	1987	2007	-3	-5.3	5.7	-0.8	21

A4.4 (ii) Sites with Significant Trends for Nitrogen Dioxide, µg m^{-3} / yr (cont)

Nitrogen Dioxide µg m^{-3} / yr - *continued*									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Middlesbrough	UI	Annual mean	1995	2007	-0.7	-2	-0.8	-0.83	13
Middlesbrough	UI	98 %ile	1995	2007	-0.6	-3.7	-0.5	-0.67	13
Newcastle Centre	UC	Annual mean	1992	2007	-1.5	-4	3	-0.9	16
Newcastle Centre	UC	98 %ile	1992	2007	-1.8	-10.7	10	-0.73	16
Norwich Centre	UC	Annual mean	1998	2007	-0.6	-0.8	1	-0.79	10
Nottingham Centre	UC	Annual mean	1997	2007	-1.8	-3.5	-1.6	-0.92	11
Oxford Centre Roadside	RS	98 %ile	1998	2007	4.2	3.8	15	0.75	10
Port Talbot	UI	Annual mean	1997	2007	-0.7	-2	-0.7	-0.91	11
Port Talbot	UI	98 %ile	1997	2007	-1.3	-2.8	1	-0.72	11
Rochester Stoke	RU	Annual mean	1996	2007	-0.6	-1.5	-0.6	-0.94	12
Rochester Stoke	RU	98 %ile	1996	2007	-1.1	-1.1	7.7	-0.88	12
Rotherham Centre	UC	98 %ile	1997	2007	1.8	-1.7	2	0.78	10
Salford Eccles	UI	Annual mean	1997	2007	-0.7	-2	0	-0.8	11
Sheffield Centre	UC	Annual mean	1996	2007	-0.8	-4	0	-0.7	12
Sheffield Centre	UC	98 %ile	1996	2007	-3	-5.3	8	-0.71	12
Sheffield Tinsley	UI	Annual mean	1991	2007	-1.3	-1.4	7	-0.93	17
Sheffield Tinsley	UI	98 %ile	1991	2007	-2.1	-5.4	15	-0.83	17
Southampton Centre	UC	Annual mean	1994	2007	-1.4	-1.8	1	-0.89	14
Southampton Centre	UC	98 %ile	1994	2007	-2.4	-3.8	2	-0.85	14
Walsall Alumwell	UB	Annual mean	1987	2007	-0.8	-6	-0.5	-0.89	21
Walsall Alumwell	UB	98 %ile	1987	2007	-1.5	-15	-1.2	-0.73	21
West London	UB	Annual mean	1987	2007	-1	-1.5	7.5	-0.89	21
West London	UB	98 %ile	1987	2007	-3	-6.3	27	-0.84	21
Wicken Fen	RU	Annual mean	1998	2007	-0.6	-0.8	0.7	-0.82	10
Wolverhampton Centre	UC	Annual mean	1996	2007	-0.6	-4.5	-0.9	-0.82	12

A4.5(i) Sites with Significant Trends for Oxides of Nitrogen (NOx), µg m^{-3} / yr

Oxides of Nitrogen µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Barnsley Gawber	UB	Annual mean	1998	2007	-3.2	-25	-4.4	-0.82	10
Bath Roadside	RS	Annual mean	1997	2007	-8.2	-22.3	-8	-0.66	11
Belfast Centre	UC	Annual mean	1992	2007	-2.6	-6.5	-1.9	-0.75	16
Belfast Centre	UC	98 %ile	1992	2007	-9.4	-68	-6.8	-0.55	16
Billingham	UI	Annual mean	1987	2007	-1.8	-15	-1.8	-0.9	21
Billingham	UI	98 %ile	1987	2007	-5.4	-105	-6.4	-0.82	21
Birmingham Centre	UC	Annual mean	1993	2007	-3.5	-6	-2.6	-0.89	15
Birmingham Centre	UC	98 %ile	1993	2007	-11.5	-21.3	23	-0.71	15
Bradford Centre	UC	Annual mean	1998	2007	-5	-17	0	-0.85	10
Bradford Centre	UC	98 %ile	1998	2007	-12.6	-133	12.3	-0.76	10
Bristol Old Market	RS	Annual mean	1997	2007	-8.3	-111	-17.3	-0.82	10
Bristol Old Market	RS	98 %ile	1997	2007	-32.5	-315	-57.5	-0.83	10
Bury Roadside	RS	Annual mean	1997	2007	-13.7	-55	-17.6	-0.94	11
Bury Roadside	RS	98 %ile	1997	2007	-38.5	-102	-25	-0.92	11
Cardiff Centre	UC	Annual mean	1992	2007	-2.7	-19	-3.5	-0.87	16
Cardiff Centre	UC	98 %ile	1992	2007	-15	-80	-15	-0.88	16
Derry	UB	Annual mean	1998	2007	-1	-7	-1	-0.75	10
Glasgow Centre	UC	Annual mean	1997	2007	-4.5	-15	-2.8	-0.91	10
Glasgow City Chambers	UB	Annual mean	1987	2007	-5	-5.4	1.8	-0.9	21
Glasgow City Chambers	UB	98 %ile	1987	2007	-22.2	-138	43	-0.89	21
Glasgow Kerbside	KS	Annual mean	1997	2007	-2.5	-37	-2.5	-0.66	11
Glasgow Kerbside	KS	98 %ile	1997	2007	-19.8	-70.7	-8.3	-0.78	11
Haringey Roadside	RS	Annual mean	1996	2007	-7.4	-12.5	20	-0.98	12
Haringey Roadside	RS	98 %ile	1996	2007	-25.7	-48.3	251	-0.85	12
Harwell	RU	Annual mean	1996	2007	-1.4	-3.9	2.2	-0.66	12
Harwell	RU	98 %ile	1996	2007	-5.6	-18.2	23.9	-0.59	12
Ladybower	RU	Annual mean	1991	2007	-0.9	-5.1	1	-0.89	16
Ladybower	RU	98 %ile	1991	2007	-4.3	-19.3	5.9	-0.84	16
Leamington Spa	UB	Annual mean	1997	2007	-1.7	-7	0.7	-0.74	11
Leeds Centre	UC	Annual mean	1993	2007	-6.3	-7.7	6	-0.92	15
Leeds Centre	UC	98 %ile	1993	2007	-16.3	-31.4	36	-0.8	15
Leicester Centre	UC	Annual mean	1994	2007	-2.3	-3.8	1	-0.91	14
Leicester Centre	UC	98 %ile	1994	2007	-6.9	-20.1	8.7	-0.64	14
London A3 Roadside	RS	Annual mean	1997	2007	-16.3	-34	-17.7	-0.95	11
London A3 Roadside	RS	98 %ile	1997	2007	-35.7	-98.7	-19	-0.93	11
London Bexley	S	Annual mean	1994	2007	-2.7	-9	-0.3	-0.8	14
London Bloomsbury	UC	Annual mean	1992	2007	-4.3	-12	2.4	-0.8	16
London Bloomsbury	UC	98 %ile	1992	2007	-15.3	-88	10.2	-0.79	16
London Brent	UB	Annual mean	1996	2007	-2.9	-13	-3.4	-0.9	12
London Brent	UB	98 %ile	1996	2007	-14.5	-69	82	-0.69	12
London Cromwell Road 2	RS	Annual mean	1998	2007	-8.6	-11	21	-0.92	10
London Cromwell Road 2	RS	98 %ile	1998	2007	-16	-40.8	5	-0.85	10

A4.5 (ii) Sites with Significant Trends for Oxides of Nitrogen (NOx), µg m^{-3} / yr (cont)

Oxides of Nitrogen µg m^{-3} / yr - *continued*									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
London Eltham	S	Annual mean	1996	2007	-2.5	-8.5	6	-0.83	12
London Eltham	S	98 %ile	1996	2007	-12.9	-46	85	-0.69	12
London Hackney	UC	Annual mean	1997	2007	-5.7	-38	-7.9	-0.98	11
London Hackney	UC	98 %ile	1997	2007	-25.5	-308	-44.1	-0.9	11
London Hillingdon	S	Annual mean	1997	2007	-7	-28	-10.4	-0.95	10
London Hillingdon	S	98 %ile	1997	2007	-23	-187	-40.3	-0.73	10
London Marylebone Road	KS	Annual mean	1998	2007	-12	-18.5	20.5	-0.85	10
London Marylebone Road	KS	98 %ile	1998	2007	-18	-49.5	54	-0.76	10
London N. Kensington	UB	Annual mean	1996	2007	-2.4	-4.5	20	-0.9	12
London N. Kensington	UB	98 %ile	1996	2007	-8.3	-58	211	-0.59	12
London Southwark	UC	Annual mean	1997	2007	-5.5	-11	-3	-0.94	11
London Southwark	UC	98 %ile	1997	2007	-17.8	-216	-32	-0.84	11
London Teddington	UB	Annual mean	1997	2007	-1.2	-19.5	-2.2	-0.68	11
London Wandsworth	UC	Annual mean	1996	2007	-5.2	-18.5	-5	-0.94	12
London Wandsworth	UC	98 %ile	1996	2007	-22.9	-67.5	132	-0.86	12
Lullington Heath	RU	Annual mean	1991	2007	-0.4	-1	0.8	-0.88	17
Lullington Heath	RU	98 %ile	1991	2007	-2.6	-4.9	1.8	-0.82	17
Manchester Piccadilly	UC	Annual mean	1996	2007	-1.3	-13	-1.2	-0.68	11
Manchester Town Hall	UB	Annual mean	1987	2007	-4.5	-4.8	2.6	-0.95	21
Manchester Town Hall	UB	98 %ile	1987	2007	-21	-57.3	62	-0.89	21
Middlesbrough	UI	Annual mean	1995	2007	-1.3	-4	0.5	-0.8	13
Middlesbrough	UI	98 %ile	1995	2007	-1.4	-19.6	10.5	-0.59	13
Newcastle Centre	UC	Annual mean	1992	2007	-4.9	-12.7	15	-0.95	16
Newcastle Centre	UC	98 %ile	1992	2007	-22.3	-59.3	76	-0.88	16
Norwich Centre	UC	Annual mean	1998	2007	-0.6	-2	2	-0.7	10
Nottingham Centre	UC	Annual mean	1997	2007	-3.5	-7.7	-2	-0.91	11
Port Talbot	UI	Annual mean	1997	2007	-1.8	-4	-1.9	-0.95	11
Port Talbot	UI	98 %ile	1997	2007	-7.7	-31	-8.1	-0.81	11
Rochester Stoke	RU	Annual mean	1996	2007	-0.5	-2.6	0.2	-0.84	12
Rochester Stoke	RU	98 %ile	1996	2007	-5.1	-10.8	24.9	-0.62	12
Rotherham Centre	UC	Annual mean	1997	2007	-2.6	-8	-2	-0.76	10
Salford Eccles	UI	Annual mean	1997	2007	-3.3	-8.7	-1.8	-0.87	11
Salford Eccles	UI	98 %ile	1997	2007	-13.2	-50	4.8	-0.69	11
Sheffield Centre	UC	Annual mean	1996	2007	-4.5	-13	7	-0.82	12
Sheffield Centre	UC	98 %ile	1996	2007	-22.3	-40.7	67	-0.71	12
Sheffield Tinsley	UI	Annual mean	1991	2007	-6.3	-11	22	-0.98	17
Sheffield Tinsley	UI	98 %ile	1991	2007	-18.8	-101	214	-0.9	17
Southampton Centre	UC	Annual mean	1994	2007	-3.9	-6.8	-1	-0.94	14
Southampton Centre	UC	98 %ile	1994	2007	-12	-48	3.7	-0.87	14
Thurrock	UB	Annual mean	1997	2007	-1.3	-5	1	-0.81	11
Tower Hamlets RS	RS	Annual mean	1996	2007	-14.9	-32.5	-12.6	-0.95	12
Tower Hamlets RS	RS	98 %ile	1996	2007	-45	-84	100	-0.85	12

A4.6 Sites with Significant Trends for PM_{10} Particulate Matter, µg m^{-3} / yr

PM_{10} Particulate Matter µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Belfast Centre	UC	Annual mean	1992	2007	-1.3	-1.3	6	-0.98	16
Belfast Centre	UC	98 %ile	1992	2007	-5	-19.5	-6.1	-0.91	16
Birmingham Centre	UC	Annual mean	1992	2007	-0.8	-2	-0.5	-0.75	16
Birmingham Centre	UC	98 %ile	1992	2007	-2.8	-11	-2.3	-0.7	16
Bury Roadside	RS	Annual mean	1997	2007	-0.7	-5	-0.7	-0.62	11
Cardiff Centre	UC	Annual mean	1993	2007	-0.9	-4	5	-0.75	15
Cardiff Centre	UC	98 %ile	1993	2007	-3.4	-14	83	-0.7	15
Derry	UB	98 %ile	1997	2007	-3.7	-5	17	-0.85	11
Glasgow Centre	UC	Annual mean	1997	2007	-1	-2	0.3	-0.77	11
Glasgow Centre	UC	98 %ile	1997	2007	-2.2	-4.5	11.7	-0.75	11
Harwell	RU	Annual mean	1998	2007	0.2	-1	0.4	0.68	10
Leeds Centre	UC	Annual mean	1993	2007	-1.1	-2	0.3	-0.7	15
Leeds Centre	UC	98 %ile	1993	2007	-4.1	-6.9	9	-0.68	15
Leicester Centre	UC	Annual mean	1994	2007	-0.4	-2	0	-0.59	14
Leicester Centre	UC	98 %ile	1994	2007	-2.3	-7	5.5	-0.59	14
London Bexley	S	Annual mean	1994	2007	-0.7	-1.8	0	-0.59	14
London Bexley	S	98 %ile	1994	2007	-2.6	-5.5	5.5	-0.72	14
London Bloomsbury	UC	Annual mean	1992	2007	-1	-2	0	-0.75	15
London Bloomsbury	UC	98 %ile	1992	2007	-4.1	-9.5	0.3	-0.74	15
London Brent	UB	Annual mean	1996	2007	-0.3	-1.5	2	-0.6	12
London Brent	UB	98 %ile	1996	2007	-1	-2	16	-0.75	12
London N. Kensington	UB	Annual mean	1996	2007	-0.3	-2	2	-0.66	12
Manchester Piccadilly	UC	Annual mean	1996	2007	-0.4	-3	1	-0.69	12
Newcastle Centre	UC	Annual mean	1992	2007	-1.5	-2.7	1	-0.87	16
Newcastle Centre	UC	98 %ile	1992	2007	-4.8	-8.3	1	-0.76	16
Nottingham Centre	UC	Annual mean	1997	2007	-0.7	-2.5	-0.7	-0.79	11
Port Talbot	UI	Annual mean	1997	2007	-0.5	-1.4	0	-0.63	11
Salford Eccles	UI	Annual mean	1997	2007	-0.5	-3	-0.7	-0.62	11
Sheffield Centre	UC	Annual mean	1996	2007	-0.8	-3.3	-1.1	-0.78	12
Southampton Centre	UC	Annual mean	1994	2007	-0.3	-1.2	0.3	-0.73	14
Southampton Centre	UC	98 %ile	1994	2007	-1.4	-5	3.5	-0.71	14
Thurrock	UB	98 %ile	1997	2007	-1.2	-17	0	-0.65	11
Wolverhampton Centre	UC	Annual mean	1996	2007	-0.7	-6	-1.2	-0.77	12
Wolverhampton Centre	UC	98 %ile	1996	2007	-1.8	-26	-4.9	-0.72	12

A4.7 Sites with Significant Trends for $PM_{2.5}$ Particulate Matter, µgm^{-3} / yr

$PM_{2.5}$ Particulate Matter µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Harwell	RU	Annual mean	1998	2007	0.2	0	0.4	0.83	10

A 4.8(i) Sites with Significant Trends for Sulphur Dioxide, µg m^{-3} / yr

Sulphur Dioxide µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Barnsley 12	UB	Annual mean	1994	2007	-1.4	-1.7	5	-0.89	14
Barnsley 12	UB	98 %ile	1994	2007	-6.7	-9	8	-0.85	14
Belfast Centre	UC	Annual mean	1992	2007	-3.4	-3.7	6	-0.97	16
Belfast Centre	UC	98 %ile	1992	2007	-17.1	-16.7	16	-0.99	16
Belfast East	UB	Annual mean	1990	2007	-4.9	-5.2	6	-0.99	18
Belfast East	UB	98 %ile	1990	2007	-25.4	-32.8	88	-0.97	18
Birmingham Centre	UC	Annual mean	1992	2007	-1.5	-3.5	-1.7	-0.99	16
Birmingham Centre	UC	98 %ile	1992	2007	-6.8	-17.5	-8	-0.99	16
Bury Roadside	RS	Annual mean	1997	2007	-2.5	-8.5	-3.7	-0.98	11
Bury Roadside	RS	98 %ile	1997	2007	-8	-24	16	-0.98	11
Cardiff Centre	UC	Annual mean	1992	2007	-1.1	-3	-1.1	-0.97	16
Cardiff Centre	UC	98 %ile	1992	2007	-4.2	-11.5	-4.2	-0.96	16
Derry	UB	98 %ile	1998	2007	-5.4	-34	-6.8	-0.93	10
Exeter Roadside	RS	Annual mean	1998	2007	-0.4	-1	-0.3	-0.86	10
Exeter Roadside	RS	98 %ile	1998	2007	-1.6	-5	-1.6	-0.85	10
Glasgow Centre	UC	Annual mean	1997	2007	-1.3	-1.1	0.5	-0.82	11
Glasgow Centre	UC	98 %ile	1997	2007	-3	-13	-2.9	-0.88	11
Harwell	RU	98 %ile	1996	2007	-1.3	-14.9	-2.5	-0.76	12
Ladybower	RU	Annual mean	1989	2007	-1.3	-3.8	2.3	-0.93	19
Ladybower	RU	98 %ile	1989	2007	-6	-26.6	14.9	-0.95	19
Leamington Spa	UB	Annual mean	1997	2007	-0.5	-0.7	0	-0.87	11
Leamington Spa	UB	98 %ile	1997	2007	-2.2	-4	5	-0.93	11
Leeds Centre	UC	Annual mean	1993	2007	-1.5	-3.7	-1.8	-0.98	15
Leeds Centre	UC	98 %ile	1993	2007	-7	-18.7	2	-0.95	15
Leicester Centre	UC	Annual mean	1994	2007	-1	-3.5	-1.3	-0.98	14
Leicester Centre	UC	98 %ile	1994	2007	-4.6	-10.5	-2	-0.97	14
London Bexley	S	Annual mean	1994	2007	-1	-2.8	1	-0.89	14
London Bexley	S	98 %ile	1994	2007	-7.6	-14.5	13	-0.87	14
London Bloomsbury	UC	Annual mean	1992	2007	-1.9	-2.3	1	-0.97	16
London Bloomsbury	UC	98 %ile	1992	2007	-10	-10.6	0	-0.98	16
London Brent	UB	Annual mean	1996	2007	-0.6	-4	-1	-0.78	12
London Brent	UB	98 %ile	1996	2007	-2.9	-11	-4	-0.91	12
London Cromwell Road 2	RS	Annual mean	1998	2007	-0.6	-3	-1	-0.92	10
London Cromwell Road 2	RS	98 %ile	1998	2007	-1.6	-8	-2.6	-0.9	10
London Eltham	S	Annual mean	1996	2007	-0.3	-3	-0.8	-0.84	12
London Eltham	S	98 %ile	1996	2007	-2.7	-18.5	-5	-0.83	12
London Hillingdon	S	Annual mean	1997	2007	-1.2	-1.5	-0.8	-0.97	11
London Hillingdon	S	98 %ile	1997	2007	-3	-9	-3	-0.9	11
London Marylebone Road	KS	Annual mean	1998	2007	-1	-5	-1.2	-0.92	10
London Marylebone Road	KS	98 %ile	1998	2007	-2	-14	-3.2	-0.95	10
London N. Kensington	UB	Annual mean	1996	2007	-0.6	-2	0	-0.92	12
London N. Kensington	UB	98 %ile	1996	2007	-2.9	-8.7	8	-0.92	12

A4.8 (ii)Sites with Significant Trends for Sulphur Dioxide, µg m^{-3} / yr (cont)

Sulphur Dioxide µg m^{-3} / yr - *continued*									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
London Southwark	UC	Annual mean	1997	2007	-0.5	-3	-0.5	-0.79	11
London Southwark	UC	98 %ile	1997	2007	-1.8	-18	-3.5	-0.91	11
London Teddington	UB	Annual mean	1997	2007	-0.5	-2.4	-0.7	-0.88	11
London Teddington	UB	98 %ile	1997	2007	-2.2	-16	-4	-0.81	11
Lullington Heath	RU	Annual mean	1988	2007	-0.3	-1.4	-0.5	-0.88	17
Lullington Heath	RU	98 %ile	1988	2007	-1.8	-11.8	-3.6	-0.91	17
Manchester Piccadilly	UC	Annual mean	1996	2007	-0.9	-3	-0.5	-0.73	11
Manchester Piccadilly	UC	98 %ile	1996	2007	-5.7	-19	-7	-0.86	11
Middlesbrough	UI	Annual mean	1995	2007	-1	-2	-0.9	-0.94	13
Middlesbrough	UI	98 %ile	1995	2007	-4.4	-8.7	-2	-0.93	13
Newcastle Centre	UC	Annual mean	1992	2007	-1.4	-1.3	4	-0.94	16
Newcastle Centre	UC	98 %ile	1992	2007	-7.8	-8.3	8	-0.98	16
Norwich Centre	UC	98 %ile	1998	2007	-3.6	-3.6	4	-0.83	10
Nottingham Centre	UC	Annual mean	1997	2007	-0.5	-2	0.5	-0.63	11
Nottingham Centre	UC	98 %ile	1997	2007	-6.2	-12	-4.3	-0.94	11
Oxford Centre Roadside	RS	Annual mean	1996	2007	-0.4	-7	-2.2	-0.71	10
Oxford Centre Roadside	RS	98 %ile	1996	2007	-1.6	-13.3	-4.6	-0.86	10
Plymouth Centre	UC	Annual mean	1998	2007	-0.6	-0.5	0.5	-0.82	10
Redcar	S	Annual mean	1997	2007	-0.8	-1	3	-0.95	11
Redcar	S	98 %ile	1997	2007	-4.3	-6	46	-0.97	11
Rochester Stoke	RU	Annual mean	1996	2007	-0.4	-2.5	-0.6	-0.92	12
Rochester Stoke	RU	98 %ile	1996	2007	-2.9	-18.6	-4.8	-0.97	12
Sheffield Centre	UC	Annual mean	1996	2007	-0.8	-5	-1.5	-0.85	12
Sheffield Centre	UC	98 %ile	1996	2007	-6.9	-24	-7.7	-0.95	12
Southampton Centre	UC	Annual mean	1994	2007	-0.6	-1.3	0	-0.92	14
Southampton Centre	UC	98 %ile	1994	2007	-1.6	-6.3	-2.4	-0.86	14
Stoke-on-Trent Centre	UC	Annual mean	1997	2007	-1.3	-1.3	2	-0.7	11
Stoke-on-Trent Centre	UC	98 %ile	1997	2007	-5	-12	2	-0.95	11
Sunderland	UB	Annual mean	1993	2007	-0.9	-5	-0.9	-0.93	14
Sunderland	UB	98 %ile	1993	2007	-5	-26	-5.7	-0.97	14
Wicken Fen	RU	98 %ile	1998	2007	-0.6	-5.6	-1.3	-0.73	10
Wolverhampton Centre	UC	Annual mean	1996	2007	-1.3	-4	-0.4	-0.85	12
Wolverhampton Centre	UC	98 %ile	1996	2007	-5.8	-13	-1	-0.97	12

A4.9 Sites with Significant Trends for Ozone, µg m^{-3} / yr

Ozone µg m^{-3} / yr									
Site	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
Aston Hill	RU	Annual mean	1987	2007	0.5	0.7	12	0.54	21
Belfast Centre	UC	Annual mean	1992	2007	0.5	-3	1.3	0.69	16
Belfast Centre	UC	98 %ile	1992	2007	0.5	-10	1.7	0.59	16
Birmingham Centre	UC	Annual mean	1992	2007	0.9	-1	1.5	0.87	16
Birmingham Centre	UC	98 %ile	1992	2007	0.4	-6	3.5	0.52	16
Bolton	UB	Annual mean	1997	2007	1	0.9	5	0.82	11
Bottesford	S	Annual mean	1981	2007	0.7	-0.7	7	0.59	27
Bradford Centre	UC	Annual mean	1998	2007	1.2	1.2	6	0.88	10
Bradford Centre	UC	98 %ile	1998	2007	1.6	1.7	12	0.78	10
Bury Roadside	RS	Annual mean	1997	2007	0.7	1	4	0.95	11
Bury Roadside	RS	98 %ile	1997	2007	1	1.4	8	0.68	11
Bush Estate	RU	Annual mean	1986	2007	0.3	-7	1	0.66	22
Cardiff Centre	UC	Annual mean	1992	2007	0.9	0.6	2.7	0.86	16
Glasgow Centre	UC	Annual mean	1997	2007	0.5	0.8	4	0.85	11
Glazebury	S	Annual mean	1988	2007	0.5	-5	0.4	0.59	20
Great Dun Fell	RE	98 %ile	1987	2007	-1	-12	1.3	-0.57	17
High Muffles	RU	98 %ile	1988	2007	-0.9	-0.7	22	-0.46	20
Ladybower	RU	98 %ile	1989	2007	-1.4	-8	2	-0.51	19
Leeds Centre	UC	Annual mean	1993	2007	1	0.3	4	0.84	15
Leeds Centre	UC	98 %ile	1993	2007	1	0.8	7	0.65	15
Leicester Centre	UC	Annual mean	1994	2007	0.4	-0.5	1.8	0.76	14
London Bexley	S	Annual mean	1995	2007	0.6	-2	1.3	0.85	13
London Bloomsbury	UC	Annual mean	1992	2007	0.6	-1	1	0.85	16
London Brent	UB	Annual mean	1996	2007	0.6	-5	1	0.67	12
London Eltham	S	Annual mean	1996	2007	0.4	-3	1	0.71	12
London Hackney	UC	Annual mean	1997	2007	1.4	0	2	0.79	10
London Haringey	UC	Annual mean	1996	2007	0.8	-1	2	0.88	12
London Hillingdon	S	Annual mean	1997	2007	0.7	0.7	3	0.86	11
London Marylebone Road	KS	Annual mean	1998	2007	0.6	0.5	1	0.96	10
London Marylebone Road	KS	98 %ile	1998	2007	1.2	1.7	10	0.77	10
London N. Kensington	UB	Annual mean	1996	2007	0.7	-4	1.7	0.85	12
London Wandsworth	UC	Annual mean	1996	2007	0.9	-2	1.3	0.84	12
Lough Navar	RE	98 %ile	1987	2007	-0.5	-1	4	-0.6	21
Mace Head	RE	Annual mean	1987	2007	0.4	1	14	0.69	21
Middlesbrough	UI	Annual mean	1996	2007	0.7	-4	2	0.61	12
Newcastle Centre	UC	Annual mean	1992	2007	0.9	0.8	2	0.88	14
Newcastle Centre	UC	98 %ile	1992	2007	0.9	-4	2.3	0.78	14
Nottingham Centre	UC	Annual mean	1997	2007	1	0.5	3.5	0.83	11
Port Talbot	UI	Annual mean	1997	2007	0.7	0.9	4	0.69	11
Salford Eccles	UI	Annual mean	1997	2007	0.8	0.3	3	0.77	11
Stoke-on-Trent Centre	UC	Annual mean	1997	2007	0.8	-3	1.2	0.7	11
Strath Vaich	RE	Annual mean	1987	2007	0.4	0.2	6	0.5	21
Wicken Fen	RU	Annual mean	1998	2007	2	0.5	4	0.91	10
Wolverhampton Centre	UC	Annual mean	1996	2007	1	-2	2	0.91	12

Appendix A5- Listing of current UK, European and WHO Air Quality Criteria

Here we summarise the UK Air Quality Strategy Standards and Objectives, together with corresponding European Community Directive Limit and Target Values and World Health Organisation advisory Guidelines for the major pollutants.

Benzene

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2] All UK England[3] & Wales[4] only: Scotland[5] & Northern Ireland [6]	Objective for Dec. 31st 2003	Running annual mean	16.25 (5)
	Objective for Dec. 31st 2010	Annual mean	5 (1.54)
	Objective for Dec. 31st 2010	Running annual mean	3.25 (1.0)
European Community 2nd Daughter Directive[7] *and* **Directive on Ambient Air Quality and CleanerAir for Europe[,8]**	Limit Value. To be achieved by Jan 1st 2010	Annual calendar year mean	5 (1.5)

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppb benzene = 3.25 μg m^{-3} at 20^{o}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)
(4) Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63))
(5) Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182)
(6) Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)
(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).

1,3-Butadiene

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2,3,4,5,6] All UK	Objective for Dec. 31st 2003	Running annual mean	2.25 (1)

(1) Conversion between μg m^{-3} and ppb is 1 ppb 1,3-butadiene = 2.25 μg m^{-3} at 20^{o}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)
(4) Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63))
(5) Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182)
(6) Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)

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)
(4) Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)
(5) Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63))
(6) Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182)
(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).

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)	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.
Set in regulations(3) for all UK:	Objective for Dec. 31st 2005, for protection of human health		Annual mean	40 (21)
Not intended to be set in regulations:	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)	Health Guideline		1-hour mean	200
(Non-Mandatory Guidelines)	Health Guideline		Annual mean	40

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb NO_2 = 1.91 $\mu g\ m^{-3}$ at 20ºC 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.

Polycyclic Aromatic Hydrocarbons (PAH)

Guideline Set By	Description	Criteria Based On	Value / ngm^{-3}
The Air Quality Strategy[(1)] England, Wales, Scotland and Northern Ireland. *Not set in regulations.*	Objective for Dec. 31st 2010	Annual mean *(using B(a)P as an indicator)*	0.25
European Community 4th Daughter Directive	Target value	Total content in the PM_{10} fraction averaged over a calendar year.	1.0
World Health Organisation[(3)] *(Non-Mandatory Guidelines)*	- (No guideline, as there is no "safe" threshold for this pollutant)	Concentration of BaP producing excess lifetime cancer risk of 1/10,000	1.2

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(2) 4th Daughter Directive (Directive 2004/107/EC Of The European Parliament And Of The Council, of 15 December 2004)
(3) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Sulphur Dioxide

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

(1) Conversions between μg m^{-3} and ppb are as used by the EC, i.e. 1ppb SO_2 = 2.66 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 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).

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 $\mu g\ m^{-3}$ 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 $\mu g\ m^{-3}$ 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 $\mu g\ m^{-3}$ 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 $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb O_3 = 2.00 $\mu g\ m^{-3}$ 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) 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 $\mu g\ m^{-3}$ (=40ppb) and 80 $\mu g\ m^{-3}$, 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).

Lead (Pb)

Guideline Set By	Description	Criteria Based On	Value / μgm^{-3}
The Air Quality Strategy[1] **Set in regulations for all UK.**	Objective for Dec. 31st 2004	Annual mean	0.5 (= 500 ng m^{-3})
	Objective for Dec. 31st 2008	Annual mean	0.25 (= 250 ng m^{-3})
1st Daughter Directive (1999/30/EEC)[2] and Directive on Ambient Air Quality [3]	Limit Value to be achieved by Jan 1st 2005	Annual mean	0.5 (= 500 ng m^{-3})
	Limit Value to be achieved by Jan 1st 2010 in the immediate vicinity of industrial sources	Annual mean	0.5 (= 500 ng m^{-3})
World Health Organisation[4] *(Non-Mandatory Guidelines)*	Health-Based Guideline	Annual Mean	0.5 (= 500 ng m^{-3})

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.
(2) Council Directive 1999/30/EC
(3) Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 On Ambient Air Quality And Cleaner Air For Europe, which supersedes (2).
(4) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Metallic Elements Arsenic (As), Cadmium (Cd), Mercury (Hg) and Nickel (Ni), and hydrocarbon Benzo (a) Pyrene

Guideline Set By	Description	Criteria Based On	Value / ng m^{-3}
4th Daughter Directive (205/107/EC)	Target Value for As	Calendar year mean	6
	Target Value for Cd	Calendar year mean	5
	Target Value for Hg	Calendar year mean	Not set
	Target Value for Ni	Calendar year mean	20
	Target Value for B(a)P	Calendar year mean	1

Target values to be non-mandatory.

Description of UK Government Pollution Indices

Old "Band"	New Index	Health Descriptor
LOW	1	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.
	2	
	3	
MODERATE	4	Mild effects unlikely to require action may be noticed amongst sensitive individuals.
	5	
	6	
HIGH	7	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their "reliever" inhaler is likely to reverse the effects on the lung.
	8	
	9	
VERY HIGH	10	The effects on sensitive individuals described for "High" levels of pollution may worsen.

Air Quality Regulations: Statutory Instruments

Date	Country	S.I. No.	Purpose
30/03/2000	England	SI 2000 No. 928	Inclusion of original Air Quality Strategy Objectives into regulations in England
19/07/2000	Wales	SI 2000 No. 1940 (W138)	Inclusion of original Air Quality Strategy Objectives into regulations in Wales
31/03/2000	Scotland	SSI 2000 No. 97	Inclusion of original Air Quality Strategy Objectives into regulations in Scotland
09/06/2001	Scotland	SSI 2001 No. 224	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for Scotland.
25/06/2001	UK	SI 2001 No. 2315	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for England.
17/07/2001	Wales	SI 2001 No. 2683 (W224)	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for Wales.
08/03/2002	Northern Ireland	Statutory Rule 2002 (94)	Implementation of 1st Daughter Directive in NI.
11/06/2002	Scotland	SSI 2002 297	Amendment of Air Quality Regulations to include more stringent objectives for PM_{10}, CO and benzene, specifically for Scotland.
21/11/2002	Northern Ireland	Statutory Rule 2002 (357)	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for Northern Ireland
11/12/2002	England	SI 2002 No 3043	Amendment of Air Quality Regulations to include more stringent objectives for CO and benzene, in England.
16/12/2002	England	SI 2002 No 3117	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for England
17/12/2002	Scotland	SSI 2002 556	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for Scotland
17/12/2002	Wales	Welsh SI 2002 3182 (W298)	Amendment of Air Quality Regulations to include more stringent objectives for CO and benzene, in Wales
17/12/2002	Wales	Welsh SI 2002 3183 (W299)	Transposition of 1st and 2nd Daughter Directives into Air Quality Limit Values Regulations for Wales.

Date	Country	S.I. No.	Purpose
01/09/2003	Northern Ireland	Statutory Rule 2003 No. 342	Air Quality Regulations (Northern Ireland) 2003. Set out LA obligations w.r.t. local air quality management.
09/09/2003	UK	SI 2003 No. 2121	The Air Quality Limit Values Regulations 2003. Transpose 1st, 2nd and 3rd Daughter Directives into Air Quality Limit Values Regulations for England: repeal regulations relating to previous directives on sulphur dioxide and suspended particulates, and NO_2.
09/09/2003	Northern Ireland	Statutory Rule 2003 No. 240	The Air Quality (Ozone) Regulations (Northern Ireland) 2003. Transpose 3rd Daughter Directive.
01/01/2004	Northern Ireland	Statutory Rule 2003 No. 543	Air Quality (Amendment) Regulations (Northern Ireland) 2003. Correct a drafting error in SR 2003 No. 342.
03/12/2004	England	SI 2004 No. 2888	The Air Quality Limit Values (Amendment) (England) Regulations 2004. Amendments relating to implementation of EC Directives.
07/01/2005	Northern Ireland	Statutory Rule 2004 No. 514	The Air Quality Limit Values (Amendment) Regulations (Northern Ireland) 2004. Amendments relating to implementation of EC Directives.
12/04/2005	Wales	Welsh SI 2005 No. 1157 (W74)	The Air Quality Limit Values (Wales) (Amendment) Regulations 2005 Amends definition of the "public" and makes provision for the use of demonstrated equivalent methods of PM_{10} monitoring.
15/02/2007	England	SI 2007 No. 64	The Air Quality Standards Regulations 2007. Transpose 1st, 2nd, 3rd & 4th Daughter Directives and introduce requirement to monitor $PM_{2.5}$, ozone precursor substances and certain polycyclic aromatic hydrocarbons.
15/03/2007	Wales	Welsh SI 2007 717 (W63)	Air Quality Standards (Wales) Regulations 2007. Transpose 1st, 2nd, 3rd & 4th Daughter Directives and introduce requirement to monitor $PM_{2.5}$, ozone precursor substances and certain polycyclic aromatic hydrocarbons.
29/03/2007	Scotland	SSI 2007 No. 182	the Air Quality Standards (Scotland) Regulations 2007 Transpose 1st, 2nd, 3rd & 4th Daughter Directives and introduce requirement to monitor $PM_{2.5}$, ozone precursor substances and certain polycyclic aromatic hydrocarbons.
28/05/2007	Northern Ireland	Statutory Rule 2007 No. 265	The Air Quality Standards Regulations (Northern Ireland) 2007. Transpose 1st, 2nd, 3rd & 4th Daughter Directives and introduce requirement to monitor $PM_{2.5}$, ozone precursor substances and certain polycyclic aromatic hydrocarbons

Appendix A6- Calculation methods, statistical methods and measurement uncertainty

Here we provide background information on measurement accuracy, trend calculation and the mathematical methods used to calculate measurement statistics.

A 6.1 Statement on accuracy of air quality measurements

The EC Air Quality Directives now specify a required level of data accuracy (uncertainty). The accuracy requirements for the various parameters are summarised in Table 1 below. Please note that there is also a requirement for 90% data capture in each year.

A common approach to determining measurement uncertainty for all pollutants is provided by a CEN (The European Centre for Standardisation) report entitled: 'Air quality – approach to uncertainty estimation for ambient air reference methods'[R3]. CEN has produced a series of standards setting out how National Networks in Member States should operate analysers in order to meet the required uncertainty of ±15% for NO_2, SO_2, CO and O_3 and ±25% for benzene and PM_{10} particulate matter (at the 95% confidence level).

The standards include a set of performance characteristics against which analysers need to be assessed for official approval, as well as activities required for ongoing Quality Assurance and Control (QA/QC). Four analyser types have currently been submitted and successfully passed the type-approval tests in the UK. These are API (models E/A), Horiba 370, Monitor Europe / Monitor Labs and Thermo Fisher. It is estimated that these type approvals cover approximately 50% of the analysers currently in use in the UK Automatic and Rural Monitoring Network (AURN).

The situation with particulate measurements is more complicated. This is because of the wide scale use of analysers that do not conform to the EU Reference Method for PM_{10} monitoring. Much work is being undertaken- both within Member States and at the EU level- to assess the performance of the different analysers and techniques used for measurement of PM_{10}.

Measurement uncertainty objectives given in EU Air Quality Directives

Pollutant	**Uncertainty for Continuous Measurement (listed as accuracy in the Directive)**
NO_2, NO_X	15%
SO_2	15%
PM_{10} Particulate Matter	25%
CO	15%
Benzene	25%
O_3	15%

Note: The percentages given in the table are for individual measurements averaged over the period considered by the limit or target value, at concentrations close to the limit or target value, for a 95% confidence interval.

A 6.2 Calculation methods

A 6.2.1 Introduction

The intention of this section is to provide all the information required to reproduce the statistics contained in this report from the original hourly dataset. This dataset is now available from the UK National Air Quality Archive on the World Wide Web- www.airquality.co.uk.

The definition of standard statistical functions, such as means, percentiles, regressions and standard errors can be obtained from a number of statistical references. A description of log-normal distributions and related statistics has also been provided elsewhere[R3].

Various air quality guidelines and statistics are defined in the documentation published by the UK Government [R4], the European Community[R1,5], the World Health Organisation[R6-R9] and The Expert Panel on Air Quality Standards (EPAQS) [R10-18]. 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 6.2.2 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}, 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 the European Council SO_2 Directive (repealed at end of 2005)[R19] .

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], the World Health Organisation[R7-10].

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 $\mu g\ m^{-3}$ is expressed as NO_2, i.e. (NO ppb + NO_2 ppb)* 1.91 = NO_x $\mu g\ m^{-3}$
- 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 Standard 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.

Exceedences

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 EC 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 table in Appendix 4.

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 EU First Air Quality Daughter Directive (1999/30/EC) specifies that measurements of PM_{10} should be carried out using the reference method, as defined in European Standard EN12341. 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 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 [R28] (APEG, 1999). 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 been applied to all TEOM PM_{10} data reported here, as recommended by the EC Working Group on Particulate Matter (2001).

However, UK equivalence trials for particulate instruments (reported in June 2006) 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 EC 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 μgm^{-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 7.3 in this report.

References

Section 2- UK and International Policy for tackling Pollution

B1 The Sixth Environment Action Programme of the European Community
http://europa.eu.int/comm/environment/newprg/index.htm

B2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Department of the Environment, Transport and the Regions in partnership with the Scottish Office, The National Assembly for Wales and the Department of the Environment in Northern Ireland. January 2000. ISBN 0-10-145482-1.
http://www.defra.gov.uk/environment/airquality/strategy/index.htm

B3 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum 6 February 2003.
http://www.defra.gov.uk/environment/airquality/strategy/addendum/index.htm

B4 The UK Air Quality Strategy, 2007
http://www.defra.gov.uk/environment/airquality/strategy/pdf/air-qualitystrategy-vol1.pdf
and
http://www.defra.gov.uk/environment/airquality/strategy/pdf/air-qualitystrategy-vol2.pdf

B5 The Air Quality Expert Group report on ‘ Air Quality and Climate Change: A UK Perspective’ can be found at
www.defra.gov.uk/environment/airquality/publications/airqual-climatechange/

B6 Council Directive 2008/50/EC of the European Parliament and of the Council of 21st May 2008, on ambient air quality and cleaner air for Europe. Available from
http://ec.europa.eu/environment/air/quality/legislation/directive.htm .

B7 Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management [Official Journal L 296,of 21.11.1996].
http://europa.eu.int/scadplus/leg/en/lvb/l28031a.htm

B8 Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.

B9 Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air.

B10 Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air

B11 Council Decision 97/101/EC of 27 January 1997 establishing a reciprocal exchange of information and data collected from networks and individual stations measuring ambient air pollution within the Member States [Official Journal L 296, 21.11.1996].
http://europa.eu.int/scadplus/leg/en/lvb/l28031b.htm

B12 Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air (4th daughter directive)

B13 The UN Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters Åarhus, Denmark, on 25 June 1998
http://europa.eu.int/comm/environment/aarhus/

B14 The INSPIRE Directive. Directive 2007/02/EC dated 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE
http://inspire.jrc.ec.europa.eu/directive/l_10820070425en00010014.pdf

B15 The Thematic Strategy on Air Pollution
http://ec.europa.eu/environment/archives/air/cafe/pdf/strat_com_en.pdf

B16 The Clean Air for Europe (CAFE) Programme: Towards a Thematic Strategy for Air Quality http://www.defra.gov.uk/environment/airquality/strategy/index.htm

B17 The National Emissions Ceilings Directive
http://www.apis.ac.uk/overview/regulations/overview_NECD.htm

B18 The UN ECE LRTAP (Long Range Transport of Air Pollution) Gothenburg Protocol on Protocol to Abate Acidification, Eutrophication and Ground-level Ozone
http://www.unece.org/env/lrtap/multi_h1.htm

B19 The Air Quality (England) Regulations 2000. Statutory Instruments 2000 N^o 928.
http://www.defra.gov.uk/environment/airquality/airqual/index.htm

B20 The Air Quality (England) (Amendment) Regulations 2002 Statutory Instrument 2002 No. 3043 http://www.hmso.gov.uk/si/si2002/20023043.htm

B21 The Environment (Northern Ireland) Order 2002 Statutory Instrument 2002 No. 3153 (N.I. 7)
http://www.northernireland-legislation.hmso.gov.uk/si/si2002/20023153.htm

B22 Air Quality Regulations (Northern Ireland) 2003 Statutory Rule 2003 No. 342
http://www.northernireland-legislation.hmso.gov.uk/sr/sr2003/20030342.htm

B23 The Air Quality (Scotland) Amendment Regulations 2002. Statutory Instrument 2002, No 297

Section 3- Where and how Air Pollution is measured

C1 Agenda 21, the Rio Declaration on Environment and Development, United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, 3 to 14 June 1992.
http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm

C2 Johannesburg Summit 2002 – the World Summit on Sustainable Development
http://www.johannesburgsummit.org/

C3 Clean Air Act 1993 (c. 11), ISBN 0105411930
http://www.hmso.gov.uk/acts/acts1993/Ukpga_19930011_en_1.htm

C4 Palmes ED, Gunnison AF, Di Mattio J and Tomczyk C "A Personal Sampler for Nitrogen Dioxide" Am Ind.Hyg. Assoc, 37, 570-577, 1976.

Section 4- High Pollution Episodes

D1 http://www.airquality.co.uk/archive/reports/cat12/0802071455_AQF_Partepi0307-final_final.pdf report for the March 07 particulate episode.

D2 http://www.airquality.co.uk/archive/reports/cat12/0807230949_AQF_Q4_07_final.pdf quarterly forecasting operational report (Q4 2007) detailing bonfire night and other winter pollution episodes.

Section 5- How air pollution varies across the UK

E1 - Kent, A J, Grice S, Stedman, J R, Cooke, S, Bush, T J, Vincent K J, Abbott J, (2007). UK air quality modelling for annual reporting 2006 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. AEA Energy & Environment. Report AEAT/ENV/R/2502.

E2 - Kent, A J and Stedman, J R (2007). UK and Gibraltar air quality modelling for annual reporting 2006 on ambient air quality assessment under Council Directives 96/62/EC and 2002/3/EC relating to ozone in ambient air. AEA Energy & Environment. Report AEAT/ENV/R/2499.

E3 - Stedman, J. R., Kent , A. J., Grice, S., Bush, T. J. and Derwent, R. G. (2007). A consistent method for modelling PM_{10} and $PM_{2.5}$ concentrations across the United Kingdom in 2004 for air quality assessment. *Atmospheric Environment*, **41**, 161-172.

Section 6- What historic monitoring networks taught us

F1 Local Authority Unit - Environment Agency, 2003. "Assessment for second revision of PG5/2, Process guidance note for Part B Environmental Protection Act 1990, Part 1, and Pollution Prevention and Control Act 1999. Gas cleaning of emissions to air, including mercury, from existing crematoria."

Section 7- How air pollution has changed over time

G 1 Derwent, R G, Simmonds, P G, Manning, A J and Spain, T G (2007) Trends over a 20-year period from 1987 to 2007 in surface ozone at the atmospheric research station, Mace Head, Ireland. *Atmospheric Environment* 41 9091–9098

G 2 Stedman, J. R. and Kent, A. J. An analysis of the spatial patterns of health related surface ozone metrics across the UK in 1995, 2003 and 2005. *Atmospheric Environment* 42, 1702-1716

Appendices

Appendix 1

P1 The Expert Panel on Air Quality Standards. **Ozone.** ISBN 0-11-752873-0, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/ozone/index.htm

P2 The Expert Panel on Air Quality Standards. **Carbon Monoxide.** ISBN 0-11-753035-2, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/co/index.htm

P3 The Expert Panel on Air Quality Standards. **Benzene**. ISBN 0-11-753034-4, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/benzene/index.htm

P4 The Expert Panel on Air Quality Standards. **1,3-Butadiene.** ISBN 0-11-752859-5, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/13butad_2nd/index.htm

P5 The Expert Panel on Air Quality Standards. **Sulphur Dioxide.** ISBN 0-11-753135-9, The Stationery Office, 1995.
http://www.defra.gov.uk/environment/airquality/aqs/so2/index.htm

P6 The Expert Panel on Air Quality Standards. **Particles.** ISBN 0-11-753135-9, The Stationery Office, 1995.
http://www.defra.gov.uk/environment/airquality/aqs/particle/index.htm

P7 The Expert Panel on Air Quality Standards. **Nitrogen Dioxide.** ISBN 0-11-753352-1, The Stationery Office, 1996.
http://www.defra.gov.uk/environment/airquality/aqs/no2/index.htm

P8 The Expert Panel on Air Quality Standards. **Lead.** ISBN 0-11-753447-1, The Stationery Office, 1998
http://www.defra.gov.uk/environment/airquality/aqs/lead/index.htm.

P9 The Expert Panel on Air Quality Standards. **Polycyclic Aromatic Hydrocarbons.** ISBN 0-11-753503-1, The Stationery Office, 1999.
http://www.defra.gov.uk/environment/airquality/aqs/poly/index.htm

P10 WHO air quality guidelines *2nd Edition Regional Office for Europe, 2000*
http://www.euro.who.int/air/Activities/20020620_1

Appendix 3

Q1 Brown, R J C, Yardley, R E, Muhunthan, D, Butterfield, D M, Williams, M, Woods, P T, Brown, A S, Goddard S L."*Twenty-five years of nationwide ambient metals measurement in the United Kingdom: concentration levels and trends*" Environmental Monitoring and Assessment, 2008, 142, (1-3), 127-140.)

Q2 D Butterfield, P Quincey, R Yardley, P Hughey and R Lipscombe "*2006 Annual Report for the UK Black Smoke Network*" NPL Report AS2, April 2007, available on the Air Quality Archive at
http://www.airquality.co.uk/archive/reports/cat05/0706141352_2006_Annual_Report_final.pdf

Appendix 6

R1 Directive 2008/50/EC of the European Parliament and of the Council of 21st May 2008 (on ambient air quality and cleaner air for Europe), Strasbourg.

R2 Air quality – approach to uncertainty estimation for ambient air reference methods'

R3 Larsen R I. A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards. US Environmental Protection Agency, Research Triangle Park, 1971.

R4 The UK Air Quality Strategy, 2007
http://www.defra.gov.uk/environment/airquality/strategy/pdf/air-qualitystrategy-vol1.pdf
and
http://www.defra.gov.uk/environment/airquality/strategy/pdf/air-qualitystrategy-vol2.pdf

R5 Directive 2004/107/EC of the European Parliament and of the Council of 15th December 2004 on arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

R6 WHO air quality guidelines *2nd Edition Regional Office for Europe, 2000*
http://www.euro.who.int/air/Activities/20020620_1

R7 Air Quality Guidelines for Europe. WHO Regional Publications, European Series N° 23, 1987.

R8 Update and Revision of the Air Quality Guidelines for Europe. Meeting of the WHO Working Group on "Classical" Air Pollutants. World Health Organisation, 1994.
http://www.euro.who.int/air/Activities/20020620_1

R9 Update and Revision of the Air Quality Guidelines for Europe. Report on the WHO Working Group on Ecotoxic Effects. World Health Organisation, 1994.

R10 The Expert Panel on Air Quality Standards. **Ozone.** ISBN 0-11-752873-0, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/ozone/index.htm

R11 The Expert Panel on Air Quality Standards. **Carbon Monoxide.** ISBN 0-11-753035-2, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/co/index.htm

R12 The Expert Panel on Air Quality Standards. **Benzene**. ISBN 0-11-753034-4, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/benzene/index.htm

R13 The Expert Panel on Air Quality Standards. **1,3-Butadiene.** ISBN 0-11-752859-5, The Stationery Office, 1994.
http://www.defra.gov.uk/environment/airquality/aqs/13butad_2nd/index.htm

R14 The Expert Panel on Air Quality Standards. **Sulphur Dioxide.** ISBN 0-11-753135-9, The Stationery Office, 1995.
http://www.defra.gov.uk/environment/airquality/aqs/so2/index.htm

R15 The Expert Panel on Air Quality Standards. **Particles.** ISBN 0-11-753135-9, The Stationery Office, 1995.
http://www.defra.gov.uk/environment/airquality/aqs/particle/index.htm

R16 The Expert Panel on Air Quality Standards. **Nitrogen Dioxide.** ISBN 0-11-753352-1, The Stationery Office, 1996.
http://www.defra.gov.uk/environment/airquality/aqs/no2/index.htm

R17 The Expert Panel on Air Quality Standards. **Lead.** ISBN 0-11-753447-1, The Stationery Office, 1998
http://www.defra.gov.uk/environment/airquality/aqs/lead/index.htm.

R18 The Expert Panel on Air Quality Standards. **Polycyclic Aromatic Hydrocarbons.** ISBN 0-11-753503-1, The Stationery Office, 1999.
http://www.defra.gov.uk/environment/airquality/aqs/poly/index.htm

R19 Guidance on the Annexes to Decision 97/101/EC on Exchange of Information as revised by Decision 2001/752/EC.

R20 Council of European Communities Directive on Air Quality Limit Values and Guide Values for Sulphur Dioxide and Suspended Particulates (80/779/EEC)

R21 The Council of the European Communities Directive on air quality standards for nitrogen dioxide, 85/203/EEC. 7 March 1985.

R21 The Council of the European Union Directive relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air, 1999/30/EC. 22 April 1999

R23 Theil H. A Rank Invariant Method of Linear and Polynomial Regression Analysis. I, II, II. Proc. Kon. Nederl. Akad. Wetsnsch. A, 53, 386-92, 521-5, 1397-1412, 1950.

R24 Spearman C. The Proof and Measurement of Association Between Two Things. American Journal of Psychology, 15, 72-101 (5.4), 1904.

R25 Kendall M G. A New Measure of Rank Correlation. Biometrika, 30, 81-93 (5.4), 1938.

R26 Conover W J. Practical Nonparametric Statistics 2ed. John Wiley and Sons, ISBN 0-471-02867-3, 1980.

R27 Air Quality Data Analysis Pilot Study. Consultants in Environment Sciences, 1998, unpublished report.

R28 Airborne Particles Expert Group (APEG), 1999. Source apportionment of particulate matter in the United Kingdom. HMSO.

R29 D Harrison et al "UK Equivalence Programme for Monitoring of Particulate Matter" Final Report for: Department for the Environment, Food and Rural Affairs; Welsh Assembly Government; Scottish Executive; Department of Environment for Northern Ireland. Bureau Veritas report Ref: BV/AQ/AD202209/DH/2396 June 2006

How to find out more

Current and forecast air quality (national & local)

This is rapidly available in a user-friendly form from:

Teletext: page 156

The Air Pollution Information Service:
freephone 0800 556677

The UK Air Quality Archive:
www.airquality.co.uk

The Scottish Air Quality Archive:
www.scottishairquality.co.uk

The Welsh Air Quality Archive:
www.welshairquality.co.uk

The Northern Ireland Air Quality Archive:
www.airqualityni.co.uk

General information on Air Quality

The UK Air Quality Information Archive:
www.airquality.co.uk

The National Atmospheric Emissions Inventory:
www.naei.org.uk

The Defra air quality information web resource:
www.defra.gov.uk/environment/airquality/index.htm

The Scottish Government Air Quality pages:
www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561

The Welsh Assembly Government Environment link:
www.wales.gov.uk/subienvironment/index.htm

The Northern Ireland Department of Environment:
www.doeni.gov.uk/epd

A companion brochure to this report entitled:
UK Air Pollution is available from Defra at:

Defra Publications
Admail 6000
London SW1A 2XX
Tel: 08459 556000, Fax: 01709 881673
e-mail: defra@cambertown.com

Health Effects of Air Pollution

A concise brochure entitled: Air Pollution, what it means for your health is available to download from the Defra air quality information web resource listed above or free of charge from Defra publications.

Local Air Quality Issues

For further information on air quality issues in your area, please contact:
The Environmental Health Department at your local District Council office.

Further information on Local Air Quality Management may also be found at:
www.defra.gov.uk/environment/airquality/laqm.htm *and*
www.airquality.co.uk/archive/laqm/laqm.php
www.scotland.gov.uk
www.airqualityni.co.uk/laqm_sca.php

This brochure has been produced by
AEA on behalf of Defra and the Devolved Administrations