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Air Pollution in the UK 2012

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A report prepared by Ricardo-AEA for Defra and the Devolved Administrations.

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Executive Summary

The UK is required to report air quality data on an annual basis under the following European Directives:

- The Council Directive on ambient air quality and cleaner air for Europe (2008/50/EC).
- The Fourth Daughter Directive 2004/107/EC under the Air Quality Framework Directive (1996/62/EC).

The report provides background information on the pollutants covered by these Directives and the UK's Air Quality Strategy; their sources and effects, the UK's statutory monitoring networks, and the UK's modelling methodology. The report then summarises the UK's 2012 submission on ambient air quality to the European Commission, presenting air quality modelling data and measurements from national air pollution monitoring networks. This includes details of the exceedances reported in 2012, with an overview of changes over time. The pollutants covered in this report are:

- Sulphur dioxide (SO_2)
- Nitrogen oxides (NO_x) comprising NO and NO_2
- PM_{10} and $PM_{2.5}$ particles
- Benzene
- 1,3-Butadiene
- Carbon Monoxide (CO)
- Metallic Pollutants
- Polycyclic aromatic hydrocarbons (PAH)
- Ozone (O_3)

These data are produced on behalf of Defra (the Department for Environment, Food and Rural Affairs) and the Devolved Administrations of Scotland, Wales and Northern Ireland.

The 2012 results can be summarised as follows:

- There were no exceedances of any EU limit values for sulphur dioxide.
- The UK exceeded the limit value for hourly mean nitrogen dioxide (NO_2) in two zones (out of the total of 43). The remaining 41 zones were compliant.
- The number of zones that exceeded the limit value for annual mean NO_2, (or the limit value plus margin of tolerance where a time extension was in place), was 34. Of the nine compliant zones, five were within the limit value, and a further four were covered by a time extension and were within the limit value plus the applicable margin of tolerance.
- After subtraction of the contribution from natural sources all zones met the limit value for daily mean concentration of PM_{10} particulate matter.
- All zones met the limit value for annual mean concentration of PM_{10} particulate matter.
- All zones met the target value for annual mean concentration of $PM_{2.5}$ particulate matter, and the Stage 1 limit value, which comes into force in 2015. After subtraction of the natural contribution, one zone did not meet the Stage 2 limit value which must be met by 2020.
- Exceedances were reported for the long term ozone objective for human health in 41 zones, and exceedances were reported for the long term ozone objective for vegetation in three zones.
- Two zones exceeded the target value for nickel in 2012, as has been the case since 2008.
- Eight zones exceeded the target value for benzo[a]pyrene in 2012.

Copies of previous annual submissions can be found on the Commission website: http://cdr.eionet.europa.eu/gb/eu/annualair. For more information on air quality in the UK visit the Defra website at www.gov.uk/defra and the UK Air Quality websites at http://uk-air.defra.gov.uk/, www.scottishairquality.co.uk, www.welshairquality.co.uk and www.airqualityni.co.uk.

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1 Introduction

The quality of the air that we breathe can affect human health and quality of life. It can also have major impacts on ecosystems and the climate. It is therefore important to monitor air pollution, in order to understand the problems and how they can be managed effectively, at local, national and international level. Monitoring is also essential for the assessment of progress towards compliance with European Union (EU) limit and target values. The broad objectives of monitoring air pollution in the UK are:

- To fulfil statutory air quality reporting requirements.
- To provide a sound scientific basis for the development of cost-effective control policies.
- To provide the public with open, reliable and up-to-date information on air pollution.
- To evaluate potential impacts on population, ecosystems and our natural environment.

All Member States of the European Union must comply with Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[1] and the 4th Air Quality Daughter Directive[2] (2004/107/EC). These Directives require all Member States to undertake air quality assessment, and to report the findings to the European Commission on an annual basis.

The UK has statutory monitoring networks in place to meet the requirements of these Directives, with air quality modelling used to supplement the monitored data. The results of the assessment are submitted to the European Commission in September each year, in the form of a standard questionnaire ("the Questionnaire"). The UK's annual submission, together with those from previous years, can be found on the Commission website:
http://cdr.eionet.europa.eu/gb/eu/annualair.

As well as reporting air quality data to the European Commission, the UK must also make the information available to the public. One way in which this is done is by the series of annual "Air Pollution in the UK" reports. "Air Pollution in the UK 2012" continues this series, and this report has two aims:

- To provide a summary of the UK's 2012 air quality report to the Commission. A separate Compliance Assessment Summary document, based upon Section 4 of this report, accompanies the UK's 2012 data submission to the Commission, making it more understandable to the public.
- To act as a State of the Environment report, providing information to a wider group of stakeholders on the ambient air quality evidence base for the year, together with analysis of trends, both spatial and temporal and information on in-year air pollution events.

This report:

- Outlines the air quality legislative and policy framework in Europe and the UK *(Section 2).*

- Describes the evidence base underpinning the UK's air quality assessment: the pollutants of concern, and where and how air pollution is measured and modelled *(Section 3)*.

- Presents an assessment of the UK's compliance with the limit values, target values and long term objectives set out in the Air Quality Directive and the 4th Daughter Directive for 2012, and compares this with recent years. *(Section 4).*

- Investigates the spatial distribution of the main pollutants of concern within the UK during 2012, and looks at how ambient concentrations have changed in recent years (*Section 5).*

- Investigates pollution events – "episodes" of high pollution – that occurred during 2012, (*Section 6*).

Further information on air quality in the UK can be found on Defra's online UK Air Information Resource (UK-AIR), at http://uk-air.defra.gov.uk/.

2 Legislative and Policy Framework

2.1 European Background

European Union Directives place a duty on each EU Member State to institute policies to protect and improve its environment and the health of its citizens. European Union action is designed to:

- Protect the environment.
- Reduce human exposure to air pollution.
- Ensure sustainable development.
- Promote better regulation.

The air quality policy adopted by the European Union has involved two complementary approaches;

(i) controlling emissions at source, and
(ii) the setting of long-term ambient air quality objectives.

The mechanism of controlling emissions and setting air quality objectives has been through various EU Directives. All Member States must incorporate - or "transpose" - the provisions of EU Directives into their own national law by a specified date. The main Directives are described below.

2.1.1 The Air Quality Directive and Fourth Daughter Directive

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, was adopted in June 2008. This Directive – referred to in this report as "the Air Quality Directive" - covers the following pollutants; sulphur dioxide, nitrogen oxides, particulate matter (as PM_{10} and $PM_{2.5}$), lead, benzene, carbon monoxide and ozone. It revised and consolidated existing EU air quality legislation relating to the above pollutants. The Fourth Daughter Directive (2004/107/EC) covers the four metallic elements cadmium, arsenic, nickel and mercury together with polycyclic aromatic hydrocarbons (PAH).

The above Directives set "limit values" and "target values" for ambient concentrations of pollutants. Limit values are legally binding and must not be exceeded. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year (if any) and a date by which it must be achieved. Some pollutants have more than one limit value.

Target values are used for some pollutants. These are set out in the same way as limit values. Target values are to be attained where possible, by taking all necessary measures not entailing disproportionate costs. However, unlike limit values they are non-mandatory.

As well as setting limit values and target values, the Air Quality Directive and Fourth Daughter Directive cover the following aspects of air quality:

- The division of the UK into zones for the purposes of compliance reporting.
- The location and number of sampling points.
- The measurement methods to be used.
- Data quality objectives.
- Criteria a monitoring station must meet.
- Provision for reporting compliance.
- Provision of information to the public.

The provisions of the Air Quality Directive and Fourth Daughter Directive were transposed by the Air Quality Standards Regulations 2010[3] in England, the Air Quality Standards (Scotland) Regulations 2010[4] in Scotland, the Air Quality Standards (Wales) Regulations 2010 in Wales[5] and the Air Quality Standards Regulations (Northern Ireland) 2010[6]. All the provisions made by the Directives are therefore incorporated into UK legislation.

2.1.2 The National Emissions Ceilings Directive

The National Emissions Ceilings Directive[7] (2001/81/EC) came into force in 2001, and has been transposed into UK legislation as The National Emission Ceilings Regulations 2002. This Directive sets national emission limits or “ceilings” for the four main air pollutants responsible for the acidification and eutrophication (nutrient enrichment) of the natural environment, and the formation of ground level ozone which impacts both human health and the environment. The ceilings had to be met by 2010. Emissions of these pollutants can impact either locally or far from their source. The latter is known as transboundary air pollution. The four pollutants for which national emission ceilings are set are:

- sulphur dioxide,
- oxides of nitrogen,
- volatile organic compounds
- ammonia.

Considerable action has been taken to reduce UK emissions at source including fitting pollution reduction technology to industrial installations and using cleaner fuels. This has helped to ensure that the UK has met international obligations under the National Emissions Ceilings Directive for all four of the above pollutants. The National Emissions Ceilings Directive report is available at http://www.eea.europa.eu/publications/nec-directive-status-report-2012.

2.2 The UK Perspective

Environmental legislation introduced over the past fifty years has provided a strong impetus to reduce the levels of harmful pollutants in the UK; as a result, current concentrations of many recognised pollutants are now at the lowest they have been since measurements began. However, although the lethal city smogs of the 1950s, 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 still die prematurely every year because of the effects of air pollution. Air pollution from man-made particles is currently estimated to reduce average UK life expectancy (from birth) by six months[8]. Moreover, it is now firmly established that air pollution (particulate matter, sulphur dioxide and ozone) contributes to thousands of hospital admissions per year[9].

2.2.1 The UK Air Quality Strategy

The Environment Act 1995 brought about the establishment of the Environment Agency and the Scottish Environment Protection Agency. It also ordered that a National Air Quality Strategy be published, containing policies for assessment and management of air quality. The Air Quality Strategy[10] for England, Scotland, Wales and Northern Ireland was first published in March 1997. The overall objectives of the Strategy are to:

- Map out future ambient air quality policy in the United Kingdom in the medium term.
- 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.
- Establish 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[11] are at least as stringent as the limit values of the relevant EU Directives – in some cases, more so. The most recent review of the Strategy was carried out in 2007.

2.2.2 National Air Quality Statistics and Indicators

The UK currently reports on the following two indicators as National Air Quality Statistics for ambient air:

- **Annual concentrations of particles and ozone**. These are the two types of air pollution believed to have the most significant impacts on public health (specifically, long-term exposure to PM_{10} and daily peak ozone levels).
- **Number of days in the year when air pollution is "Moderate" or higher**. This may relate to any one of five key air pollutants and is based on the UK's Daily Air Quality Index (see section 2.2.4). From the 1st January 2012, $PM_{2.5}$ particles replaced carbon monoxide in this suite of pollutants. Also, the thresholds used to define "Moderate" and higher pollution levels in the air quality index were also revised at the beginning of 2012.

The National Air Quality Statistics summary for 2012 was released in April 2013 and is available from the Defra website[12].

In May 2013, Defra published the England Natural Environment Indicators. Two of the indicators for Environmental Quality and Health relate to air quality. These are:

- the average number of days per site when air pollution is "moderate" or higher – for urban and for rural sites,
- Regional mortality due to anthropogenic particulate air pollution, compared to the England national average (5.6% in 2010, which is being taken as the baseline year for this indicator).

In 2012 the UK Government published its Public Health Outcomes Framework for England, which recognises the burden of ill-health resulting from poor air quality as well as other public health concerns. This Framework sets out 60 health outcome indicators for England, and includes as an indicator:

- the fraction of annual all-cause adult mortality attributable to long-term exposure to current levels of anthropogenic particulate air pollution (measured as fine particulate matter, $PM_{2.5}$)[13]

This indicator is intended to enable Directors of Public Health to appropriately prioritise action on air quality in their local area. The baseline data for the indicator have been calculated for each upper tier local authority in England based on modelled concentrations of fine particulate air pollution ($PM_{2.5}$) in 2010. Estimates of the percentage of mortality attributable to long term exposure to particulate air pollution in local authority areas range from around 4% in rural areas to over 8% in cities, where pollution levels are highest. The Defra document "Air Quality: Public Health Impacts and Local Actions" can be found at http://laqm.defra.gov.uk/documents/air_quality_note_v7a-(3).pdf .

2.2.3 National Emissions Statistics

The UK reports annual emissions of the following pollutants via an annual National Statistics Release:

- sulphur dioxide,
- oxides of nitrogen,
- non-methane volatile organic compounds (NMVOCs),
- ammonia (NH_3),
- particulate matter (as PM_{10} and $PM_{2.5}$).

The most recent National Statistics Release covers 1970 to 2011 (the most recent year for which emission statistics are available).

The main conclusions presented in the document are as follows:

- There has been a long-term decrease in the emissions of all of the pollutants covered. For sulphur dioxide and particulate matter, the rate of decline was most pronounced in the 1990s, and has slowed in recent years.
- Ammonia emissions have increased in each of the last three years by a total of four per cent, although this follows a relatively large fall between 2006 and 2008. The remaining air pollutants have seen decreases in 2011 compared to 2010, of between 2.5 and 6.6 per cent.
- The UK has continued to meet international obligations for emissions of the four pollutants for which it has legally binding commitments for 2010 onwards.

New statistics for 2012 will be available in December 2013, and all these publications are available at: https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/air-quality-and-emissions-statistics

There are two main international agreements that aim to reduce transboundary air pollution:

- the National Emission Ceilings Directive (NECD) as described in Section 2.1.2; and
- The Gothenburg Protocol under the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP). This sets similar or identical UK emissions ceilings for the same pollutants for 2010 and thereafter. This Protocol was revised in May 2012 and now sets further emission reduction commitments for the same four pollutants and $PM_{2.5}$, for 2020.

The Statistics Release presents the emissions data alongside the new emission reduction commitments for 2020.

2.2.4 The Air Pollution Forecasting System

Daily UK air pollution forecasts are produced for five pollutants; nitrogen dioxide, sulphur dioxide, ozone, PM_{10} particles and $PM_{2.5}$ particles. The forecasts are communicated using the Daily Air Quality Index http://uk-air.defra.gov.uk/air-pollution/daqi which is a scale of one to ten divided into four bands. This allows the public to see at a glance whether the air pollution is low, moderate, high or very high and to look up any recommended actions to take.

The group of pollutants covered, and the thresholds between the various index bands, were updated by Defra as of 1st January 2012, in the light of recommendations by the Committee on the Medical Effects of Air Pollutants (COMEAP) in their 2011 review of the UK air quality index[14].

The daily forecast is available from UK-AIR and from the Scottish, Welsh and Northern Ireland air quality websites (see section 7), and is further disseminated via e-mail and a free recorded information telephone helpline on 0800 556677. Anyone may subscribe to the free air pollution bulletins at: http://uk-air.defra.gov.uk/subscribe Latest forecasts are issued twice daily, at: http://uk-air.defra.gov.uk/forecasting/. Defra also provide automated updates on current and forecast air quality via Twitter @DefraUKAIR– see http://uk-air.defra.gov.uk/twitter.

2.3 Local Authority Air Quality Management

Requirements for local air quality management are set out in Part IV of the Environment Act 1995, and the Environment (Northern Ireland) Order 2002[15]. Authorities are required to carry out regular "Review and Assessments" of air quality in their area and take action to improve air quality when the objectives set out in regulation cannot be met by the specified dates.

Local Authorities in England, Scotland and Wales have completed four rounds of review and assessment against the Strategy's objectives prescribed in the 2000 Air Quality Regulations[16], together with subsequent amendments[17,18,19,20]. The fifth round began in 2012.

When the Review and Assessment process identifies an exceedance of an Air Quality Strategy objective, the Local 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. At present, 258 Local Authorities – roughly 64% of those in the UK – have one or more AQMAs.

Information on the UK's AQMAs is summarised in Table 2-1 below. Please note some AQMAs are for more than one pollutant, and many Local Authorities have more than one AQMA.

Table 2-1 Current UK-wide status of Air Quality Management Areas (AQMAs) and Action Plans (as of Jul 2013.)

Region	Total LAs	Number of LAs with AQMAs	For NO_2	For PM_{10}	For SO_2	For Benzene	LA's with Action Plans submitted	LA's with Action Plans awaited
England (outside London)	292	190	463	40	6	0	161	80
London	33	33	33	29	0	0	33	1
Scotland	32	13	21	21	1	0	9	8
Wales	22	10	33	1	0	0	5	6
N. Ireland	26	12	23	6	0	0	13	5
TOTAL	**405**	**258**	**573**	**97**	**7**	**0**	**221**	**100**

Most Air Quality Management Areas in the UK are in urban areas and result from traffic emissions of nitrogen dioxide or $PM_{10.}$ Emissions from transport (road and other types) are the main source in 97% of the AQMAs declared for NO_2; only a few have been declared as a result of other sources, such as industrial or domestic emissions. Figure 2-1 shows the numbers of AQMAs in the UK that have been declared as a result of various sources of pollutant emissions.

Figure 2-1 Number of Air Quality Management Areas resulting from Various Sources

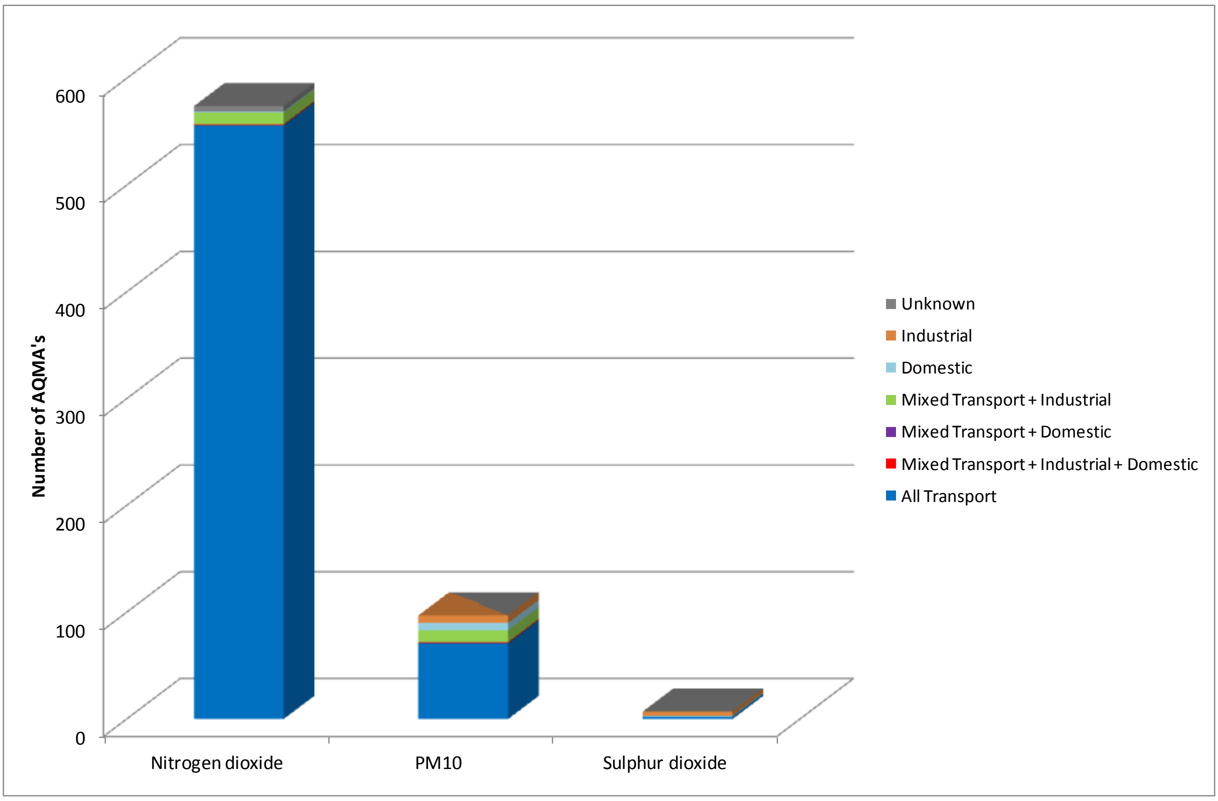
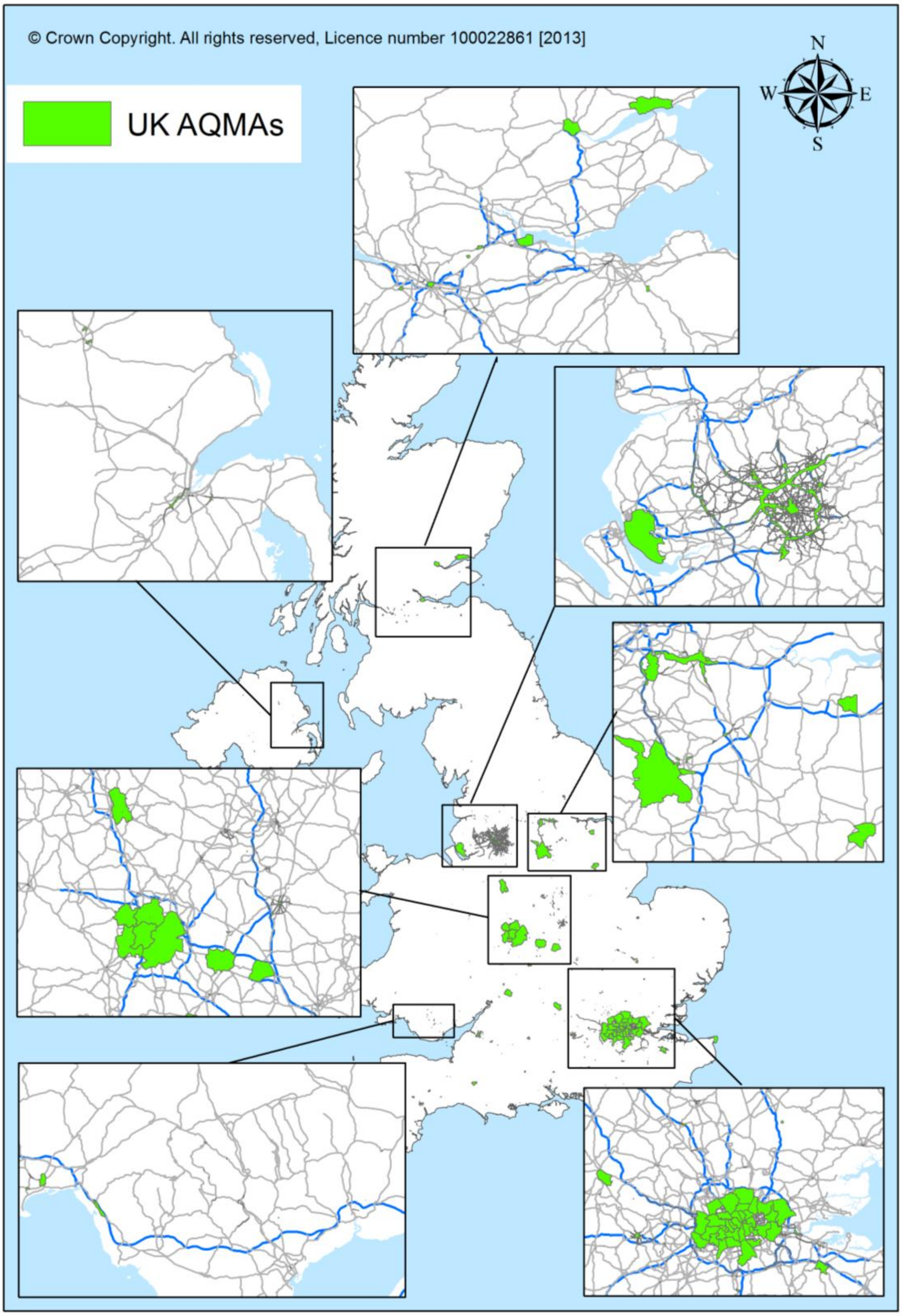


Table 2-1 shows that a total of 321 authorities have now submitted action plans or are in the process of preparing them. These formally set out the measures the Local Authority proposes to take to work towards meeting the air quality objectives.

Advice for Local Authorities on preparing an Action Plan is available from the Defra LAQM web pages at http://laqm.defra.gov.uk/action-planning/aqap-supporting-guidance.html.

The locations of the UK's AQMAs are shown in Figure 2-2. Information on the UK's Air Quality Management Areas (AQMAs) is published on the Defra's LAQM website. Information is provided on each one, together with a map of the AQMA, where available.

Figure 2-2 Air Quality Management Areas in the UK, as at end of 2012



3 The Evidence Base

A programme of air quality assessment and research is in place in the UK, the rationale for which is set out in the Atmosphere and Local Environment Evidence Plan. The evidence plan can be viewed at https://www.gov.uk/government/publications/evidence-plans.

This section explains Defra and the Devolved Administration's evidence base for the annual assessment of compliance with the EU Directives on ambient air quality. It describes the air pollutants which are of concern and how these are monitored and modelled in the UK.

3.1 Pollutants of Concern

Table 3-1 below summarises the sources, effects and typical UK concentrations of the pollutants being assessed in relation to the Air Quality Directive and 4th Daughter Directive.

The information on sources has largely been summarised from the National Atmospheric Emission Inventory (NAEI) pollutant information pages[21] together with Table 1 of the Air Quality Strategy[22].

Information on health effects is summarized (and further information can be sought) from the following sources:

- The World Health Organization's Air Quality Guidelines Global Update (2005)[23] (which covers particulate matter, sulphur dioxide, nitrogen dioxide and ozone).
- The World Health Organization's *"Air Quality and Health"* factsheet (factsheet 313) at http://www.who.int/mediacentre/factsheets/fs313/en/index.html
- Three reports by the Committee on the Medical Effects of Air Pollution (COMEAP):
    - COMEAP's 2011 review of the air quality index[14]
    - COMEAP's 2009 report on long-term exposure to air pollution and its effect on mortality[24] (referred to in the table below as COMEAP 2009.)
    - COMEAP's 2010 report on the mortality effects of long-term exposure to particulate air pollution in the United Kingdom[25] (referred to in the table as COMEAP 2010).
    - Expert Panel on Air Quality Standards (EPAQS) report "Metals and Metalloids[26] (referred to as EPAQS 2009 in the table below).
- Public Health England's Compendium of Chemical Hazards web pages at http://www.hpa.org.uk/Topics/ChemicalsAndPoisons/CompendiumOfChemicalHazards/
- World Health Organization's 2013 "Review of Evidence on Health Aspects of Air Pollution" (REVIHAAP) report[27].
- The Air Quality Strategy[22].

Information on typical ambient concentrations in the UK has been summarised from the Defra online air information resource, UK-AIR at http://uk-air.defra.gov.uk/.

Table 3-1 Sources, Effects and Typical UK Concentrations

Pollutant and Sources	Health Effects	Environmental Effects	Typical Ambient Concentrations in the UK
Sulphur Dioxide (SO_2): an acid gas formed when fuels containing sulphur impurities are burned. The largest UK source is currently power generation. Other important sources include industry, commercial fuel use, and residential fuel use in some areas.	A respiratory irritant that can cause constriction of the airways. People with asthma are considered to be particularly sensitive. Health effects can occur very rapidly, making short-term exposure to peak concentrations important. (Source: WHO AQG 2005)	Harmful to plants at high concentrations. Contributes to acidification of terrestrial and aquatic ecosystems, damaging habitats and leading to biodiversity loss. SO_2 is also a precursor to the formation of secondary sulphate particles in the atmosphere.	Annual mean concentrations are typically less than 5 µg m^{-3} except at sites in industrial locations or in residential areas with high use of solid fuel for heating.
Nitrogen Oxides (NOx): NOx, which comprises nitric oxide (NO) and nitrogen dioxide (NO_2), is emitted from combustion processes. Main sources include power generation, industrial combustion and road transport. According to the NAEI, road transport is now the largest single UK source of NOx, accounting for one third of UK emissions.	Short-term exposure to concentrations of NO_2 higher than 200 µg m-^{3} can cause inflammation of the airways. NO_2 can also increase susceptibility to respiratory infections and to allergens. It has been difficult to identify the direct health effects of NO_2 at ambient concentrations because it is emitted from the same sources as other pollutants such as particulate matter (PM). Studies have found that both day-to-day variations and long-term exposure to NO_2 are associated with mortality and morbidity. Evidence from studies that have corrected for the effects of PM is suggestive of a causal relationship, particularly for respiratory outcomes (Source: WHO 2013 REVIHAAP report).	In the presence of sunlight, nitrogen oxides can react with Volatile Organic Compounds to produce photochemical pollutants including ozone. NO_X contributes to the formation of secondary nitrate particles in the atmosphere. High levels of NOx can harm plants. NOx also contributes to acidification and eutrophication of terrestrial and aquatic ecosystems, damaging habitats and leading to biodiversity loss.	Annual mean concentrations of NO_2 beside busy roads frequently exceed 40 µg m^{-3}. This is not a UK-specific problem and is common in many other European countries. At urban background locations, annual mean NO_2 concentrations are lower, typically 15-40 µg m^{-3}. Peak hourly mean concentrations exceed 100 µg m^{-3} at most urban locations, and occasionally exceed 300 µg m^{-3} at congested urban roadside sites.

Pollutant and Sources	Health Effects	Environmental Effects	Typical Ambient Concentrations in the UK
Particulate Matter: PM_{10}. This can be primary (emitted directly to the atmosphere) or secondary (formed by the chemical reaction of other pollutants in the air such as SO_2 or NO_2). The main source is combustion, e.g. vehicles and power stations. Other man-made sources include quarrying and mining, industrial processes and tyre and brake wear. Natural sources include wind-blown dust, sea salt, pollens and soil particles.	Research shows a range of health effects (including respiratory and cardiovascular illness and mortality) associated with PM_{10}. No threshold has been identified below which no effects occur. (Source: WHO AQG 2000)	Black carbon in PM is implicated in climate change. Secondary PM includes sulphate, nitrate and ammonium, formed from SO_2, NOx and NH_3 which are the main drivers for acidification and eutrophication.	Annual mean PM_{10} concentrations for urban AURN monitoring sites have been typically in the range 10-28 µg m^{-3} in recent years.
Particulate Matter: $PM_{2.5}$. Like PM_{10}, the finer size fraction $PM_{2.5}$ can be primary or secondary, and has the same sources. Road transport becomes an increasingly important sector as the particle size decreases.	Fine particulate matter can penetrate deep into the lungs and research in recent years has strengthened the evidence that both short-term and long-term exposure to $PM_{2.5}$ are linked with a range of health outcomes including (but not restricted to) respiratory and cardiovascular effects. COMEAP estimated that the burden of anthropogenic particulate air pollution in the UK in 2008 was an effect on mortality equivalent to nearly 29,000 deaths at typical ages and an associated loss of life across the population of 340,000 years. The burden can also be represented as a loss of life expectancy from birth of approximately six months. (Source: COMEAP 2010.)	Secondary PM includes sulphate, nitrate and ammonium, formed from SO_2, NOx and NH_3 which are the main drivers for acidification and eutrophication.	Annual mean urban $PM_{2.5}$ concentrations in the UK are typically in the low teens of µg m^{-3} but exceed 20 µg m^{-3} at a few urban roadside locations.

Pollutant and Sources	Health Effects	Environmental Effects	Typical Ambient Concentrations in the UK
Benzene: (C_6 H_6) is an organic chemical compound. Ambient benzene concentrations arise domestic and industrial combustion and road transport. (source: Air Quality Strategy).	Benzene is a recognised human carcinogen and repeated exposure targets the blood and the immune system and affects the genetic material. No absolutely safe level can be specified in ambient air. Acute exposure to high concentrations affects the central nervous system. (Source: WHO AQG 2000, PHE Compendium of Chemical Hazards)	Can also pollute soil and water, leading to exposure via these routes.	Annual mean concentrations of benzene are now low (consistently below 2 μg m^{-3}) due to the introduction of catalytic converters on car exhausts. The UK meets the benzene limit value of 5 μg m^{-3}.
Carbon Monoxide (CO) is produced when fuels containing carbon are burned with insufficient oxygen to convert all the carbon to carbon dioxide (CO_2). Although CO emissions from petrol-engined road vehicles have been greatly reduced by the introduction of catalytic converters, road transport is still the most significant source of this pollutant (Source: NAEI).	CO affects the ability of the blood to take up oxygen from the lungs, and can lead to a range of symptoms as the concentration increases. People are more likely to be exposed to dangerous concentrations of CO indoors, due to faulty or poorly ventilated cooking and heating appliances. Cigarette smoke is also a major source of exposure. (Source: NAEI, PHE Compendium of Chemical Hazards.)	Can contribute to the formation of ground-level ozone.	The UK is compliant with the European limit value for CO, with the 8-hour running mean concentration consistently below 10 mg m^{-3} at all monitoring sites in recent years.
Ozone (O_3) is a secondary pollutant produced by the effect of sunlight on NOx and VOCs from vehicles and industry. Ozone concentrations are greatest in the summer on hot, sunny, windless days. O_3 can travel long distances, accumulate and reach high concentrations far away from the original sources.	A respiratory irritant: short-term exposure to high ambient concentrations can cause inflammation of the respiratory tract and irritation of the eyes, nose, and throat. High levels may exacerbate asthma or trigger asthma attacks in susceptible people and some non-asthmatic individuals may also experience chest discomfort whilst breathing. Evidence is also emerging of effects due to long-term exposure (WHO AQG 2000, WHO 2013 - REVIHAAP).	Ground level ozone can also cause damage to many plant species leading to loss of yield and quality of crops, damage to forests and impacts on biodiversity. Ozone is also a greenhouse gas implicated in climate change. In the upper atmosphere the ozone layer has a beneficial effect, absorbing harmful ultraviolet radiation from the sun.	In recent years, the annual mean daily maximum 8-hour running mean measured at AURN sites has been typically in the range 30-80 μg m^{-3}. NO_X emitted in cities reduces local O_3 concentrations as NO reacts with O_3 to form NO_2 and levels of O_3 are often higher in rural areas than urban areas.

Pollutant and Sources	Health Effects	Environmental Effects	Typical Ambient Concentrations in the UK
Lead (Pb): a very toxic metallic element. Historically, lead was used as an additive in petrol, and road vehicles were the main source. This use was phased out in 1999, since when there has been a 98% reduction in UK emissions. Today, the main sources are metal production and industrial combustion of lubricants containing small amounts of lead. (Source: NAEI.)	Lead inhalation can affect red blood cell formation and have effects on the kidneys, heart, gastrointestinal tract, the joints, reproductive systems, and can cause acute or chronic damage to the central nervous system (CNS). Long term low level exposure has been shown to affect intellectual development in young children (Source: EPAQS 2009). A threshold, below which the adverse effects of lead are not anticipated, has not been established (source: WHO AQG 2000, PHE Compendium of Chemical Hazards).	Can also pollute soil and surface waters. Exposure to contaminated soil and water may then become a health risk. Lead may accumulate in other organisms such as fish, and be passed up the food chain.	In recent years, UK annual mean concentrations of lead have typically ranged from less than 5 ng m^{-3} at rural monitoring sites, to nearly 90 ng m^{-3} at urban industrial sites. The EU limit value for Pb (0.5 µg m^{-3} or 500 ng m^{-3}) is met throughout the UK.
Nickel (Ni) is a toxic metallic element found in ambient air as a result of releases from oil and coal combustion, metal processes, manufacturing and other sources. Currently the main source is the combustion of heavy fuel oil, the use of coal having declined. (Source: NAEI.)	Nickel compounds are human carcinogens by inhalation exposure. Can cause irritation to the nose and sinuses and allergic responses and can lead to the loss of the sense of smell. Long-term exposure may lead to respiratory diseases and cancers. (Source: WHO AQG 2000, EPAQS 2009, PHE Compendium of Chemical Hazards.)	Can also pollute soil and water, leading to exposure via these routes.	Annual mean ambient particulate phase concentrations in the urban environment are typically of the order of 1 ng m^{-3} with the exception of a few industrial areas, where higher annual means may occur, in some locations exceeding the 4^{th} Daughter Directive target value of 20 ng m^{-3}.
Arsenic (As) is a toxic element emitted into the atmosphere in the form of particulate matter. Historically the largest source was coal combustion, but as this has declined, the use of wood treated with preservatives containing As has become the most significant component of As emissions. (Source: NAEI.)	Acute inhalation exposure to high levels of arsenic primarily affects the respiratory system and can cause coughs, sore throat, breathlessness and wheezing. Long term inhalation exposure is associated with toxic effects on the respiratory tract and can cause lung cancer. (Source: WHO AQG 2000, EPAQS 2009, PHE Compendium of Chemical Hazards.)	Can also pollute soil and water, leading to exposure via these routes. Arsenic in water or soil can be taken up by plants or fish.	Measured UK annual mean concentrations in the particulate phase range from approximately 0.1 ng m^{-3} to approximately 1.2 ng m^{-3}, meeting the 4^{th} Daughter Directive target value of 6 ng m^{-3}.

Pollutant and Sources	Health Effects	Environmental Effects	Typical Ambient Concentrations in the UK
Cadmium (Cd): a toxic metallic element whose main sources are energy production, non-ferrous metal production, iron and steel manufacture (as well as other forms of industrial combustion). (Source: NAEI.)	Acute inhalation exposure to cadmium causes effects on the lung such as pulmonary irritation. Chronic effects via inhalation can cause a build-up of cadmium in the kidneys that can lead to kidney disease and long term inhalation can lead to lung cancer. (Source: WHO AQG 2000, EPAQS 2009, PHE Compendium of Chemical Hazards.)	Can also pollute soil and water, leading to exposure via these routes.	Annual mean particulate phase concentrations in the UK in recent years currently range from approximately 0.02 ng m^{-3} to approximately 3 ng m^{-3}, and meet the 4th Daughter Directive target value of 5 ng m^{-3}.
Mercury (Hg): released to the air by human activities, such as fossil fuel combustion, iron and steel production processes, waste incineration, the manufacture of chlorine in mercury cells, and coal combustion. Emissions have declined in recent years as a result of improved controls on mercury cells, the reduction in coal use, and improved controls on waste incineration processes from 1997 onwards. (Source: NAEI.)	Acute exposure to high levels of Hg can cause chest pain and shortness of breath, and affect the central nervous system (CNS). Chronic exposure leads to CNS disorders, kidney damage and stomach upsets. (Source: WHO AQG 2000, PHE Compendium of Chemical Hazards.)	Can also pollute soil, fresh water and sea water. Exposure to contaminated soil and water may then become a health risk. Mercury may accumulate in other organisms such as fish, and be passed up the food chain.	There is no target value for mercury. Annual mean ambient concentrations (total of vapour and particulate phases) are typically in the range 1-3 ng m^{-3}, although higher concentrations (over 20 ng m^{-3}) have been measured at industrial sites.
Benzo[a]pyrene (B[a]P) is used as a 'marker' for a group of compounds known as polycyclic aromatic hydrocarbons (PAHs). The main sources of B[a]P in the UK are domestic coal and wood burning, fires (eg accidental fires, bonfires, forest fires, etc), and industrial processes such as coke production. (Source: Air Quality Strategy).	PAHs are a large group of persistent, bio-accumulative, organic compounds with toxic and carcinogenic effects. Lung cancer is most obviously linked to exposure to PAHs through inhaled air. (Source: WHO AQG 2000, PHE Compendium of Chemical Hazards)	PAHs can bio-accumulate and be passed up the food chain.	Annual mean concentrations in most urban areas are below the EU target value of 1 ng m^{-3}: the only exceptions are areas with specific local sources – such as industrial installations or domestic solid fuel burning.

3.2 Assessment of Air Quality in the UK

The evidence base for the annual assessment of compliance is based on a combination of information from the UK national monitoring networks and the results of modelling assessments. Considerably more monitoring sites would be required across the whole of the UK if monitoring data were to be used as the sole source of information for compliance assessment. The use of models has the added benefits of enabling air quality to be assessed at locations without monitoring sites and providing additional information on source apportionment and projections required for the development and implementation of air quality plans.

UK compliance assessment modelling is undertaken using a national model known as the Pollution Climate Mapping (PCM) model. The PCM models have been designed to assess compliance with the limit values at locations defined within the Directives. Modelled compliance assessments are undertaken for 11 air pollutants each year. This assessment needs to be completed each year over the relatively short period between the time when the input data (including ratified monitoring data and emission inventories), become available and the reporting deadline at the end of September.

Local Air Quality Management (LAQM) modelling is different in scope, purpose and methodology from the national modelling and will usually output contour plots showing dispersion away from the source, on a fine resolution grid. National modelling focuses on concentrations at four metres away from selected road links. The level of detail and resolution of LAQM modelling is therefore much greater in order to focus on local exposure and hotspots. See section 3.5 for more details on modelling.

3.3 Current UK Air Quality Monitoring

During 2012 there were 273 national air quality monitoring sites across the UK, comprising several networks, each with different objectives, scope and coverage. This section provides a brief description of those used to monitor compliance with the Air Quality Directive and the 4th Daughter Directive. A summary of the UK national networks is provided in Table 3-2 (the numbers of sites shown in this table add up to considerably more than 273, because some sites belong to more than one network). This table shows the numbers of sites in operation during part or all of 2012.

3.3.1 The Automatic Urban and Rural Network (AURN)

The AURN is currently the largest automatic monitoring network in the UK and forms the bulk of the UK's statutory compliance monitoring evidence base. Data from the AURN are available on Defra's online UK Air Information Resource, UK-AIR at http://uk-air.defra.gov.uk/.

The techniques used for monitoring within the AURN are the reference methods of measurement defined in the relevant EU Directives for the gaseous pollutants. For particulate matter the AURN uses methods which have demonstrated equivalence to the reference method, but which (unlike the reference method) allow continuous on-line monitoring. Details are provided in Table 3-3.

Table 3-2 The UK's Air Quality Monitoring Networks in 2012

Network	Statutory or Research	Pollutants	Number of Sites in 2012
Automatic Urban and Rural Network (AURN)	Statutory	CO, NOx, NO_2, SO_2, O_3, PM_{10}, $PM_{2.5}$.	131
UK Urban and Industrial Metals Network	Statutory	Metals : As,Cd,Co,Cr,Cu,Fe,Hg[p],Hg[t],Mn,Ni,Pb, Pt,Se,V,Zn	25
Non-Automatic Hydrocarbon	Statutory	Benzene	41
Automatic Hydrocarbon	Statutory	Range of VOCs	4
Polycyclic Aromatic Hydrocarbons (PAH). Digital samplers	Statutory	21 PAH species including benzo[a]pyrene	32
Toxic Organic Micropollutants	Research	Range of toxic organics including dioxins and dibenzofurans.	6
UK Eutrophying and Acidifying Pollutants: NO_2Net (rural diffusion tubes)	Research	NO_2	24
UK Eutrophying and Acidifying Pollutants: AGANet	Research	NO_3,HCl,HNO_3,HONO,SO_2,SO_4	30
UK Eutrophying and Acidifying Pollutants: NAMN	Research	NH_3 and/or NH_4	86
UK Eutrophying and Acidifying Pollutants : PrecipNet	Research	Major ions in rain water	39
European Monitoring and Evaluation Programme (EMEP)	Research and statutory	Wide range of parameters relating to air quality, precipitation, meteorology and composition of aerosol in PM_{10} and $PM_{2.5}$.	2
Particle concentrations and numbers	Research	Total particle number, concentration, size distribution, anions, EC/OC, PM_{10} and $PM_{2.5}$ speciation.	5
Black Carbon	Research	Black Carbon	25[a]
Acid Waters Monitoring	Research	Chemical and biological species in water	23
Rural Metals Network	Research and statutory	Al,As,Ba,Be,Cd,Co,Cr,Cs,Cu,Fe,Li,Mn,Mo, Ni,Pb,Rb,Sb,Sc,Se,Sn,Sr,Ti,U,V,W,Zn	11 in particulate 14 in rainwater

Footnote a to Table 3-2: the Black Carbon Network was reorganised in 2012, leaving 14 sites in operation.

Table 3-3 AURN Measurement Techniques

Pollutant	Method used including details on CEN Standard Methods
O_3	EN 14625:2005 "Ambient air quality – standard method for the measurement of the concentration of ozone by ultraviolet photometry"[28]
NO_2/NO_x	EN 14211:2005 "Ambient air quality - Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by Chemiluminescence"[29]
SO_2	EN 14212:2005 "Ambient air quality – Standard method for the measurement of the concentration of sulphur dioxide by UV fluorescence"[30]
CO	EN 14625:2005 "Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by infra red absorption"[31]
PM_{10} and $PM_{2.5}$	EN 12341:1999 "Air quality. Determination of the PM_{10} fraction of suspended particulate matter. Reference method and field test procedure to demonstrate reference equivalence of measurement methods."[32] EN 14907:2005 "Ambient air quality - Standard gravimetric measurement method for the determination of the $PM_{2.5}$ mass fraction of suspended particulate matter"[33] The AURN uses three methods which are equivalent for one or both pollutants: the Filter Dynamic Measurement System (**FDMS**), which determines particulate concentration by continuously weighing particles deposited on a filter: the **Beta-Attenuation Monitor** (BAM) which measures the attenuation of beta rays passing through a paper filter on which particulate matter from sampled air has been collected, and the **Partisol –** a gravimetric sampler that collects daily samples onto a filter for subsequent weighing.

3.3.2 The UK Urban and Industrial Metals Network

The UK Urban and Industrial Metals Network forms the basis of the UK's compliance monitoring for:

- The Air Quality Directive (for lead).
- The 4th Daughter Directive (for arsenic, cadmium and nickel and mercury).

This network monitors a range of metallic elements at urban and industrial sites, using a method equivalent to the CEN standard method[34]. In 2012, it comprised 25 sites, all of which monitored a suite of metals including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), platinum (Pt), vanadium (V) and zinc (Zn).

3.3.3 Non-Automatic Hydrocarbon Network

In this network of 41 sites, ambient concentrations of benzene are measured by the CEN standard method[35], which involves pumping air through an adsorption tube to trap the compound, which is later analysed in a laboratory. This network monitors compliance with the Air Quality Directive's limit value for benzene. All sites in the Non-Automatic Hydrocarbon Network are co-located with AURN sites.

3.3.4 Automatic Hydrocarbon Network

The Air Quality Directive also requires measurement and reporting of ozone precursor substances (29 species), which include volatile organic compounds (VOCs). Annex X (ten) of the Directive provides a list of compounds recommended for measurement. Ozone precursor measurement is carried out by the Automatic Hydrocarbon Network.

Automatic hourly measurements of a range of hydrocarbon species (including all those specified in Annex X of the Directive except formaldehyde and total non-methane hydrocarbons), are made using automated pumped sampling with *in-situ* gas chromatography, at four sites in the UK. The VOCs monitored include benzene, which is covered by the Air Quality Directive as a pollutant in its own right.

Two monitoring sites, at Harwell in Oxfordshire and Auchencorth Moss in Lothian, are also part of the European EMEP programme, an international co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe.

3.3.5 PAH Monitoring Network

The PAH Network monitors compliance with the 4th Daughter Directive, which includes a target value of 1 ng m^{-3} for the annual mean concentration of benzo[a]pyrene as a representative PAH, not to be exceeded after 31st December 2012. This network uses the PM_{10} Digitel sampler. Ambient air is sampled through glass fibre filters and polyurethane foam pads, which capture the PAH compounds for later analysis in a laboratory. During 2012, there were 32 sites in this network.

3.3.6 TOMPS Network

This network monitors a range of toxic organic micropollutants (compounds that are present in the environment at very low concentrations, but are highly toxic and persistent). These include dioxins, dibenzofurans and polychlorinated biphenyls. The TOMPS Network consists of six sites in England and Scotland.

3.3.7 UK Eutrophying and Acidifying Pollutants

The UK Eutrophying and Acidifying Atmospheric Pollutants (UKEAP) network provides information on deposition of eutrophying and 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 UKEAP network is an "umbrella" project covering four groups of sites:

- The UKEAP rural NO_2 diffusion tube network (NO_2Net), which measures NO_2 at 24 rural sites.
- The Acid Gas and Aerosol Network (AGANet) which currently comprises 30 sites in the UK, measuring wet bulk deposition on a fortnightly basis.
- The National Ammonia Monitoring Network (NAMN) which characterizes ammonia and ammonium concentrations using passive samplers at 86 locations.
- The Precipitation Network (PrecipNet) which in 2012 consisted of 39 sites at which the chemical composition of precipitation (i.e. rainwater) is measured. The network allows estimates of wet deposition of sulphur and nitrogen chemicals. Samples are collected fortnightly at all 39 sites and daily at 2 sites.

3.3.8 EMEP

EMEP (European Monitoring and Evaluation Programme) is an EU programme set up by Member States to provide governments with qualified scientific information on air pollutants, under the UNECE Convention on Long-range Transboundary Air Pollution. In the UK there are two EMEP "supersites", at Auchencorth Moss in Lothian (representing the north of the UK) and at Harwell in Oxfordshire (representing the south). A very wide range of measurements are taken at these sites, supplemented by data from other UK networks which are co-located. Monitoring includes:

- Hourly meteorological data.
- Soil and vegetation measurements.
- Metallic elements in PM_{10} and precipitation.
- Deposition of inorganic ions.
- Trace gases (ozone, NO_x and SO_2).
- Black carbon, organic carbon (OC) and elemental carbon (EC).
- Ammonia.
- Daily and hourly PM_{10} and $PM_{2.5}$ mass.
- Volatile Organic Compounds.
- Carbonyls.
- CH_4 and N_2O fluxes.

3.3.9 Particle Concentrations and Numbers

This research-oriented network currently consists of five measurement sites; two in London, two rural sites at Auchencorth Moss and Harwell, and one in Birmingham. Among the pollutants measured are:

- Total particle numbers per cubic centimetre of ambient air.
- Particle numbers in different particle size fractions.
- Major ions in PM_{10}.
- Organic carbon (OC) and elemental carbon (EC).

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

The Air Quality Directive requires that the chemical composition of $PM_{2.5}$ is characterised at background locations in the United Kingdom. Monitoring of the major ions in $PM_{2.5}$ began in 2006 and 2009 at Auchencorth Moss and Harwell, respectively. Measurements of elemental carbon (EC) and organic carbon (OC) began at both stations at the start of 2011. At both stations EC and OC measurements are made using a thermal/optical method involving both reflectance and transmission correction methods. Comparing both correction methods aims to provide valuable understanding of the measurement process for EC and OC.

3.3.10 Black Carbon

Black carbon is fine, dark carbonaceous particulate matter produced from the incomplete combustion of materials containing carbon (such as coal, oil, and biomass such as wood). It is of concern due to health effects, and also as a suspected contributor to climate change.

In 2012 the Black Carbon Network was reorganised to leave 14 sites across the UK, measuring this parameter using an automatic instrument called an aethalometer[36]. The aethalometer measures black carbon directly, using a real-time optical transmission technique. The objectives of the network as set out in the report reviewing the network are as follows:

- To maintain coverage of black carbon measurements across the whole UK;
- To maintain continuity of historic datasets;
- To gather data for epidemiological studies of black carbon and health effects
- To gather information about black carbon PM sources in the UK;
- To assess PM reductions from air quality management interventions;
- To quantify the contribution of wood burning to black carbon and ambient PM in the UK; and
- To gather data to address future policy considerations including black carbon and climate change.

3.3.11 Acid Waters Monitoring

The UK Acid Waters Monitoring Network (AWMN) was set up in 1998 to assess the chemical and biological response of acidified lakes and streams in the UK to the planned reduction in emissions. It provides chemical and biological data on the extent and degree of surface water acidification in the UK uplands, in particular to underpin the science linking acid deposition to water quality and to monitor the response of aquatic ecosystems to reductions in air pollution. The sites making up the network were selected on the basis of acid deposition inputs being the only major sources of pollution, i.e. with no point sources of pollution or direct catchment disturbances other than traditional upland land use practices such as sheep grazing or forestry. There are 23 monitoring sites including 11 lakes and 12 streams across the UK, monitoring a range of parameters and life forms including sediment, water chemistry, fish, invertebrates, and aquatic organisms.

3.3.12 Rural Metals

The Rural Metals (metals deposition mapping) network measures metal concentrations in PM_{10} (at 11 rural sites) and concentrations in rain water (at 14 rural sites). The concentration fields are then combined with the local meteorological data (rainfall etc.) to calculate values for wet deposition (from rain and snow etc.), dry deposition (from dust settling etc.) and cloud deposition (condensation of cloud droplets).

This rural network complements the statutory UK Metals Network (described in section 3.3.2), which predominantly monitors at industrial and urban locations.

3.4 Quality Assurance and Quality Control

Air quality monitoring in the UK is subject to rigorous procedures of validation and ratification. The well-established monitoring networks each have a robust and documented Quality Assurance and Quality Control (QA/QC) programme designed to ensure that measurements meet the defined standards of quality with a stated level of confidence. Essentially, each programme serves to ensure that the data obtained are:

- Representative of ambient concentrations existing in the various areas under investigation.
- Sufficiently accurate and precise to meet specified monitoring objectives.
- Comparable and reproducible. Results must be internally consistent and comparable with international or other accepted standards, if these exist.
- Consistent over time. This is particularly important if long-term trend analysis of the data is to be undertaken.
- Representative over the period of measurement; for most purposes, a yearly data capture rate of not less than 90% is usually required for determining compliance with EU limit values where applicable.
- Consistent with Data Quality Objectives[37]. The uncertainty requirements of the EU Directives are specified as data quality objectives. In the UK, all air quality data meet the data quality requirements of the EU Directives in relation to uncertainty.
- Consistent with methodology guidance defined in EU Directives for relevant pollutants and measurement techniques. The use of tested and approved analysers that conform to Standard Method (or equivalent) requirements and harmonised on-going QA/QC procedures allows a reliable and consistent quantification of the uncertainties associated with measurements of air pollution.

Most UK networks use a system of regular detailed audits of all monitoring equipment at every site. These audits supplement more regular calibrations and filter changes and test all critical parameters of the measuring equipment including, where appropriate, linearity, converter efficiency (in the case of NOx analysers) response time, flow rate etc.

Data ratification is the process of checking and validating the data. Data entered on the Defra Air Information Resource (UK-AIR at http://uk-air.defra.gov.uk) in near real time are provided as provisional data. All these data are then carefully screened and checked via the ratification process. The ratified data then overwrite the provisional data on the website. It should however be noted that there are occasionally circumstances where data which have been flagged as "Ratified" could be subject to further revision. This may be for example where:

- A QA/QC audit has detected a problem which affects data back into an earlier ratification period.
- Long-term analysis has detected an anomaly between expected and measured trends which requires further investigation and possible data correction. This was the case with 2000-2008 gravimetric particulate monitoring data in the UK national network.
- Further research comes to light which indicates that new or tighter QA/QC criteria are required to meet the data quality objectives. This may require review and revision of historical data by applying the new criteria.

Only ratified data are provided to the Commission in compliance with EU Directives.

Further details on the QA/QC procedures appropriate to each network can be obtained from the annual reports of the monitoring networks, and (in the case of the AURN) from the report "QA/QC Procedures for the UK Automatic Urban and Rural Air Quality Monitoring Network (AURN)"[38] available from Defra's air quality web pages.

3.5 Modelling

3.5.1 Why Do Modelling?

The UK's monitoring programmes are supplemented by air quality modelling. There are several benefits of using modelling to complement the monitoring data gathered across the UK national monitoring networks:

- The reduced need for fixed continuous monitoring for compliance with European air quality Directives – freeing up resources and ensuring value for money.
- Coverage of the whole UK rather than specific locations where there is a monitoring site. A monitoring site might not fully represent the wider region in which it is located due to local characteristics such as buildings affecting dispersion, localised or temporary sources.
- Providing a framework within which to assess different air quality scenarios – for example projecting concentrations forward to assess levels in future years, representing potential changes to emissions in order to assess the impact of policy initiatives on air quality.

3.5.2 How the Models Work

The national modelling methodology varies between pollutants. The detailed methodology is explained in separate reports[39],[40] (the latest versions of these can be found in the Library section of Defra's UK-AIR website[41]).

Defra's air quality national modelling assessment for the UK consists of two components:

- Background concentrations – on a 1x1km resolution, representing ambient air quality concentrations at background locations.
- Roadside concentrations – concentrations at the roadside of urban major road links throughout the UK (i.e. motorways and major A-roads). There are approximately 9,000 of these road links.

Roadside concentrations are not modelled for CO, SO_2, ozone, benzo[a]pyrene (BaP) and metals as these are deemed not to have significant traffic-related sources.

The models have been designed to assess compliance at locations defined by the Directives as relevant for air quality assessment.

3.5.3 Background Air Quality

The 1x1 km background maps are made up of several components which are modelled separately and then added together to make the final grid. These individual components (supplemented by some additional components for various pollutants) are:

- Large point sources (e.g. power stations, steel works, oil refineries).
- Small point sources (e.g. boilers in town halls, schools or hospitals, crematoria).
- Distant sources (characterised by the rural background concentration).
- Local area sources (e.g. road traffic, domestic and commercial combustion, agriculture).

In order to ensure that these ambient concentrations from area sources are representative of the real world situation, they are validated against measurements taken from the national networks (including the AURN). After the validation has been completed the large points, small points, distant sources and validated area source components are added together to provide the final background map.

3.5.4 Roadside Air Quality

Roadside concentrations are determined by using a roadside increment model which attempts to estimate the contribution from road traffic sources and adds this on top of the modelled background concentrations discussed above.

For each of the road links that are modelled, there are emissions estimates from the National Atmospheric Emissions Inventory[42] (NAEI) for each pollutant and road traffic counts. A roadside increment is calculated for road links with a roadside monitoring station on them by taking the link's modelled background concentration (from the 1x1 km modelled maps) away from the relevant measured roadside concentration. The emission for the road link is scaled according to annual average daily traffic flow for that link and then this is compared against the roadside increment to establish a relationship. This relationship is then used to scale the link emission for different ranges of traffic flow and added to the modelled background concentration to calculate an estimated roadside concentration.

3.6 Access to Assessment Data

Data from the UK's air quality monitoring networks and annual compliance modelling is available under the Open Government Licence http://www.nationalarchives.gov.uk/doc/open-government-licence/version/2/ from UK-AIR.

Defra has produced a searchable online catalogue of air quality and emissions datasets which allows people to browse the extent of data available and access key metadata. This is available at http://uk-air.defra.gov.uk/data/data-catalogue.

Historical monitoring data can be accessed through the data selector tools in UK-AIR, at http://uk-air.defra.gov.uk/data/. Modelled data from the Pollution Climate Mapping model are available as csv files for download from the modelled air quality data pages at http://uk-air.defra.gov.uk/data/modelling-data or can be accessed through the Ambient Air Quality Interactive Map at http://uk-air.defra.gov.uk/data/gis-mapping - a GIS tool which provides enhanced visualisation capability and access to roadside concentration data.

4 Assessment of Compliance

4.1 Definition of Zones

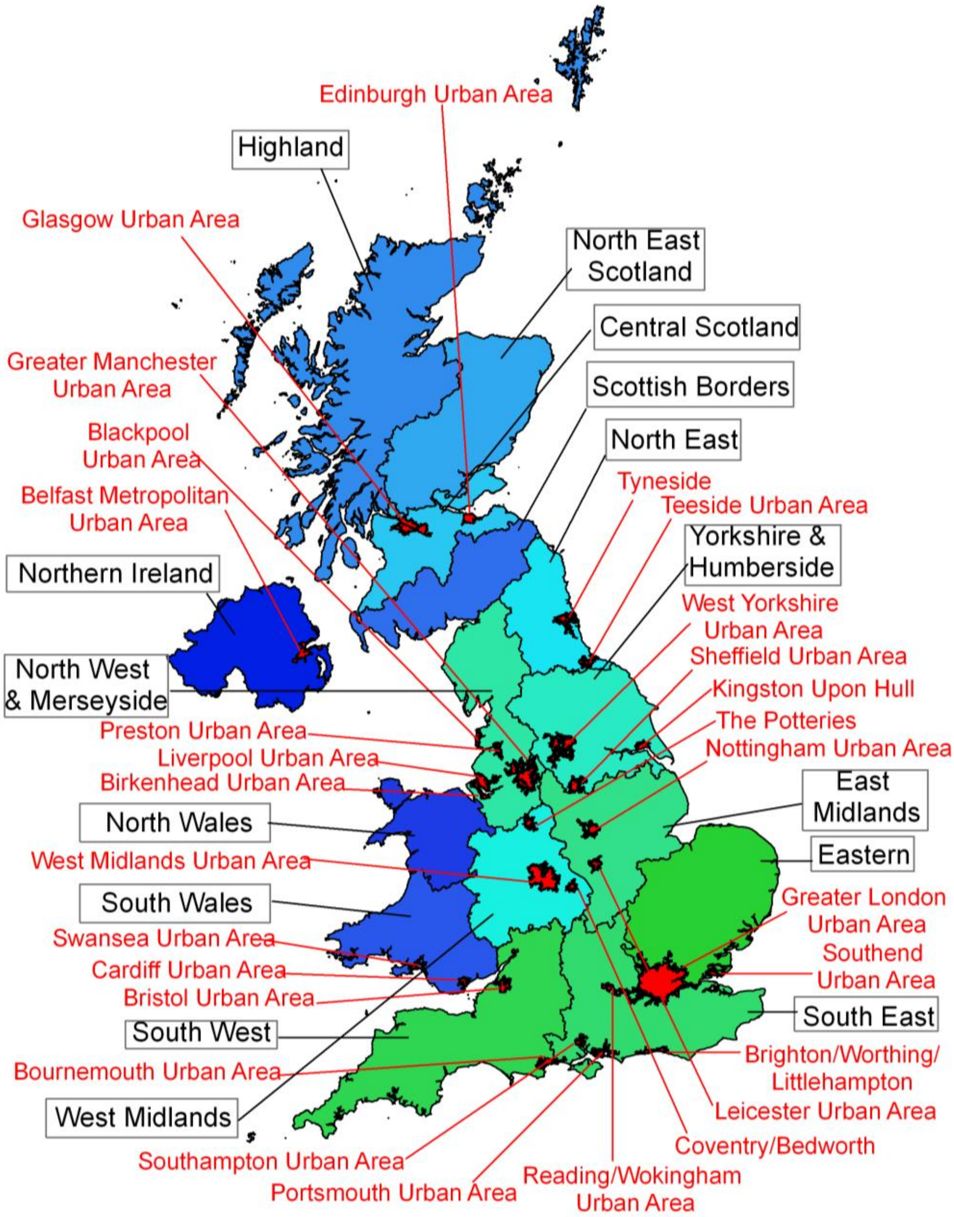
The UK is divided into 43 zones for air quality assessment. There are 28 agglomeration zones (large urban areas) and 15 non-agglomeration zones. Details are included in Form 2 of the Questionnaire (the annual compliance assessment report to the European Commission). Each zone is assigned an identification code. Zones are listed in Table 4-1 and shown in Figure 4-1.

Table 4-1 UK Zones and Agglomerations for Ambient Air Quality Reporting 2012

Zone	Zone code	Ag or Non-ag*
Greater London Urban Area	UK0001	Ag
West Midlands Urban Area	UK0002	Ag
Greater Manchester Urban Area	UK0003	Ag
West Yorkshire Urban Area	UK0004	Ag
Tyneside	UK0005	Ag
Liverpool Urban Area	UK0006	Ag
Sheffield Urban Area	UK0007	Ag
Nottingham Urban Area	UK0008	Ag
Bristol Urban Area	UK0009	Ag
Brighton/Worthing/Littlehampton	UK0010	Ag
Leicester Urban Area	UK0011	Ag
Portsmouth Urban Area	UK0012	Ag
Teesside Urban Area	UK0013	Ag
The Potteries	UK0014	Ag
Bournemouth Urban Area	UK0015	Ag
Reading/Wokingham Urban Area	UK0016	Ag
Coventry/Bedworth	UK0017	Ag
Kingston upon Hull	UK0018	Ag
Southampton Urban Area	UK0019	Ag
Birkenhead Urban Area	UK0020	Ag
Southend Urban Area	UK0021	Ag
Blackpool Urban Area	UK0022	Ag
Preston Urban Area	UK0023	Ag
Glasgow Urban Area	UK0024	Ag
Edinburgh Urban Area	UK0025	Ag
Cardiff Urban Area	UK0026	Ag
Swansea Urban Area	UK0027	Ag
Belfast Metropolitan Urban Area	UK0028	Ag
Eastern	UK0029	Non-ag
South West	UK0030	Non-ag
South East	UK0031	Non-ag
East Midlands	UK0032	Non-ag
North West & Merseyside	UK0033	Non-ag
Yorkshire & Humberside	UK0034	Non-ag
West Midlands	UK0035	Non-ag
North East	UK0036	Non-ag
Central Scotland	UK0037	Non-ag
North East Scotland	UK0038	Non-ag
Highland	UK0039	Non-ag
Scottish Borders	UK0040	Non-ag
South Wales	UK0041	Non-ag
North Wales	UK0042	Non-ag
Northern Ireland	UK0043	Non-ag

Ag = agglomeration zone, Non-ag = non-agglomeration zone

Figure 4-1 UK Zones and Agglomerations for Ambient Air Quality Reporting 2012



Agglomeration zones (red)
Non-agglomeration zones (blue/green)

4.2 Air Quality Assessment for 2012

The air quality assessment for each pollutant is derived from a combination of measured and modelled concentrations. Where both measurements and model results are available the assessment of compliance for each zone is based on the higher concentration of the two.

The results of the air quality assessment submitted to the European Commission are summarised in the tables below. The tables have been completed as follows:

- Where all measurements were within the relevant limit values in 2012, the table shows this as "OK".
- Where a margin of tolerance is applicable, if some or all measurements were above the limit value, but within the limit value plus margin of tolerance, the table shows this as "≤LV +MOT".
- In the above cases, where compliance was determined by modelling or supplementary assessment, this is indicated by "(m)" – i.e. "OK (m)" or "≤LV +MOT (m)" as appropriate.
- Where locations were identified as exceeding a limit value, limit value plus margin of tolerance, target value, long-term objective, this is identified as ">LV", ">LV+MOT", ">TV" or ">LTO" as applicable.
- Where an exceedance was determined by modelling or supplementary assessment, this is indicated by (m), as above.

Zones that complied with the relevant limit values, targets or long-term objectives are shaded blue, while those that did not are shaded red.

Where a time extension has been granted, and a margin of tolerance applies, zones that exceeded the relevant limit value but not the limit value plus margin of tolerance are shaded orange. For ozone, zones that met the relevant target value but not the long-term objective are shaded purple.

The abbreviation "n/a" (not applicable) means that an assessment is not relevant for this zone, such as for the NO_X vegetation critical level in agglomeration zones.

4.2.1 Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe

Sulphur dioxide (SO_2): the results of the air quality assessment for sulphur dioxide are presented in Form 8a of the Questionnaire.

In 2012, all zones and agglomerations within the UK complied with the limit values for 1-hour mean and 24-hour mean SO_2 concentration, set for protection of human health.

All non-agglomeration zones within the UK also complied with the critical levels for annual mean and winter mean SO_2 concentration, set for protection of ecosystems. (These are not applicable to built-up areas).

Nitrogen dioxide (NO_2): the results of the air quality assessment for nitrogen dioxide for each zone are presented in Form 8b of the Questionnaire, and summarised in Table 4-2.

Two zones had locations where the 1-hour limit value (200 µg m^{-3}) was exceeded on more than the permitted 18 occasions during 2012: Greater London Urban Area (UK0001) and the South East (UK0031). Forty-one of the UK's 43 zones and agglomerations complied with the 1-hour mean NO_2 limit value.

Five zones ***met*** the annual mean limit value for NO_2 in 2012:

- Blackpool Urban Area (UK0022)
- Preston Urban Area (UK0023)
- Highland (UK0039)

- Scottish Borders (UK0040)
- Northern Ireland (UK0043).

The remaining 38 zones had locations with measured or modelled annual mean NO_2 concentrations higher than the annual mean limit value (40 µg m^{-3}). The UK has been granted a time extension for compliance with the NO_2 annual limit value in the following ten zones and agglomerations;

- Nottingham Urban Area,
- Leicester Urban Area,
- Portsmouth Urban Area,
- Reading/Wokingham Urban Area,
- Southend Urban Area,
- Edinburgh Urban Area,
- Cardiff Urban Area,
- Central Scotland,
- North Wales and
- Northern Ireland

This extension applies until 1st January 2015 for all but Reading/Wokingham Urban Area (where it applied until 1st January 2013) and Northern Ireland zone (where it applies until 1st January 2014).

The following four zones exceeded the annual mean limit value, but were within the annual mean limit value plus margin of tolerance in 2012:

- Reading/Wokingham Urban Area,
- Southend Urban Area,
- Edinburgh Urban Area, and
- Central Scotland.

Therefore, a total of nine zones and agglomerations were compliant either with the annual mean NO_2 limit value, or where applicable the annual mean limit value plus margin of tolerance. The remaining 34 zones and agglomerations exceeded the annual mean limit value, or annual mean limit value plus margin of tolerance.

All non-agglomeration zones within the UK complied with the critical level for annual mean NO_X concentration, set for protection of vegetation.

PM_{10} Particulate matter: the results of the air quality assessment for PM_{10} for each zone are presented in Form 8c of the Questionnaire, and summarised in Table 4-3.

There were no longer any time extensions in place for PM_{10} during 2012. The former time extension for compliance with the 24-hour PM_{10} limit value in the Greater London Urban Area (UK0001) expired on 10th June 2011.

Under the Air Quality Directive, Member States are required to inform the Commission where exceedances of PM_{10} limit values are due to natural sources, and where this is the case, the exceedance does not count as non compliance. The Greater London zone (UK001) exceeded the daily limit value (50 µg m^{-3}) in 2012 due to natural sources. Following subtraction of natural source contribution, the number of exceedances was reduced from 46 to 35 days. Therefore, all zones were compliant with the daily mean limit value. *In Table 4-3, natural source contribution has only been subtracted for zone UK0001.*

All zones and agglomerations complied with the annual mean limit value of 40 µg m^{-3} for PM_{10}.

$PM_{2.5}$ Particulate matter: the results of the air quality assessment for $PM_{2.5}$ for each zone are presented in Form 9c of the Questionnaire, and summarised in Table 4-4. This table includes the target value (25 µg m^{-3} to be achieved by 1st Jan 2010), the Stage 1 limit value (25 µg m^{-3} to be achieved by 1st Jan 2015) and the Stage 2 limit value (20 µg m^{-3} to be achieved by 1st Jan 2020). All three apply to the calendar year mean.

Natural contributions have been removed from the $PM_{2.5}$ exceedance listed in Table 4-4. Exceedance of limit values of $PM_{2.5}$ due to natural events (1999/30/EC Article 5(4)) or natural contributions (2008/50/EC Article 20) are as follows:

- Measured exceedance of the Stage 2 limit value in zone UK0001 (site: London Marylebone Road, annual mean: 21 μg m^{-3}). This remains even if the natural contribution (sea salt) is subtracted.

Natural contributions have *only* been removed where there was an exceedance, i.e. only for London and only for the Stage 2 limit value.

Annual mean concentrations of $PM_{2.5}$ were within the target value of 25 μg m^{-3} in all zones and agglomerations.

Under the Air Quality Directive, Member States will be required to achieve a national exposure reduction target for $PM_{2.5}$, over the period 2010 to 2020. This is based on the Average Exposure Indicator statistic. The Average Exposure Indicator (AEI) for the UK is calculated as follows: the arithmetic mean $PM_{2.5}$ concentration at appropriate UK background urban sites only is calculated for three consecutive calendar years, and the mean of these values taken as the AEI.

The AEI for the reference year (2010) was used to determine the National Exposure Reduction Target (NERT), to be achieved by 2020 (see Annex XIV of the Air Quality Directive). The UK's reference year AEI was 13 μg m^{-3}; on this basis, the Air Quality Directive sets an exposure reduction target of 15%. (The detailed methodology and results of this calculation are presented in Defra's technical report on UK air quality assessment[43].)

The AEI for the reference year 2015 is set at 20 μg m^{-3} as an Exposure Concentration Obligation (ECO) in the Air Quality Directive. The UK already meets this obligation. There are no obligations or target values for the years *between* 2010, 2015 and 2020, but the running AEIs for these intervening years give an indication of progress towards the 2020 target.

The running year AEI for 2012 was calculated as follows:

- 2010: 13 μg m^{-3}
- 2011: 14 μg m^{-3}
- 2012: 12 μg m^{-3}.

The mean of these three values (to the nearest integer) is 13 μg m^{-3}.

Carbon monoxide (CO), benzene and lead: the results of the air quality assessment for lead, benzene and CO are presented in Forms 8d, 8e and 8f of the Questionnaire respectively. All zones and agglomerations were compliant with the limit values for these three pollutants in 2012. The 2012 compliance assessment for CO was based on objective estimation (explained in Defra's technical report on UK air quality assessment[43]) underpinned by NAEI emission trends, AURN measurement trends and historical modelling.

Ozone: the results of the air quality assessment for ozone for each zone are presented in Form 9a of the Questionnaire, and summarised in Table 4-5.

For ozone, there is a target value based on the maximum daily 8-hour mean. All 43 zones and agglomerations were compliant with this target value. There is also a long-term objective for protection of human health, based on the maximum daily 8-hour mean. Forty-one of the 43 zones and agglomerations were *above* the long-term objective (LTO) for health, the exceptions being Edinburgh Urban Area (UK0025) and North East Scotland (UK0038).

There is also a target value based on the AOT40 statistic[1]. The AOT40 statistic (expressed in μg m^{-3} .hours) is the sum of the difference between hourly concentrations greater than 80 μg m^{-3} (= 40 ppb) and 80 μg m^{-3} over a given period using only the one-hour values measured between 0800 and 2000 Central European Time each day. All 43 zones and agglomerations met the target value based on the AOT40 statistic. There is also a long-term objective, for protection of vegetation, based on this statistic. Three zones were above the long-term objective for vegetation: these were the South West, the North East and Yorkshire and Humberside.

Table 4-2 Results of Air Quality Assessment for Nitrogen Dioxide in 2012

Zone	Zone code	NO_2 LV for health (1hr mean)	NO_2 LV for health (annual mean)	NOx critical level for vegetation (annual mean)
Greater London Urban Area	UK0001	> LV	> LV	n/a
West Midlands Urban Area	UK0002	OK	> LV	n/a
Greater Manchester Urban Area	UK0003	OK	> LV	n/a
West Yorkshire Urban Area	UK0004	OK	> LV	n/a
Tyneside	UK0005	OK	> LV	n/a
Liverpool Urban Area	UK0006	OK	> LV (m)	n/a
Sheffield Urban Area	UK0007	OK	> LV (m)	n/a
Nottingham Urban Area *	UK0008	OK	> LV + MOT (m)	n/a
Bristol Urban Area	UK0009	OK	> LV (m)	n/a
Brighton/Worthing/Littlehampton	UK0010	OK	> LV (m)	n/a
Leicester Urban Area *	UK0011	OK	> LV + MOT (m)	n/a
Portsmouth Urban Area *	UK0012	OK	> LV + MOT (m)	n/a
Teesside Urban Area	UK0013	OK	> LV (m)	n/a
The Potteries	UK0014	OK	> LV (m)	n/a
Bournemouth Urban Area	UK0015	OK	> LV (m)	n/a
Reading/Wokingham Urban Area *	UK0016	OK	≤ LV + MOT (m)	n/a
Coventry/Bedworth	UK0017	OK	> LV (m)	n/a
Kingston upon Hull	UK0018	OK	> LV (m)	n/a
Southampton Urban Area	UK0019	OK	> LV (m)	n/a
Birkenhead Urban Area	UK0020	OK (m)	> LV (m)	n/a
Southend Urban Area *	UK0021	OK (m)	≤ LV + MOT (m)	n/a
Blackpool Urban Area	UK0022	OK	OK	n/a
Preston Urban Area	UK0023	OK	OK	n/a
Glasgow Urban Area	UK0024	OK	> LV	n/a
Edinburgh Urban Area *	UK0025	OK	≤ LV + MOT (m)	n/a
Cardiff Urban Area *	UK0026	OK	> LV + MOT (m)	n/a
Swansea Urban Area	UK0027	OK	> LV (m)	n/a
Belfast Urban Area	UK0028	OK	> LV (m)	n/a
Eastern	UK0029	OK	> LV (m)	OK
South West	UK0030	OK	> LV	OK
South East	UK0031	> LV	> LV	OK
East Midlands	UK0032	OK	> LV	OK
North West & Merseyside	UK0033	OK	> LV (m)	OK (m)
Yorkshire & Humberside	UK0034	OK	> LV (m)	OK
West Midlands	UK0035	OK	> LV (m)	OK (m)
North East	UK0036	OK	> LV (m)	OK (m)
Central Scotland *	UK0037	OK	≤ LV + MOT (m)	OK (m)
North East Scotland	UK0038	OK	> LV	OK (m)
Highland	UK0039	OK	OK	OK (m)
Scottish Borders	UK0040	OK	OK	OK
South Wales	UK0041	OK	> LV (m)	OK
North Wales *	UK0042	OK	> LV + MOT (m)	OK
Northern Ireland *	UK0043	OK	OK	OK (m)

LV = limit value, MOT = margin of tolerance, (m) indicates that the compliance or exceedance was determined by modelling.

Asterisk (*) indicates a time extension granted.

Table 4-3 Results of Air Quality Assessment for PM_{10} in 2012 (after subtraction of contribution from natural sources where applicable).

Zone	Zone code	PM_{10} LV (daily mean)	PM_{10} LV (annual mean)
Greater London Urban Area	UK0001	OK (m)	OK
West Midlands Urban Area	UK0002	OK	OK
Greater Manchester Urban Area	UK0003	OK	OK
West Yorkshire Urban Area	UK0004	OK	OK
Tyneside	UK0005	OK	OK
Liverpool Urban Area	UK0006	OK	OK
Sheffield Urban Area	UK0007	OK	OK
Nottingham Urban Area	UK0008	OK (m)	OK (m)
Bristol Urban Area	UK0009	OK	OK
Brighton/Worthing/Littlehampton	UK0010	OK (m)	OK (m)
Leicester Urban Area	UK0011	OK	OK
Portsmouth Urban Area	UK0012	OK	OK
Teesside Urban Area	UK0013	OK	OK
The Potteries	UK0014	OK	OK
Bournemouth Urban Area	UK0015	OK (m)	OK (m)
Reading/Wokingham Urban Area	UK0016	OK	OK
Coventry/Bedworth	UK0017	OK (m)	OK (m)
Kingston upon Hull	UK0018	OK	OK
Southampton Urban Area	UK0019	OK	OK
Birkenhead Urban Area	UK0020	OK (m)	OK (m)
Southend Urban Area	UK0021	OK (m)	OK (m)
Blackpool Urban Area	UK0022	OK (m)	OK (m)
Preston Urban Area	UK0023	OK (m)	OK (m)
Glasgow Urban Area	UK0024	OK (m)	OK (m)
Edinburgh Urban Area	UK0025	OK (m)	OK (m)
Cardiff Urban Area	UK0026	OK	OK
Swansea Urban Area	UK0027	OK	OK
Belfast Urban Area	UK0028	OK	OK
Eastern	UK0029	OK	OK
South West	UK0030	OK	OK
South East	UK0031	OK	OK
East Midlands	UK0032	OK	OK
North West & Merseyside	UK0033	OK	OK
Yorkshire & Humberside	UK0034	OK	OK
West Midlands	UK0035	OK	OK
North East	UK0036	OK	OK
Central Scotland	UK0037	OK	OK
North East Scotland	UK0038	OK	OK
Highland	UK0039	OK	OK
Scottish Borders	UK0040	OK (m)	OK (m)
South Wales	UK0041	OK	OK
North Wales	UK0042	OK	OK
Northern Ireland	UK0043	OK	OK

Prior to the subtraction of natural source contribution Greater London (UK0001) exceeded the daily mean limit value on more than the permitted 35 occasions (based upon the modelling assessment only). However, subtraction of the contribution from natural sources reduced the number of exceedances of this limit value from 46 to 35. Natural sources have only been subtracted for zone UK0001 in this table and only for the daily mean limit value.

LV = limit value, (m) indicates that the compliance or exceedance was determined by modelling.

Table 4-4 Results of Air Quality Assessment for $PM_{2.5}$ in 2012 (after subtraction of contribution from natural sources where applicable).

Zone	Zone code	$PM_{2.5}$ target value (annual mean for 1st Jan 2010)	$PM_{2.5}$ Stage 1 limit value (annual mean, for 1st Jan 2015)	$PM_{2.5}$ Stage 2 limit value (annual mean, for 1st Jan 2020)
Greater London Urban Area	UK0001	OK	OK	> LV
West Midlands Urban Area	UK0002	OK	OK	OK
Greater Manchester Urban Area	UK0003	OK	OK	OK
West Yorkshire Urban Area	UK0004	OK	OK	OK
Tyneside	UK0005	OK	OK	OK
Liverpool Urban Area	UK0006	OK	OK	OK
Sheffield Urban Area	UK0007	OK	OK	OK
Nottingham Urban Area	UK0008	OK	OK	OK
Bristol Urban Area	UK0009	OK	OK	OK
Brighton/Worthing/Littlehampton	UK0010	OK	OK	OK
Leicester Urban Area	UK0011	OK	OK	OK
Portsmouth Urban Area	UK0012	OK	OK	OK
Teesside Urban Area	UK0013	OK	OK	OK
The Potteries	UK0014	OK	OK	OK
Bournemouth Urban Area	UK0015	OK	OK	OK
Reading/Wokingham Urban Area	UK0016	OK	OK	OK
Coventry/Bedworth	UK0017	OK (m)	OK (m)	OK (m)
Kingston upon Hull	UK0018	OK	OK	OK
Southampton Urban Area	UK0019	OK	OK	OK
Birkenhead Urban Area	UK0020	OK	OK	OK
Southend Urban Area	UK0021	OK (m)	OK (m)	OK (m)
Blackpool Urban Area	UK0022	OK (m)	OK (m)	OK (m)
Preston Urban Area	UK0023	OK	OK	OK
Glasgow Urban Area	UK0024	OK	OK	OK
Edinburgh Urban Area	UK0025	OK (m)	OK (m)	OK (m)
Cardiff Urban Area	UK0026	OK (m)	OK (m)	OK (m)
Swansea Urban Area	UK0027	OK	OK	OK
Belfast Urban Area	UK0028	OK	OK	OK
Eastern	UK0029	OK	OK	OK
South West	UK0030	OK (m)	OK (m)	OK (m)
South East	UK0031	OK	OK	OK
East Midlands	UK0032	OK	OK	OK
North West & Merseyside	UK0033	OK	OK	OK
Yorkshire & Humberside	UK0034	OK	OK	OK
West Midlands	UK0035	OK	OK	OK
North East	UK0036	OK	OK	OK
Central Scotland	UK0037	OK	OK	OK
North East Scotland	UK0038	OK	OK	OK
Highland	UK0039	OK	OK	OK
Scottish Borders	UK0040	OK (m)	OK (m)	OK (m)
South Wales	UK0041	OK	OK	OK
North Wales	UK0042	OK	OK	OK
Northern Ireland	UK0043	OK	OK	OK

Prior to subtraction of natural source contribution, the Greater London Urban Area (UK0001) exceeded the Stage 2 limit value (to be met by 1st Jan 2020). The exceedance of the Stage 2 limit value remained after the subtraction of the natural $PM_{2.5}$ contribution. Natural sources have only been subtracted for zone UK0001 in this table, and only for the Stage 2 limit value.

LV = limit value, (m) indicates that the compliance or exceedance was determined by modelling.

Table 4-5 Results of Air Quality Assessment for Ozone in 2012

Zone	Zone code	O_3 TV and LTO for health (8hr mean)	O_3 TV and LTO for vegetation (AOT40)
Greater London Urban Area	UK0001	Met TV, > LTO	OK
West Midlands Urban Area	UK0002	Met TV, > LTO	OK
Greater Manchester Urban Area	UK0003	Met TV, > LTO	OK
West Yorkshire Urban Area	UK0004	Met TV, > LTO	OK
Tyneside	UK0005	Met TV, > LTO (m)	OK
Liverpool Urban Area	UK0006	Met TV, > LTO (m)	OK
Sheffield Urban Area	UK0007	Met TV, > LTO	OK
Nottingham Urban Area	UK0008	Met TV, > LTO	OK
Bristol Urban Area	UK0009	Met TV, > LTO	OK
Brighton/Worthing/Littlehampton	UK0010	Met TV, > LTO	OK
Leicester Urban Area	UK0011	Met TV, > LTO (m)	OK
Portsmouth Urban Area	UK0012	Met TV, > LTO	OK
Teesside Urban Area	UK0013	Met TV, > LTO (m)	OK
The Potteries	UK0014	Met TV, > LTO	OK
Bournemouth Urban Area	UK0015	Met TV, > LTO	OK
Reading/Wokingham Urban Area	UK0016	Met TV, > LTO	OK
Coventry/Bedworth	UK0017	Met TV, > LTO	OK
Kingston upon Hull	UK0018	Met TV, > LTO (m)	OK
Southampton Urban Area	UK0019	Met TV, > LTO	OK
Birkenhead Urban Area	UK0020	Met TV, > LTO (m)	OK
Southend Urban Area	UK0021	Met TV, > LTO	OK (m)
Blackpool Urban Area	UK0022	Met TV, > LTO	OK
Preston Urban Area	UK0023	Met TV, > LTO	OK
Glasgow Urban Area	UK0024	Met TV, > LTO (m)	OK
Edinburgh Urban Area	UK0025	OK	OK
Cardiff Urban Area	UK0026	Met TV, > LTO	OK
Swansea Urban Area	UK0027	Met TV, > LTO	OK
Belfast Urban Area	UK0028	Met TV, > LTO (m)	OK
Eastern	UK0029	Met TV, > LTO	OK
South West	UK0030	Met TV, > LTO	Met TV, > LTO
South East	UK0031	Met TV, > LTO	OK
East Midlands	UK0032	Met TV, > LTO	OK
North West & Merseyside	UK0033	Met TV, > LTO	OK
Yorkshire & Humberside	UK0034	Met TV, > LTO	Met TV, > LTO
West Midlands	UK0035	Met TV, > LTO	OK
North East	UK0036	Met TV, > LTO (m)	Met TV, > LTO (m)
Central Scotland	UK0037	Met TV, > LTO (m)	OK
North East Scotland	UK0038	OK	OK
Highland	UK0039	Met TV, > LTO	OK
Scottish Borders	UK0040	Met TV, > LTO	OK
South Wales	UK0041	Met TV, > LTO	OK
North Wales	UK0042	Met TV, > LTO	OK
Northern Ireland	UK0043	Met TV, > LTO	OK

TV = target value, LTO = long-term objective, (m) indicates that the compliance or exceedance was determined by modelling.

In 2012 there were two measured exceedances of the ozone information thresholds and no exceedances of any of the alert threshold. The information threshold exceedances are detailed in Table 4-6.

Table 4-6 Measured Exceedances of the Ozone Information Threshold Value

Site name	Zone code	Number of 1-hour exceedances of information threshold	Maximum 1-hour concentration (μg m^{-3})
London N. Kensington	UK0001	2	186
Charlton Mackrell	UK0030	1	182

4.2.2 Fourth Daughter Directive 2004/107/EC

The results of the air quality assessment for arsenic (As), cadmium (Cd), nickel (Ni) and benzo[a]pyrene (B[a]P) for each zone are presented in Form 9b of the Questionnaire, and illustrated in Table 4-7.

All zones and agglomerations met the target values for arsenic and cadmium. Two zones (Swansea Urban Area and the South Wales zone) exceeded the target value for nickel. In both these zones, the exceedance has been attributed to industrial sources.

Concentrations of B[a]P were above the target value in eight zones (Teesside Urban Area, Swansea Urban Area, Belfast Urban Area, Yorkshire and Humberside, the North East, South Wales, North Wales and Northern Ireland). In Belfast Urban Area, Northern Ireland and North Wales, the exceedance of the target value is attributed to the relatively high level of domestic coal and solid fuel use in these zones. In Teesside, Swansea and the North East, the exceedance is attributed to emissions from industrial sources. In Yorkshire and Humberside and North Wales, the exceedances are attributed to a combination of industrial sources and domestic solid fuel use. All the remaining 35 zones were compliant with the target value for B[a]P, as shown in Table 4-7.

Table 4-7 Results of Air Quality Assessment for As, Cd, Ni and benzo[a]pyrene in 2012

Zone	Zone code	As TV	Cd TV	Ni TV	B[a]P TV
Greater London Urban Area	UK0001	OK	OK	OK	OK
West Midlands Urban Area	UK0002	OK	OK	OK	OK
Greater Manchester Urban Area	UK0003	OK	OK	OK	OK
West Yorkshire Urban Area	UK0004	OK (m)	OK (m)	OK (m)	OK
Tyneside	UK0005	OK (m)	OK (m)	OK (m)	OK
Liverpool Urban Area	UK0006	OK (m)	OK (m)	OK (m)	OK
Sheffield Urban Area	UK0007	OK	OK	OK	OK (m)
Nottingham Urban Area	UK0008	OK (m)	OK (m)	OK (m)	OK (m)
Bristol Urban Area	UK0009	OK (m)	OK (m)	OK (m)	OK (m)
Brighton/Worthing/ Littlehampton	UK0010	OK (m)	OK (m)	OK (m)	OK
Leicester Urban Area	UK0011	OK (m)	OK (m)	OK (m)	OK (m)
Portsmouth Urban Area	UK0012	OK (m)	OK (m)	OK (m)	OK (m)
Teesside Urban Area	UK0013	OK (m)	OK (m)	OK (m)	> TV (m)
The Potteries	UK0014	OK (m)	OK (m)	OK (m)	OK (m)
Bournemouth Urban Area	UK0015	OK (m)	OK (m)	OK (m)	OK (m)
Reading/Wokingham Urban Area	UK0016	OK (m)	OK (m)	OK (m)	OK (m)
Coventry/Bedworth	UK0017	OK (m)	OK (m)	OK (m)	OK (m)
Kingston upon Hull	UK0018	OK (m)	OK (m)	OK (m)	OK (m)
Southampton Urban Area	UK0019	OK (m)	OK (m)	OK (m)	OK (m)
Birkenhead Urban Area	UK0020	OK (m)	OK (m)	OK (m)	OK (m)
Southend Urban Area	UK0021	OK (m)	OK (m)	OK (m)	OK (m)
Blackpool Urban Area	UK0022	OK (m)	OK (m)	OK (m)	OK (m)
Preston Urban Area	UK0023	OK (m)	OK (m)	OK (m)	OK (m)
Glasgow Urban Area	UK0024	OK	OK	OK	OK (m)
Edinburgh Urban Area	UK0025	OK (m)	OK (m)	OK (m)	OK
Cardiff Urban Area	UK0026	OK	OK	OK	OK
Swansea Urban Area	UK0027	OK	OK	> TV	> TV (m)
Belfast Urban Area	UK0028	OK	OK	OK	> TV (m)
Eastern	UK0029	OK	OK	OK	OK
South West	UK0030	OK	OK	OK	OK (m)
South East	UK0031	OK	OK	OK	OK
East Midlands	UK0032	OK	OK	OK	OK
North West & Merseyside	UK0033	OK	OK	OK	OK
Yorkshire & Humberside	UK0034	OK	OK	OK	> TV
West Midlands	UK0035	OK (m)	OK (m)	OK (m)	OK (m)
North East	UK0036	OK	OK	OK	> TV (m)
Central Scotland	UK0037	OK	OK	OK	OK
North East Scotland	UK0038	OK	OK	OK	OK (m)
Highland	UK0039	OK (m)	OK (m)	OK (m)	OK
Scottish Borders	UK0040	OK	OK	OK	OK (m)
South Wales	UK0041	OK (m)	OK (m)	> TV (m)	> TV (m)
North Wales	UK0042	OK (m)	OK (m)	OK (m)	> TV (m)
Northern Ireland	UK0043	OK (m)	OK (m)	OK (m)	> TV (m)

TV = Target Value, (m) indicates that the compliance or exceedance was determined by modelling.

Total deposition rates of arsenic, cadmium, nickel, mercury and PAH compounds (in µg m^{-2} per day), at two rural sites (representing the north and the south of the UK), are also reported in the Questionnnaire (Form 16d). Table 4-8 shows the mean total deposition rates for these species reported for 2012 at the two rural sites where they are measured. There are no limit values or target values for deposition.

Table 4-8 Annual Mean Daily Deposition Rates of 4th Daughter Directive Pollutants

Site	Zone	As $\mu g m^{-2} day^{-1}$	Cd $\mu g m^{-2} day^{-1}$	Ni $\mu g m^{-2} day^{-1}$	B[a]P $\mu g m^{-2} day^{-1}$
Harwell	South East	0.15	0.021	0.37	0.036
Auchencorth Moss	Central Scotland	0.14	0.016	0.58	0.050

4.3 Comparison with Previous Years

Table 4-9 to Table 4-13 summarise the results of the air quality assessment for 2012 and provide a comparison with the results of the assessments carried out in previous years since 2008 (the year in which the Air Quality Directive came into force). For information on compliance with the 1st and 2nd Daughter Directives in earlier years, please see previous reports in this series. There are no longer any margins of tolerance (MOT) in force except where granted by a time extension. Table 4-9 shows the number of zones exceeding the limit value itself: where some of these were within the limit value plus an agreed MOT (and therefore compliant) this is explained in the table or its footnotes.

Table 4-9 (Part 1 of 2) Exceedances of Limit Values for Air Quality Directive

Pollutant	Averaging time	2008	2009	2010	2011	2012
SO_2	1-hour	None	None	None	None	None
SO_2	24-hour	None	None	None	None	None
SO_2	Annual[i]	None	None	None	None	None
SO_2	Winter[i]	None	None	None	None	None
NO_2	1-hour[ii]	3 zones measured (London, Glasgow, NE Scotland)	2 zones measured (London, Glasgow)	3 zones measured (London, Teesside, Glasgow)	3 zones measured (London, Glasgow, South East)	2 zones measured (London, South East)
NO_2	Annual	40 zones (10 measured + 30 modelled)	40 zones (9 measured + 31 modelled)	40 zones (11 measured + 29 modelled)	40 zones (8 measured, + 32 modelled)[iii]	38 zones (10 measured + 28 modelled)[iv]
NO_x	Annual[i]	None	None	None	None	None

[i] Applies to vegetation and ecosystem areas only. Critical Levels are already in force, no MOT.
[ii] No modelling for 1-hour LV.
[iii] Five of the 40 zones that exceeded the annual mean NO_2 LV in 2011 were covered by time extensions and were within the LV+ MOT.
[iv] Four of the 38 zones that exceeded the annual mean NO_2 LV in 2012 were covered by time extensions and were within the LV+ MOT; an additional five zones had time extensions but exceeded the MOT.

Table 4-9 is continued on next page.

Table 4-9 (Part 2 of 2) Exceedances of Limit Values for Air Quality Directive

Pollutant	Averaging time	2008	2009	2010	2011	2012
PM_{10}	Daily	2 zones (1 measured + 1 modelled) *1 zone measured after subtraction of natural contribution*	3 zones (1 measured + 2 modelled) *1 zone modelled after subtraction of natural contribution*	1 (modelled, after subtraction of natural contribution: time ext. granted.)	1 (modelled, after subtraction of natural contribution)[v]	None (after subtraction of natural contribution. No time extension.)
PM_{10}	Annual	None	None	None	None	None
Lead	Annual	None	None	None	None	None
Benzene	Annual	None	None	None	None	None
CO	8-hour	None	None	None	None	None

[v] The one zone that exceeded the daily mean PM_{10} limit value more than the permitted 35 times in 2011 was covered by a time extension, and was within the LV+MOT.

The UK has been compliant with the limit values for both lead and CO since 2003, and for benzene since 2007: these limit values are the same as those contained in the 1st and 2nd Daughter Directives, which the Air Quality Directive superseded.

Table 4-10 Exceedances of Air Quality Directive Target Values for Ozone (Health)

Pollutant	Averaging time	2008	2009	2010	2011	2012
O_3	8-hour	1 zone measured (Eastern)	None	None	None	None
O_3	AOT40	None	None	None	None	None

Table 4-11 Exceedances of Air Quality Directive Long Term Objectives for Ozone

Pollutant	Averaging time	2008	2009	2010	2011	2012
O_3	8-hour	43 zones (35 measured + 8 modelled)	39 zones (25 measured + 14 modelled)	41 zones (19 measured + 22 modelled)	43 zones (31 measured + 12 modelled)	41 zones (31 measured and 10 modelled)
O_3	AOT40	41 zones (25 measured + 16 modelled)	10 zones (8 measured + 2 modelled)	6 zones (3 measured + 3 modelled)	3 zones (2 measured + 1 modelled)	3 zones (2 measured + 1 modelled)

Table 4-12 Exceedances of 4th Daughter Directive Target Values

Pollutant	Averaging time	2007	2008	2009	2010	2011	2012
As	Annual	None	None	None	None	None	None
Cd	Annual	None	None	None	None	None	None
Ni	Annual	1 zone (Swansea Urban area, measured but low data capture, so reported as m)	2 zones modelled (Swansea, S Wales, measured at non-network site, so reported as m)	2 zones modelled (Swansea, S Wales)	2 zones modelled (Swansea, S Wales)	2 zones, 1 measured 1 modelled (Swansea, S Wales)	2 zones, 1 measured 1 modelled (Swansea, S Wales)
B[a]P	Annual	1 zone measured (Yorkshire & Humberside)	6 zones, (3 zones measured Yorkshire & Humberside, Teesside, N Ireland + 3 zones modelled Swansea, S Wales, Belfast)	6 zones, (2 zones measured Yorkshire & Humberside, N Ireland + 4 zones modelled Teesside, Swansea, North East, S Wales)	8 zones, (2 zones measured: Yorkshire & Humberside, N Ireland + 6 zones modelled; Teesside, Belfast, W Midlands, North East, S Wales, N Wales.)	7 zones (2 measured; Yorkshire & Humberside, N Ireland, + 5 modelled; Teesside, Swansea, Belfast, North East, South Wales)	8 zones (1 measured; Yorkshire & Humberside, + 7 modelled; Teesside, Swansea, Belfast, the North East, South Wales, North Wales, Northern Ireland.)

Table 4-13 Exceedances of Ambient Air Quality Directive Target Value for $PM_{2.5}$

Pollutant	Averaging time	2009	2010	2011	2012
$PM_{2.5}$	Annual	None	None	None	None

5 Spatial Variation and Changes Over Time

This section looks at the spatial distribution of pollutants across the UK, based upon the modelled maps of ambient pollutant concentration discussed in section 3.5 of this report, "Modelling". In the case of traffic-related pollutants such as NO_2, both roadside and background concentrations are discussed.

For each pollutant, this section also discusses how ambient concentrations have changed over time, using data from the relevant ambient air quality monitoring networks: the Automatic Urban and Rural Network (AURN), the Automatic Hydrocarbon Network, the Non-Automatic Hydrocarbon Network, the Urban and Industrial Metals Network (and its predecessors), and the PAH Network.

These changes over time are compared to changes in estimated total UK emissions where appropriate. Estimated UK emission data are taken from the National Atmospheric Emissions Inventory (NAEI) website at http://naei.defra.gov.uk/index.php. (Please note that the most recent year for which NAEI emission estimates are available is 2011).

In all the maps in this section, the legends show the upper limit of the concentration band – for example, "30-40" means greater than 30 µg m^{-3}, less than or equal to 40 µg m^{-3}.

5.1 Sulphur Dioxide

5.1.1 SO_2: Spatial Distribution in the UK

Figure 5-1 shows how the 99.73rd percentile[a] of hourly mean sulphur dioxide concentration varied across the UK during 2012. This statistic corresponds approximately to the 25th highest hourly mean (in the case of a full year's data); if greater than the hourly mean limit value it indicates that the limit value was exceeded on more than the 24 permitted occasions. There were no areas in which this statistic exceeded the limit value of 350 µg m^{-3}.

Figure 5-2 shows the 99.18th percentile of 24-hour means (which corresponds to the 4th highest day in a full year). If greater than the 24-hourly mean limit value of 125 µg m^{-3}, this indicates that there were more than the permitted three exceedances in the year. There were no areas of the UK where this was the case in 2012.

[a] Where the Directive allows exceedances on a number of occasions (i.e. limit value not to be exceeded more than a specified number of times), percentiles are used to illustrate this.

Figure 5-1 99.73rd percentile of 1-hour mean SO_2 concentration, 2012 (µg m^{-3})

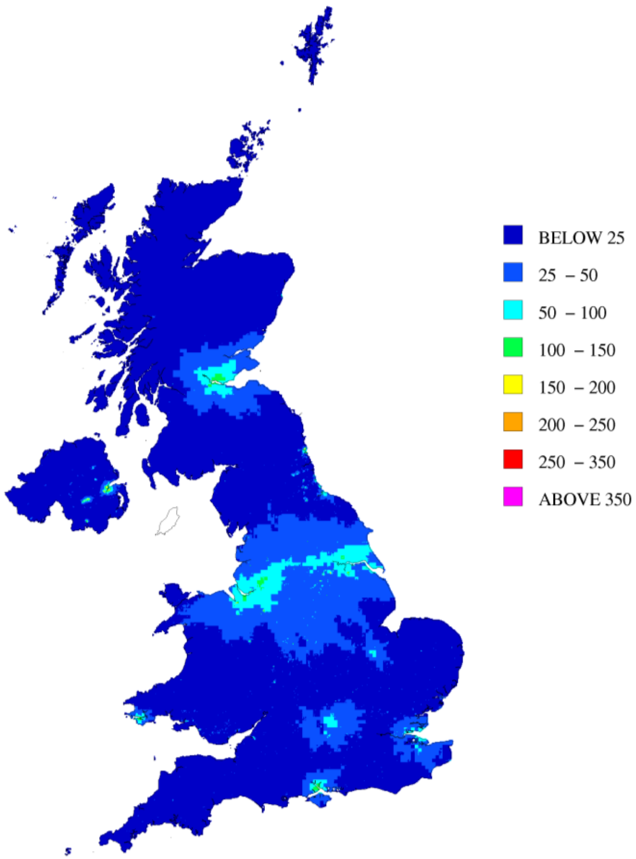
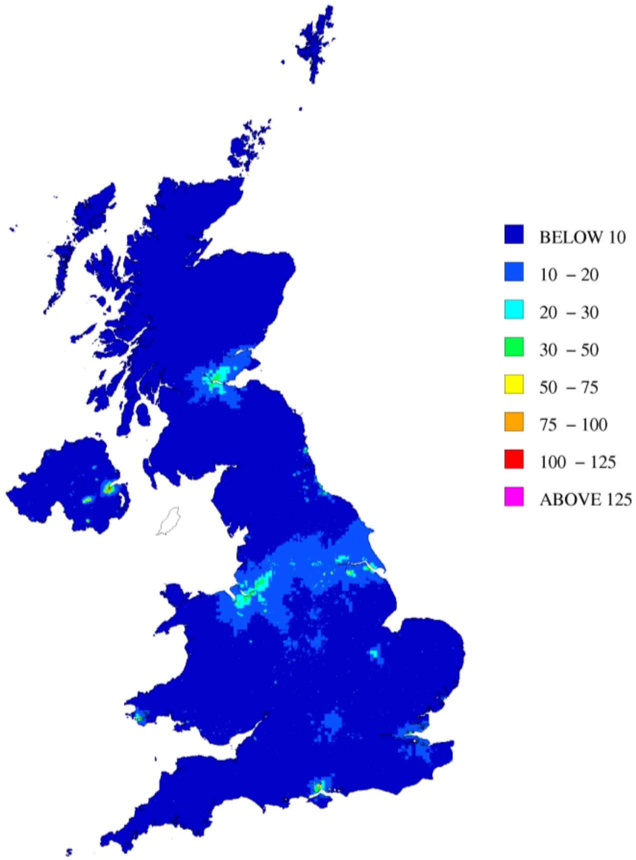


Figure 5-2 99.18th percentile of 24-hour mean SO_2 concentration, 2012 (µg m^{-3})



5.1.2 SO_2: Changes Over Time

Figure 5-3 shows a time series chart of annual mean sulphur dioxide concentrations from 1990 onwards, based on the average of all non-roadside urban and suburban sites. Ambient concentrations decreased sharply during the 1990s, and this year-on-year decrease continued in the following decade.

Figure 5-3 Annual mean SO_2 concentration: all background urban AURN sites

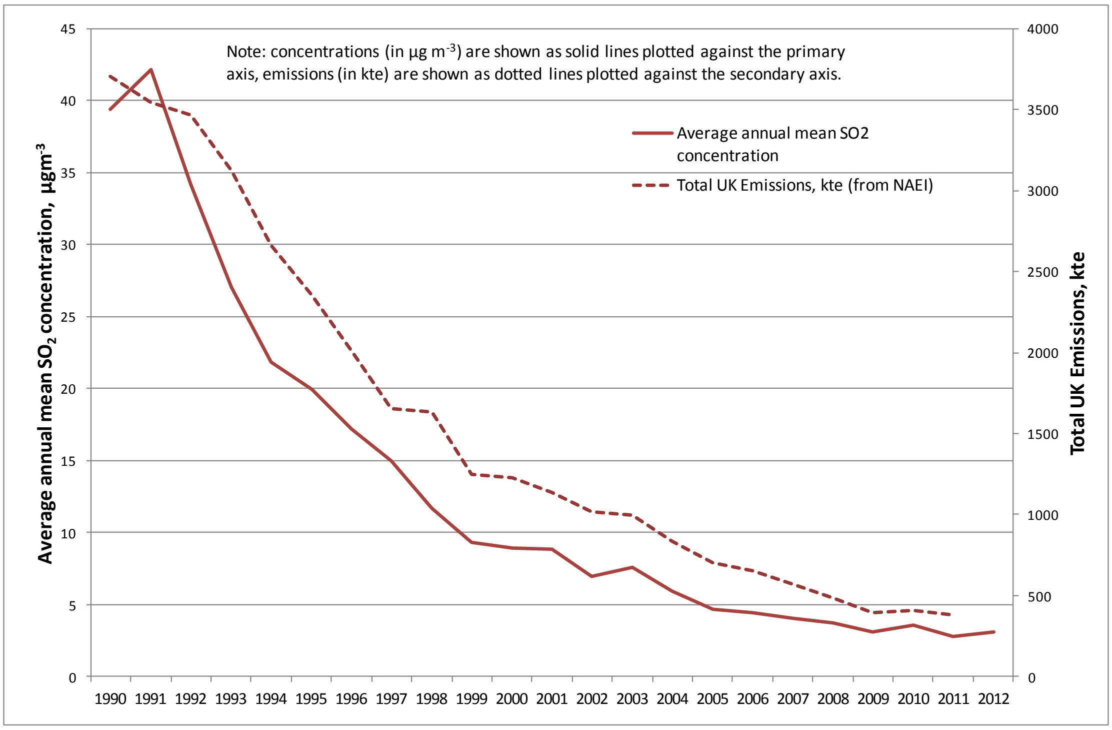


Figure 5-3 also shows how the UK's estimated total emissions of sulphur dioxide have decreased since 1990 (based on data from the NAEI available at www.naei.org.uk, shown in the graph as a dotted line). The main source of this pollutant is fossil fuel combustion. SO_2 emissions in the UK have decreased substantially since 1990, due to reductions in the use of coal, gas and oil, and also to reductions in the sulphur content of fuel oils and DERV (diesel fuel used for road vehicles). The fall in emissions is reflected by a corresponding fall in ambient concentration. It should be noted that the decrease in emissions over time shown here is the continuation of an on-going trend observed by the NAEI throughout the 1970s and 1980s, partly due to the decline of the UK's heavy industry.

5.2 Nitrogen Dioxide

5.2.1 NO_2: Spatial Distribution in the UK

Figure 5-4 shows the annual mean NO_2 concentrations for 2012, at *urban roadside* locations only. Although not every road link is clearly visible, it is possible to see that many are shaded yellow, orange and red - indicating that they had annual mean NO_2 concentrations above the limit value of 40 µg m^{-3}. These locations are widespread in London and also visible in urban areas elsewhere in the UK.

Figure 5-5 shows the annual mean *background* NO_2 concentrations for 2012. The major urban areas, and principal road links, are clearly visible. Most background locations were within the limit value of 40 µg m^{-3}, but some (in city centres) were not. These are shaded yellow, orange and red. These appear to be confined to London in 2012, in contrast to 2011 and 2010 when they also occurred in the centres of some other cities.

5.2.2 NO_2: Changes Over Time

Figure 5-6 shows how ambient concentrations of nitrogen dioxide (averaged over all sites in the AURN) have decreased since 1990. Time series of annual mean NO_2 concentrations are shown for the following groups of sites:

- All background urban sites (comprising AURN urban non-roadside sites, i.e. urban centre, urban background, urban industrial and suburban sites).
- From 1993 onwards, a sub-set of eight long-running urban background sites (Belfast Centre, Billingham, Cardiff Centre, Leeds Centre, London Bloomsbury, Newcastle Centre, Sheffield Tinsley, Southampton Centre). These have been in operation from 1993-4 until 2012. This is intended to show changes over time without any effects due to changes in the number and distribution of sites.
- All traffic-related urban monitoring sites (i.e. those less than 10 m from the kerb of a major road). This statistic is shown from 1997 only, as before then only one such site was in operation.
- From 1998 onwards, a set of eight long-running traffic urban sites which have been consistently in operation from that time until 2012 (Bath Roadside, Camden Roadside, Glasgow Kerbside, Exeter Roadside, Haringey Roadside, London Marylebone Road, Oxford Centre Roadside, and Tower Hamlets Roadside). This is intended to show changes over time without any effects due to changes in the number and distribution of sites.

Also shown (as dotted lines) are the estimated total annual emission of oxides of nitrogen, and the estimated total emission of NOx from road vehicles (data from the NAEI), both in kilotonnes (kte). These are plotted against the axis on the right.

The annual mean NO_2 concentration averaged for all urban background sites in the AURN shows a steady decrease, generally consistent with the downward trend in the amount of total NO_X emitted until the mid-2000s. After this time, the estimated NOx emission continues to fall while the annual mean NO_2 concentration levels off.

The annual mean NO_2 concentration averaged for the eight long-running urban background sites also shows a general decrease, again generally consistent with the downward trend in the amount of total NO_X emitted, until the early part of the last decade (around 2002). Subsequently, the average concentration at this sub-set of sites has remained stable, with very little further overall decrease in the years to 2012. This also departs from the pattern shown by the estimated total NOx emission.

Figure 5-4 Urban major roads, annual mean roadside NO_2 concentration, 2012 (µg m^{-3})

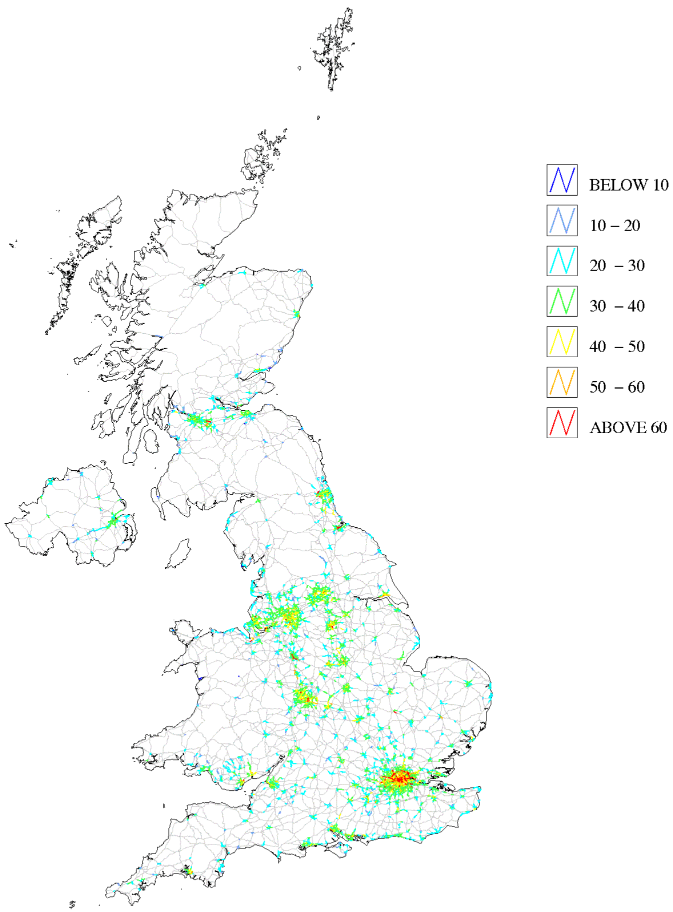
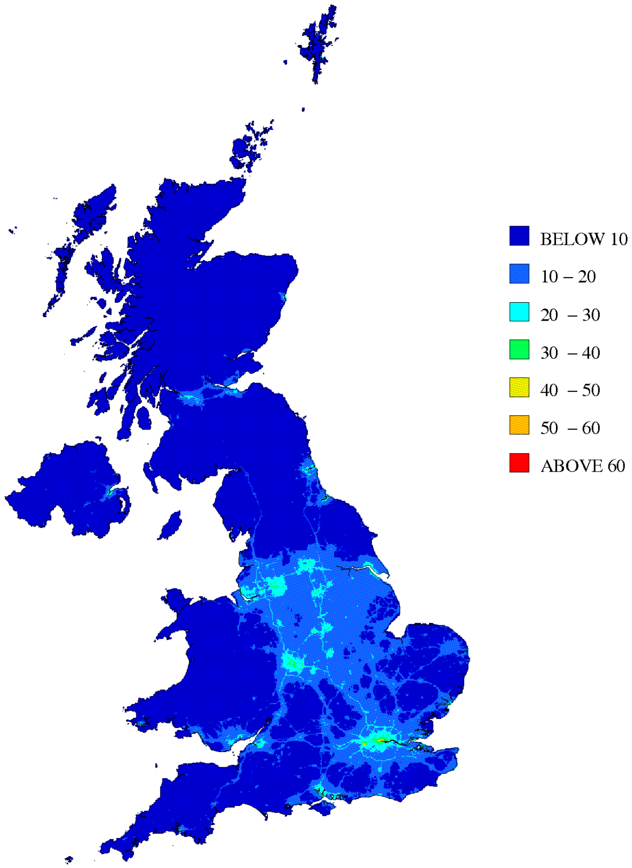


Figure 5-5 Annual mean background NO_2 concentration, 2012 (µg m^{-3})

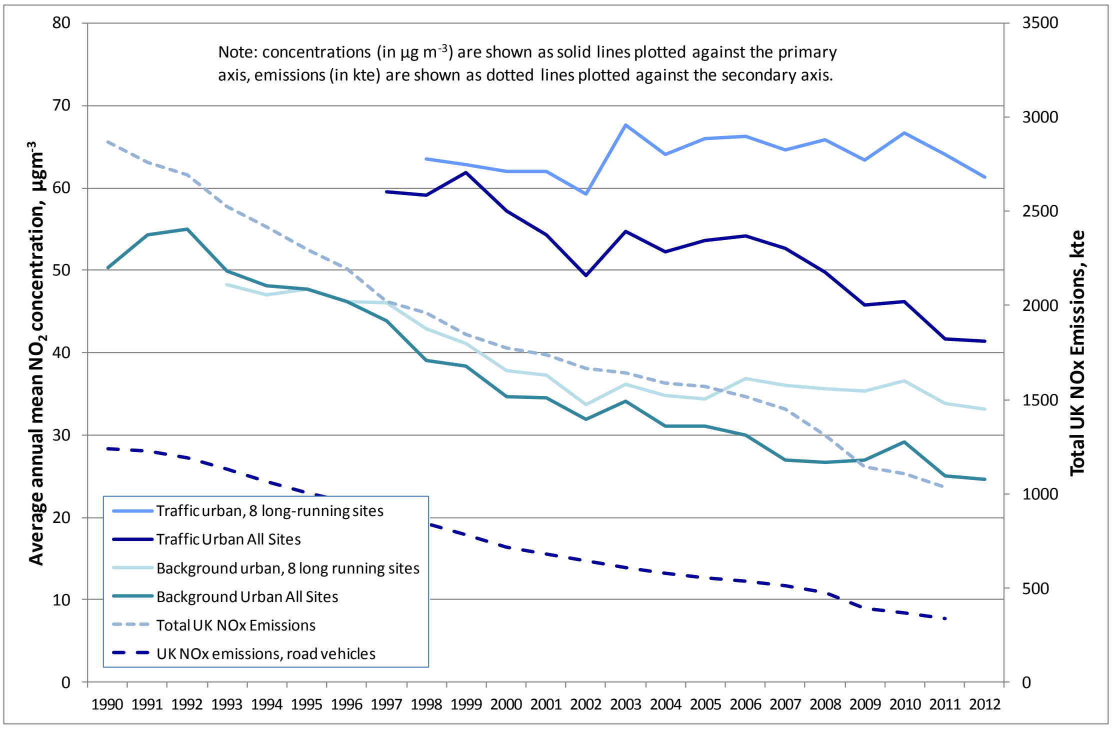


There is a small but noticeable peak in 2010, particularly for background urban sites. This may be attributable to the cold winter weather at both the beginning and end of 2010.

The annual mean NO_2 concentration averaged for all urban traffic AURN sites is higher than the average for background sites, but shows a similar (though less consistent) decrease over time. However, the annual mean averaged over the eight long-running urban traffic sites shows a different pattern: in contrast to the decrease shown by the average for all sites, the average for the eight long-running sites shows no clear increase or decrease, although there is considerable year-on-year fluctuation.

A 2011 study by King's College London, the University of Leeds and AEA carried out trend analysis for ambient concentrations of NOx and NO_2[44]. It highlights that from 2004 onwards, ambient concentrations of oxides of nitrogen have decreased less than predicted on the basis of emissions estimates. Using vehicle remote sensing data, the study concludes firstly that older petrol vehicles (Euro 1-3) emit more NOx than previously thought, which is likely to be due to emissions system degradation. Secondly the study concludes that NOx emissions from diesel cars and light goods vehicles (LGV) have decreased little in the past 15–20 years and that the Euro Standards have failed to deliver the expected improvements for these vehicles, for this pollutant.

Figure 5-6 Average annual mean NO_2 concentration: background urban and traffic urban AURN sites



5.3 PM_{10} Particulate Matter

5.3.1 PM_{10}: Spatial Distribution

Figure 5-7 shows modelled annual mean urban roadside PM_{10} concentrations in 2012. No roadside locations had an annual mean concentration greater than 40 µg m^{-3}. This is consistent with the compliance assessment reported in section 4.

Figure 5-8 shows annual mean background PM_{10} concentrations in 2012. Background concentrations are higher in the southern and eastern parts of the country, because these regions receive a larger transboundary contribution of particulate pollution from mainland

Europe. The elevated levels of PM_{10} associated with urban areas and major roads can also be seen.

Natural source contribution has not been subtracted from these maps.

The concentration bands used in Figure 5-7 and Figure 5-8 include the ranges >30-31.5 μg m^{-3}, and >31.5-40 μg m^{-3}. The significance of the division at 31.5 μg m^{-3} is that where the annual mean PM_{10} concentration exceeds this value, it is likely also that the 24-hour mean has exceeded the daily mean limit value of 50 μg m^{-3} on more than the permitted 35 occasions. Road links with annual mean concentrations greater than 31.5 μg m^{-3} are shaded red in Figure 5-7. Some red shaded road links are just visible on the map, in London. This is consistent with what is reported in section 4, that before subtraction of the natural source contribution, there were locations in Greater London where the 24-hour limit value was exceeded. However, after subtraction of the natural source contribution the zone was compliant.

5.3.1 PM_{10} Changes Over Time

Figure 5-9 shows a time series graph of annual mean ambient PM_{10} concentration. This shows the average of all background urban sites in the AURN. Also shown is the average of 17 long-running background urban sites in the AURN, all of which have been in operation since 1997. This is intended to show changes over time without any influences due to changes in the number and distribution of sites. The 17 sites used are Belfast Centre, Cardiff Centre, Derry, Glasgow Centre, Leamington Spa, Leeds Centre, Leicester Centre, London Bloomsbury, London North Kensington, Middlesbrough, Newcastle Centre, Nottingham Centre, Salford Eccles, Sheffield Centre, Southampton Centre, Stoke on Trent and Thurrock.

In this case, the mean for all sites shows a similar pattern to the mean for the sub-set of long-running sites. In both cases, ambient concentrations decreased steadily throughout the 1990s, before levelling off slightly in the early 2000s, after which the general decrease appears to have resumed to some extent.

A small increase occurred in 2010 and 2011, possibly due to cold winter weather giving rise to "winter" type pollution episodes in some regions, also high concentrations of secondary particulate matter (notably, $PM_{2.5}$) during the spring of 2011.

Also shown (by the dotted line, plotted against the right-hand axis) is the total UK annual emission of particulate matter (as PM_{10}), as estimated in the NAEI. Throughout the past two decades, the observed decrease in ambient PM_{10} concentration appears to reflect estimated reductions in emissions, including some levelling off in the early 2000s.

Figure 5-7 Urban major roads, annual mean roadside PM_{10} concentration, 2012 (µg m^{-3}, gravimetric)

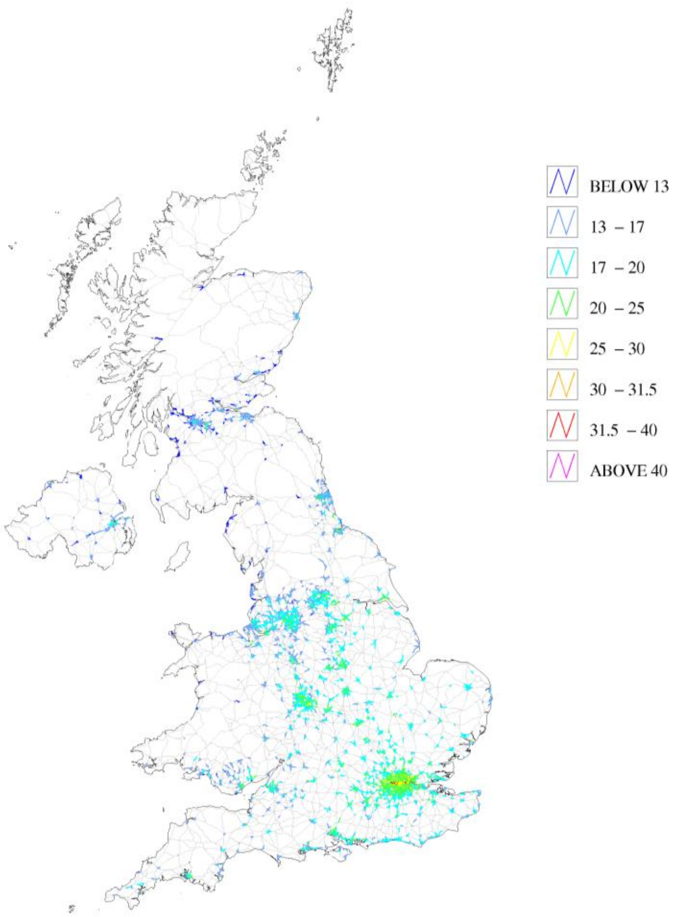


Figure 5-8 Annual mean background PM_{10} concentration, 2012 (µg m^{-3}, gravimetric)

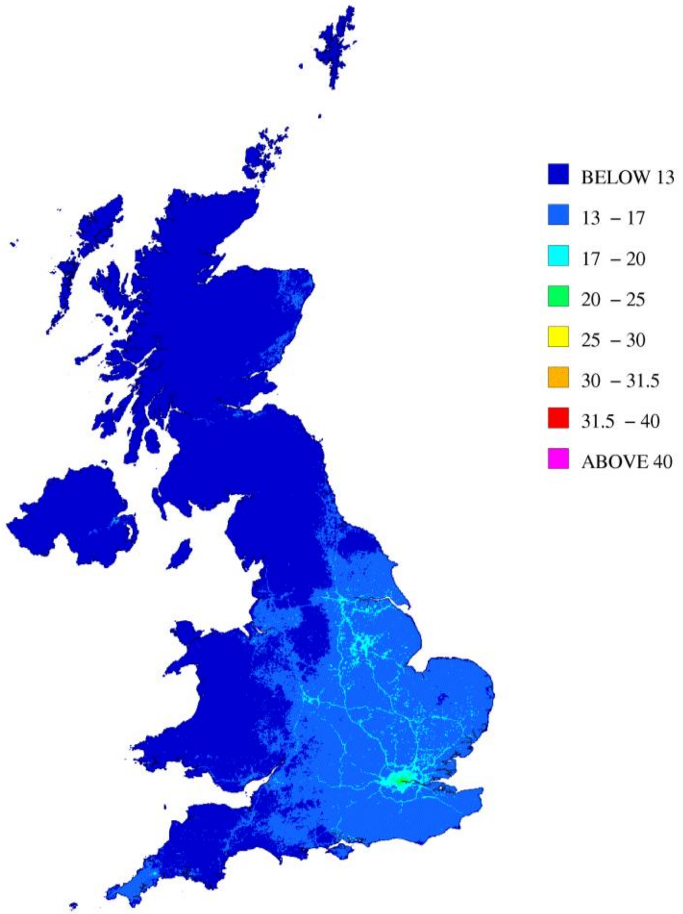
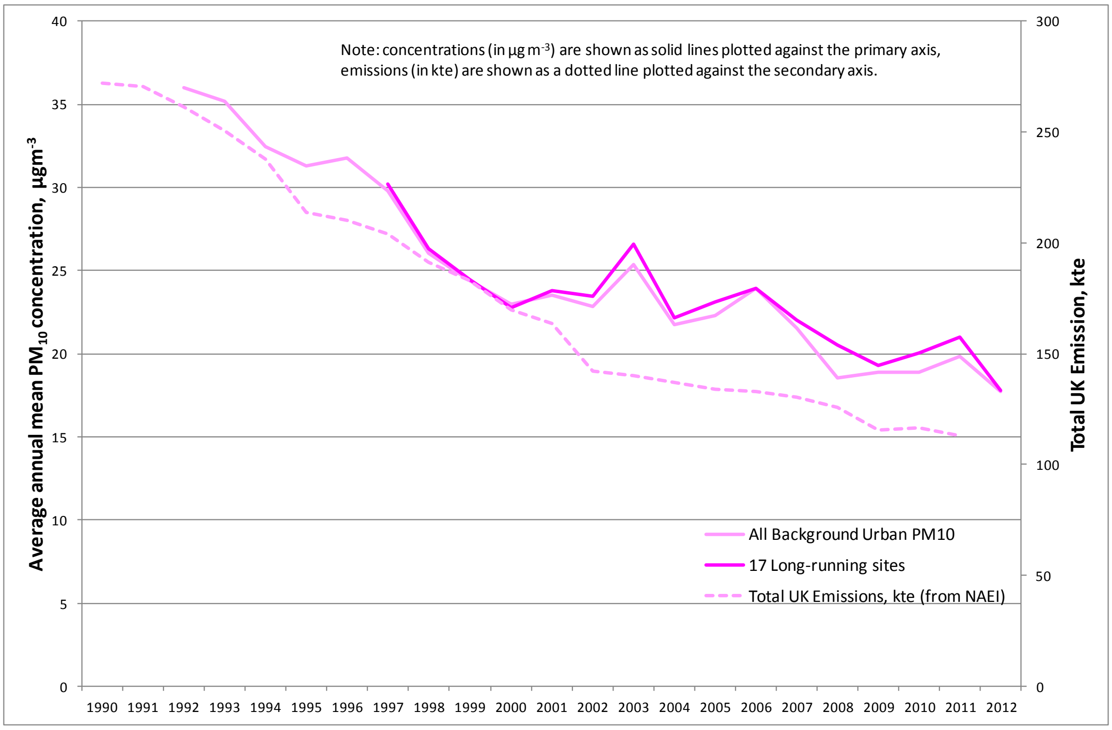


Figure 5-9 Annual mean ambient PM_{10} concentration, and total annual emissions.



5.4 $PM_{2.5}$ Particulate Matter

5.4.1 $PM_{2.5}$: Spatial Distribution

Figure 5-10 shows the annual mean urban roadside $PM_{2.5}$ concentrations in 2012. No roadside locations had annual means greater than the target value of 25 µg m^{-3} although many were in the range 20 - 25 µg m^{-3} especially in London. Figure 5-11 shows annual mean background $PM_{2.5}$ concentrations in 2012. The pattern shows some similarities to that observed for PM_{10}, in that levels are higher in the southern and eastern areas, due to the contribution of particulate matter from mainland Europe. Also, the map shows elevated levels of $PM_{2.5}$ around major urban areas and alongside major routes. The area with background annual mean $PM_{2.5}$ concentration greater than 10 µg m^{-3} was slightly smaller than in 2011, covering less of the South East and Midlands.

5.4.2 $PM_{2.5}$: Changes Over Time

Until 2008, routine monitoring of $PM_{2.5}$ was only carried out at one urban background AURN site (London Bloomsbury). This site is thought to have been affected by emissions from localised sources in recent years. For this reason, a graph of changes over time is not included here.

Figure 5-10 Urban major roads, annual mean roadside $PM_{2.5}$ concentration, 2012 (µg m^{-3}, gravimetric)

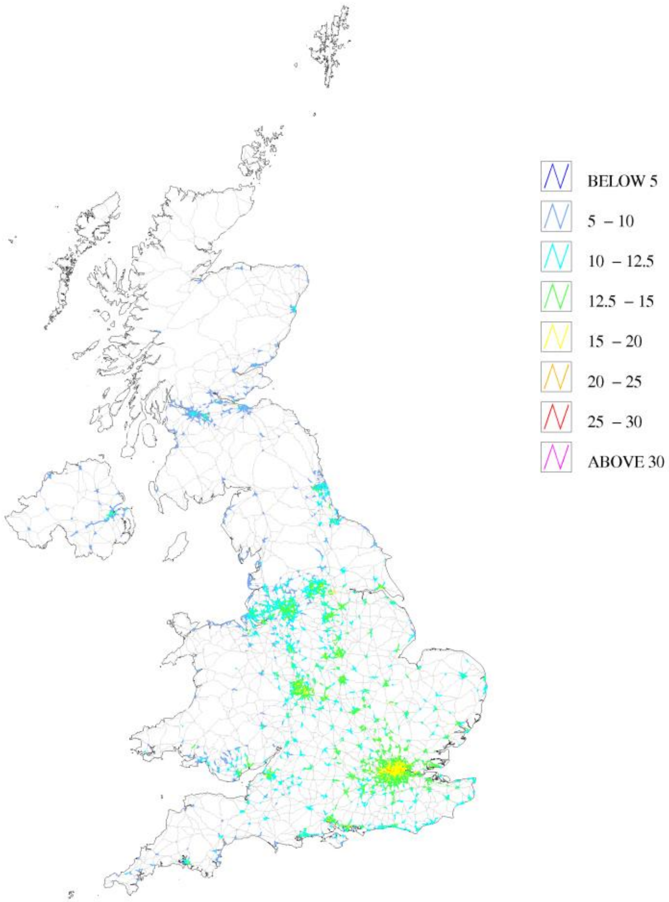
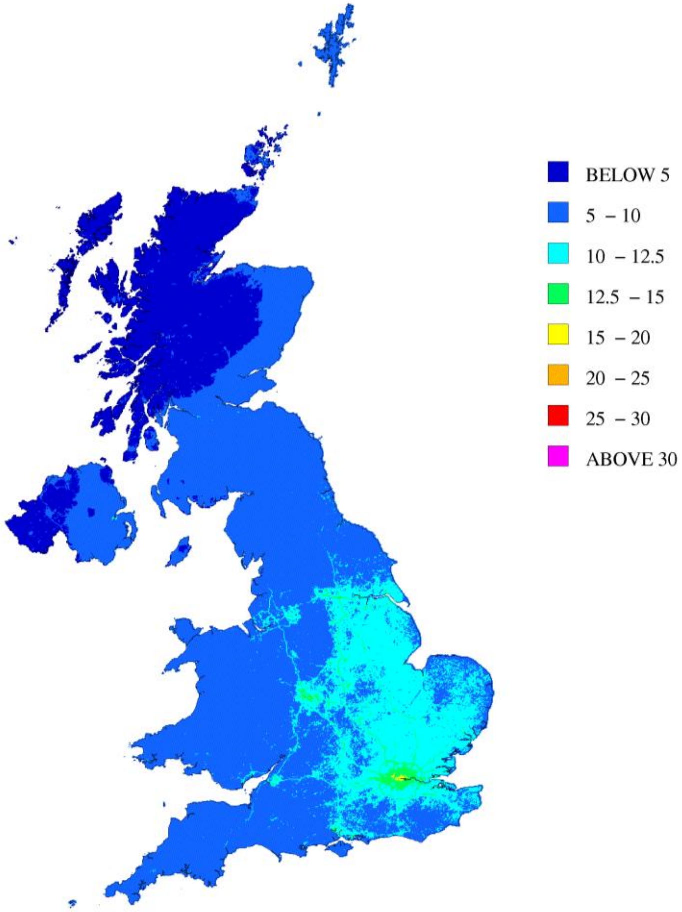


Figure 5-11 Annual mean background $PM_{2.5}$ concentration, 2012 (µg m^{-3}, gravimetric)



5.5 Benzene

5.5.1 Benzene: Spatial Distribution

Benzene is found in petrol and in vehicle emissions, therefore elevated levels may be expected at roadside locations.

Figure 5-12 shows annual mean benzene concentrations at roadside locations in 2012. Figure 5-13 shows the modelled annual mean background concentrations of benzene in 2012. Modelled background concentrations were below 0.5 µg m^{-3} over most of the UK, with marginally higher concentrations for urban areas. However, background concentrations everywhere are well below the limit value for benzene.

5.5.2 Benzene: Changes Over Time

Figure 5-14 shows a time series of annual mean benzene concentrations, based upon the average of 20 long-running sites in the Non-Automatic Hydrocarbon Network. These are: Barnsley Gawber, Belfast Centre, Bristol Old Market, Coventry Memorial Park, Grangemouth, Haringey Roadside, Leamington Spa, Leeds Centre, Leicester Centre, Liverpool Centre, London Bloomsbury, Manchester Piccadilly, Middlesbrough, Newcastle Centre, Northampton, Nottingham Centre, Oxford Centre Roadside, Plymouth Centre, Southampton Centre and Stoke on Trent Centre. All of these sites have at least 75% data capture for all years between 2002 and 2012.

The average for these 20 sites shows a general decrease from 2002 to 2012. The decrease has not been consistent from year to year; the largest change appears to have happened between 2005 and 2008.

The dotted line on the graph shows the estimated total annual UK emission of benzene (in kilotonnes), plotted against the right-hand y-axis. This too appears to have decreased over the 10 years shown – although more steadily than the average measured ambient concentration.

Figure 5-12 Urban major roads, annual mean roadside benzene concentration, 2012 (μg m^{-3})

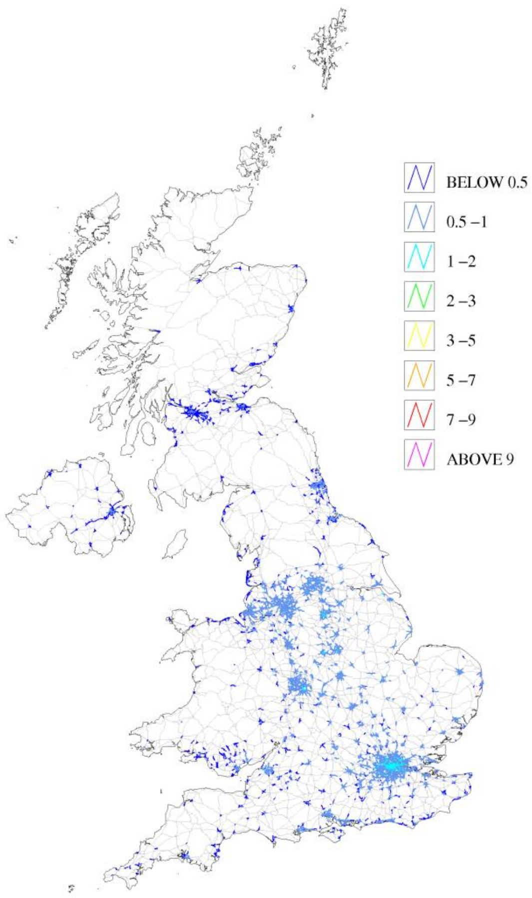


Figure 5-13 Annual mean background benzene concentration, 2012 (μg m^{-3})

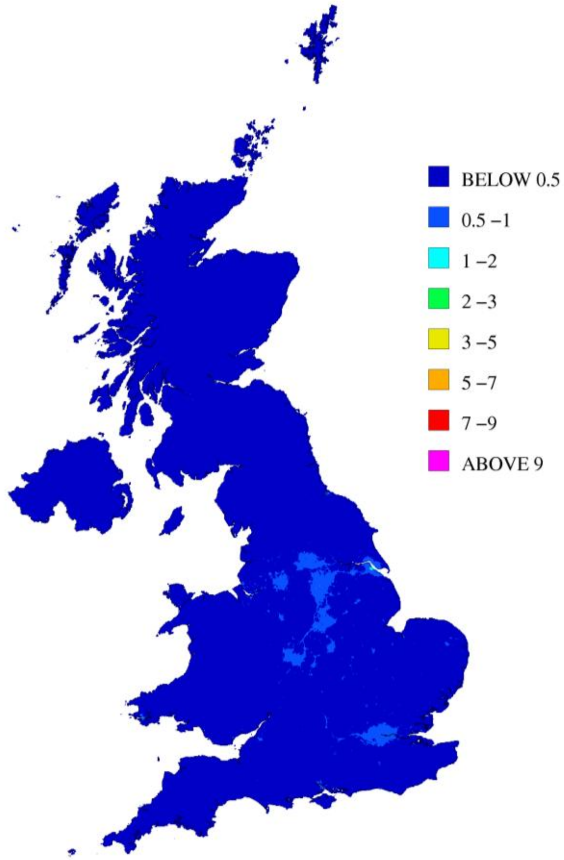
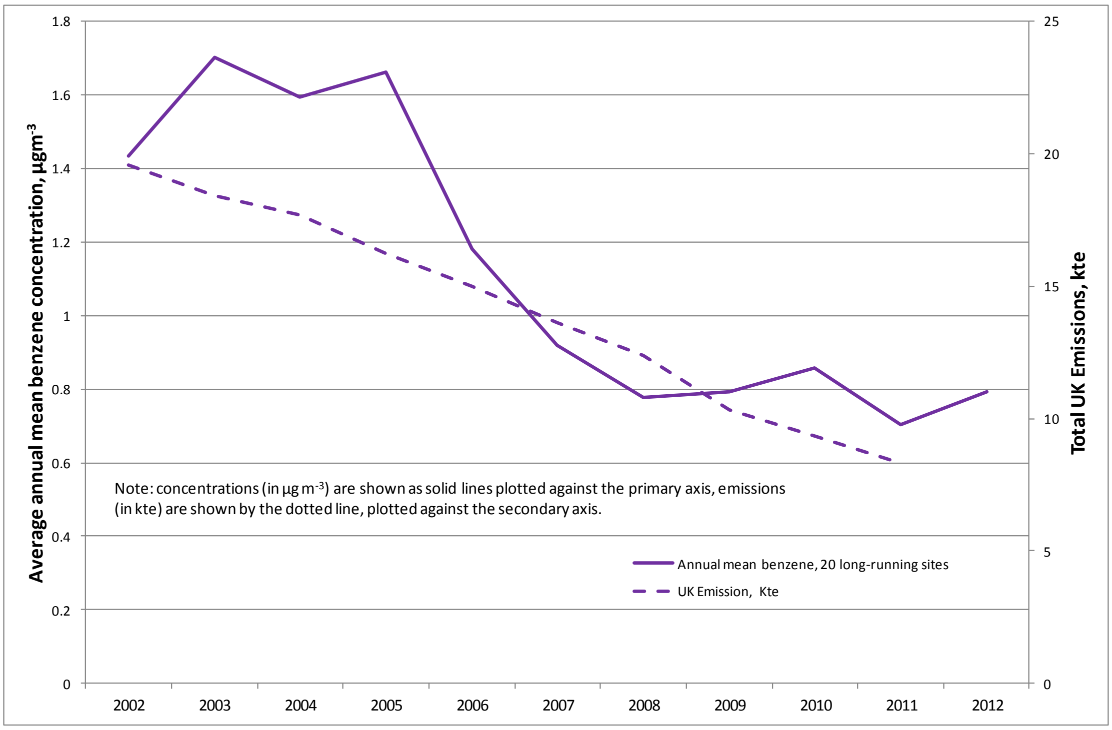


Figure 5-14 Annual mean benzene concentration, mean of 20 long-running non-automatic sites



5.6 1,3-Butadiene

5.6.1 1,3-Butadiene: Compliance with AQS Objective

The ambient concentration of 1,3-butadiene is not covered by any EU Directives. However, it is within the scope of the UK Air Quality Strategy. In the UK, there is an Air Quality Strategy objective of 2.25 µg m^{-3} as a maximum running annual mean, to have been achieved by 31st December 2003. This objective was met throughout the UK by the due date.

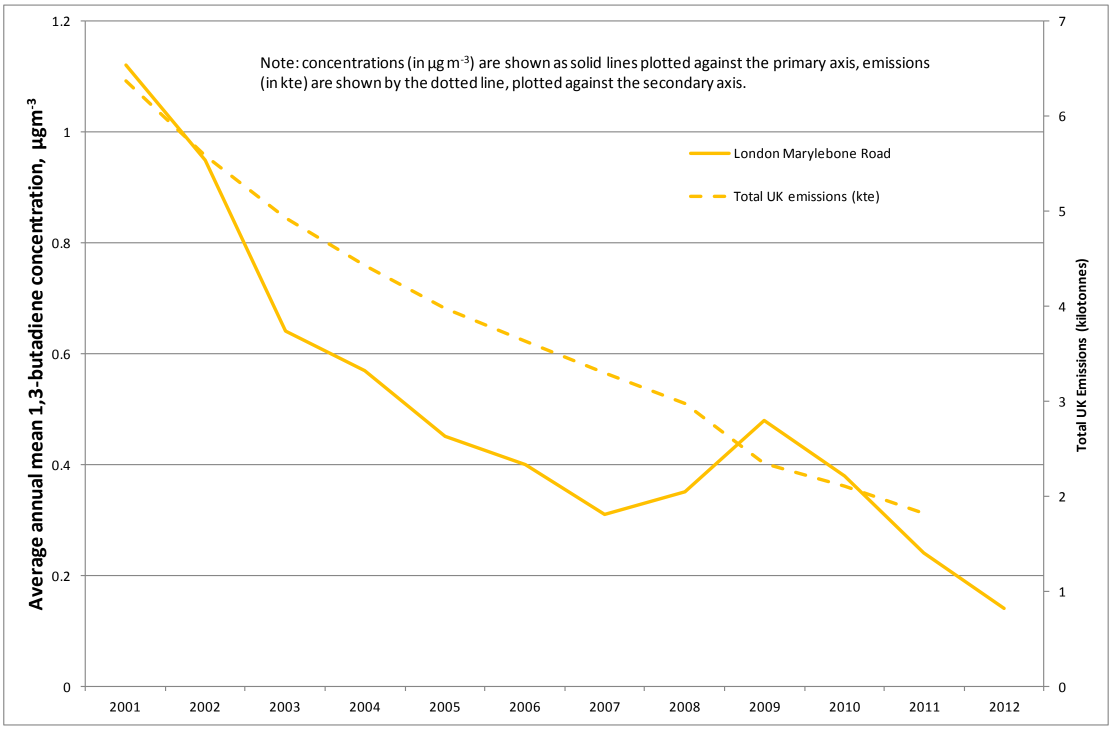
Only one network currently measures ambient concentrations of 1,3-butadiene: the Automatic Hydrocarbon Network. This network currently consists of two rural sites (Auchencorth Moss and Harwell) and two urban sites (London Eltham and London Marylebone Road). The running annual means at all four sites were within the Air Quality Strategy objective in 2012.

5.6.2 1,3-Butadiene: Changes Over Time

Figure 5-15 shows the annual mean 1,3-butadiene concentration measured from 2001 at London Marylebone Road. This site has been selected because it typically records the highest results of any site in the network, has been operating for a long period of time and has good data capture in most years. The minimum data capture for inclusion in this chart in 50%: a lower threshold has been used here than in other similar charts. The reason for this is that ambient concentrations of 1,3-butadiene at all the sites are very low, and frequently below the detection limit. When this occurs, the data are counted as null. Therefore, data capture figures for this pollutant tend to be low.

Also shown (plotted against the right-hand y-axis) is the total estimated UK annual emission of this compound, in kilotonnes. This appears to have decreased steadily over the past decade. The main source of 1,3-butadiene is vehicle emissions, and the use of catalytic converters since the early 1990s has substantially reduced emissions from this source.

Figure 5-15 Annual mean 1,3-butadiene concentration at London Marylebone Road



5.7 Carbon Monoxide

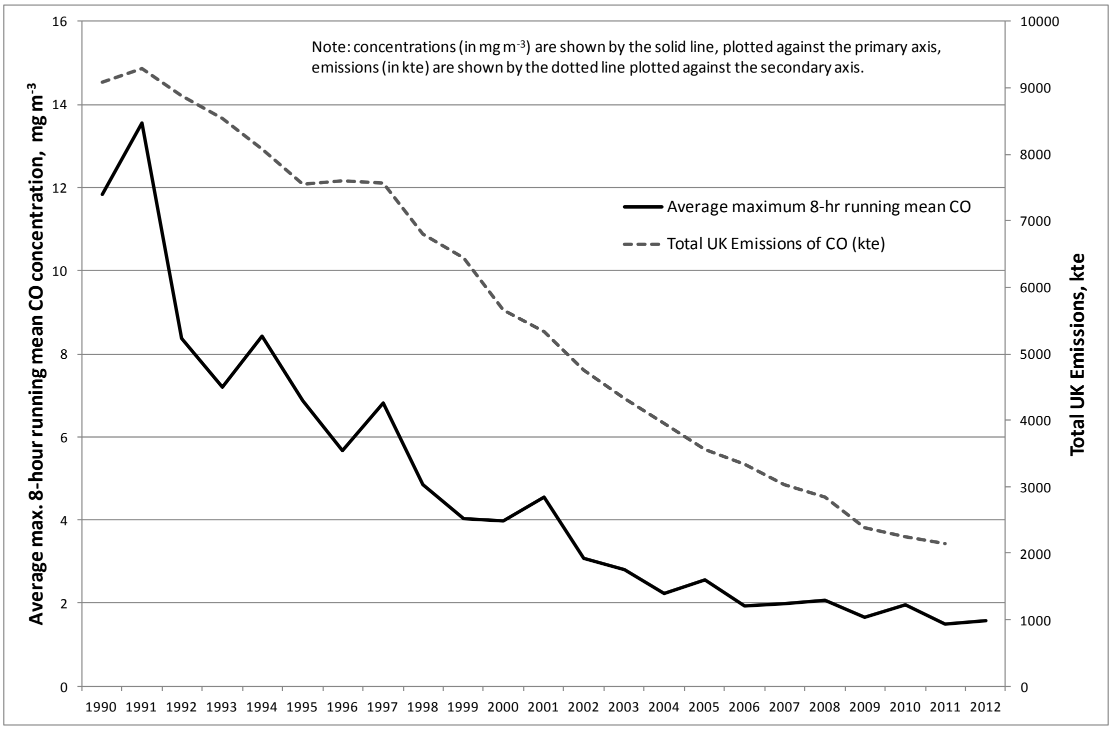
5.7.1 CO: Spatial Distribution

Previous reports in this series (for years up to 2010) have shown modelled maps of the annual maximum 8-hour mean CO concentration, alongside major urban roads and at background locations. However, as ambient concentrations throughout the UK have been well within the limit value for many years, maps are no longer routinely produced for CO.

5.7.2 CO: Changes over time

Figure 5-16 shows a time series chart of the average maximum 8-hour running mean CO concentration, for all AURN sites 1990 - 2012. There is a clear decrease with time. Figure 5-16 also shows total annual UK emissions of CO for the same period. The decreasing ambient concentrations reflect declining emissions over the last two decades. UK emissions of this pollutant have decreased substantially over recent decades. The NAEI attributes this decrease to *"significant reductions in emissions from road transport, agricultural field burning and the domestic sector"*.[45]

Figure 5-16 Time series graph of average maximum 8-hour running mean CO concentration, all AURN sites.



5.8 Ozone

5.8.1 O_3: Spatial Distribution

Figure 5-17 shows the average number of days per year with ozone concentration > 120 µg m^{-3}, over the **three** years 2010-2012. This average was less than five days over most of the UK, but higher (5-10 days) in two small areas of coastal East Anglia and the South East coast: this pattern reflects the nature of ozone as a transboundary, secondary pollutant.

Figure 5-18 shows the same statistic, for 2012 only (i.e. not averaged over three years). Ozone concentrations for 2012 were slightly lower than the three-year average. No parts of the UK had more than 10 days above the target value.

Figure 5-19 shows the AOT40 statistic, averaged over the past **five** complete years, 2008-2012. The AOT40 statistic (expressed in µg m^{-3}.hours) is the sum of the difference between hourly concentrations greater than 80 µg m^{-3} (= 40 ppb) and 80 µg m^{-3} over a given period using only the one-hour values measured between 0800 and 2000 Central European Time each day.

Figure 5-20 shows the same statistic, for 2012 only. The values for 2012 only are lower than those for the past five years.

Figure 5-17 Average no. of days with ozone concentration > 120 µg m^{-3} 2010-2012

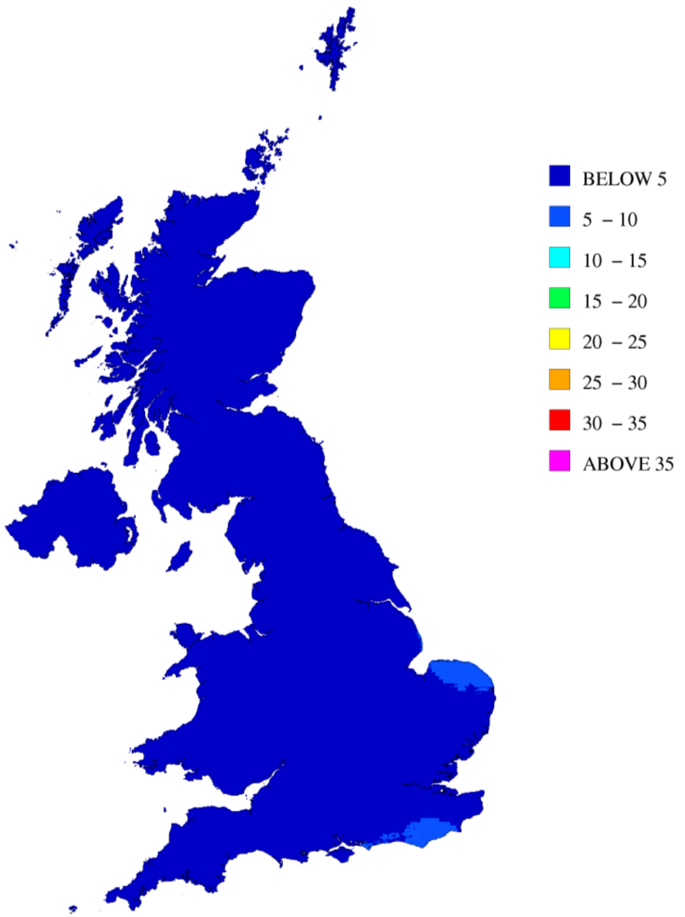


Figure 5-18 Days with ozone concentration > 120 µg m^{-3} in 2012

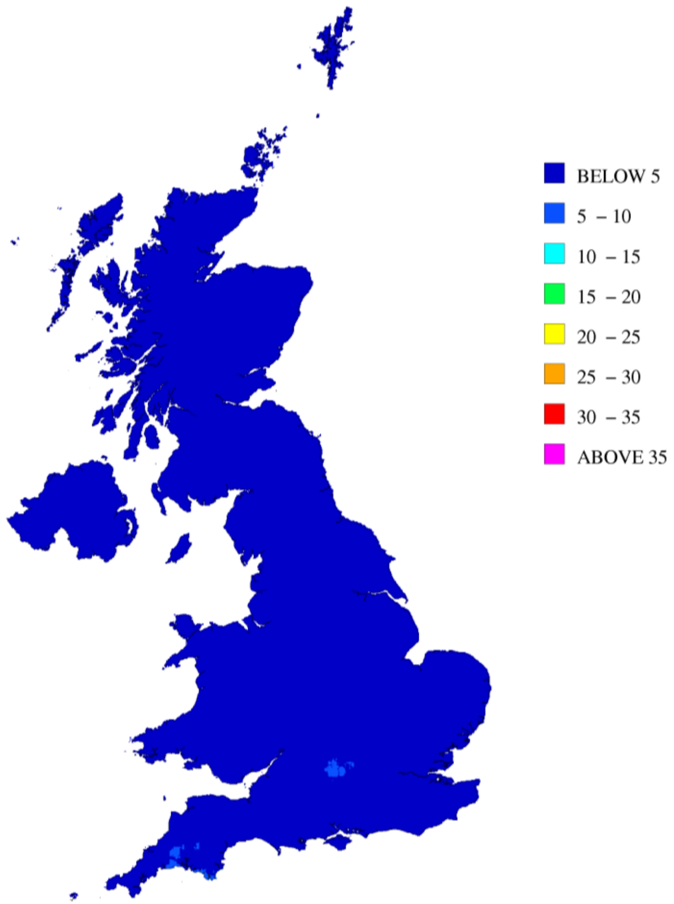


Figure 5-19 Average AOT40, 2008-2012($\mu g\ m^{-3}$.hours)

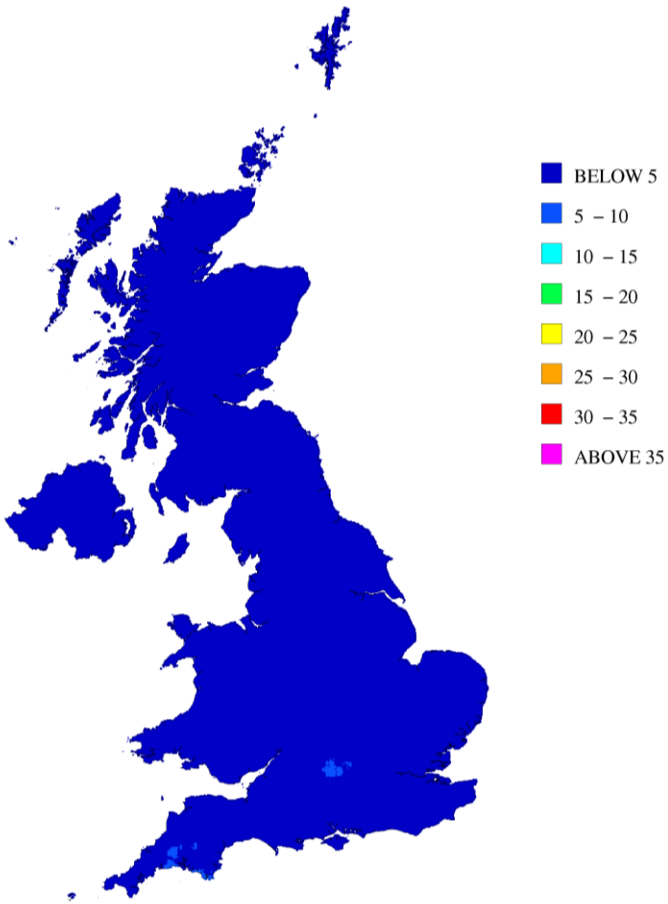
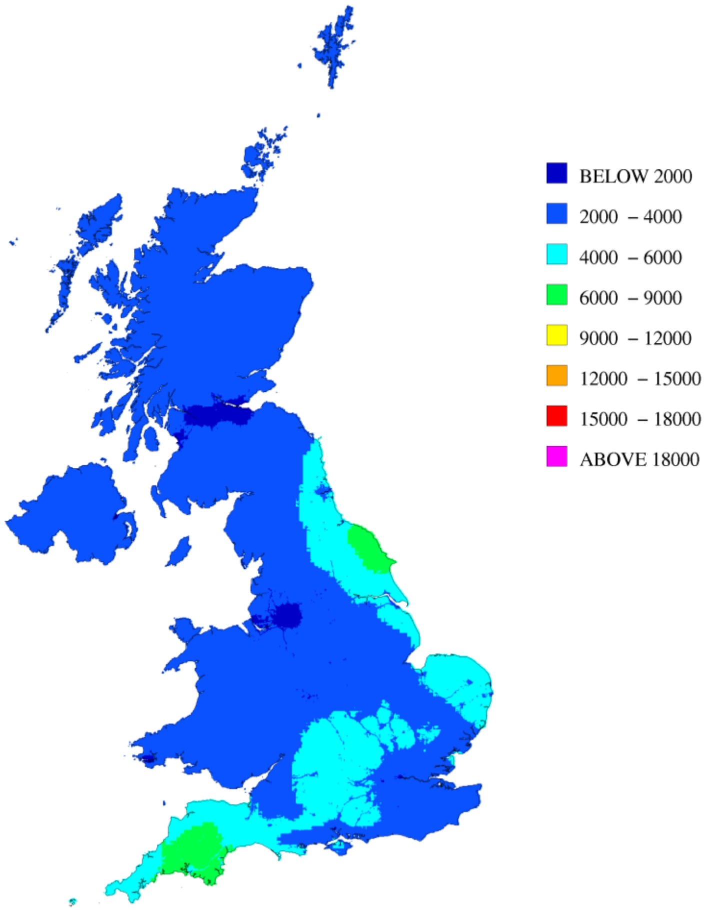


Figure 5-20 Average AOT40, 2012 ($\mu g\ m^{-3}$.hours)

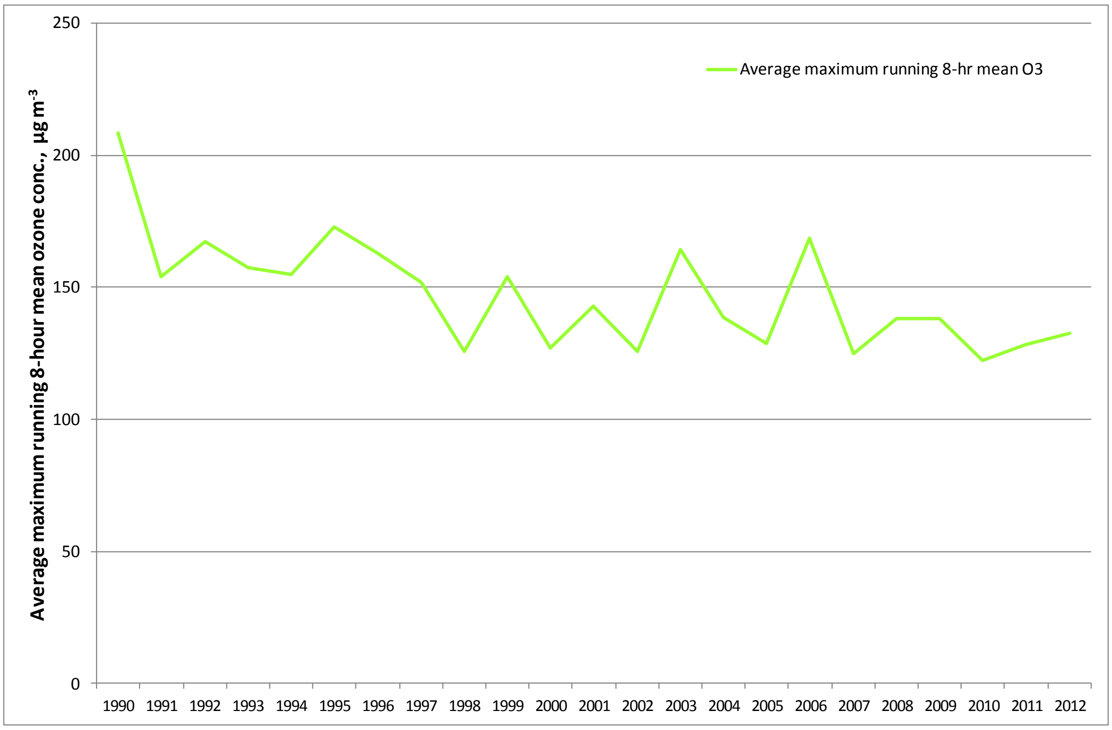


5.8.2 O_3: Changes Over Time

Figure 5-21 shows a time series graph of the annual maximum 8-hour running mean ozone concentration. Although there is some year-to-year variation in this measurement of peak ozone concentrations, there is no clear upward or downward slope. The implication of this is that areas currently at risk of exceeding target values are likely to remain at risk of exceeding in the near future.

No emissions data are included; ozone is not emitted in significant quantities directly from any source in the UK (instead, it is formed from reactions involving other pollutants). Therefore ozone is not included in the NAEI.

Figure 5-21 Time series of annual maximum 8-hour running mean, all AURN sites.



5.9 Metallic Pollutants

5.9.1 Metals: Spatial Distribution

Figure 5-22, Figure 5-23, Figure 5-24 and Figure 5-25 show modelled annual mean concentrations of Pb, As, Cd and Ni respectively in 2012. The spatial distribution patterns are discussed below.

Pb: background concentrations were less than 10 ng m^{-3} over most of the UK. Higher levels are visible in urban areas (particularly industrial areas). Higher concentrations are also clearly visible along major routes: this is not caused by vehicle emissions (leaded petrol having been banned within the EU from January 2000), but by re-suspended road dust.

As: background concentrations were less than 0.6 ng m^{-3} over most of the UK. However, higher concentrations occurred in some areas – particularly the north eastern part of England including the north east, Yorkshire and Humberside. This pattern reflects the natural sources of airborne arsenic, particularly wind-blown dust. Modelled concentrations are therefore highest in areas where agricultural practices give rise to wind-blown dust (such as parts of eastern England) and where the natural arsenic content of the soil is relatively high (such as parts of Cornwall).

Cd: background concentrations were less than 0.5 ng m^{-3} over almost all of the UK. The only locations with higher concentrations were small spots relating to specific point sources. Please note that the scale used for Cd concentrations was changed in the 2010 report in this series, reflecting the decrease observed in ambient concentrations over recent years.

Ni: background concentrations of Ni were typically less than 2.0 ng m^{-3} (well away from urban areas, usually less than 1.0 ng m^{-3}). Some major road routes are visible in the map: like lead, nickel is found in suspended road dust.

Figure 5-22 Annual mean background Lead concentration, 2012 (ng m^{-3})

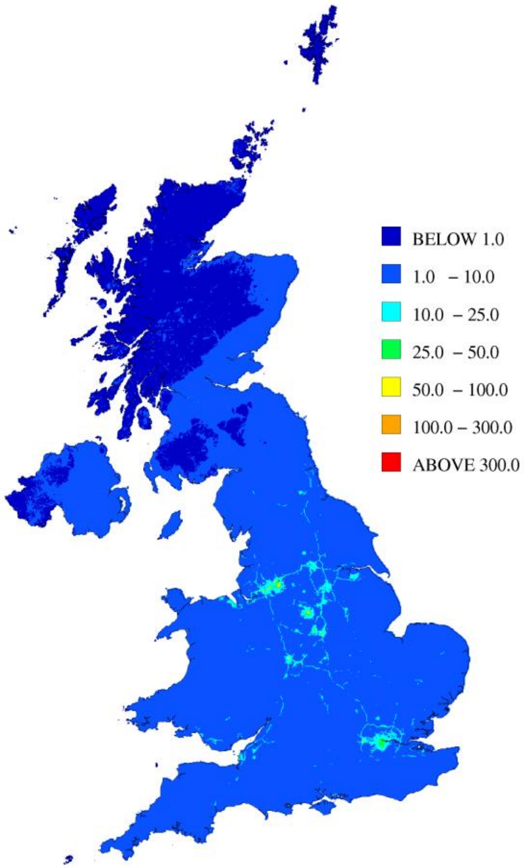


Figure 5-23 Annual mean background Arsenic concentration, 2012 (ng m^{-3})

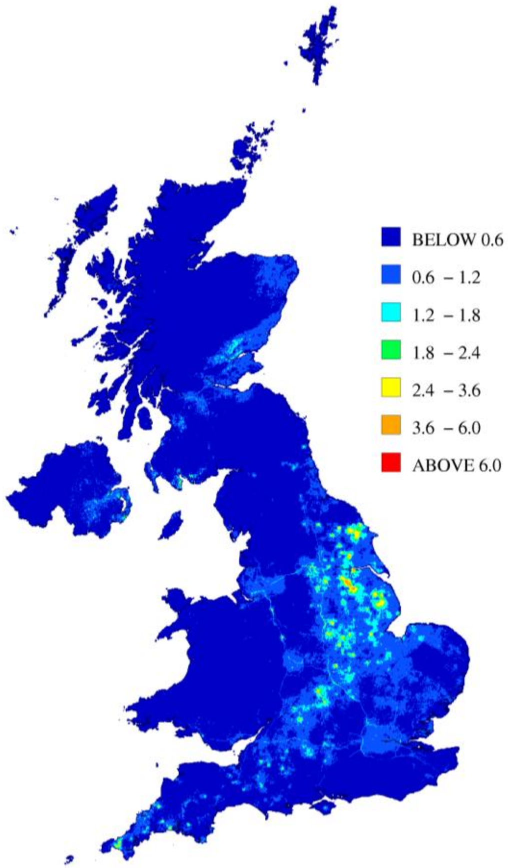


Figure 5-24 Annual mean background Cadmium concentration, 2012 (ng m^{-3})

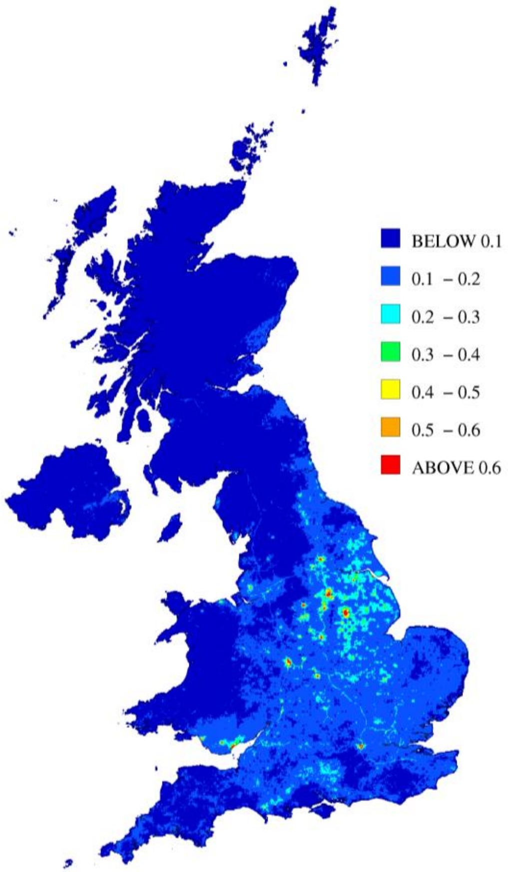
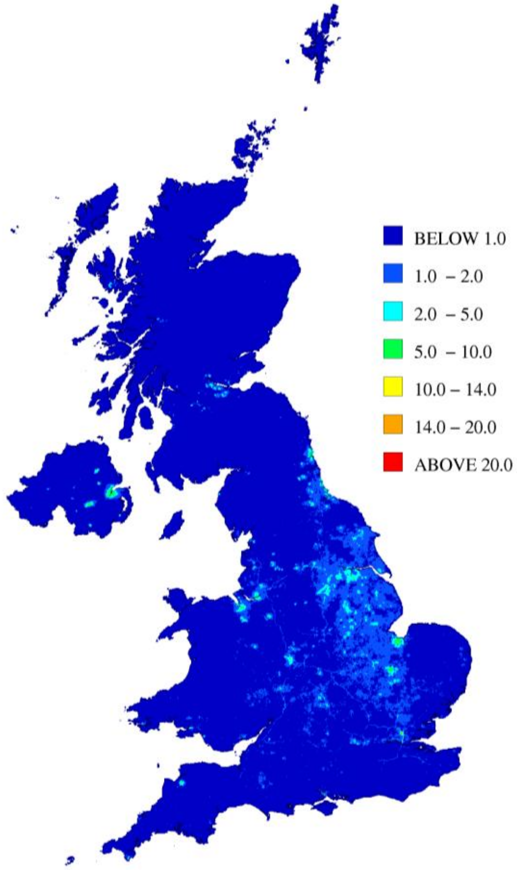


Figure 5-25 Annual mean background Nickel concentration, 2012 (ng m^{-3})



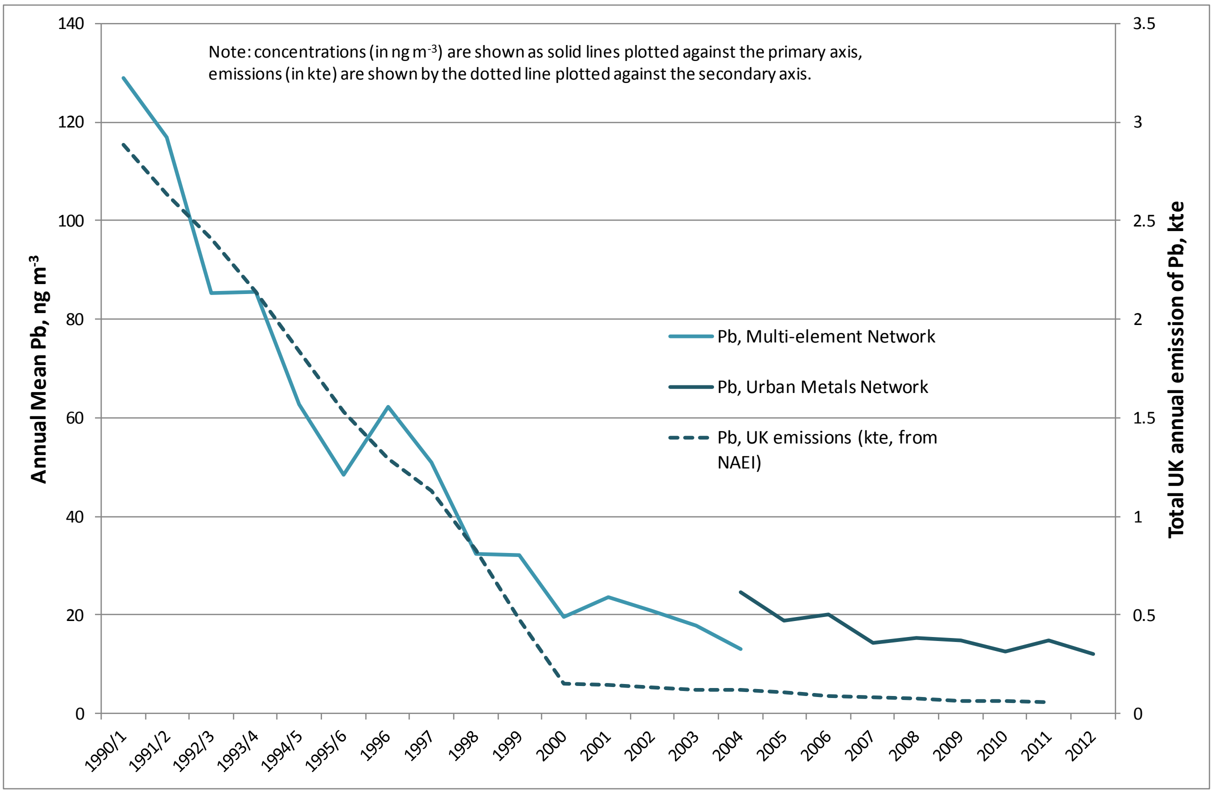
5.9.2 Lead: Changes Over Time

Figure 5-26 shows a time series of annual mean concentration of Pb in the particulate phase. For years prior to 2004, the graph shows the annual mean concentration of Pb in the particulate phase, as measured by the six sites comprising the former Multi-Element Network. (The sampling method used by this network was not size-selective.)

From 2004 onwards, Pb was monitored in the PM_{10} fraction by the Urban and Industrial Metals Network, described in section 3.3.2 above. The annual mean of all 24 sites is shown. The mean for all sites is well below the Air Quality Directive limit value for annual mean Pb, of 500 ng m^{-3}.

Figure 5-26 also shows estimated total annual UK emissions of this metal, from the NAEI (plotted as a dotted line, on the right-hand y-axis). Measured ambient concentrations follow the same pattern, with a steep downward slope throughout the 1990s, with some levelling off after 2000.

Figure 5-26 Ambient Concentrations of Particulate-phase Pb, and Total UK Emissions



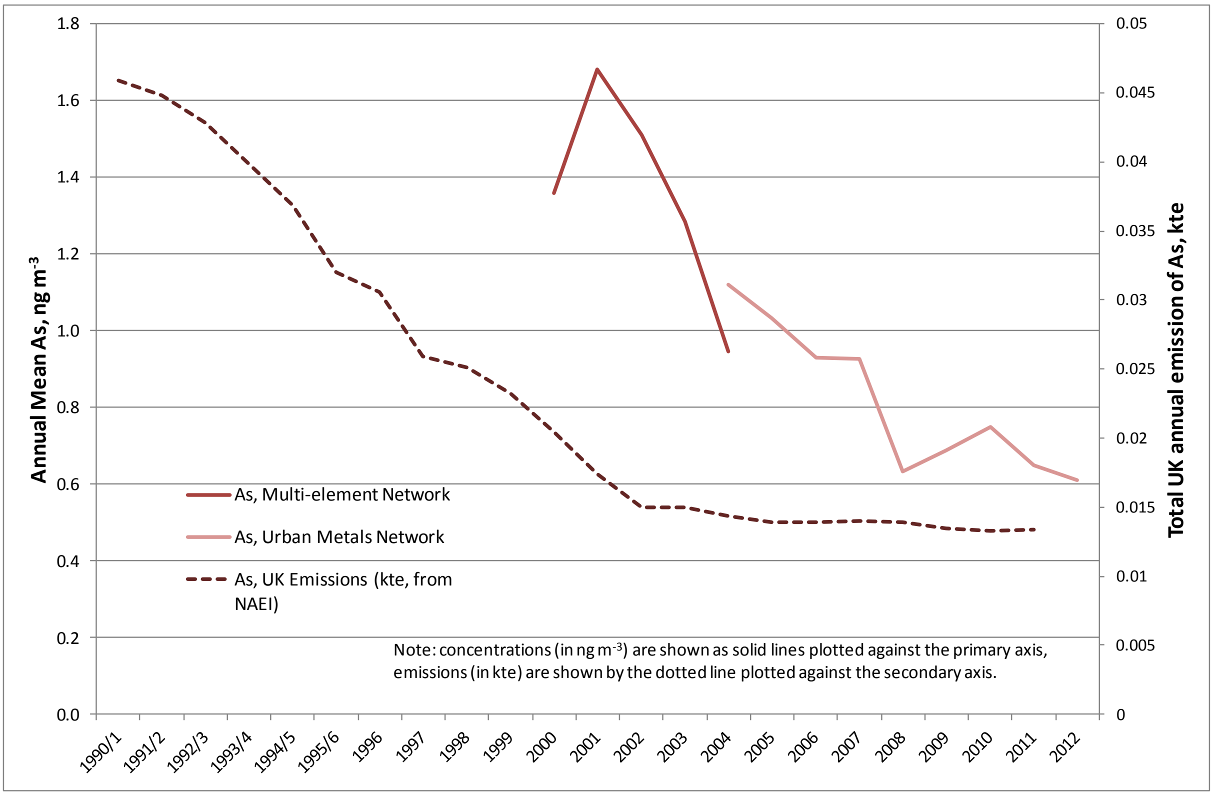
5.9.3 Arsenic: Changes Over Time

Figure 5-27 shows a time series of annual mean concentrations of As in the particulate phase. Arsenic monitoring began in 2000, at just two of the sites in the former Multi-Element Network. The other four sites began sampling As in 2003.

From 2004 onwards, As was monitored in the PM_{10} fraction by the Urban and Industrial Metals Network, described in section 3.3.2 above. The annual mean of all sites is shown. This parameter is well within the Fourth Daughter Directive target value of 6 ng m^{-3}.

Also shown is the UK's estimated total annual emission of As (from the NAEI), in kilotonnes. This is plotted as a dotted line, against the right-hand y-axis. The decrease in emissions is generally reflected in the decrease in measured ambient concentrations.

Figure 5-27 Ambient Concentrations of Particulate-phase As, and Total UK Emissions



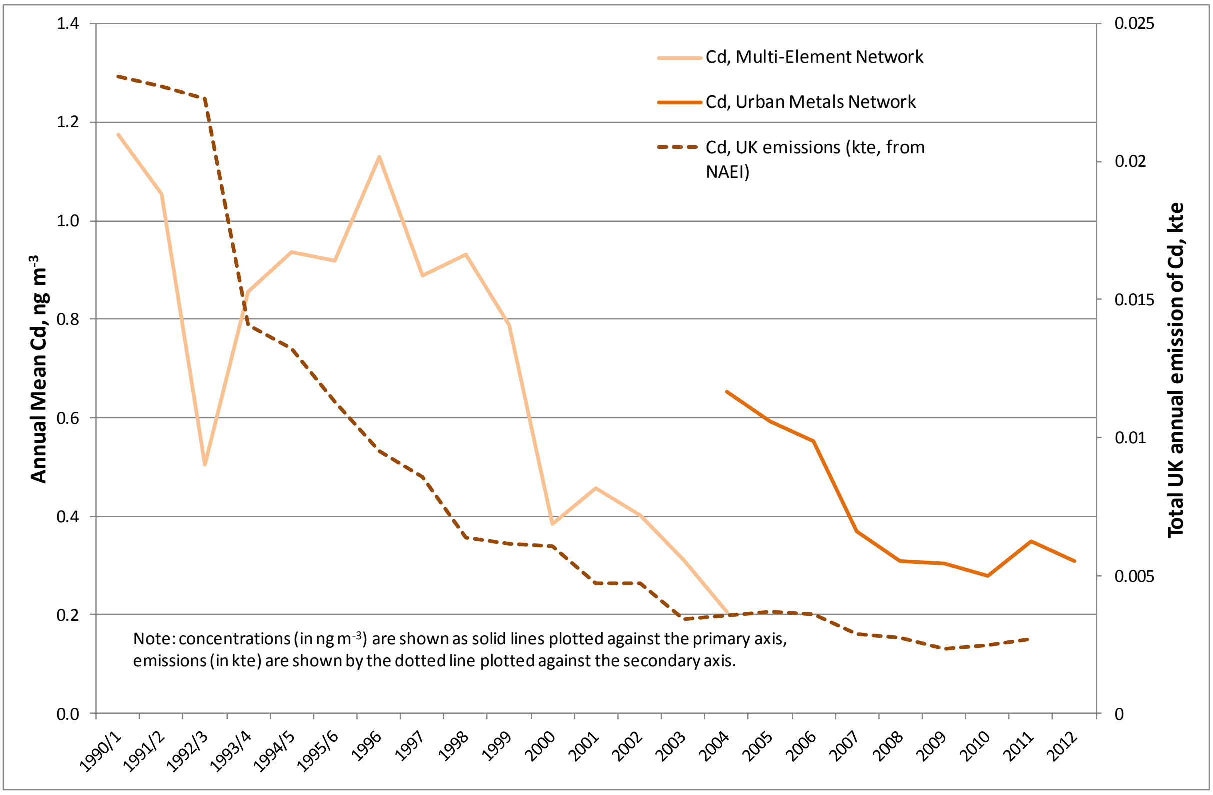
5.9.4 Cadmium: Changes Over Time

Figure 5-28 shows a time series of annual mean concentration of Cd in the particulate phase. Cd was monitored at five of the six sites in the former Multi-Element Network, until 2000 when monitoring also began at the rural Eskdalemuir site.

From 2004 onwards, Cd was monitored in the PM_{10} fraction by the Urban and Industrial Metals Network, described in section 3.3.2 above. The annual mean of all sites is shown. There is a discontinuity between the averages measured by the two networks in 2004, probably caused by the introduction of 11 new sites, increasing the number of sites from six to 17. In 2011 there was an increase in the annual mean Cd concentration measured by all sites. This appears to be due to a few of the industrial sites measuring slightly higher concentrations in 2011 than in previous years, in particular, the introduction of two new sites in industrial areas. The average concentration does not appear to have returned to its pre-2010 level in 2012. However, it should be noted that Cd concentrations are very low, and well within the Fourth Daughter Directive target value of 5 ng m^{-3} at all sites.

Also shown (plotted as a dotted line, against the right-hand axis) is the UK's estimated total annual emission of Cd (in kilotonnes), from the NAEI. The decrease in emissions is generally reflected in the decrease in measured ambient concentrations.

Figure 5-28 Ambient Concentrations of Particulate-phase Cd, and Total UK Emissions



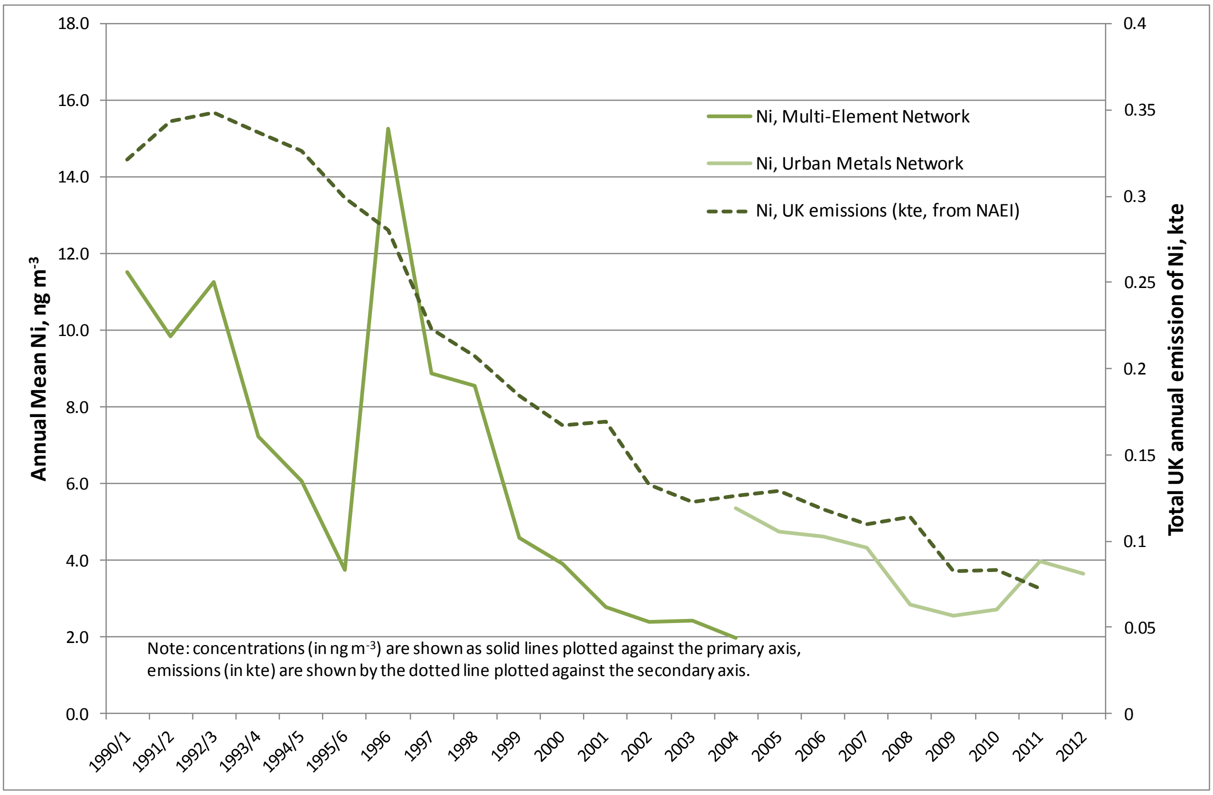
5.9.5 Nickel: Changes Over Time

Figure 5-29 shows a time series of annual mean concentrations of Ni in the particulate phase. Measurements up to 2004 are from the six sites in the former Multi-Element Network, measurements from 2004 onwards are from the Urban and Industrial Metals Network. One site in Pontardawe exceeded the Fourth Daughter Directive target value of 20 ng m^{-3}; this site also measured an exceedance in 2011. This was the measured exceedance in the Swansea agglomeration highlighted in Table 4-10 (in addition to the *modelled* exceedance in the South Wales zone in 2012).

Figure 5-29 also shows total estimated annual UK emissions of Ni, from the NAEI (as a dotted line, plotted against the right-hand axis). From the late 1990s, the NAEI data show a decrease in the UK's total emissions of Ni. This is generally reflected in the average ambient concentrations measured by the Multi-Element Network. The peak in 1996 is due to an unusually high annual mean at one of the six Multi-Element Network sites (London Brent) that year.

Like Cd, ambient concentrations of Ni have also shown a small increase in 2011 – thought to be due to the introduction to the network of an industrial site in Pontardawe, South Wales which has recorded particularly high Ni concentrations.

Figure 5-29 Ambient Concentrations of Particulate-phase Ni, and Total UK Emissions



5.9.6 Mercury: Changes Over Time

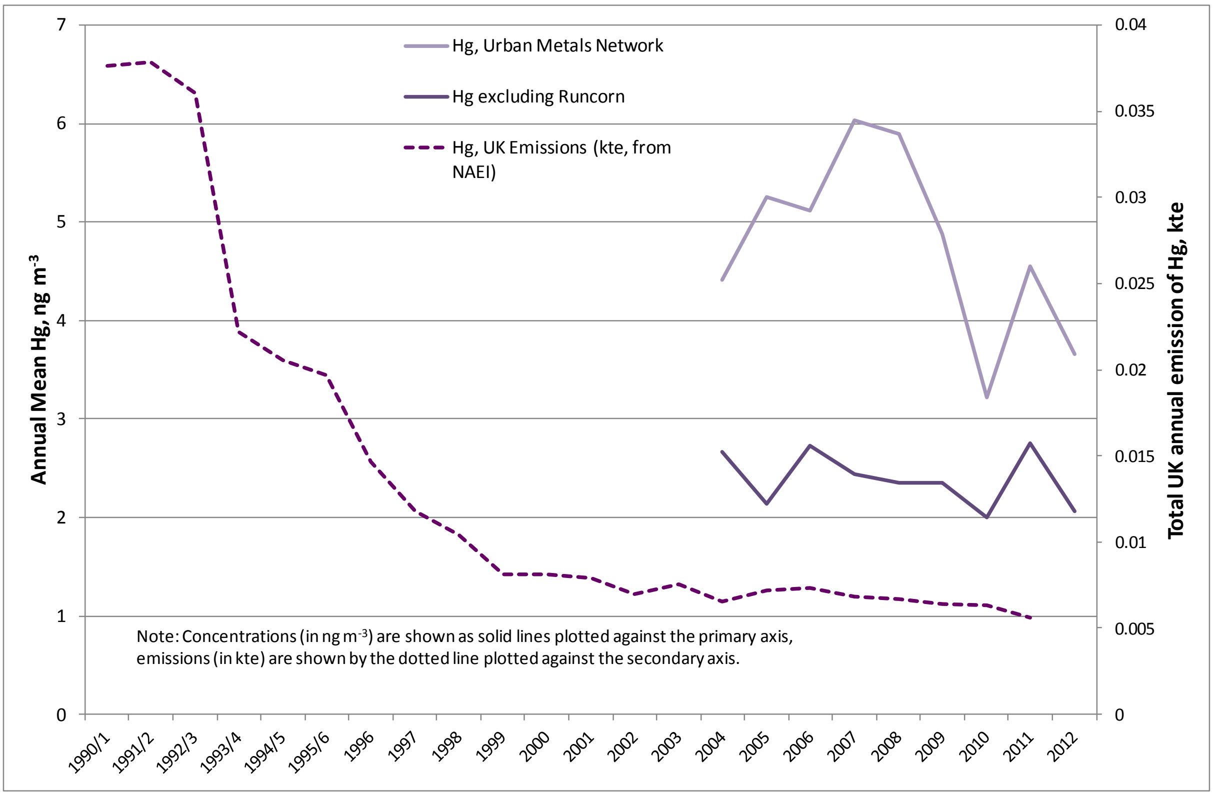
Figure 5-30 shows a time series of total annual mean concentrations of Hg, as measured by the Urban and Industrial Metals Network from 2004. The graph shows the sum of the vapour phase and particulate phase components: the majority of ambient Hg is in the vapour phase. Although the former Multi-Element Network began measuring particulate phase mercury in 2000, vapour phase measurements are only available from 2004 onwards.

Two lines are shown for annual mean ambient Hg: the lighter coloured line represents the mean of all sites in the network. However, this average is dominated by one site, Runcorn Weston Point. This site is located near an industrial installation (a chlor-alkali plant) that used to use mercury in the past, and measures ambient Hg concentrations an order of magnitude greater than any other sites in the network.

The second, darker coloured line shows the annual mean for all sites *excluding* Runcorn Weston Point. This is likely to be more representative of changes over time. On the basis of this average, the ambient total Hg concentration appears to have remained stable in the range 2-3 ng m^{-3} over the past eight years.

Figure 5-30 also shows total annual UK emissions of this metal (from the NAEI). Although emissions decreased substantially throughout the 1990s, they have levelled off from the early 2000s, and there is no clear trend in emissions in the past seven years. This is reflected in the mean ambient concentration for all sites excluding Runcorn.

Figure 5-30 Ambient Concentrations of Particulate and Vapour phase Hg, and Total UK Emissions



5.10 Benzo [a] Pyrene

5.10.1 B[a]P: Spatial Distribution

Figure 5-31 shows the modelled annual mean background concentration of B[a]P. The areas of highest concentration reflect the distribution of industrial sources, and also areas where there is widespread domestic use of oil and solid fuels for heating. These include the Belfast area and other urban parts of Northern Ireland: also parts of Yorkshire, Humberside and South Wales.

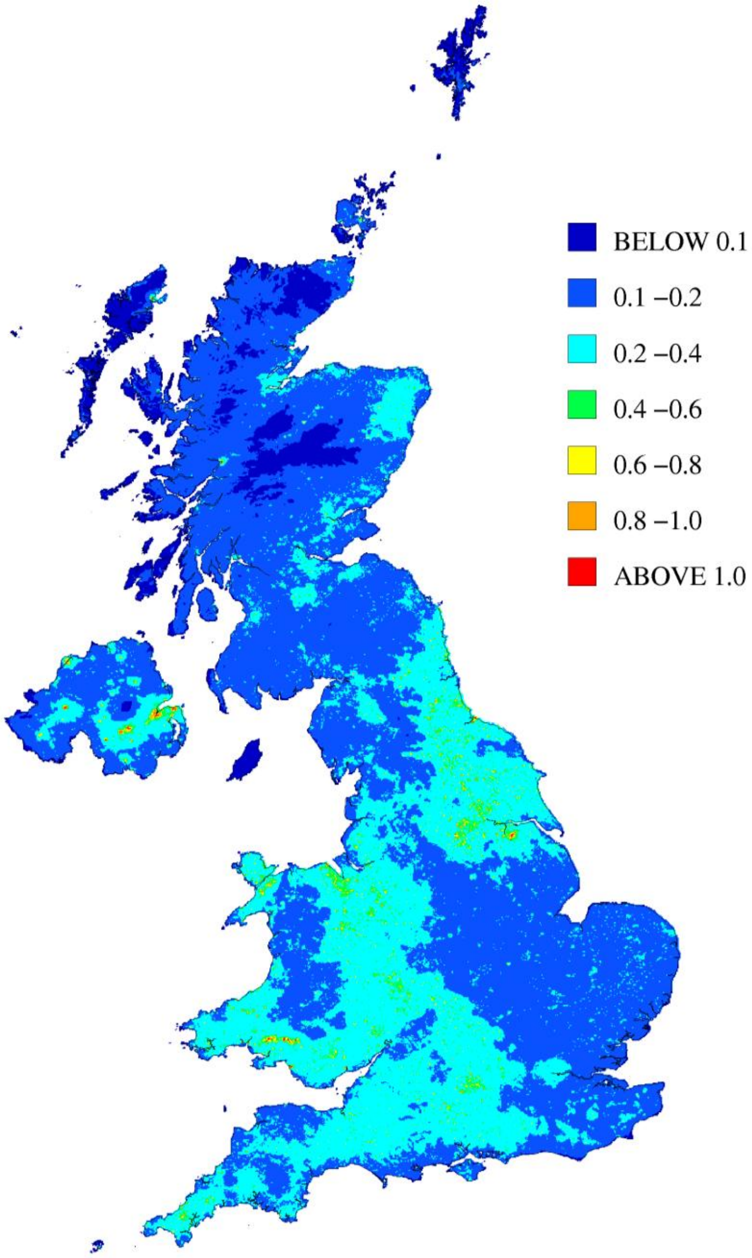
5.10.1 B[a]P: Changes Over Time

The PAH monitoring network began operation in 1991, comprising a small number of sites, and was increased to over 20 in the late 1990s. However, during the years 2007-2008, the network underwent a further major expansion and re-organisation, including a change of sampling technique.

The newer sampling technique used at most sites from 2008 onwards (the Digital PM_{10} sampler) has been found to give higher results than the older method. The reason for this is likely to be due to a number of factors, predominantly the fact that the new samplers have a shorter collection period. The shorter collection period is likely to decrease the degradation of the PAHs by ozone or other oxidative species[46].

Because of these changes in the composition of the network, and in particular the techniques used, temporal variation in PAH concentrations have not been analysed in this report. It is intended that this will be investigated in future reports, when there are sufficient data using the new technique.

Figure 5-31 Annual mean background B[a]P concentration, 2012 (ng m^{-3})

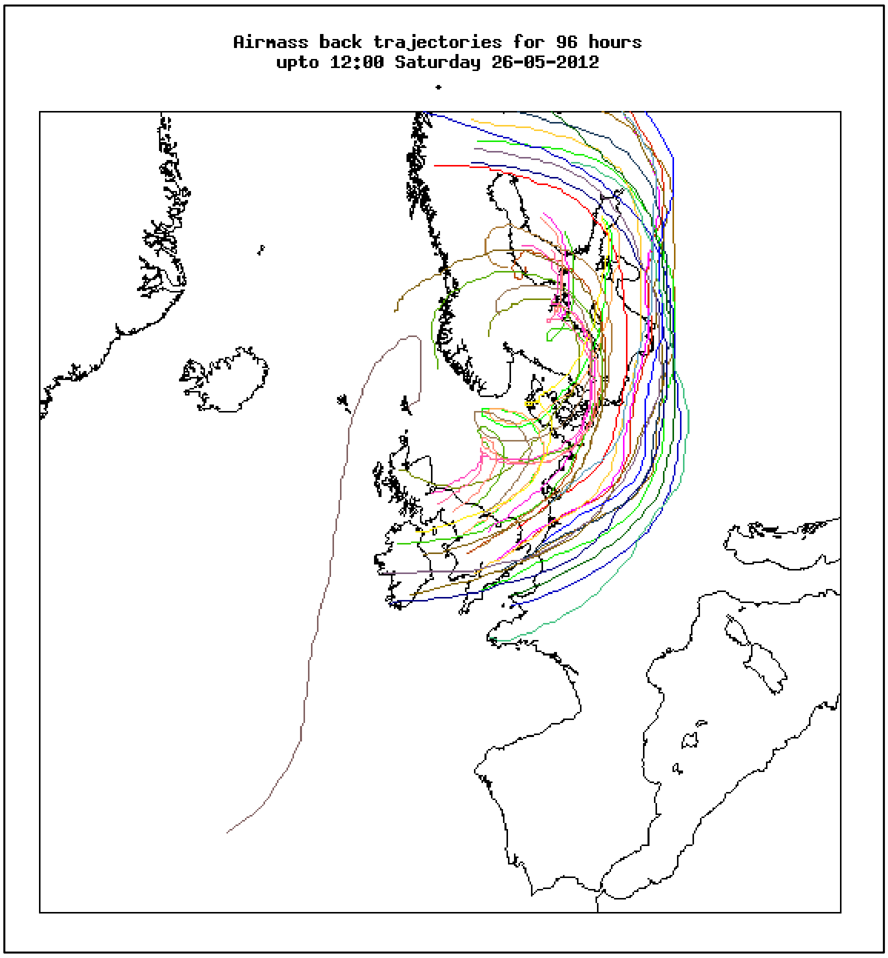


6 Pollution Events in 2012

6.1 Ozone Episodes

Air pollution episodes due to ozone usually occur in late spring and summer; at this time of year, meteorological conditions are conducive to ozone formation, and the hemispheric background concentration is at its highest. In 2012 the first ozone episode was recorded between 22nd and 28th May. During the first four days of the episode many AURN monitoring sites measured "Moderate" ozone, reaching air pollution index 6 at Northampton. On 26th May, 63 AURN sites recorded "High" ozone across the UK reaching index 7, with the highest ozone concentration measured at Yarner Wood in Devon. Widespread "Moderate" levels of ozone continued until 28th of May. Figure 6-1 shows the modelled back trajectories for the air masses arriving over the UK on the 26th May.

Figure 6-1: Modelled Back Trajectories for Air Masses Arriving in the UK on 26th May 2012



The second ozone episode in 2012 occurred between 22nd and 26th July. Increased concentrations of ozone, reaching the "Moderate" band (index 4) were recorded across an extensive area of southern England by Tuesday 24th July. By the evening of Wednesday 25th July more monitoring sites recorded widespread elevated ozone concentrations (index 5 and 6) in southern England and index 7 at London North Kensington, Sibton and Brighton Preston Park. On 26th July, the highest concentrations were recorded further west with index 7 reported at Northampton, Bournemouth and Charlton Mackrell (Somerset). This ozone episode was mainly caused by central European air masses arriving over the British Isles. Concentration levels declined by Friday July 27th and then remained generally "Low" everywhere for the remainder of the month as weather fronts moved across southern England from the west. A "snapshot" of this ozone episode on 26th July –as depicted by the interactive map on UK-AIR - is shown in Figure 6-2.

Figure 6-2 Widespread Ozone Episode as measured by Rural AURN sites, 26th July 2012.

Note: Screen shot of the interactive map on http://uk-air.defra.gov.uk/ accessed on 26th July 2012

6.2 Winter Particulate Pollution Episodes

In 2012 there were several periods of elevated particulate pollution recorded by AURN monitoring sites across the UK. These occurred between January and May 2012. During the first episode between 14th and 17th January, 24-hour mean concentration of PM_{10} and $PM_{2.5}$ reached the "Moderate" band at many AURN sites, with 14 AURN monitoring sites recording "High" on 17th January. This episode was mainly due to calm weather conditions, and a high pressure system centred over the British Isles. There were a number of "Moderate" and "High" PM_{10} and $PM_{2.5}$ concentrations measured across the UK from Tuesday January 31st to Monday February 13th.

March began with a period of high pressure and low wind speeds bringing "Moderate" and "High" particulate pollution to London, the south-east of England, the Midlands and Wales. Between March 5th and March 12th particulate concentrations remained mainly "Low". From Tuesday March 13th until Saturday March 17th, widespread increases in particulate matter concentrations were observed, reaching "Moderate" and "High". After a brief lull, concentrations rose again from Thursday March 22nd through to the end of the month, with instances of "Moderate", "High" and "Very High" pollution observed at a number of different UK locations and varying from day to day.

Figure 6-3 shows the four-day day air mass back-trajectory plot for 16th March 2012. This illustrates that air masses arriving in the UK on 16th March 2012 were mostly coming from the north of mainland Europe. The data are sourced from the NOAA website, http://ready.arl.noaa.gov/HYSPLIT.php.

Figure 6-3: Illustration of elevated levels of pollution arriving over the UK from continental Europe, 16th March 2012 (Source: NOAA Hysplit)

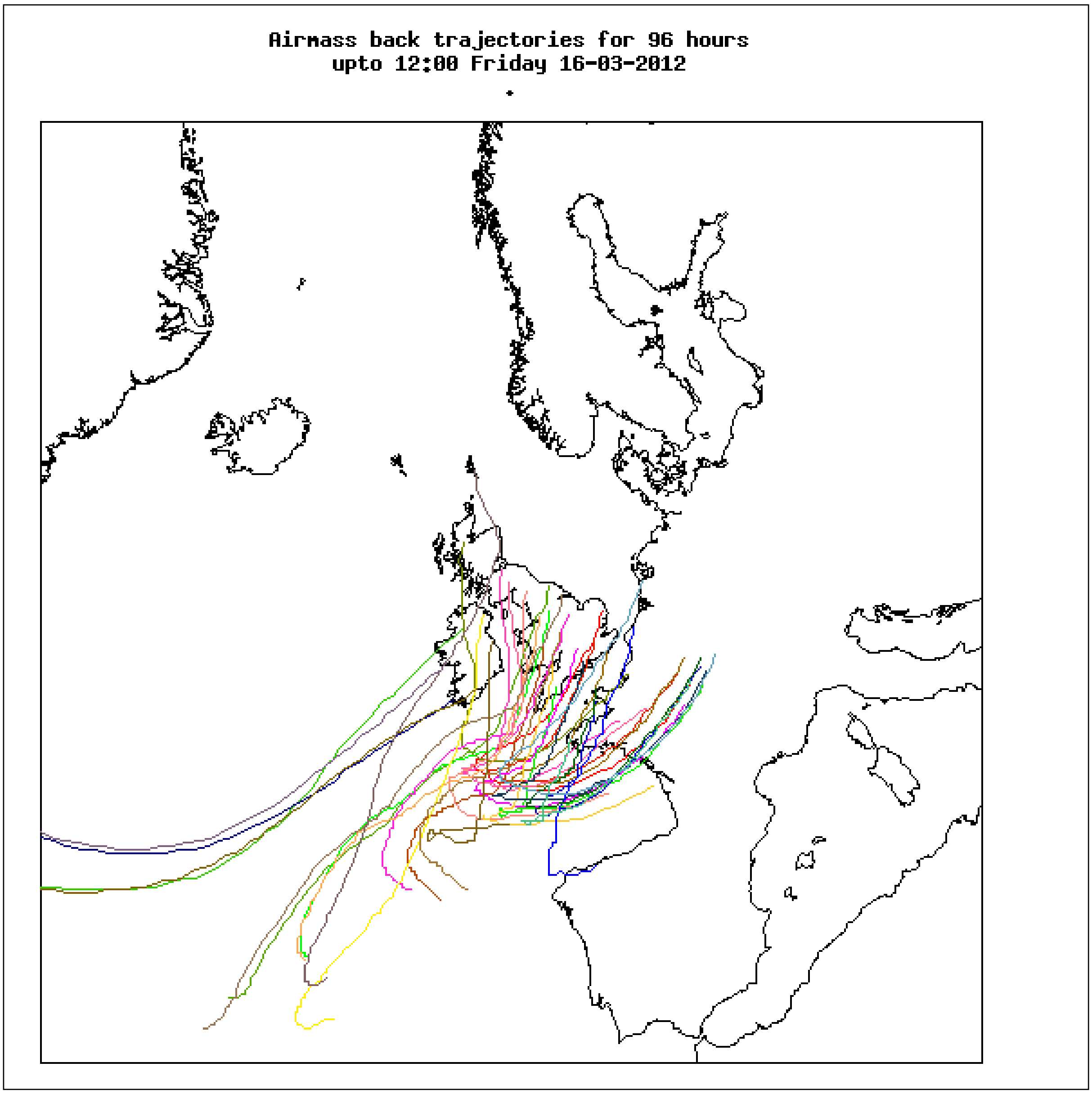
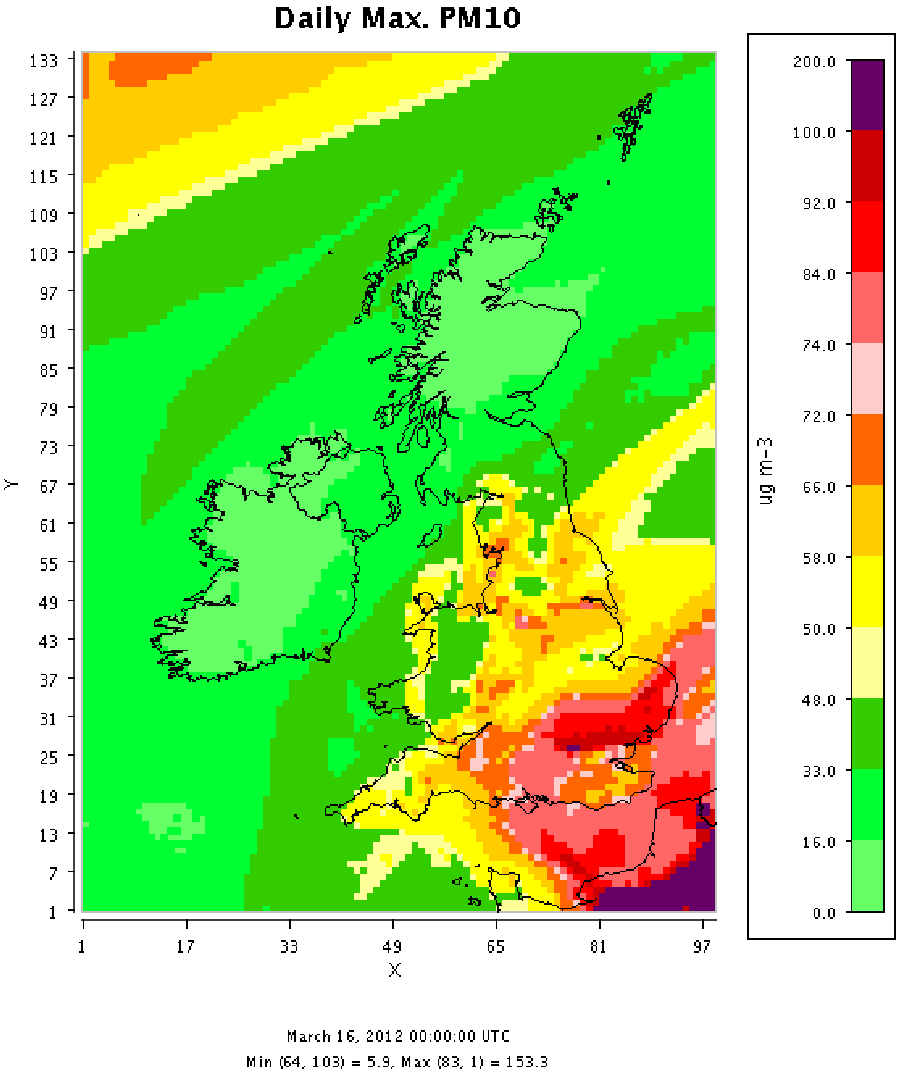


Figure 6-4 shows a modelled map predicting elevated concentrations of particulate matter to arrive over the UK on 16th Mar 2012. This modelled map was produced using CMAQ (the Community Multi-scale Air Quality modelling system, an open-source tool developed by the United States Environmenal Protection Agency Atmospheric Science Modeling Division. CMAQ consists of a suite of programs for conducting air quality model simulations, and is available online, at http://cmascenter.org/cmaq/.

Figure 6-4 CMAQ Model Predicting Elevated levels of PM_{10} in the South-East of the UK on 16th Mar 2012.



7 Where to Find Out More

Defra's web pages relating to air quality can be found at https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-for-air-quality
These provide details of what the UK is doing to tackle air pollution, and the science and research programmes in place.

Also, Defra has published a Guide to Air Pollution Information Resources, available at http://uk-air.defra.gov.uk/reports/cat14/1307241318_Guide_to_UK_Air_Pollution_Information_Resources.pdf.

Information on the UK's air quality, now and in the past, is provided by UK-AIR, the Defra online air quality resource at http://uk-air.defra.gov.uk/. UK-AIR is the national repository for historical ambient air quality data. It contains measurements from automatic measurement programmes dating back to 1972, together with non-automatic sampler measurements dating back to the 1960s. The data archive brings together into one coherent database both data and information from all the UK's measurement networks. New tools recently been added to UK-AIR include the UK Ambient Air Quality Interactive Map at http://uk-air.defra.gov.uk/data/gis-mapping.

Similar national online air quality resources have also been developed for Scotland, Wales and Northern Ireland:

- The Welsh Air Quality Archive at www.welshairquality.co.uk
- The Scottish Air quality Archive at www.scottishairquality.co.uk
- The Northern Ireland Archive at www.airqualityni.co.uk

Together, these four national websites provide a comprehensive resource for data and analyses covering all aspects of air quality throughout the UK and all its regions.

UK-AIR also provides a daily air quality forecast, which is further disseminated via e-mail, via a free telephone service on 0800 556677, and via Twitter (see http://uk-air.defra.gov.uk/twitter). Latest forecasts are issued twice daily, at http://uk-air.defra.gov.uk/forecasting/.

Detailed pollutant emission data for the UK are available from the National Atmospheric Emissions Inventory (NAEI) at www.naei.org.uk.

Additional information from the Devolved Administrations of Scotland, Wales and Northern Ireland can be found at:

- The Scottish Government Air Quality pages on http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215

- The Welsh Government Environment link at http://wales.gov.uk/topics/environmentcountryside/epq/airqualitypollution/airquality/?lang=en

- The Northern Ireland DoE Environmental Policy Division website at http://www.doeni.gov.uk/index/protect_the_environment/local_environmental_issues/air_and_environmental_quality.htm

The Devolved Administrations each produce their own short annual report, providing more specific information on air quality in their regions. These reports are available from the above websites.

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