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Air Pollution in the UK 2013

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Air Pollution in the UK 2013

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 2013 submission on ambient air quality to the European Commission, presenting air quality modelling data and measurements from national air pollution monitoring networks. 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 reported on behalf of Defra (the Department for Environment, Food and Rural Affairs) and the Devolved Administrations of Scotland, Wales and Northern Ireland.

For the purposes of air quality monitoring, the UK is divided into 43 zones. The 2013 results can be summarised as follows:

- The UK met the EU limit values for sulphur dioxide.
- The UK met the limit value for hourly mean nitrogen dioxide (NO_2) in all but one zone (out of the total of 43).
- Twelve zones were compliant with the limit value for annual mean NO_2, (or the limit value plus margin of tolerance where a time extension was in place). Of these 12 compliant zones, five were within the limit value, and a further seven were covered by a time extension and were within the limit value plus the applicable margin of tolerance. The remaining 31 zones exceeded the limit value (or limit value plus margin of tolerance where applicable).
- 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.
- All zones met both the target values for ozone; the target value based on the maximum daily eight-hour mean, and the target value based on the AOT40 statistic.
- Thirty-three zones exceeded the long-term objective for ozone, set for the protection of human health. This is based on the maximum daily eight-hour mean.
- Eight zones exceeded the long-term objective for ozone, set for the protection of vegetation. This is based on the AOT40 statistic.
- Two zones exceeded the target value for nickel in 2013.
- Six zones exceeded the target value for benzo[a]pyrene in 2013.

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 levels of air pollution. 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, enabling them to take appropriate action to minimise health impacts.
- To evaluate potential impacts on population, ecosystems and our natural environment.

Air quality standards are set in European Union (EU) 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 must be submitted to the European Commission each year. As of 2013, the air quality compliance assessment is submitted to the Commission via e-Reporting (see section 2.1.2). The UK's annual submission for 2013 can be found on the Commission website at http://cdr.eionet.europa.eu/gb/eu/aqd. All the compliance results come under "Information on the Attainment of Environmental Objectives" in e-Reporting Data Flow G. Previous years' submissions (which were in the form of a standard questionnaire) can be found at 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 2013" continues this series, and this report has two aims:

- To provide a summary of the UK's 2013 air quality report to the Commission. A separate Compliance Assessment Summary document, based upon Section 4 of this report, accompanies the UK's 2013 data submission to the Commission, providing a concise summary aimed at the public.
- To act as a State of the Environment report, providing a wider group of stakeholders with information on the ambient air quality evidence base for the year. This includes analysis of trends and spatial distribution, together with information on pollution events during the year.

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 2013, and compares this with previous recent years. *(Section 4).*

- Explains the spatial distribution of the main pollutants of concern within the UK during 2013, and looks at how ambient concentrations have changed in recent years (*Section 5).*

- Explains pollution events – "episodes" of high pollution – that occurred during 2013, (*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 (EU) air pollution legislation follows two complementary approaches;

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

All Member States must incorporate - or "transpose" - the provisions of EU Directives into their own national law by a specified date and comply with legally binding implementing rules set out in the Decisions. The main Directives and Decisions are described below.

2.1.1 The Air Quality Directive and Fourth Daughter Directive

Directive 2008/50/EC of 21st May 2008, on Ambient Air Quality and Cleaner Air for Europe – 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.

Directive 2004/107/EC of 15th December 2004, relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air - referred to in this report as "the Fourth Daughter Directive" - covers the four metallic elements cadmium, arsenic, nickel and mercury and polycyclic aromatic hydrocarbons (PAH).

These two Directives set "limit values", "target values" and "long-term objectives" for ambient concentrations of pollutants.

Limit values are legally binding and must not be exceeded. They are set for individual pollutants and comprise a concentration value, an averaging period for the concentration value, a number of exceedances allowed (per year) and a date by which it must be achieved. Some pollutants have more than one limit value.

Target values and long-term objectives are set for some pollutants and are configured in the same way as limit values. Member States must take all necessary measures not entailing disproportionate costs to meet the target values and long-term objectives.

The Air Quality Directive and Fourth Daughter Directive include detailed provisions on monitoring and reporting air quality, including:

- 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 Air Quality Directive also made provision for adapting standardised procedures to streamline the data provision, assessment and reporting of air quality, to electronically release information in line with the INSPIRE Directive (2007/2/EC). This led to the adoption of new implementing rules for reporting (IPR) (Decision 2011/850/EC, referred to in this report as the Air Quality e-Reporting IPR). Section 2.1.2 provides a detailed description of the Air Quality e-Reporting IPR. The report of 2013 is the first in which e-Reporting has been used to report emissions.

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 Air Quality e-Reporting

Air Quality e-Reporting is a new process, developed by the European Commission, for reporting of compliance and provision of data under the Air Quality Directive. The development has been driven by the requirements of the INSPIRE Directive (which is concerned with the sharing of spatial data across EU Member States in a consistent and computer-readable format).

European Commission Implementing Decision 2011/850/EC[7] was introduced on 12th December 2011. This Decision laid down rules for the reciprocal exchange of information, and reporting on ambient air quality, in relation to the Air Quality Directive. The Decision provided an opportunity to modernise data reporting, improve data quality, facilitate information sharing and reduce the administrative burden of reporting. In adapting the procedures, Air Quality e-Reporting has embraced digital formats for reporting, and the internet as the core medium for reporting. Air Quality e-Reporting extends the core requirements of the INSPIRE Directive to meet the particular requirements of regulatory and informative air quality reporting.

The European Commission developed the new procedures with assistance from the European Topic Centre on Air and Climate Change Mitigation and the European Environment Agency (EEA), and in close liaison with the European Environment Information and Observation Network (EIONET) air quality community. The new reporting system covers all regulatory and informative reporting agreements set out by the Exchange of Information Decision (EoI) (Council Decision 97/101/EC[8]), the Air Quality Directive and the 4th Daughter Directive. By adopting data modelling approaches prescribed by INSPIRE, the new e-Reporting data model is streamlined, internally consistent and meets modern standards for data encoding and data sharing. The data model is now organised into eight broad air quality data themes that service all reporting and information sharing needs of the air quality community.

Air Quality e-Reporting has been instrumental in engaging UK air quality data systems with the INSPIRE initiative and aligning these with the Defra's broader Open Data Strategy.

2.1.3 The National Emission Ceilings Directive

The National Emission Ceilings Directive[9] (2001/81/EC) came into force in 2001, and has been transposed into UK legislation by the National Emission Ceilings Regulations 2002. The 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. They reflect the ceilings agreed in the Gothenburg Protocol to the Convention on Long Range Transboundary Air Pollution (CLRTAP). Emissions of these pollutants can impact either locally or across national borders. 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. The UK meets the ceilings set under the National Emission Ceilings Directive for all four of the above pollutants. The National Emission Ceilings Directive report is available at http://www.eea.europa.eu//publications/nec-directive-status-report-2013.

The Gothenburg 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 European Commission published a proposal to revise the National Emission Ceilings Directive in December 2013 to set ceilings for 2020 implementing the Gothenburg commitments and further ceilings for 2030. The proposal must be agreed by the Council and the Parliament before it can become law. The negotiations are expected to take around 2 years.

2.2 The UK Perspective

Environmental legislation introduced over the past seventy 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[10]. Moreover, it is now firmly established that air pollution (particulate matter, sulphur dioxide and ozone) contributes to thousands of hospital admissions per year[11].

2.2.1 The UK Air Quality Strategy

The Environment Act 1995 required that a National Air Quality Strategy be published, containing policies for assessment and management of air quality. The Air Quality Strategy[12] 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[13] 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 2013 was released in April 2014 and is available from the Defra website[14].

In May 2014, Defra published a revised edition of 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).

The UK Government's Public Health Outcomes Framework for England (published in 2012) 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, $PM_{2.5}$)[15]

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 .

Northern Ireland has a similar Public Health Strategy: *"Making Life Better – A Whole System Framework for Public Health 2013-2023"*. This document can be found at http://www.dhsspsni.gov.uk/mlb-strategic-framework-2013-2023.pdf , and also includes an air quality indicator.

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 2012 (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 particulate matter and non-methane volatile organic compounds, the rate of decline was most pronounced in the 1990s, and has slowed in recent years.
- Emissions of sulphur dioxide increased in 2012 compared to 2011 by 10.7%, undoing a decrease of 7.1% in the previous year. The rate of reduction has slowed since the large decreases seen in the 1990s and has remained level since 2009 around an average of 0.41 million tonnes.
- Emissions of nitrogen oxides slightly increased in 2012 compared to 2011 by 1.6%. Emissions of particulate matter as PM_{10} remained the same in 2012 as in 2011. All three other emissions - ammonia, non-methane volatile organic compounds and particulate matter as $PM_{2.5}$ – decreased slightly in 2012 compared to 2011, by between 1.3% and 1.7%.
- 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 2013 will be available in December 2014, 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 .

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[16].

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 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[17]. 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[18], together with subsequent amendments[19,20,21,22]. 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, 257 Local Authorities – roughly 63% 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 2014.)

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)	291	189	468	40	6	0	166	84
London	33	33	33	29	0	0	33	1
Scotland	32	13	21	21	1	0	10	7
Wales	22	10	36	1	0	0	6	6
N. Ireland	26	12	23	6	0	0	13	5
TOTAL	**404**	**257**	**581**	**97**	**7**	**0**	**228**	**103**

Note: some of the LA’s with Action Plans awaited have already submitted earlier Action Plans (for other AQMAs or other pollutants). Hence the total of the two right-hand columns is greater than the total number of LA’s with AQMAs.

Most Air Quality Management Areas in the UK are in urban areas and result from traffic emissions of nitrogen dioxide or PM_{10}. Transport is the main source in 97% of the AQMAs declared for NO_2; this is predominantly road transport but may include some other types, e.g. trains or shipping. A further 2% result from transport mixed with either domestic or industrial sources, and only 1% result from non-traffic (or unknown) sources alone. 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

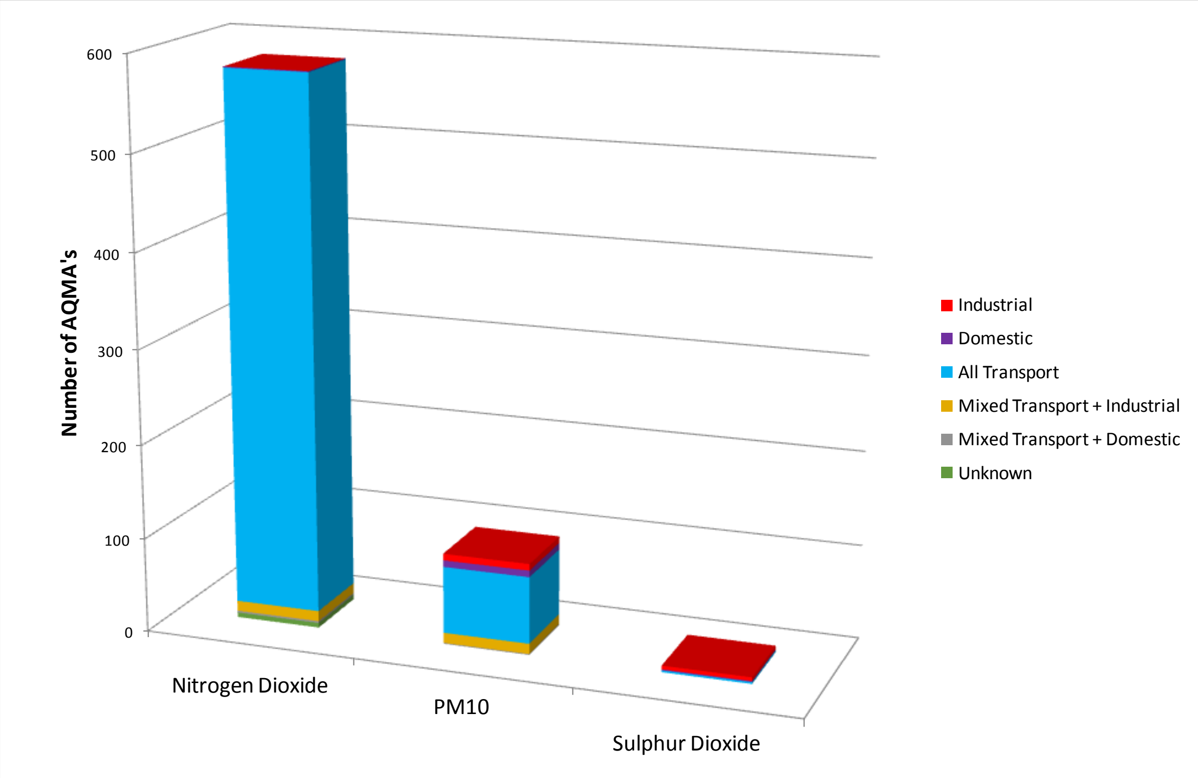


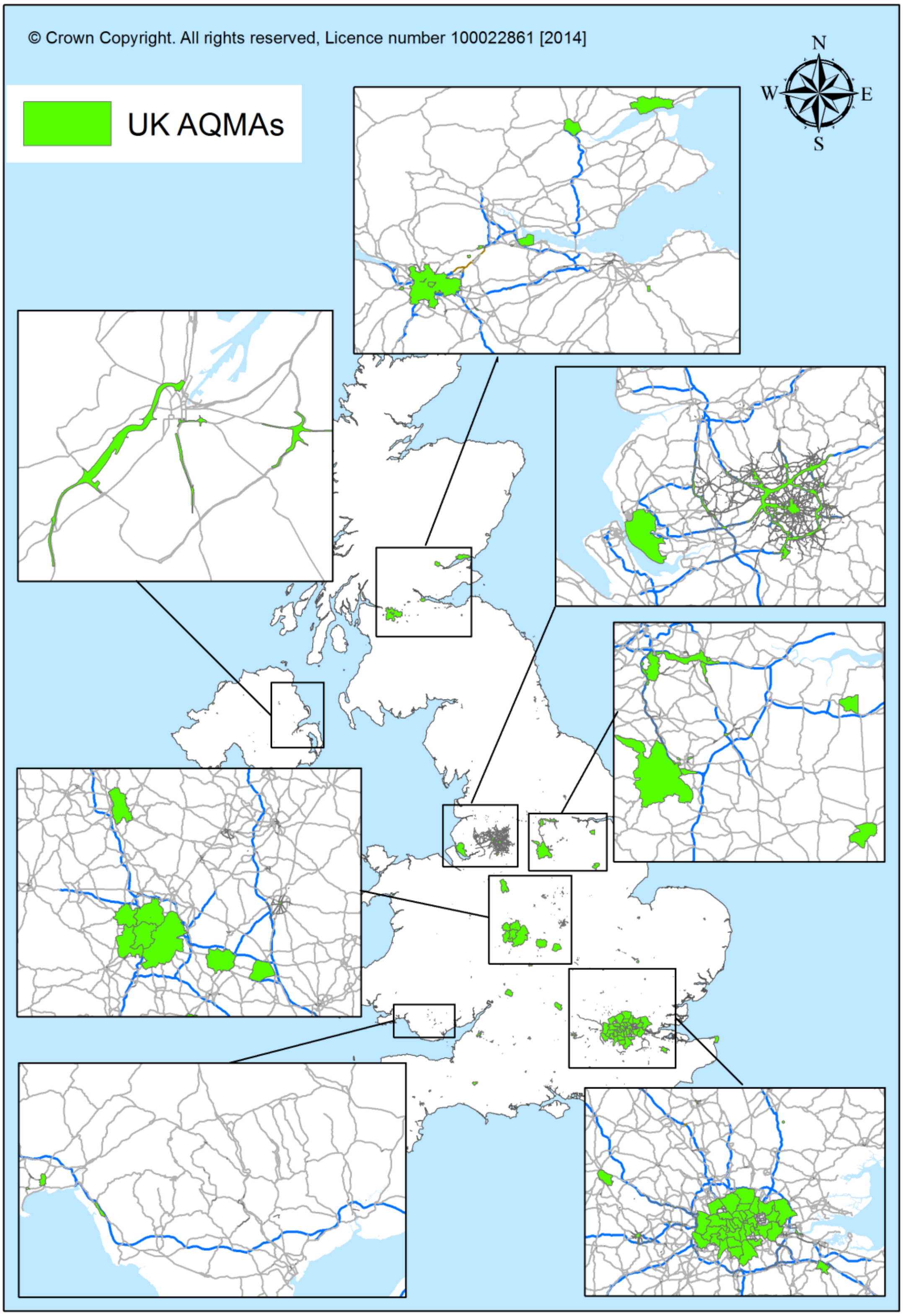
Table 2-1 shows that a total of 228 Local Authorities have now submitted Action Plans, and that 103 Local Authorities are in the process of preparing them. For some of these 103 Authorities, it is not their first Action Plan; they have already submitted one or more, for a different area or pollutant. Therefore, they are also counted within the total of 228 Authorities with plans submitted; hence these two totals add up to *more* than 257 (the number of Local Authorities with AQMAs).

Action Plans 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 is published on the Defra LAQM website. Information is provided on each one, together with a map of the AQMA, where available.

In 2013 Defra consulted on potential changes to LAQM. These were aimed at reducing the burden on local authorities and improving the delivery of action to address air pollution. There was a significant response to the consultation. The summary of responses and Government's reply can be found at https://www.gov.uk/government/consultations/local-air-quality-management-in-england-review .

Figure 2-2 Air Quality Management Areas in the UK, as at end of 2013



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[23] together with Table 1 of the Air Quality Strategy[24].

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)[25] (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[16]
  - COMEAP's 2009 report on long-term exposure to air pollution and its effect on mortality[26] (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[27] (referred to in the table as COMEAP 2010).
  - Expert Panel on Air Quality Standards (EPAQS) report "Metals and Metalloids[28] (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[29].
- A 2011 study by King's College London, the University of Leeds and AEA (now Ricardo-AEA), which investigated the reasons why ambient concentrations of NOx and NO_2 have decreased less than predicted on the basis of emissions estimates[30].
- The Air Quality Strategy[12].

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 almost 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. The reasons why roadside NO_2 concentrations have not decreased as expected is believed to be the failure of Euro vehicle emission standards for diesel vehicles to deliver the anticipated reductions in emissions in real world driving conditions[30] (see section 5.2.2 of this report). 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 adverse health 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 from domestic and industrial combustion processes, in addition to road transport. (Source: Air Quality Strategy).	Benzene is a recognised human carcinogen. Repeated exposure can result in the deterioration of genetic material (mutagenic effect) of the circulatory and immune systems. 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 carbon inputs to carbon dioxide (CO_2). Although CO emissions from petrol-engine 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 Lead's use in petrol was phased out in 1999, resulting in a 98% reduction of pre-1999 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 are now typically less than 1 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 are now typically < 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 (e.g. 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. The use of models reduces the number of monitoring stations required. It 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 national models known as the Pollution Climate Mapping (PCM) models. 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 2013 there were 268 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 268, because some sites belong to more than one network). This table shows the numbers of sites in operation during part or all of 2013.

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 the gaseous pollutants within the AURN are the reference methods of measurement defined in the relevant EU Directives. 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 2013

Network	Statutory or Research	Pollutants	Number of Sites in 2013
Automatic Urban and Rural Network (AURN)	Statutory	CO, NOx, NO_2, SO_2, O_3, PM_{10}, $PM_{2.5}$.	133
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	26
Non-Automatic Hydrocarbon	Statutory	Benzene	37
Automatic Hydrocarbon	Statutory	Range of VOCs	4
Polycyclic Aromatic Hydrocarbons (PAH). Digital samplers	Statutory	21 PAH species including benzo[a]pyrene	31
Toxic Organic Micropollutants	Research	Range of toxic organics including dioxins and dibenzofurans.	5
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	15
Acid Waters Monitoring	Research	Chemical and biological species in water	24
Rural Metals Network	Research and statutory	Al,As,Ba,Be,Cd,Co,Cr,Cs,Cu,Fe,Hg,Li,Mn, Mo,Ni,Pb,Rb,Sb,Sc,Se,Sn,Sr,Ti,U,V,W,Zn	12[a] in particulate 14 in rainwater

Footnote a to Table 3-2: includes Eskdalemuir.

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"[31]
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"[32]
SO_2	EN 14212:2005 "Ambient air quality – Standard method for the measurement of the concentration of sulphur dioxide by UV fluorescence"[33]
CO	EN 14626:2005 "Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by non-dispersive infrared spectroscopy"[34]
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."[35] EN 14907:2005 "Ambient air quality - Standard gravimetric measurement method for the determination of the $PM_{2.5}$ mass fraction of suspended particulate matter"[36] 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[37]. In 2013, it comprised 26 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 37 sites, ambient concentrations of benzene are measured by the CEN standard method[38], 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.

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 2013, there were 31 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 five 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. 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 2013 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 a programme set up 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 2013, the Black Carbon Network measured black carbon at 15 sites using an automatic instrument called an Aethalometer. 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 24 monitoring sites including 11 lakes and 13 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 12 rural sites, including Eskdalemuir) 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 Urban and Industrial 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[39]. 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)"[40] 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 a technical report[41] (the latest versions of these can be found in the Library section of Defra's UK-AIR website[42]).

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 and oil refineries).
- Small point sources (e.g. boilers in town halls, schools or hospitals and crematoria).
- Distant sources (characterised by the rural background concentration).
- Local area sources (e.g. road traffic, domestic and commercial combustion and 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 emission estimates from the National Atmospheric Emissions Inventory[43] (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

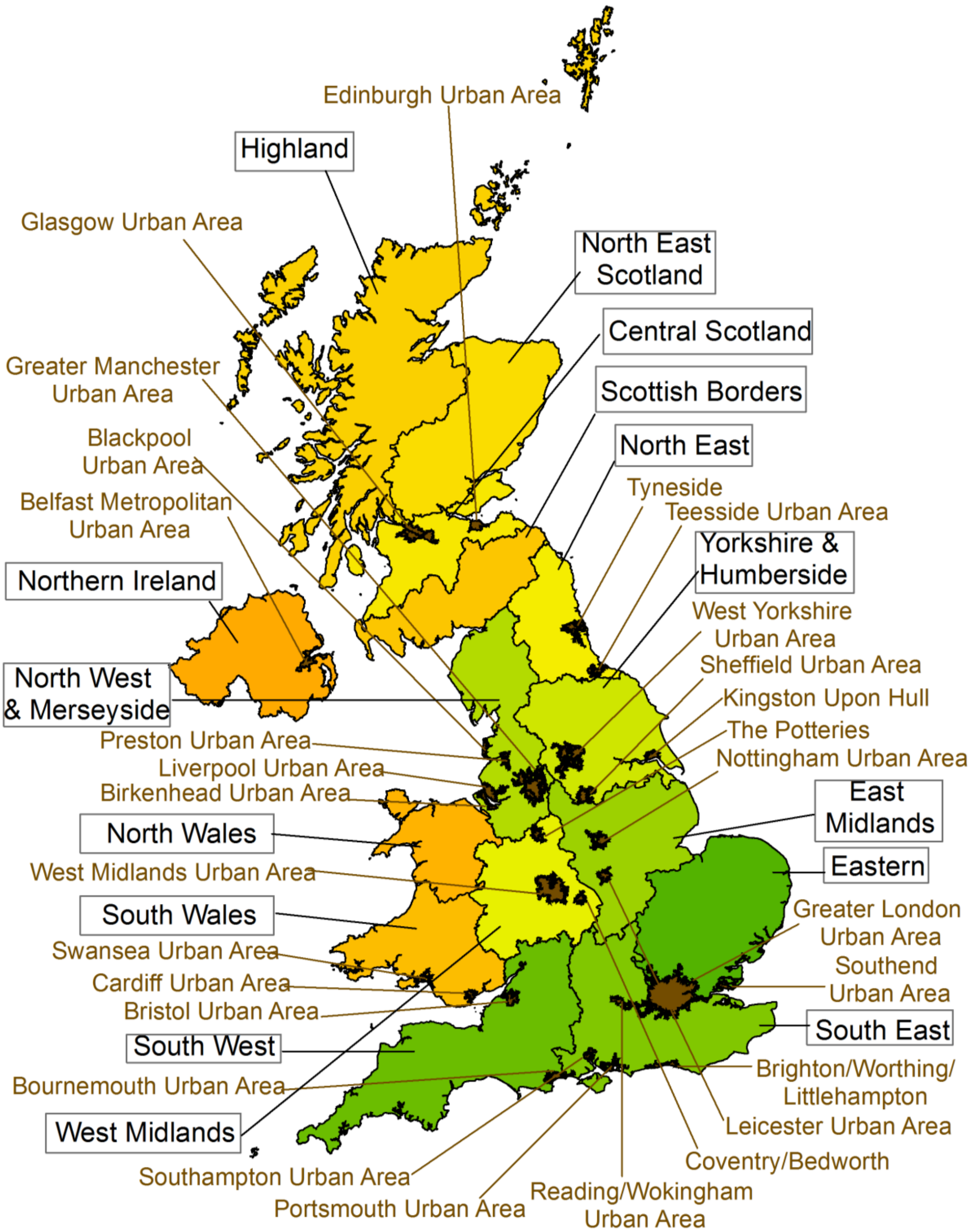
The UK is divided into 43 zones for air quality assessment. There are 28 agglomeration zones (large urban areas) and 15 non-agglomeration zones. Each zone is assigned an identification code. Zones are listed in Table 4-1 and shown in Figure 4-1.

Table 4-1 UK Zones and Agglomerations for Ambient Air Quality Reporting 2013

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 2013



Agglomeration zones (brown)
Non-agglomeration zones (yellow/green)

4.2 Air Quality Assessment for 2013

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.

As of 2013, the air quality compliance assessment is submitted to the European Commission via e-Reporting. All the compliance results come under "Information on the Attainment of Environmental Objectives" in e-Reporting Data Flow G.

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 2013, 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 or long-term objective, this is identified as ">LV", ">LV+MOT", ">TV" or ">LTO" as applicable.
- Where a non-compliance 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): In 2013, 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 summarised in Table 4-2.

One zone had locations where the 1-hour limit value (200 µg m^{-3}) was exceeded on more than the permitted 18 occasions during 2013: Greater London Urban Area (UK0001). The remaining 42 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 2013:

- 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 mean limit value in the following zones and agglomerations;

- Nottingham Urban Area (UK0008)
- Leicester Urban Area (UK0011)
- Portsmouth Urban Area (UK0012)
- Birkenhead Urban Area (UK0020)
- Southend Urban Area (UK0021)
- Preston Urban Area (UK0023)
- Edinburgh Urban Area (UK0025)
- Cardiff Urban Area (UK0026)
- Swansea Urban Area (UK0027)
- Central Scotland zone (UK0037)
- North Wales zone (UK0042) and
- Northern Ireland zone (UK0043).

(Reading/Wokingham Urban Area – zone UK0016 – also had a time extension, but this ended on 1st January 2013 and so is not relevant to this report). Where a time extension applies, Article 2 of the Commission Decision of 26th June 2012 requires the UK to provide the Commission with data indicating that the annual mean NO_2 concentrations in these zones have remained below the annual limit value plus the maximum margin of tolerance (60 µg m^{-3}) specified in Annex XI to Directive 2008/50/EC.

The following seven zones exceeded the annual mean limit value, but were within the annual mean limit value plus margin of tolerance in 2013:

- Portsmouth Urban Area (UK0012)
- Birkenhead Urban Area (UK0020)
- Southend Urban Area (UK0021)
- Edinburgh Urban Area (UK0025)
- Swansea Urban Area (UK0027)
- Central Scotland (UK0037) and
- North Wales (UK0042).

Therefore, a total of 12 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 31 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.

Table 4-2 Results of Air Quality Assessment for Nitrogen Dioxide in 2013

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 (m)	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 (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	≤ LV + MOT (m)	n/a
Southend Urban Area *	UK0021	OK	≤ 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 + MOT (m)	n/a
Belfast Metropolitan Urban Area	UK0028	OK	> LV (m)	n/a
Eastern	UK0029	OK	> LV (m)	OK
South West	UK0030	OK	> LV	OK
South East	UK0031	OK	> 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 in place during 2013.

PM_{10} Particulate matter: the results of the air quality assessment for PM_{10} for each zone summarised in Table 4-3. No time extensions were in place for PM_{10} during 2013.

Under Section 20 of 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. Prior to subtraction of contributions from natural sources the Greater London zone (UK0001) exceeded the daily limit value (50 µg m^{-3}) on more than the permitted 35 occasions in 2013 (as assessed by modelling). Following subtraction of the natural source contribution, the number of exceedances was reduced from 42 to 33 days. Therefore, all zones were compliant with the daily mean limit value. *In Table 4-3, natural source contribution has only been subtracted for Greater London (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 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.

$PM_{2.5}$ contributions due to natural events (1999/30/EC Article 5(4)) or natural contributions (2008/50/EC Article 20) have been removed from the $PM_{2.5}$ exceedance listed in Table 4-4 in the following case:

- Exceedance of the Stage 2 limit value in Greater London Urban Area (UK0001) based upon the modelling assessment only. This exceedance remains even after subtraction of the natural contribution (sea salt).

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

Annual mean concentrations of $PM_{2.5}$ were within the Stage 2 limit value of 20 µg m^{-3} in the remaining 42 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[44].)

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 2013 was calculated as follows:

- 2011: 14 µg m^{-3}
- 2012: 12 µg m^{-3}
- 2013: 12 µg m^{-3}.

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

Table 4-3 Results of Air Quality Assessment for PM_{10} in 2013 (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	OK
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	OK
Edinburgh Urban Area	UK0025	OK	OK
Cardiff Urban Area	UK0026	OK	OK
Swansea Urban Area	UK0027	OK	OK
Belfast Metropolitan 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 42 to 33. 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 2013 (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 (m)
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	OK	OK
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	OK	OK
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	OK	OK
Cardiff Urban Area	UK0026	OK	OK	OK
Swansea Urban Area	UK0027	OK	OK	OK
Belfast Metropolitan Urban Area	UK0028	OK	OK	OK
Eastern	UK0029	OK	OK	OK
South West	UK0030	OK	OK	OK
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.

Carbon monoxide (CO), benzene and lead: all zones and agglomerations were compliant with the limit values for these three pollutants in 2013. The 2013 compliance assessment for CO was based on objective estimation (explained in Defra's technical report on UK air quality assessment[44]) underpinned by National Atmospheric Emissions Inventory trends, Automatic Urban and Rural Network measurement trends and historical modelling.

Ozone: the results of the air quality assessment for ozone are summarised in Table 4-5.

Table 4-5 Results of Air Quality Assessment for Ozone in 2013

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

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

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. Thirty-three of the 43 zones and agglomerations were *above* the long-term objective (LTO) for health, the exceptions being West Yorkshire (UK0004), Tyneside (UK0005), Sheffield Urban Area (UK0007), Teesside (UK0013), Kingston upon Hull (UK0018), Glasgow Urban Area (UK0024), Edinburgh Urban Area (UK0025), the North East (UK0036), Central Scotland (UK0037) 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 hourly mean 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. Eight zones were above the long-term objective for vegetation: these were Greater London Urban Area (UK0001), Bristol Urban Area (UK0009), Brighton/Worthing/Littlehampton (UK0010), Bournemouth Urban Area (UK0015), the South West (UK0030), the South East (UK0031), the West Midlands (UK0035) and South Wales (UK0041).

In 2013 there were three measured exceedances of the ozone information thresholds (at two sites) but no exceedances 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 in 2013

Site name	Zone code	Number of 1-hour exceedances of information threshold	Maximum 1-hour concentration (µg m^{-3})
Brighton Preston Park	UK0010	1	182
Canterbury	UK0031	2	187

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 summarised in Table 4-7.

All zones and agglomerations met the target values for arsenic and cadmium. Two zones (Swansea Urban Area and South Wales, zones UK0027 and UK0041 respectively) 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 six zones; Teesside Urban Area (UK0013), Swansea Urban Area (UK0027), the East Midlands (UK0032), Yorkshire and Humberside (UK0034), the North East (UK0036) and South Wales (UK0041). In Teesside, Swansea and the North East, the exceedances are attributed to emissions from industrial sources. In the East Midlands, the exceedance is attributed to domestic fuel use. In South Wales, the exceedance results from a combination of industrial sources and domestic solid fuel use while in Yorkshire and Humberside it is predominantly due to industrial emissions with some contribution from domestic sources. The remaining 37 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 2013

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
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 Metropolitan Urban Area	UK0028	OK	OK	OK	OK
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	> TV (m)
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	OK	> TV (m)	> TV (m)
North Wales	UK0042	OK (m)	OK (m)	OK (m)	OK (m)
Northern Ireland	UK0043	OK (m)	OK (m)	OK (m)	OK

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 to the Commission. Table 4-8 shows the mean total deposition rates for these species reported for 2013 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 2013

Site	Zone	As µgm^{-2}day^{-1}	Cd µgm^{-2}day^{-1}	Ni µgm^{-2}day^{-1}	Hg µgm^{-2}day^{-1}	B[a]P µgm^{-2}day^{-1}
Harwell	South East	0.155	0.0266	0.364	0.008	0.0231
Auchencorth Moss	Central Scotland	0.151	0.0166	2.180	0.005	0.0071

4.3 Comparison with Previous Years

Table 4-9 to Table 4-13 summarise the results of the air quality assessment for 2013 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 for these pollutants except where granted by a time extension. Table 4-9 shows the number of zones exceeding the limit value plus any agreed margin of tolerance (i.e. the numbers of zones that were non-compliant). If any additional zones were within the limit value plus an agreed MOT (and therefore compliant), this is shown in the footnotes.

Table 4-9 (Part 1 of 2) Non-Compliances with the Limit Values of the Air Quality Directive

Pollutant	Averaging time	2008	2009	2010	2011	2012	2013
SO_2	1-hour	None	None	None	None	None	None
SO_2	24-hour	None	None	None	None	None	None
SO_2	Annual[i]	None	None	None	None	None	None
SO_2	Winter[i]	None	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)	1 zone measured (London)
NO_2	Annual	40 zones (10 measured + 30 modelled)	40 zones (9 measured + 31 modelled)	40 zones (11 measured + 29 modelled)	35 zones (8 measured, + 27 modelled)[iii]	34 zones (10 measured + 24 modelled)[iv]	31 zones (9 measured + 22 modelled)[v]
NO_x	Annual[i]	None	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] A further five zones exceeded the annual mean NO_2 LV in 2011 but were covered by time extensions and within the LV+ MOT, therefore compliant.
[iv] A further four zones exceeded the annual mean NO_2 LV in 2012 but were covered by time extensions and within the LV+ MOT, therefore compliant.
[v] A further seven zones exceeded the annual mean NO_2 LV in 2013 but were covered by time extensions and within the LV+ MOT, therefore compliant.

Table 4-9 is continued on the next page.

Table 4-9 (Part 2 of 2) Non-Compliances with the Limit Values of the Air Quality Directive

Pollutant	Averaging time	2008	2009	2010	2011	2012	2013
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*	None (after subtraction of natural contribution)[vi]	None (after subtraction of natural contribution)[vii]	None (after subtraction of natural contribution. No time extension.)	None (after subtraction of natural contribution. No time extension.)
PM_{10}	Annual	None	None	None	None	None	None
Lead	Annual	None	None	None	None	None	None
Benzene	Annual	None	None	None	None	None	None
CO	8-hour	None	None	None	None	None	None

[vi] One zone exceeded the daily mean PM_{10} limit value more than the permitted 35 times in 2010, after subtraction of natural contribution. This zone was covered by a time extension, and was within the LV+MOT so was therefore compliant.
[vii] One zone exceeded the daily mean PM_{10} limit value more than the permitted 35 times in 2011, after subtraction of natural contribution. This zone was covered by a time extension, and was within the LV+MOT so was therefore compliant.

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	2013
O_3	8-hour	1 zone measured (Eastern)	None	None	None	None	None
O_3	AOT40	None	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	2013
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)	33 zones (21 measured and 12 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)	8 zones (6 measured +2 modelled)

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

Pollutant	Averaging time	2007	2008	2009	2010	2011	2012	2013
As	Annual	None	None	None	None	None	None	None
Cd	Annual	None	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)	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.)	6 zones (1 measured; Yorkshire & Humberside, + 5 modelled; Teesside, Swansea, the East Midlands, the North East, South Wales.)

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

Pollutant	Averaging time	2009	2010	2011	2012	2013
$PM_{2.5}$	Annual	None	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, roadside and background concentrations are discussed separately.

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 2012).

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 <u>*or equal to*</u> *40 µg m^{-3}.*

5.1 Sulphur Dioxide

5.1.1 SO_2: Spatial Distribution in the UK

Figure 5-1 shows how the modelled 99.73rd percentile[a] of hourly mean sulphur dioxide concentration varied across the UK during 2013. 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 modelled 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 2013.

[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 per year), percentiles are used to illustrate this.

Figure 5-1 99.73rd percentile of 1-hour mean SO_2 concentration, 2013 (µg m^{-3})[b]

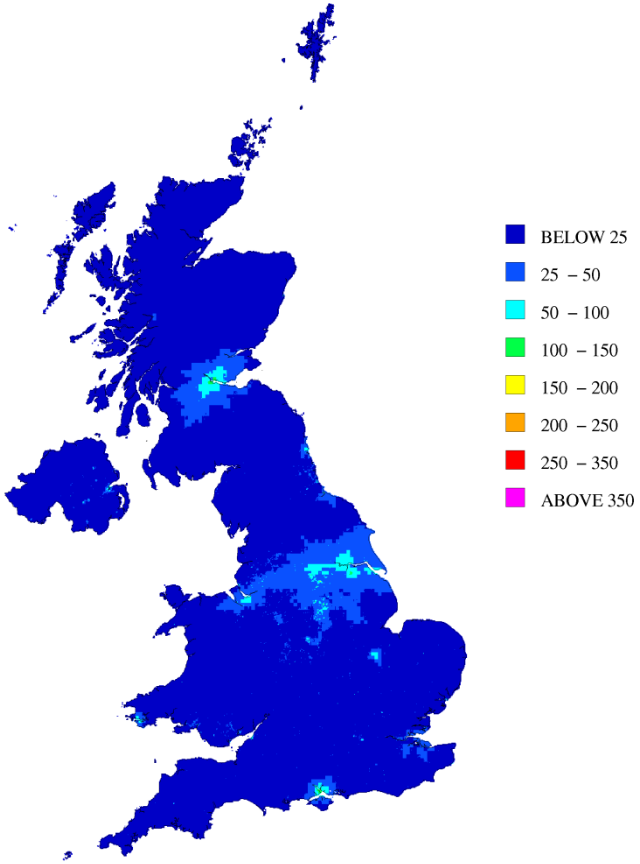
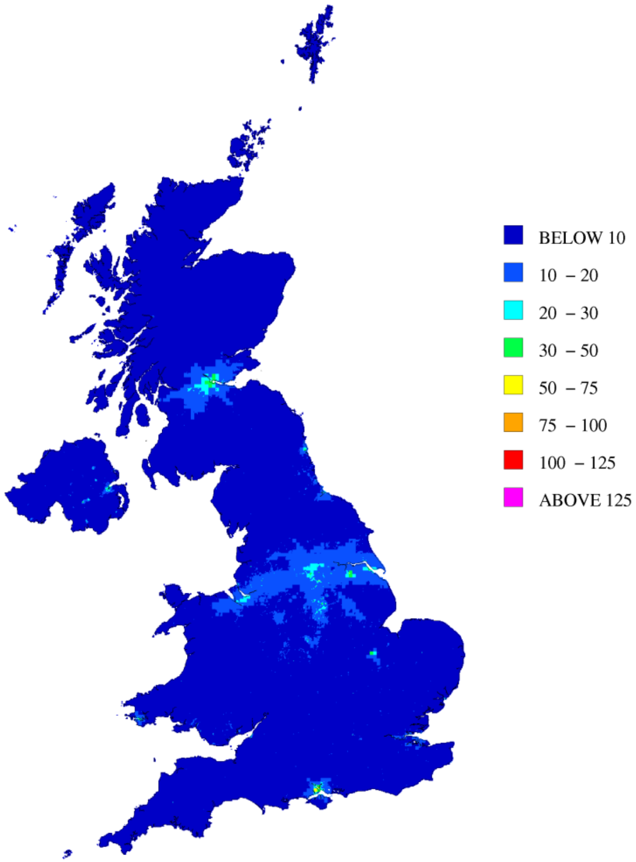


Figure 5-2 99.18th percentile of 24-hour mean SO_2 concentration, 2013 (µg m^{-3})



[b] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "25-50" means greater than 25 µg m^{-3}, less than or equal to 50 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 a year-on-year decrease continued to occur over the following decade. There has, however, been a levelling-off of the downward trend in the most recent years.

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

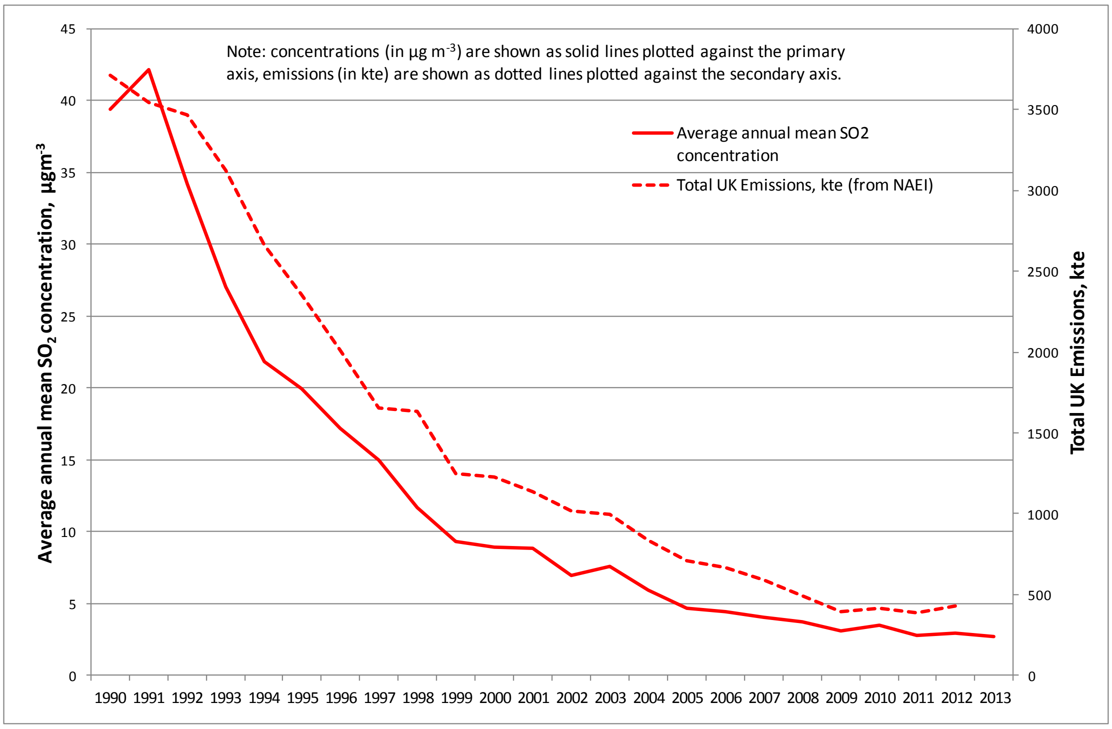


Figure 5-3 also shows how the UK's estimated total emissions of sulphur dioxide have decreased since 1990 (based on data from the NAEI available at www.naei.org.uk, shown in the graph as a dotted line). The main source of this pollutant is fossil fuel combustion. SO_2 emissions in the UK have decreased 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.

There was a slight upturn in UK emissions of sulphur dioxide in 2012. The NAEI pollutant information page for SO_2 (at http://naei.defra.gov.uk/overview/pollutants?pollutant_id=8) explains this as follows: the economic downturn has led to a drive to cut energy costs. This has resulted in an increase in solid fuel use. Estimated emissions of some pollutants that arise from coal burning have therefore increased, particularly in 2012.

5.2 Nitrogen Dioxide

5.2.1 NO_2: Spatial Distribution in the UK

Figure 5-4 shows the modelled annual mean NO_2 concentrations for 2013, 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 modelled annual mean *background* NO_2 concentrations for 2013. 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 have been largely confined to London in 2013.

5.2.2 NO_2: Changes Over Time

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

- All AURN urban non-traffic sites (comprising urban centre, urban background, urban industrial and suburban sites).
- A sub-set of eight long-running urban background sites operating since 1993 or earlier (Belfast Centre, Billingham, Cardiff Centre, Leeds Centre, London Bloomsbury, Newcastle Centre, Sheffield Tinsley and Southampton Centre), to show changes over time, unaffected by variations in the distribution and number of monitoring 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.
- A sub-set of eight long-running traffic urban sites in operation since 1998 (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 monitoring 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 non-traffic sites in the AURN shows a steady decrease, generally consistent with the downward trend in the amount of total NO_X emitted until around 2007. The estimated NOx emission then continues to fall until around 2011, while the annual mean NO_2 concentration appears to level off slightly.

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 NOx emitted, until around 2002. Subsequently, the average concentration at this sub-set of sites remained generally stable until around 2011. This also departs from the pattern shown by the estimated total NOx emission. From 2011 – 2013 the downward trend in NO_2 concentration appears to have resumed.

Figure 5-4 Urban major roads, annual mean roadside NO_2 concentration, 2013 (µg m^{-3})[c]

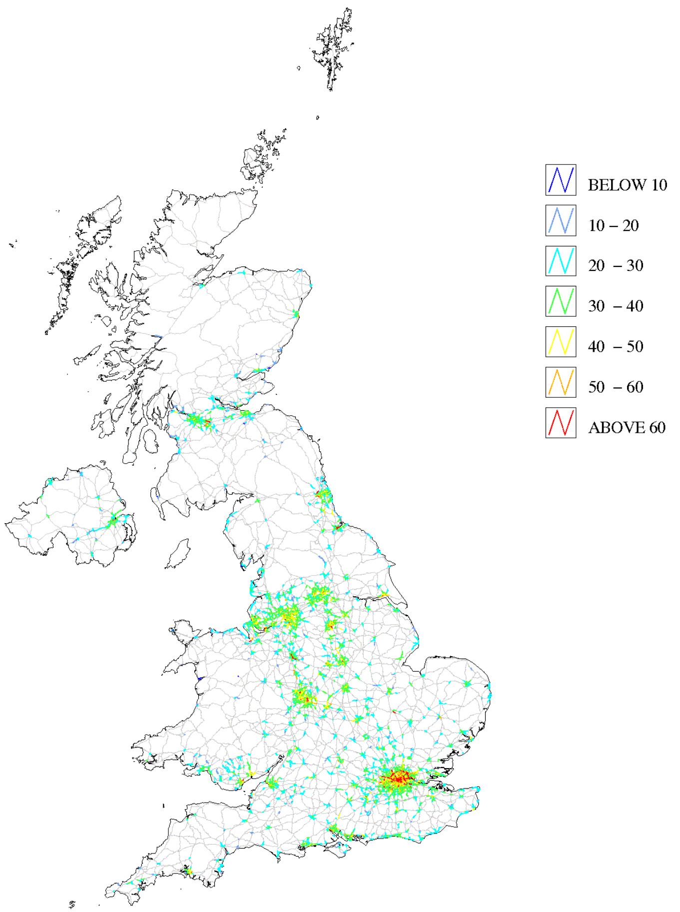
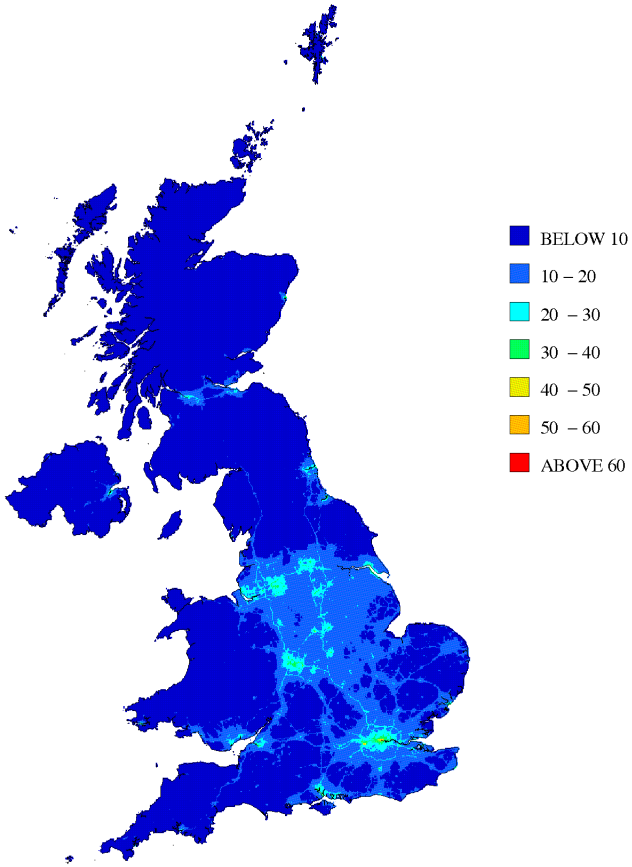


Figure 5-5 Annual mean background NO_2 concentration, 2013 (µg m^{-3})



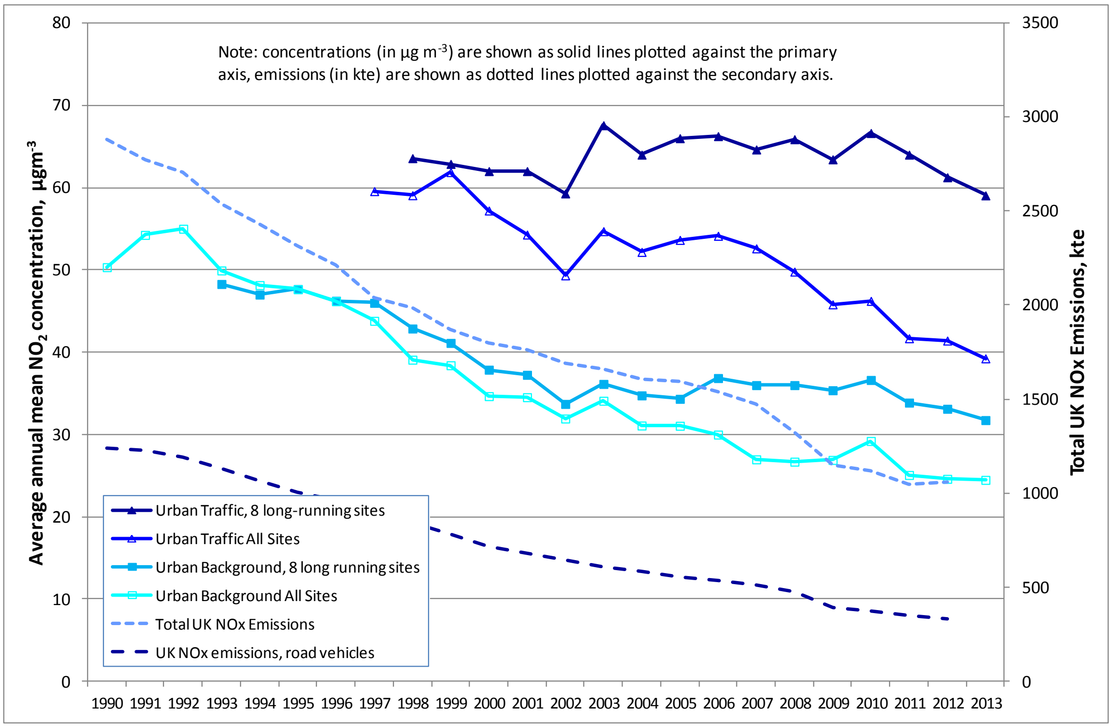
[c] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "30-40" means greater than 30 µg m^{-3}, less than* *<u>or equal to</u>* *40 µg m^{-3}.*

There is a small but noticeable peak in 2010, particularly for background urban sites. This may be attributable to the cold winter weather in 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 clear decrease over time, particularly since 2006. 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, and there is considerable year-on-year fluctuation. There is some indication of a year-on-year decrease from 2010 onwards: future years' data will confirm whether or not this is the beginning of a long-term downward trend in roadside concentrations of NO_2.

A 2011 study by King's College London, the University of Leeds and AEA (now Ricardo-AEA) carried out a trend analysis for ambient concentrations of NOx and NO_2[30]. 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 2013. 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 2013. 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. Larger areas of the UK, particularly in the East Midlands and Humberside areas, had annual mean concentrations of 17 µg m^{-3} and above in 2013, compared with 2012.

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 15 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 15 sites used are Belfast Centre, Cardiff Centre, Derry, Leamington Spa, Leeds Centre, London Bloomsbury, London North Kensington, Middlesbrough, Newcastle Centre, Nottingham Centre, Plymouth Centre, Salford Eccles, Southampton Centre, Stoke on Trent Centre 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. Both sets of sites show a consistent decrease throughout the 1990s, with a general – though more variable - decrease in subsequent years. There is considerable variation from year to year.

There are clear peaks in 2003 (which was recognised as a high year), also 2011 (when high concentrations of secondary particulate matter were measured during the spring). The averages for 2013 are slightly higher than those for 2012.

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 after 2000.

Figure 5-7 Urban major roads, annual mean roadside PM_{10} concentration, 2013 ($\mu g\ m^{-3}$)[d]

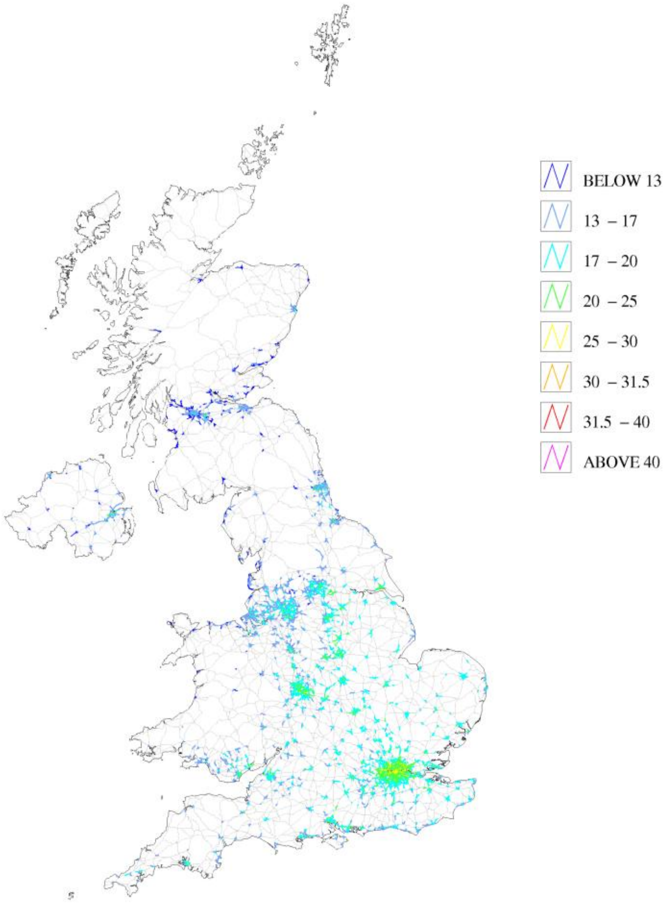
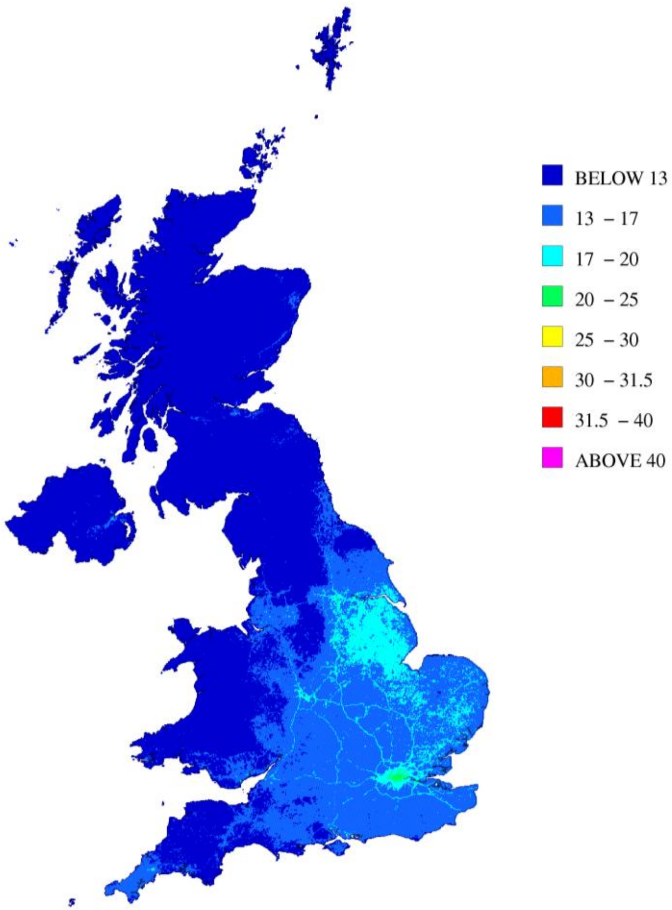
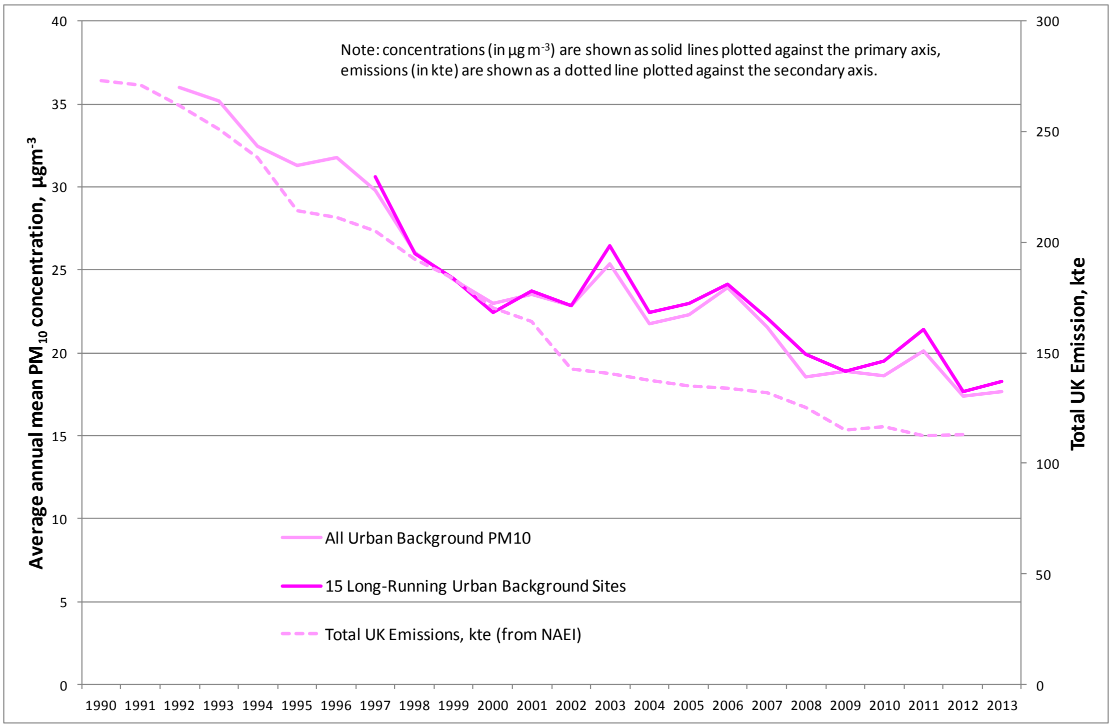


Figure 5-8 Annual mean background PM_{10} concentration, 2013 ($\mu g\ m^{-3}$)



[d] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "25-30" means greater than 25 $\mu g\ m^{-3}$, less than or equal to 30 $\mu g\ m^{-3}$.*

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 modelled annual mean urban roadside $PM_{2.5}$ concentrations in 2013. No roadside locations had annual means greater than the target value of 25 µg m^{-3} although some in London were in the range 20 - 25 µg m^{-3}. Figure 5-11 shows annual mean background $PM_{2.5}$ concentrations in 2013. 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. A substantial part of eastern England had modelled background annual mean $PM_{2.5}$ concentrations greater than 10 µg m^{-3}; these covered a wider area than in the 2012 map.

Figure 5-10 Urban major roads, annual mean roadside $PM_{2.5}$ concentration, 2013 ($\mu g\ m^{-3}$)[e]

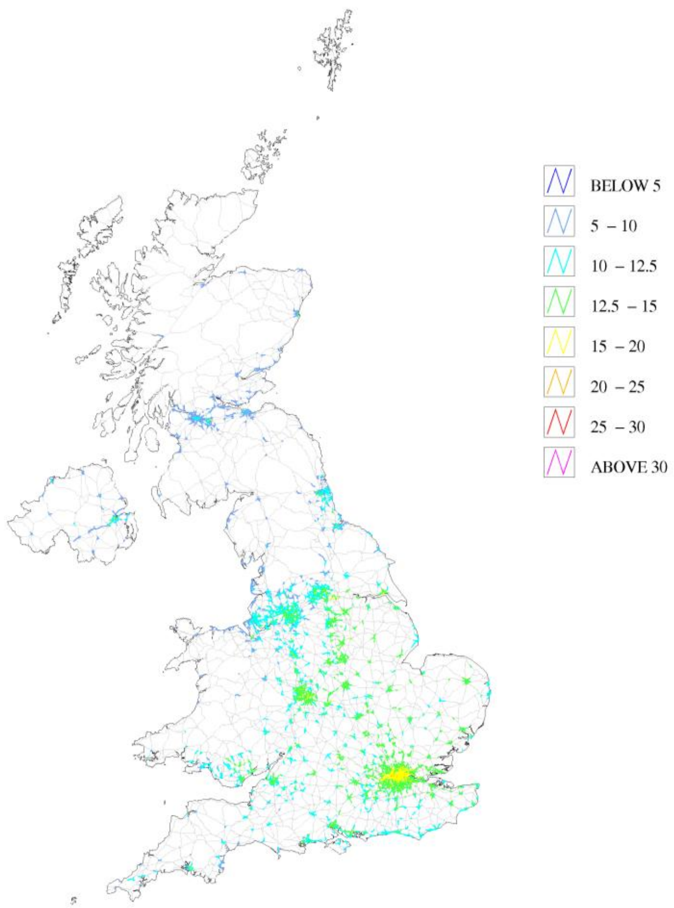
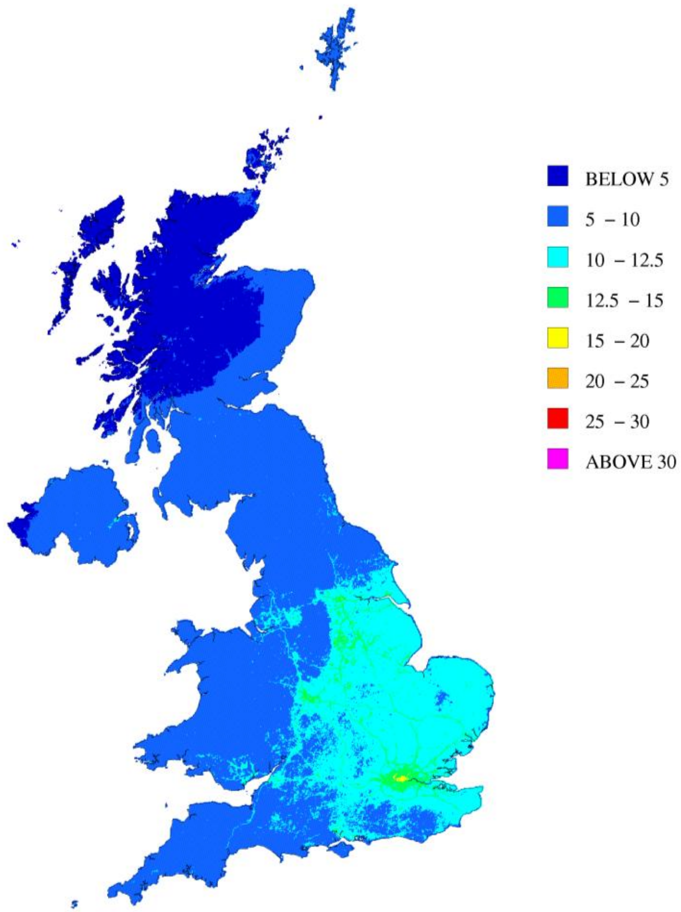


Figure 5-11 Annual mean background $PM_{2.5}$ concentration, 2013 ($\mu g\ m^{-3}$)

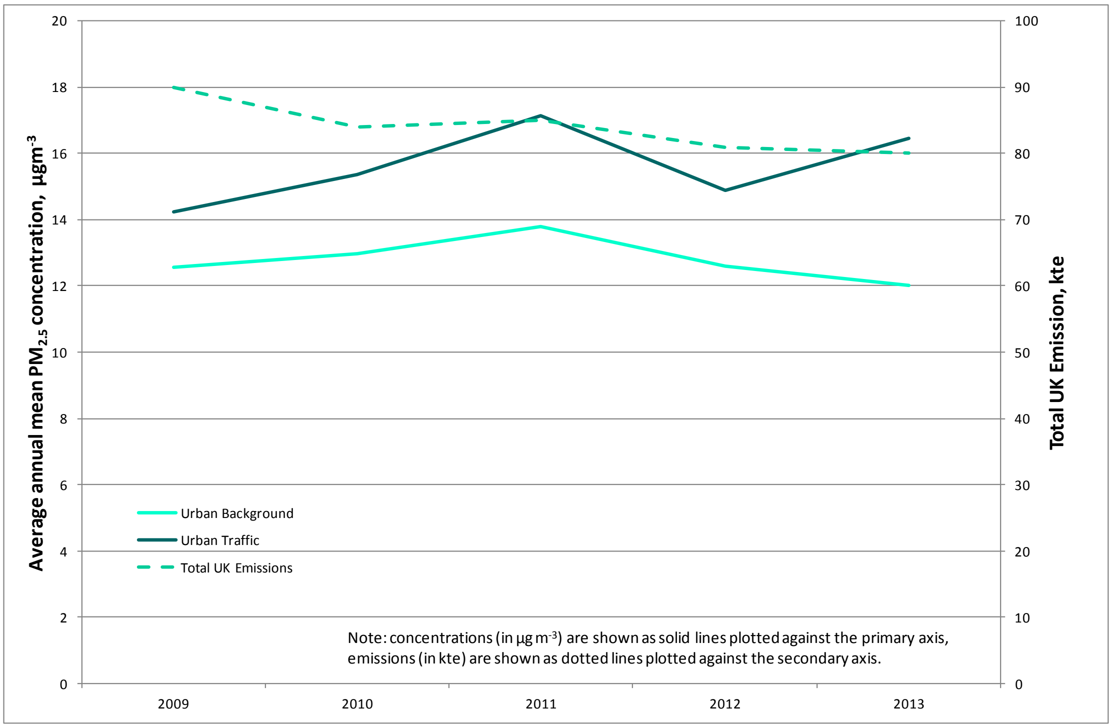


[e] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "5-10" means greater than 5 μg m^{-3}, less than <u>or equal to</u> 10 μg m^{-3}.*

5.4.1 $PM_{2.5}$: Changes Over Time

The number of urban AURN sites monitoring $PM_{2.5}$ increased substantially in 2009; prior to this there had been only two urban sites at which it was routinely measured. Since it is usually considered that at least five years' worth of data are required to assess long-term changes in ambient pollutant concentration, previous reports in this series have not presented time series graphs of $PM_{2.5}$, or have concentrated upon specific sites. Data over a five-year period are now available from a large number of sites across the UK, making it possible to prepare a time series graph for $PM_{2.5}$ from 2009 onwards. Figure 5-12 shows the average annual mean concentration for all urban background AURN sites, all urban traffic AURN sites, and the total estimated annual UK emission of $PM_{2.5}$, for years 2009 onwards. While estimated emissions appear to be decreasing slightly year on year, there is as yet no clear decrease evident in ambient concentrations.

Figure 5-12 Annual mean ambient $PM_{2.5}$ concentration, and total annual emissions.



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 5-13 shows modelled annual mean benzene concentrations at roadside locations in 2013. Figure 5-14 shows the modelled annual mean background concentrations of benzene in 2013. Modelled background concentrations were below 0.5 µg m^{-3} over most of the UK, with marginally higher concentrations for most urban areas. A few small areas, for example in London and Humberside, had concentrations in excess of 3 µg m^{-3}. However, background concentrations everywhere are well below the limit value of 5 µg m^{-3} for benzene.

Figure 5-13 Urban major roads, annual mean roadside benzene concentration, 2013 (µg m^{-3})[f]

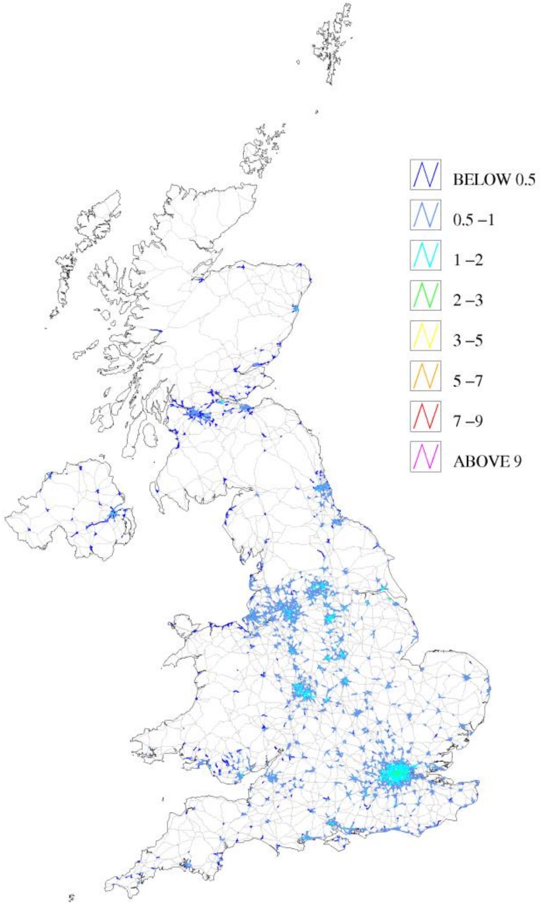
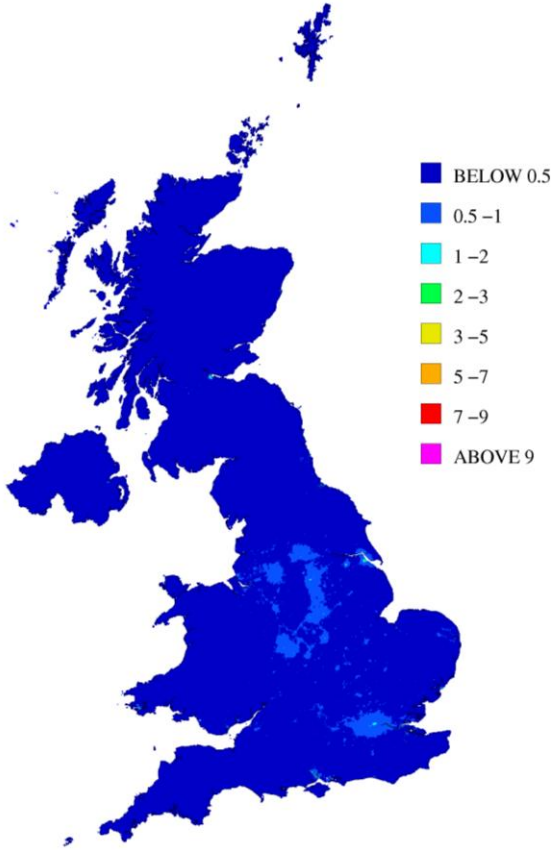


Figure 5-14 Annual mean background benzene concentration, 2013 (µg m^{-3})



[f] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "2-3" means greater than 2 µg m^{-3}, less than or equal to 3 µg m^{-3}.*

5.5.2 Benzene: Changes Over Time

Figure 5-15 shows a time series of annual mean benzene concentrations, based upon the average of 17 long-running sites in the Non-Automatic Hydrocarbon Network. These are: Barnsley Gawber, Belfast Centre, Coventry Memorial Park, Grangemouth, Haringey Roadside, Leamington Spa, Leeds Centre, Leicester Centre, Liverpool Speke, London Bloomsbury, Manchester Piccadilly, Middlesbrough, Newcastle Centre, Nottingham Centre, Oxford Centre Roadside, Southampton Centre and Stoke on Trent Centre.

The average for these 17 sites shows a general decrease from 2002 to 2011. The decrease has not been consistent from year to year; the largest change appears to have happened between 2005 and 2008. There has been a slight upturn in 2012 and 2013.

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 5-15 Annual mean benzene concentration, mean of 17 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

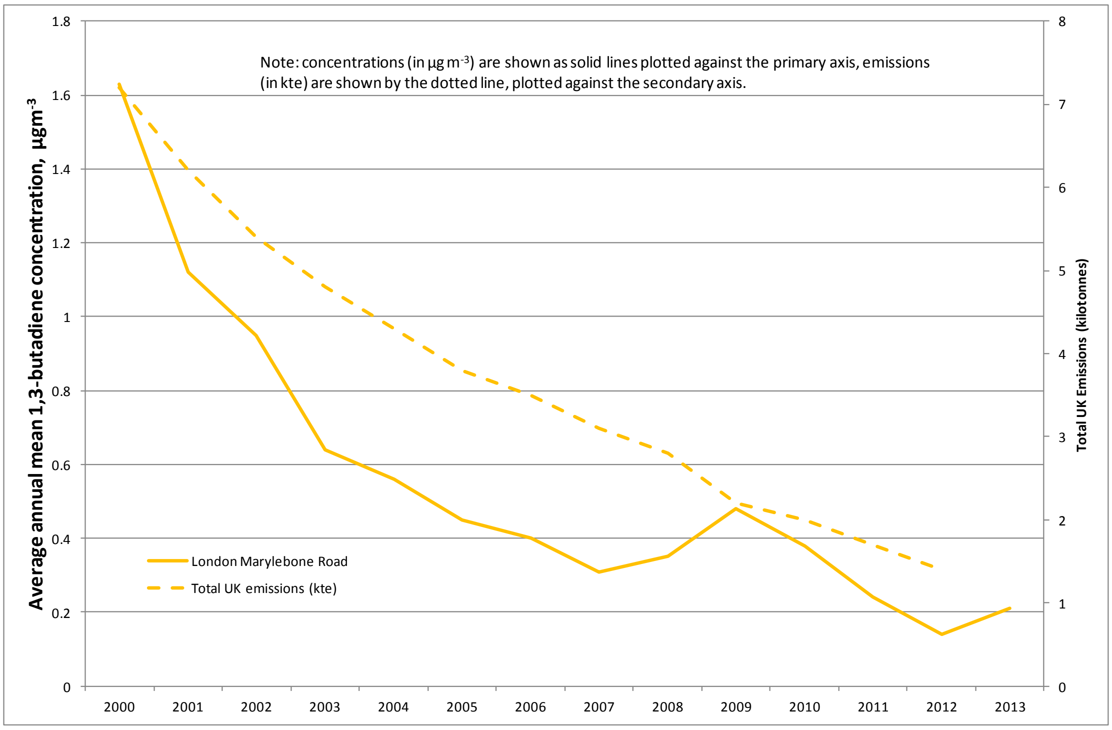
Marylebone Road). The running annual means at all four sites were within the Air Quality Strategy objective in 2013.

5.6.2 1,3-Butadiene: Changes Over Time

Figure 5-16 shows the annual mean 1,3-butadiene concentration measured from 2000 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. No data capture threshold has been applied to the data included in this chart. 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. However, data capture for all annual means shown is at least 70% with the exception of 2011 when data capture was 44%.

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 5-16 Annual mean 1,3-butadiene concentration at London Marylebone Road



5.7 Carbon Monoxide

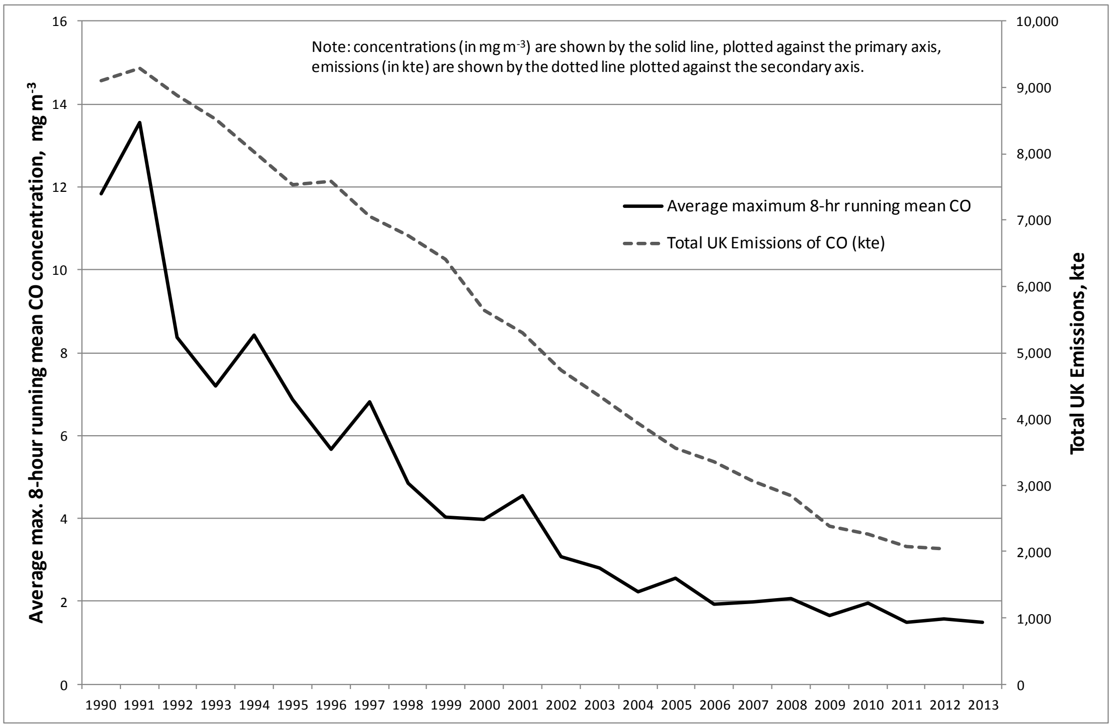
5.7.1 CO: Spatial Distribution

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 5-17 shows a time series chart of the average maximum 8-hour running mean CO concentration, for all AURN sites 1990 - 2013. There is a clear decrease with time. Figure 5-17 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, iron and steel production and the domestic sector"*.[45]

Figure 5-17 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 5-18 shows the average number of days per year with ozone concentration > 120 µg m^{-3}, over the **three** years 2011-2013. This average was less than five days over almost all of the UK, but higher (5-10 days) in just one very small area of the South West.

Figure 5-19 shows the same statistic, for 2013 only (i.e. not averaged over three years). This map shows a slightly larger area of the South West with greater than five days above 120 µg m^{-3} than was the case for the three-year average. No parts of the UK had more than 10 days above the target value.

Figure 5-20 shows the AOT40 statistic, averaged over the past **five** complete years, 2009-2013. 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 5-21 shows the same statistic, for 2013 only. The pattern for 2013 only is slightly different from that shown for the past five years; the highest concentrations in 2013 appear to be mainly in the South West rather than East Anglia.

Figure 5-18 Average no. of days with ozone concentration > 120 µg m^{-3} 2011-2013[9]

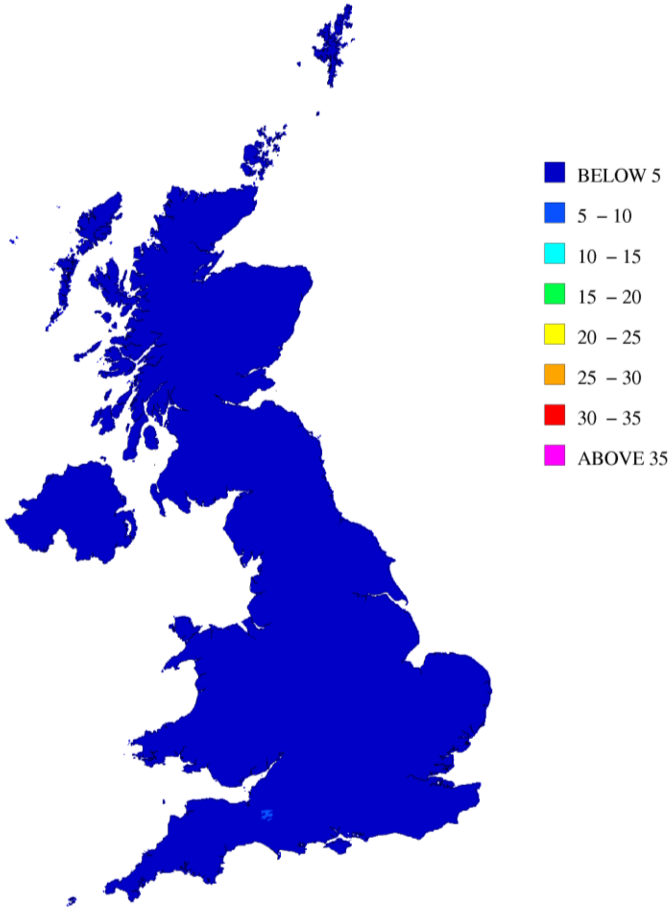
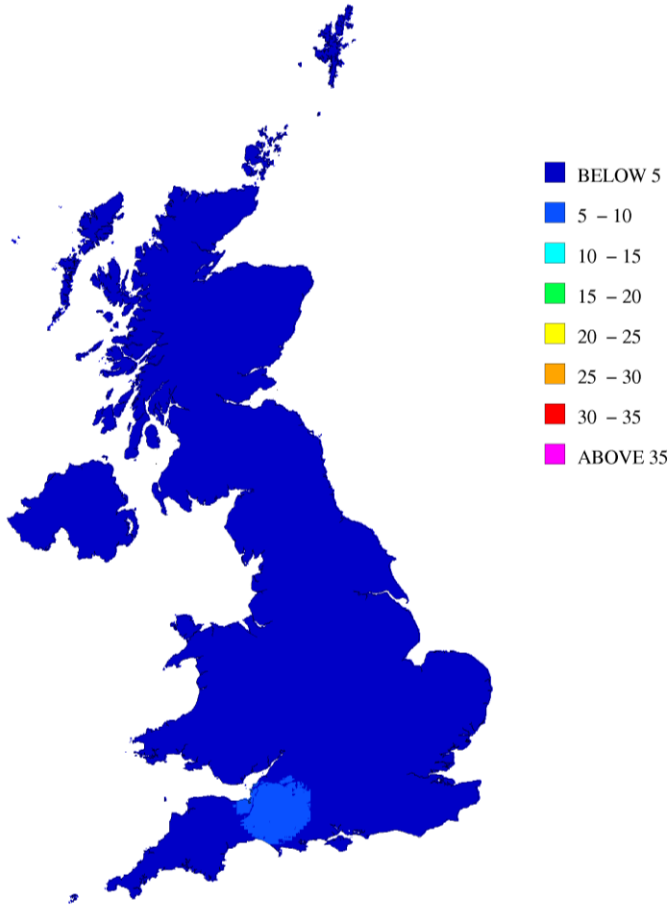


Figure 5-19 Days with ozone concentration > 120 µg m^{-3} in 2013



[9] *In both the maps on this page, the legends show the upper limit of the band – for example, "5-10" means more than 5 days, but less than* *<u>or equal to</u>* *10 days.*

Figure 5-20 Average AOT40, 2009-2013 (µg m^{-3}.hours)[h]

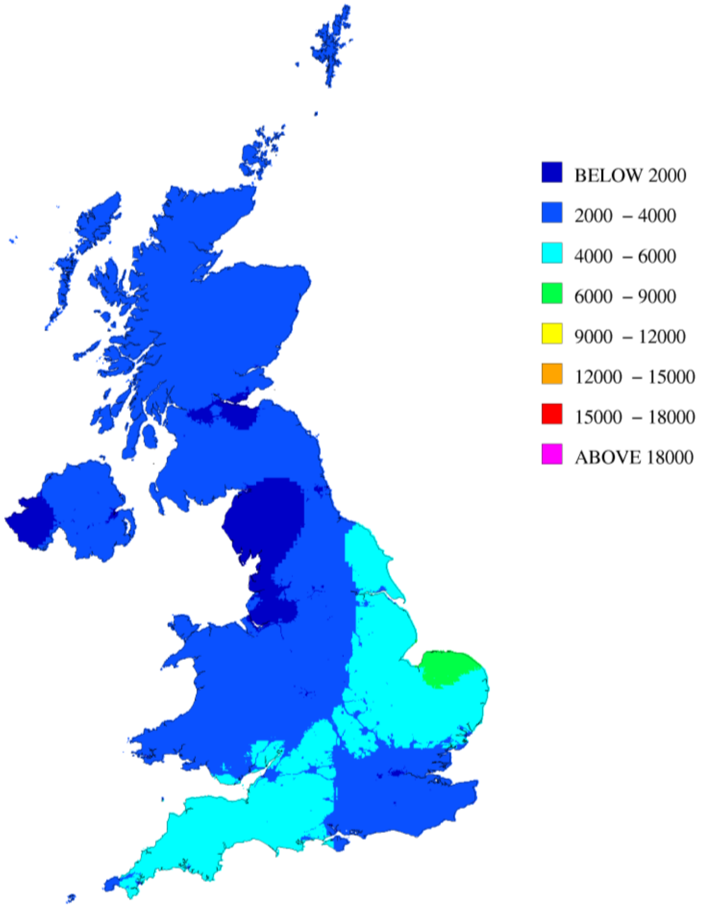
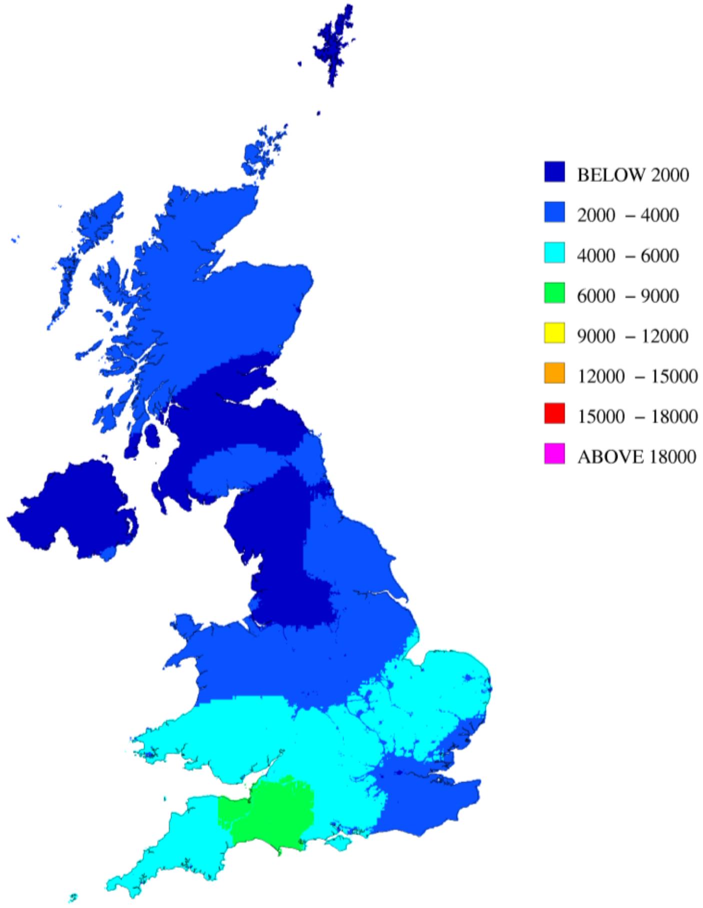


Figure 5-21 Average AOT40, 2013 (µg m^{-3}.hours)



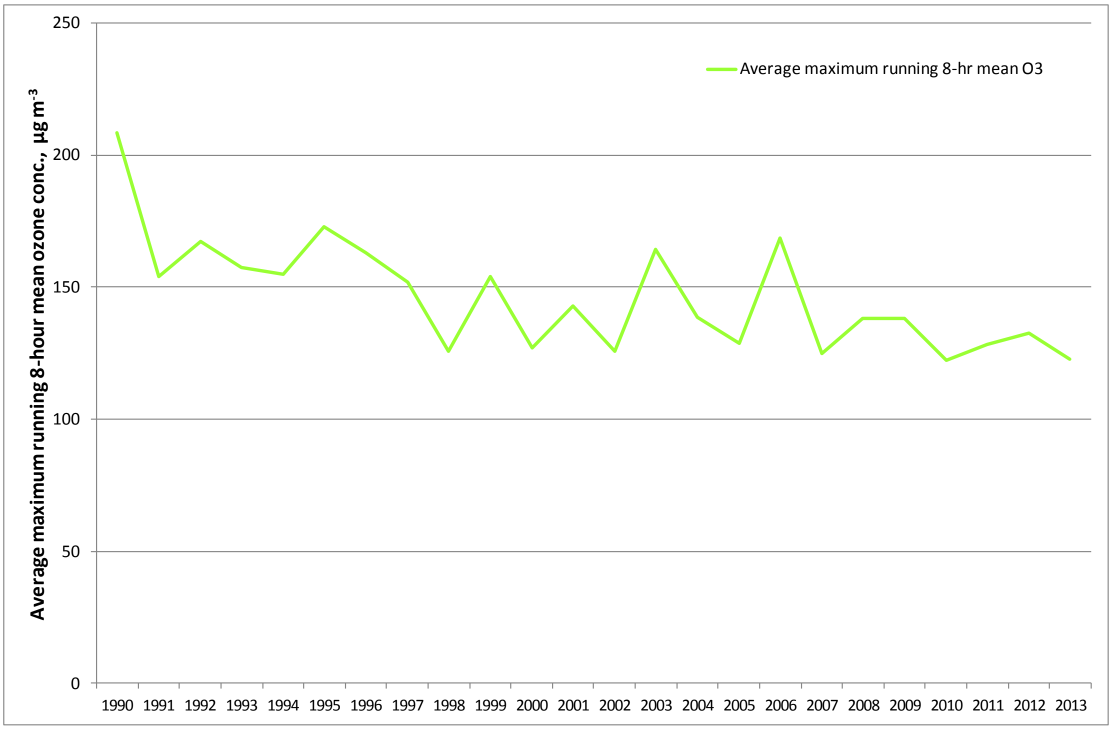
[h] *In both maps on this page, the legends show the upper limit of the concentration band – for example, "6000-9000" means greater than 6000 µg m^{-3}.hrs, less than or equal to 9000 µg m^{-3}.hrs.*

5.8.2 O_3: Changes Over Time

Figure 5-22 shows a time series graph of the annual maximum 8-hour running mean ozone concentration. For many years it was impossible to identify any clear upward or downward trend, however data from recent years now indicate that this statistic has indeed decreased.

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 5-22 Time series of annual max. 8-hour running mean O_3, all AURN sites.



5.9 Metallic Pollutants

5.9.1 Metals: Spatial Distribution

Figure 5-23, Figure 5-24, Figure 5-25 and Figure 5-26 show modelled annual mean concentrations of Pb, As, Cd and Ni respectively in 2013. 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 the whole UK, and less than 2.4 ng m^{-3} over most of the country. However, concentrations of 2.4 ng m^{-3} and above occurred in some areas – particularly the north eastern part of England, 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. There are also some small areas with higher concentrations due to industrial activity.

Figure 5-23 Annual mean background Lead concentration, 2013 (ng m^{-3})[i]

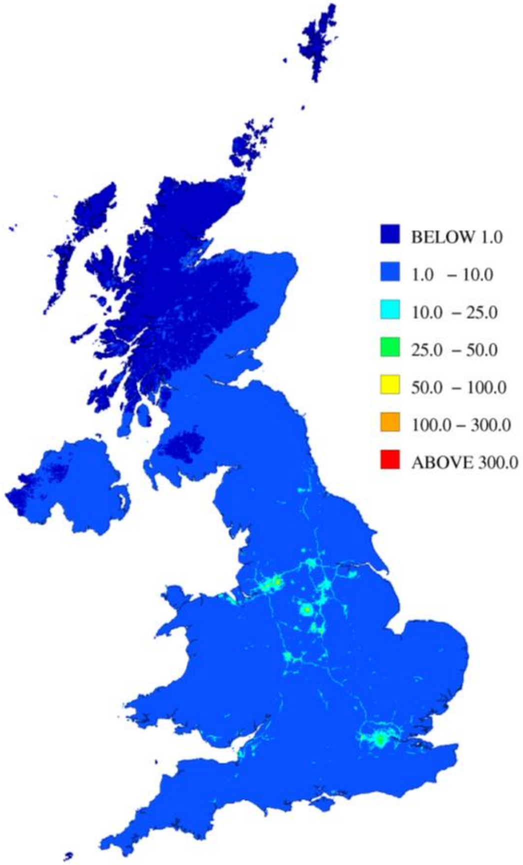
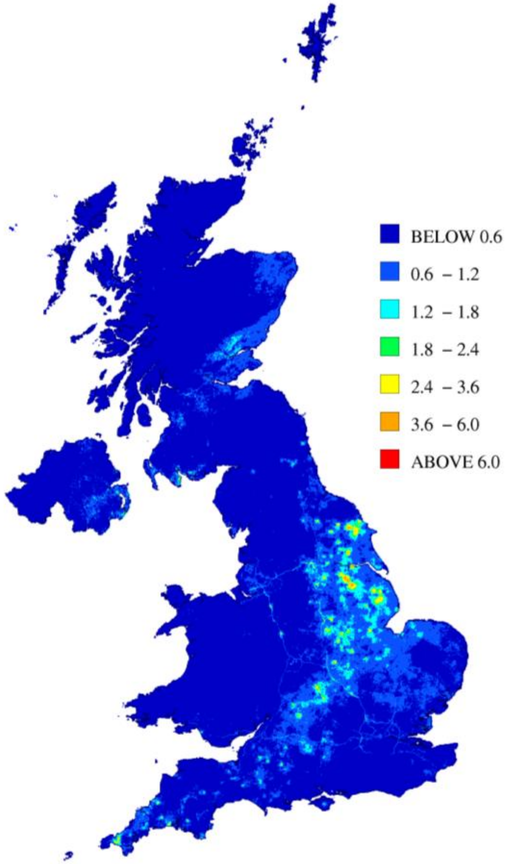


Figure 5-24 Annual mean background Arsenic concentration, 2013 (ng m^{-3})



[i] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "25-50" means greater than 25 ng m^{-3}, less than* *or equal to* *50 ng m^{-3}.*

Figure 5-25 Annual mean background Cadmium concentration, 2013 (ng m^{-3})[j]

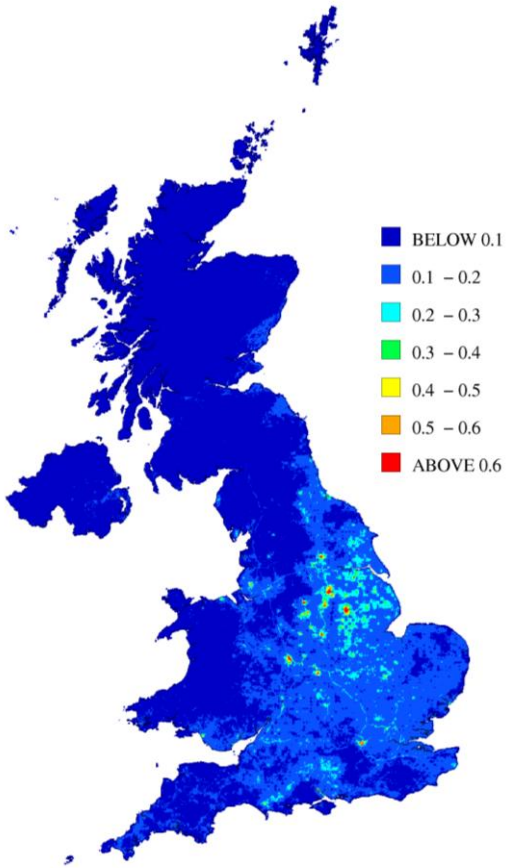
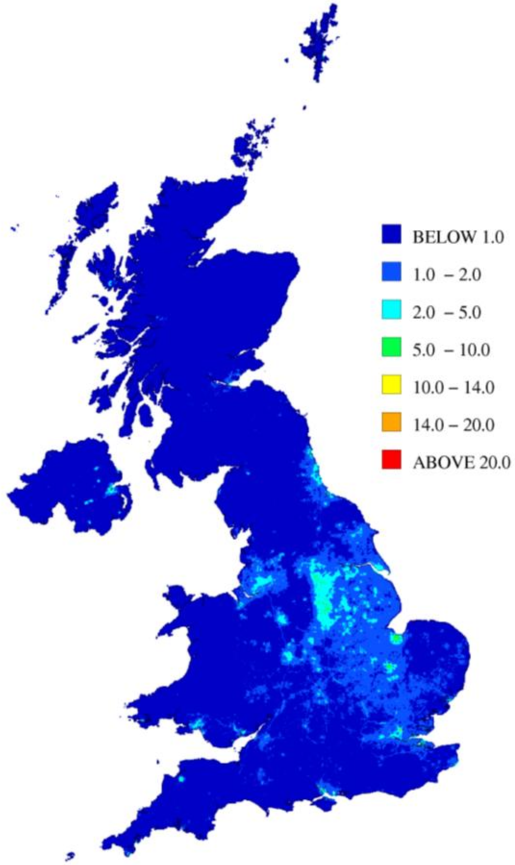


Figure 5-26 Annual mean background Nickel concentration, 2013 (ng m^{-3})



[j] *In both the maps on this page, the legends show the upper limit of the concentration band – for example, "0.3-0.4" means greater than 0.3 ng m^{-3}, less than or equal to 0.4 ng m^{-3}.*

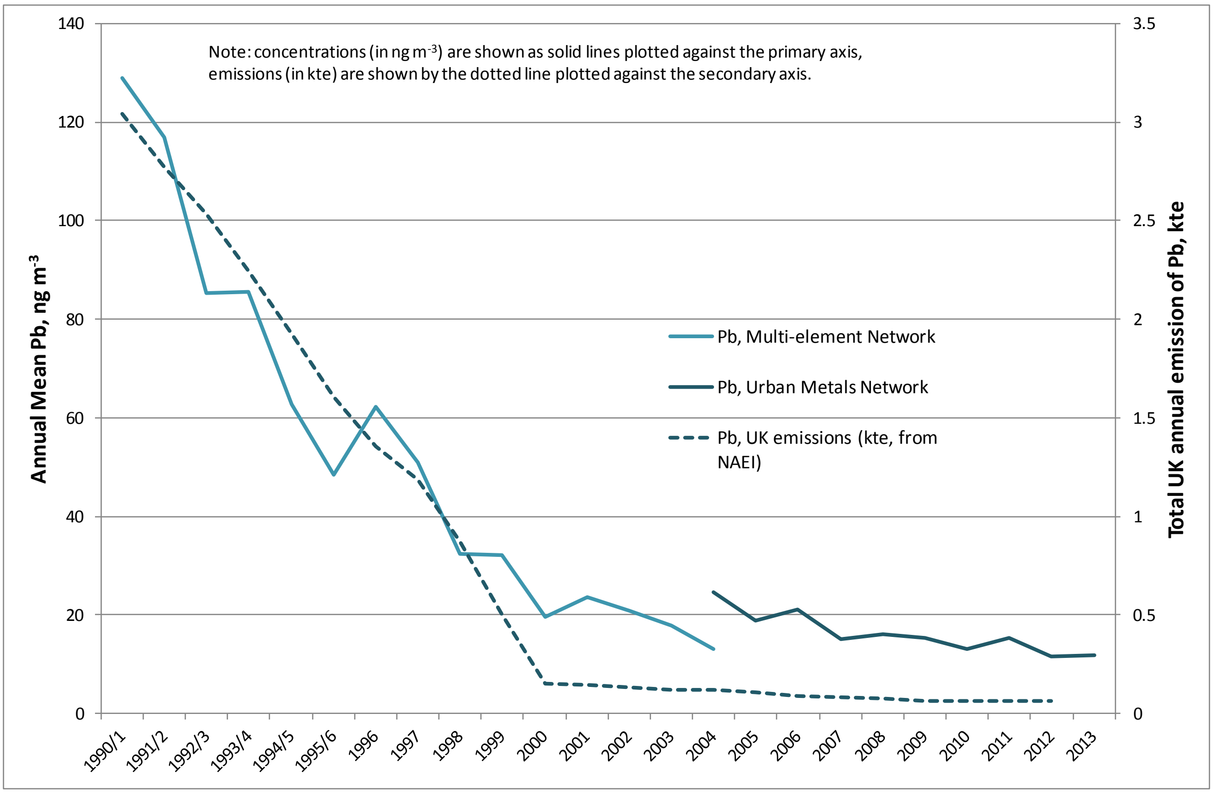
5.9.2 Lead: Changes Over Time

Figure 5-27 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 sites is shown: in 2013 there were 26 sites. The mean for all sites is well below the Air Quality Directive limit value for annual mean Pb, of 500 ng m^{-3}.

Figure 5-27 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. However, the data from 2004 onwards (from the current Urban and Industrial Metals Network) also shown a general decrease over the past ten years.

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



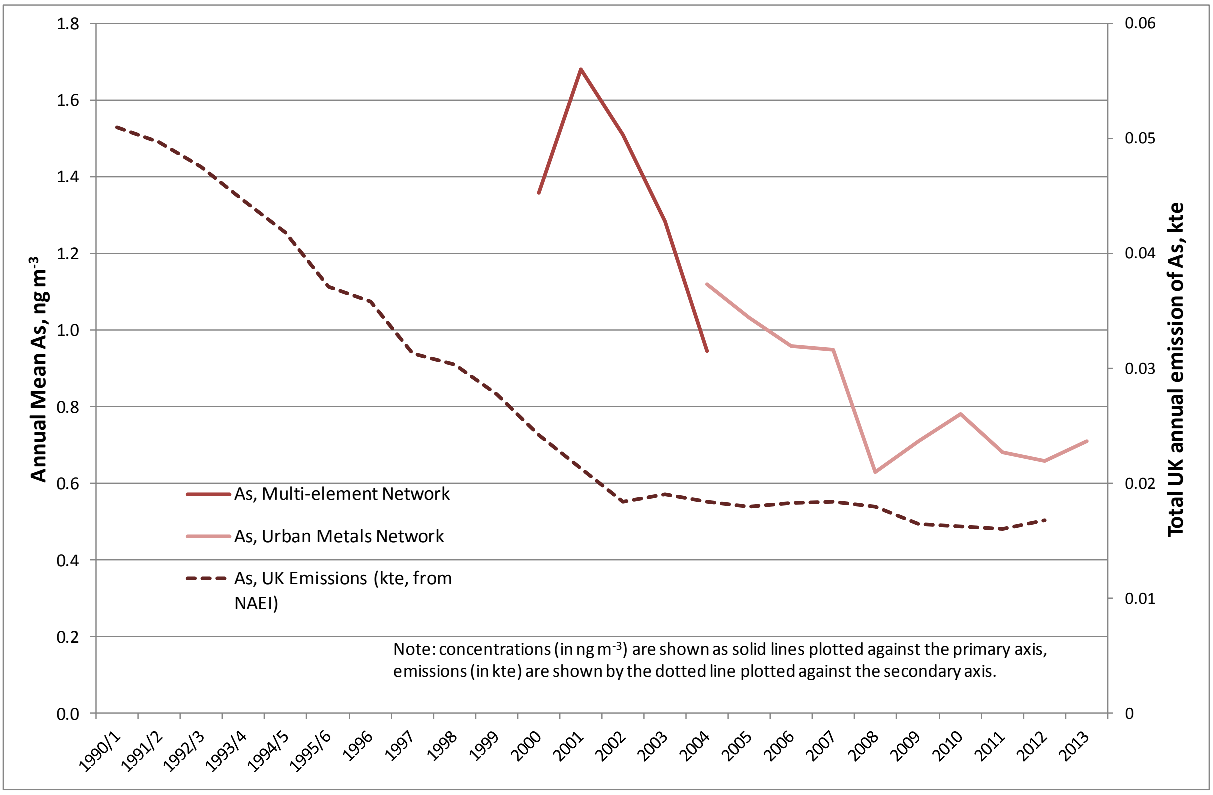
5.9.3 Arsenic: Changes Over Time

Figure 5-28 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 (26 sites in 2013) is shown. This parameter is well within the Fourth Daughter Directive target value of 6 ng m^{-3}. There appears to have been a small increase in 2013 compared to the previous year.

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



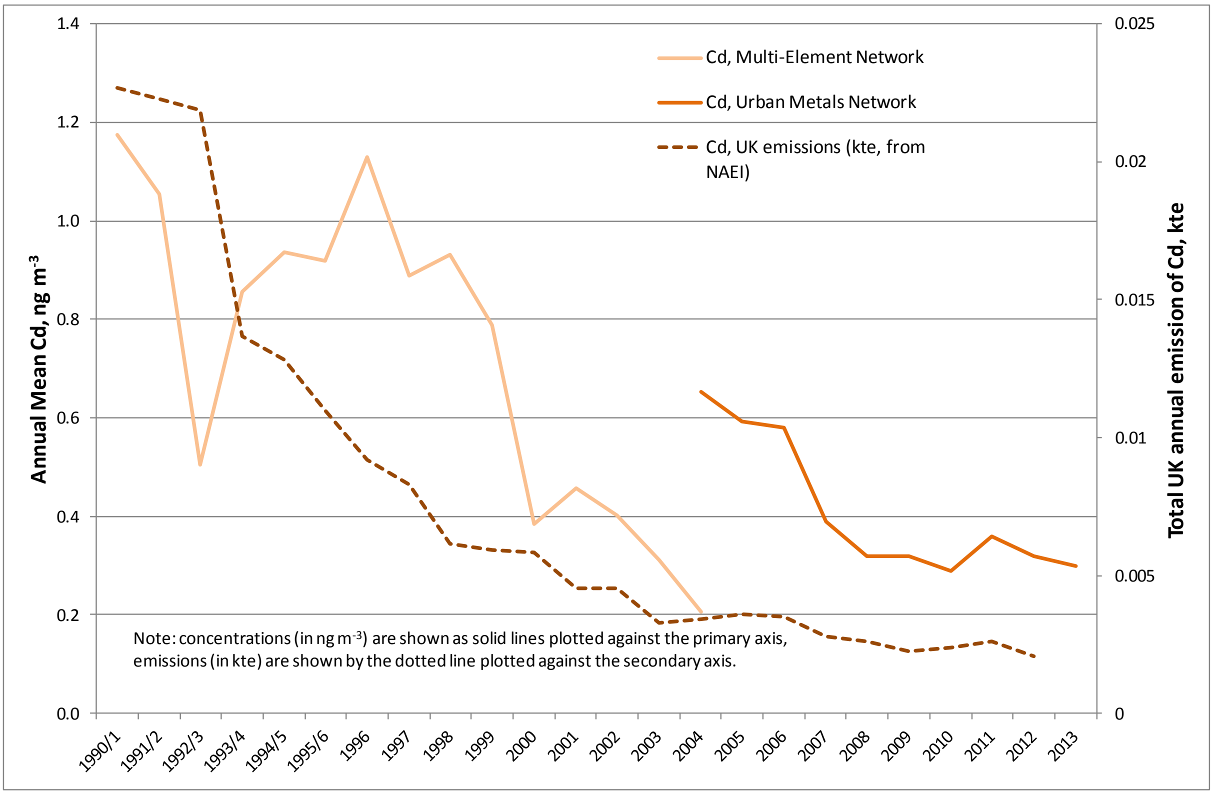
5.9.4 Cadmium: Changes Over Time

Figure 5-29 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 total 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; further influenced by the introduction of two new industrial area sites. The average concentration has almost returned to its 2010 level in 2013. Cadmium 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 5-29 Ambient Concentrations of Particulate-phase Cd, and Total UK Emissions



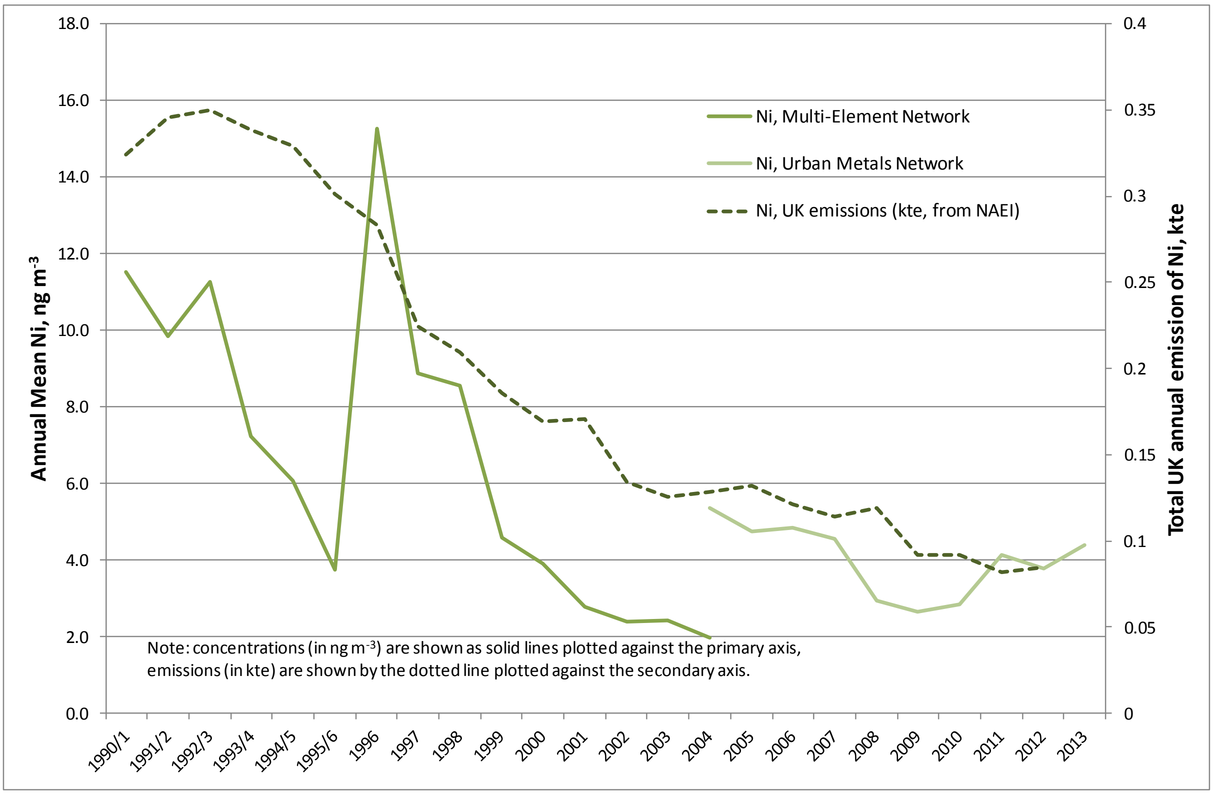
5.9.5 Nickel: Changes Over Time

Figure 5-30 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 (of which there were 26 in 2013). One site in Pontardawe exceeded the Fourth Daughter Directive target value of 20 ng m^{-3}, as it has since measurements began there, in 2011. This was the measured exceedance in the Swansea agglomeration highlighted in Table 4-7 (in addition to the *modelled* exceedance in the South Wales zone).

Figure 5-30 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.

Ambient concentrations of Ni (averaged across all sites) appear to have increased slightly since 2011. However, this is thought to be due to the introduction to the network of the industrial Pontardawe site, which recorded particularly high Ni concentrations and increased the network average.

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



5.9.6 Mercury: Changes Over Time

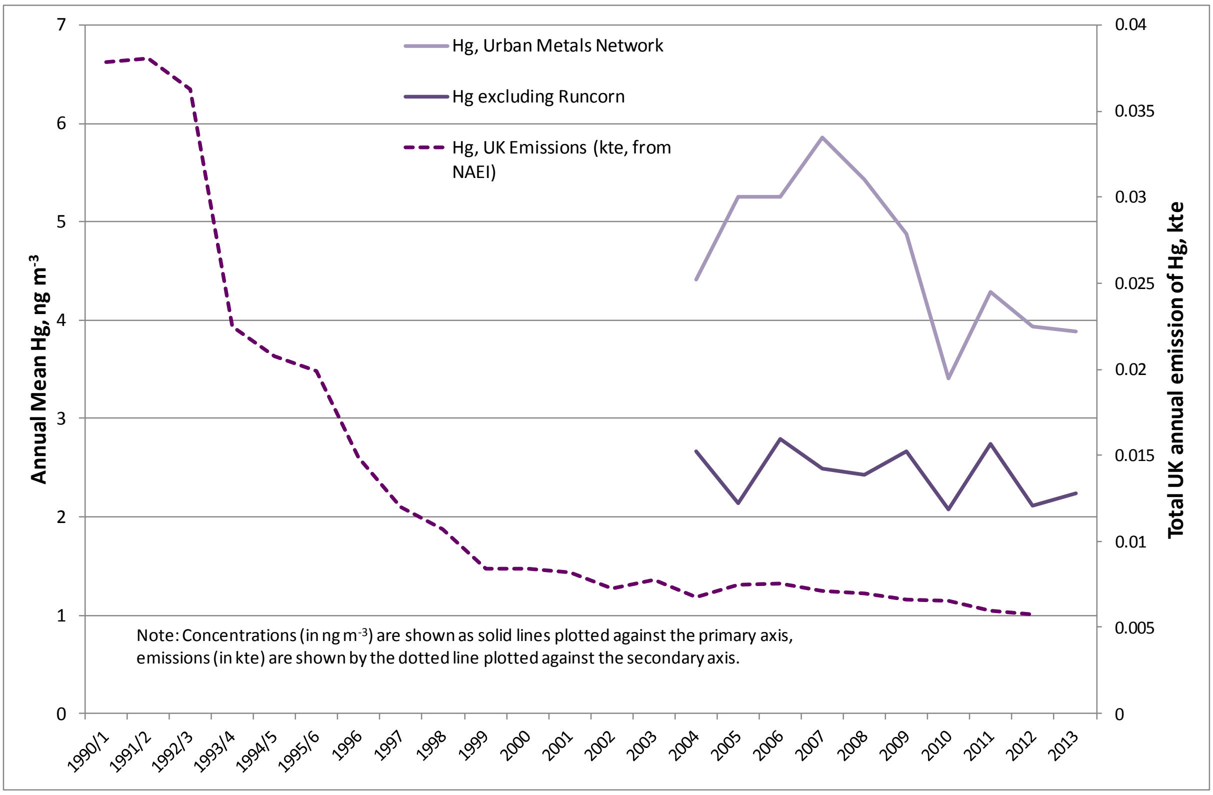
Figure 5-31 shows a time series of total annual mean concentrations of Hg, as measured by the Urban and Industrial Metals Network from 2004. The graph shows the sum of the vapour phase and particulate phase components: the majority of ambient Hg is in the vapour phase. Although the former Multi-Element 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 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 5-31 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. However, there is some indication of a further small decrease in the past decade.

Figure 5-31 Ambient Concentrations of Particulate and Vapour phase Hg, and Total UK Emissions



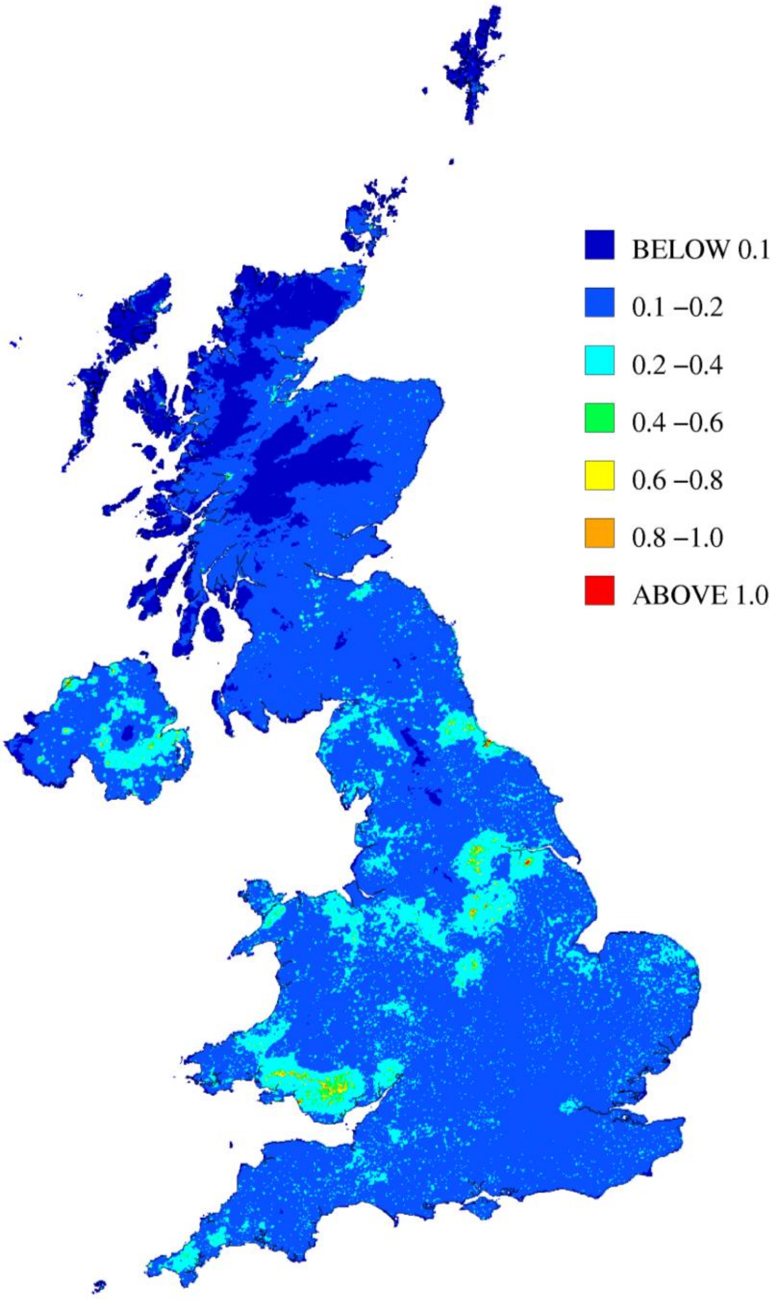
5.10 Benzo [a] Pyrene

5.10.1 B[a]P: Spatial Distribution

Figure 5-32 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. This has previously included the Belfast area and other urban parts of Northern Ireland: also parts of Yorkshire, Humberside and South Wales.

However, the 2013 map indicates a considerable reduction in the area with modelled B[a]P concentrations above 0.2 ng m^{-3} compared with 2012. There were no areas in Northern Ireland with modelled concentrations in excess of 1 ng m^{-3} in 2013.

Figure 5-32 Annual mean background B[a]P concentration, 2013 (ng m^{-3})



In this map, the legend shows the upper limit of the concentration band – for example, "0.6-0.8" means greater than 0.6 ng m^{-3}, less than or equal to 0.8 ng m^{-3}.

5.10.1 **B[a]P: Changes Over Time**

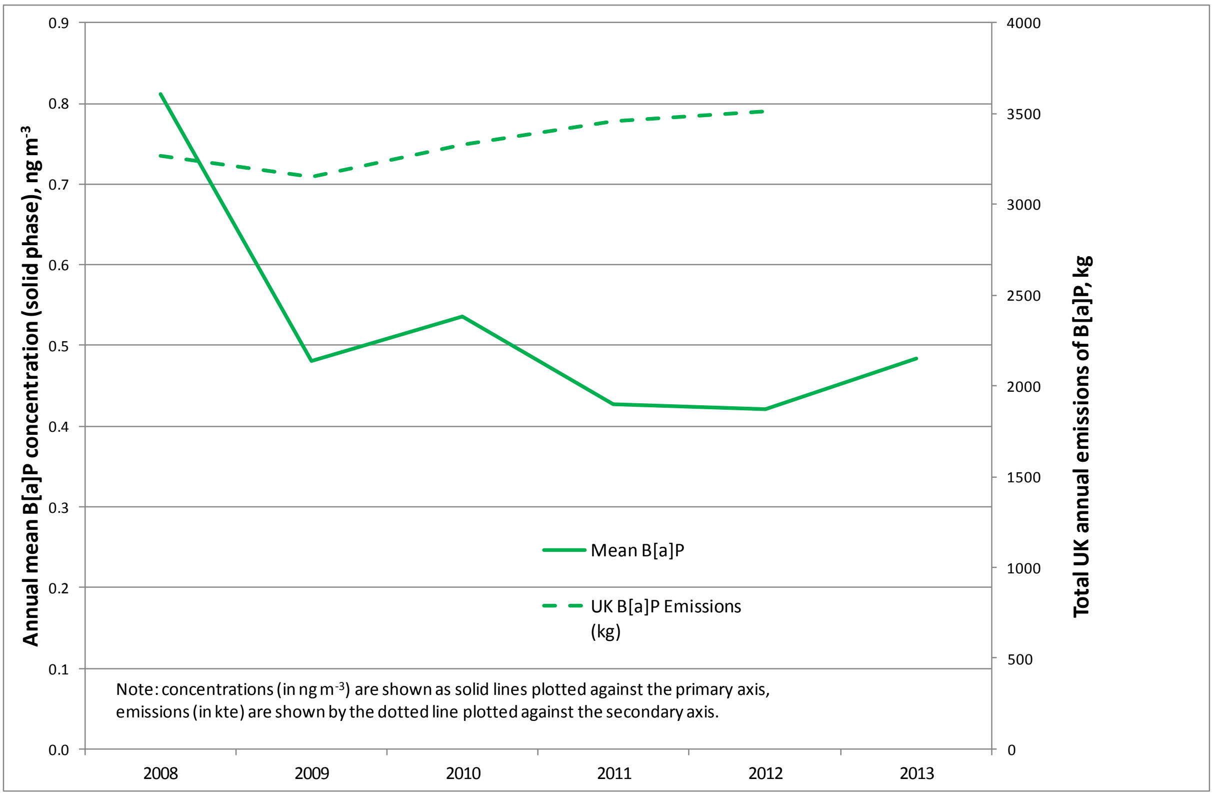
The PAH monitoring network began operation in 1991, comprising a small number of sites, and was increased to over 20 in the late 1990s. However, during the years 2007-2008, the network underwent a further major expansion and re-organisation, including a change of sampling technique.

The newer sampling technique used at most sites from 2008 onwards (the "Digitel" 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 only been analysed from 2008 in this report. Figure 5-33 shows how the average annual mean B[a]P concentration has changed in the past six years. This graph is based on the average of all sites in the PAH Network: the composition of this network has changed little since 2008 so it is considered appropriate here to use the average of all sites. There appears to have been a marked drop in average measured concentrations of B[a]P between 2008 and 2009: however since then there is no clear trend

Figure 5-33 also shows the estimated total annual UK emission of B[a]P (in kg), from the NAEI. This appears to show considerable fluctuation; however to put this into context, estimated total UK emissions of this compound have decreased substantially in recent decades and are an order of magnitude lower than in the early 1990. According to the NAEI, most of this reduction is due to decreasing emissions from industry, and the banning of stubble burning in 1993. Emissions have been stable since 2006; trends in B[a]P emissions are dominated by trends in domestic combustion of coal.

Figure 5-33 Ambient Concentrations of Particulate Phase Benzo[a]pyrene, and Total UK Emissions



6 Pollution Events in 2013

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. The first ozone episode of 2013 was recorded between Monday 1st April and Saturday 6th April, with "Moderate" ozone air pollution across most UK regions. This was due to the high background at this time of the year, coupled with a small contribution from the incoming easterly air. On Sunday 7th April this "Moderate" ozone became confined to the south: then from Monday 8th a more southerly airflow brought "Moderate" or "High" particulate matter pollution to most UK areas until Friday 12th. From Saturday 13th April until Thursday 18th April "Moderate" concentrations of ozone and particulate matter were observed across the UK.

The next ozone episode began on 7th - 8th May, as a change from a mainly clean westerly airstream to a more southerly airstream brought air from mainland Europe towards the UK. "Moderate" air pollution was observed across the UK for both ozone and particles. From 17th to 20th May, "Moderate" ozone was observed across the most southerly regions, up to Daily Air Quality Index 5. Widespread "Moderate" ozone was measured from Saturday 25th May until Friday 31st May. Figure 6-1 shows the modelled back trajectories for the air masses arriving over the UK on the 20th May. The data are sourced from the NOAA website, http://ready.arl.noaa.gov/HYSPLIT.php.

Figure 6-1: Modelled Back Trajectories for Air Masses Arriving in the UK on 20th May 2013 (Source: NOAA Hysplit)

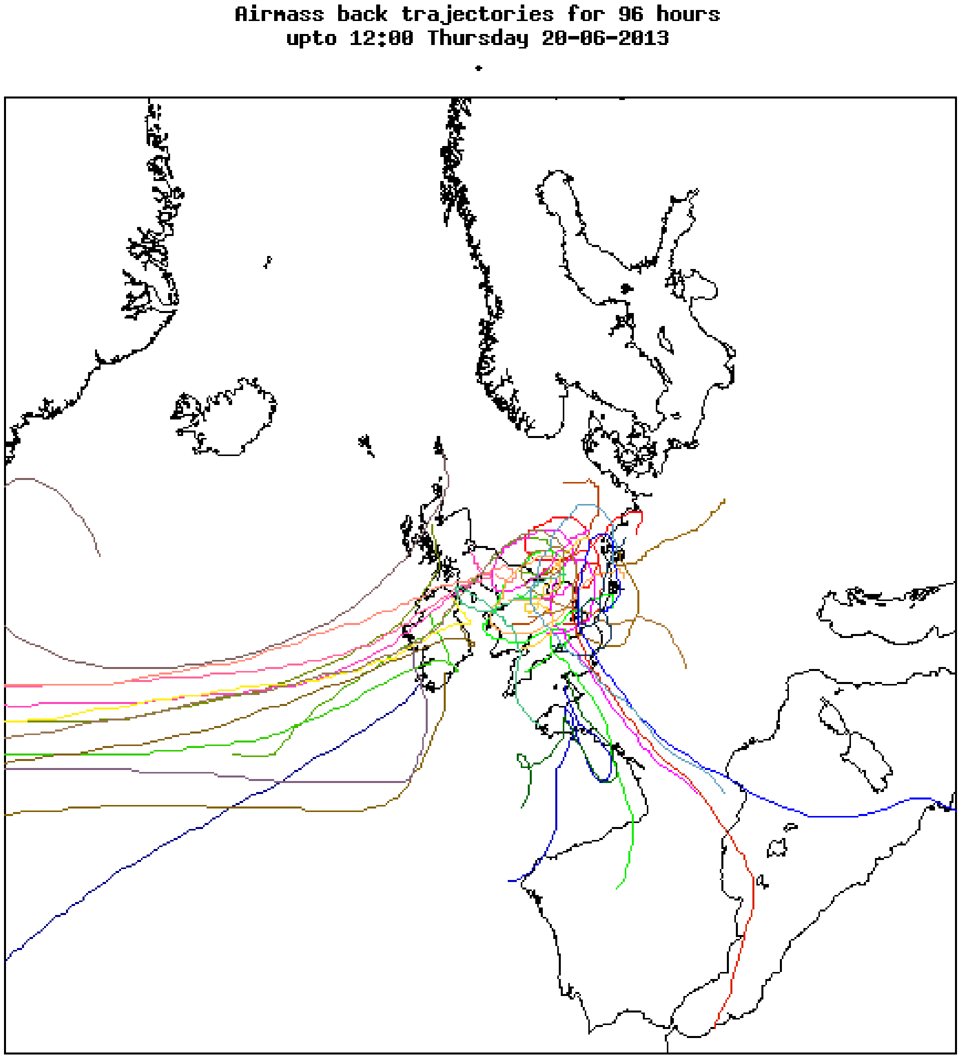
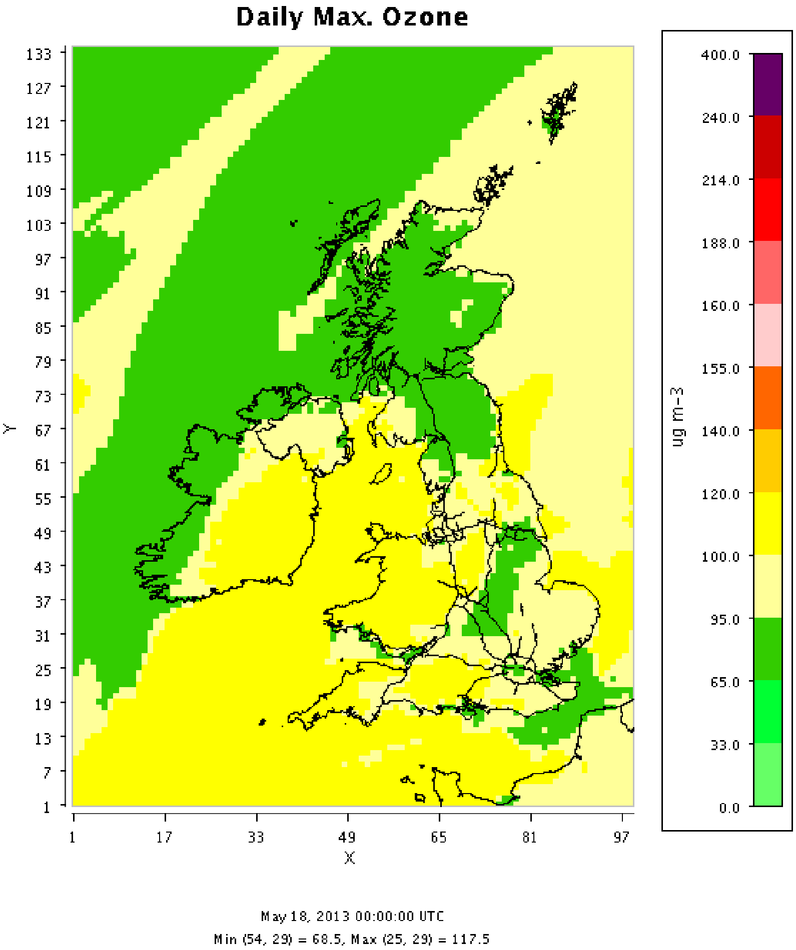


Figure 6-2 shows a modelled map predicting elevated concentrations of ozone, expected to arrive over the UK on 18th May 2013. This modelled map was produced using CMAQ (the Community Multi-scale Air Quality modelling system), an open-source tool developed by the United States Environmental Protection 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 6-2: CMAQ Model Predicting Elevated levels of Ozone across the UK on 18th May 2013.

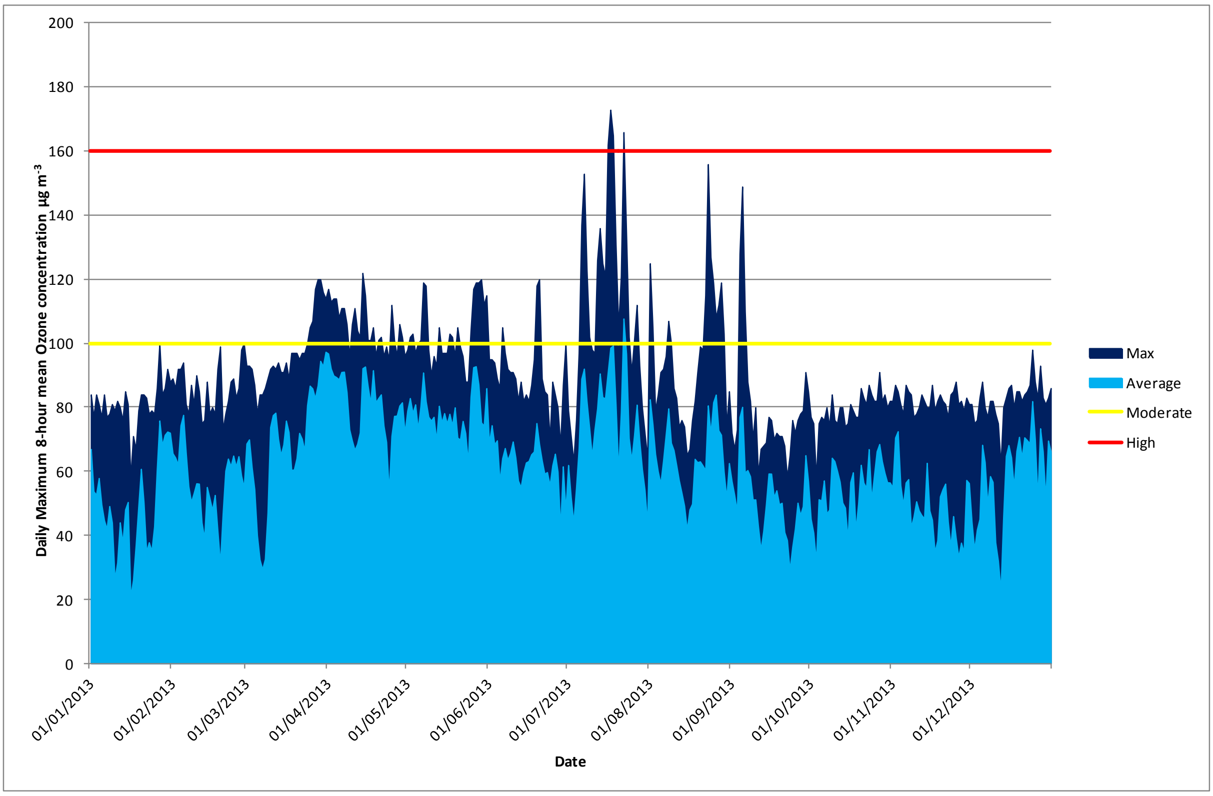


On 19th to 20th June, the south of England saw an increase to "Moderate" levels (Daily Air Quality Index 4 and 5) of ozone and particles as clean westerly winds changed to southerly winds. Some of the particles may have been Saharan dust which was forecast to pass over the UK.

July had the longest heat wave period since 1997 with extensive sunshine and high temperatures across the UK. From Saturday 5th July until Wednesday 24th July "Moderate" ozone (index 4, 5 and 6) was observed across most areas of the UK during a period of settled, warm and sunny weather. Between 17th and 22nd July, several AURN monitoring stations recorded ozone concentrations in the "High" banding, including Canterbury, Charlton Mackrell, London Teddington and Leominster. The EU Population Information Threshold of 180 µg m^{-3} (as an hourly mean) was exceeded in the early afternoon of 22nd July, at two sites: Brighton Preston Park and Canterbury. (However, no sites exceeded the higher EU Population Warning Threshold of 240 µg m^{-3} at any time in 2013.) From Thursday 25th July onwards, thunderstorms and cooler conditions meant that ozone concentrations returned to the "Low" banding, apart from a day of "Moderate" levels of ozone on Saturday 27th July.

Figure 6-3 shows how the daily maximum 8-hour mean ozone concentration varied throughout the year. This graph shows the average daily maximum 8-hour mean (averaged over all non-traffic-related AURN monitoring stations), and also the highest 8-hour mean concentration measured at any of these stations on each day. The lower thresholds of the "Moderate" and "High" bands are also shown. The spring and summer ozone "episodes" discussed above can clearly be seen, especially the one from 17th to 22nd July, when several sites recorded "High" concentrations of this pollutant.

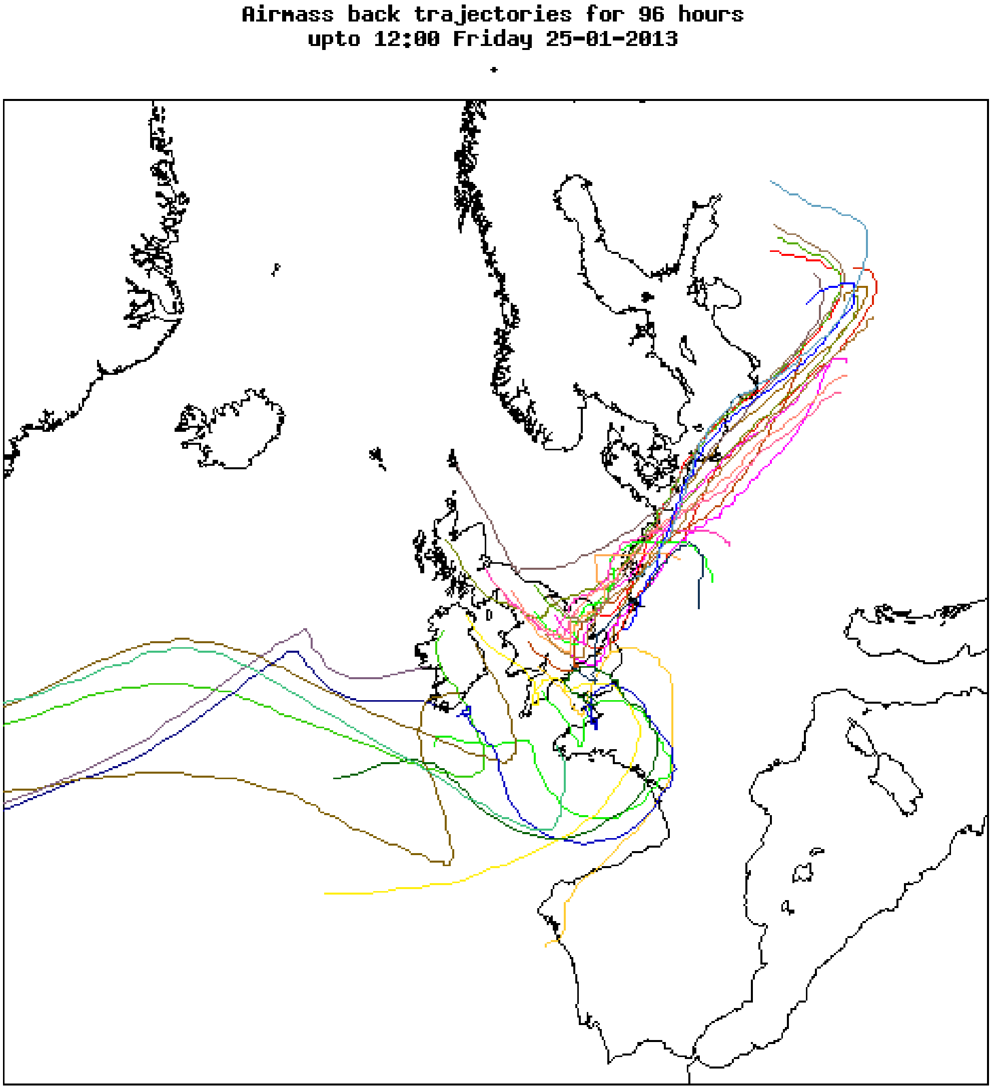
Figure 6-3 Daily Maximum Running 8-hour Mean Ozone Concentration, AURN non-traffic sites, 2013.



6.2 Winter Particulate Pollution Episodes

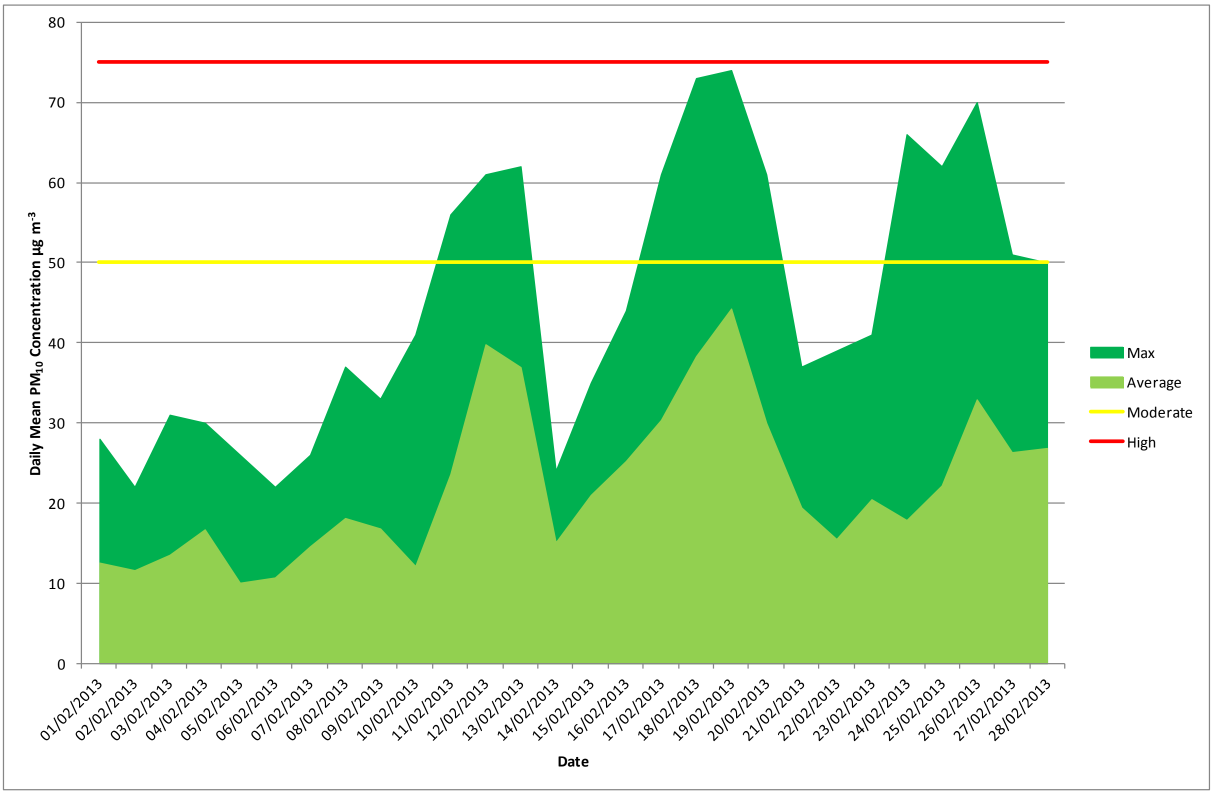
The winter months of 2013 brought several periods of elevated particulate pollution, recorded by AURN monitoring sites across the UK. These occurred between January and May 2013 and then in November and December 2013. During the first episode (10th - 14th January) there were localised increases in PM concentrations to "High" levels across Northern Ireland due to low wind speeds and low overnight temperatures. A pollution alert was issued by the Department of Environment in Northern Ireland. There were also "Moderate" PM concentrations across north-west England under freezing fog conditions on the 11th January. Subsequently, there was widespread "Moderate" PM pollution across the eastern side of England during cold, frosty weather from Thursday January 17th until Thursday 24th January. On Friday 25th January this extended to Wales and Northern Ireland. Figure 6-4 shows the four-day day air mass back-trajectory plot for 25th January 2013. This illustrates that air masses arriving in the UK on 25th January 2013 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 6-4 Modelled Back Trajectories for Air Masses Arriving over the UK from Continental Europe, 25th January 2013 (Source: NOAA Hysplit)



From Sunday 10th February until the end of the month there were periods of "Moderate" particulate matter (PM) pollution, due to a stable high pressure system over the UK. Highest concentrations were measured on days when there were localised poor dispersion conditions, combined with some incoming pollution arriving from continental Europe. However, local pollutant emissions were generally more significant than transboundary pollution during February. Figure 6-5 shows how daily mean PM_{10} concentrations changed over this period. This graph shows the daily average for all AURN sites, also the maximum daily mean recorded for any AURN site.

Figure 6-5 Elevated Levels of PM_{10} Between 1st – 28th February 2013

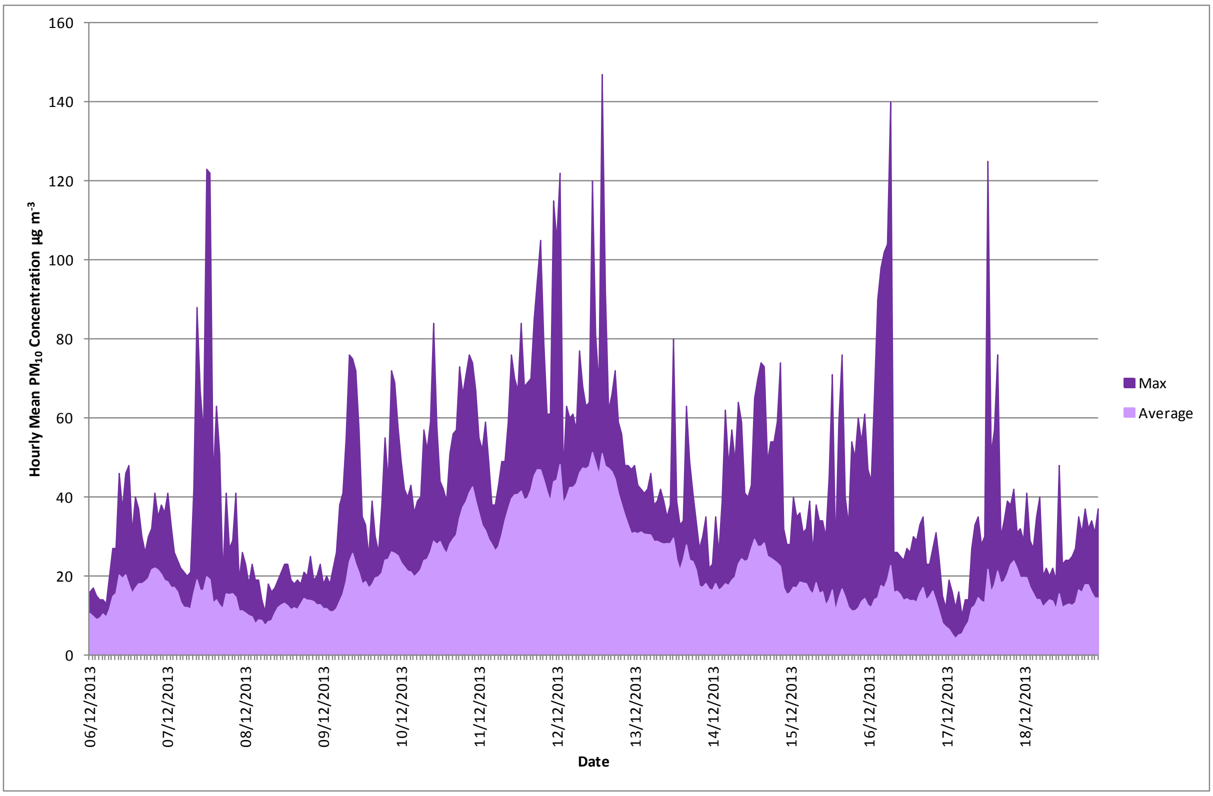


From 20th until 31st March, widespread increases to "Moderate" levels were observed, as the easterly airflow continued across the UK. On Monday 8th April the direction of the incoming air changed to a more southerly direction, which brought "Moderate"/"High" particulate matter pollution to most UK areas until Friday 12th April. From Saturday 13th April until Thursday 18th April a mixture of "Moderate" ozone and particulate matter was widespread across the UK.

There were also some winter particulate pollution episodes towards the end of the year – though Bonfire Night (5th November) was relatively uneventful in 2013. From 22nd to 26th November "Moderate" pollution was observed across Northern Ireland and Central Scotland with some localised "High" measurements for Northern Ireland on 24th November and in Glasgow on 25th November.

"Moderate" PM concentrations were observed in London and South East England on 10th December. This was due to still weather conditions and cold overnight temperatures. Widespread "Moderate" extended across England and South Wales with "High" PM concentrations observed in London on 11-13th December. These were due to a combination of overnight cold, still weather conditions, some recirculation of air over northern Europe, and possible influx of Saharan dust. Figure 6-6 shows elevated hourly mean PM_{10} concentrations observed across South East England, South West England and Wales between 6th December and 18th December 2013. Seventeen AURN sites in these regions had data for this period: the graph shows the average hourly mean for each hour, also the highest hourly mean concentration measured at any of these sites. (The index thresholds are not shown on this graph as they apply to the daily mean PM_{10} concentration rather than the hourly mean).

Figure 6-6 Hourly Mean Concentrations of PM_{10} across South East England, South West England and Wales between 6th December and 18th December 2013



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 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.

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.

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 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 web page at http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215

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

- The Northern Ireland DoE Air and Environmental Quality web page at http://www.doeni.gov.uk/index/protect_the_environment/local_environmental_issues/air_and_environmental_quality.htm

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