AIR QUALITY IN LONDON 2003
FINAL REPORT

THE ELEVENTH REPORT OF THE LONDON AIR QUALITY NETWORK

Environmental Research Group
King's College London
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The measurements detailed in this report result from a team effort undertaken by staff who are dedicated and committed to their work. Further information can be gained from the following contacts:

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FOREWORD

Professor Frank Kelly, Director of the Environmental Research Group (ERG)

Welcome to the eleventh annual report of the London Air Quality Network (LAQN), which provides a strategic overview of air pollution across London during 2003. The report is important both as a stand-alone document for comparison with other cities, and as a component of the LAQN's ongoing annual air pollution record for London. This publication provides a vital resource for anyone interested in air quality, especially those who are working at local and national levels or are developing policies to help reduce the level of air pollution in the UK.

The LAQN is managed by the Air Quality Monitoring Group, led by Gary Fuller at King's College London (KCL). The information in this report is further enhanced by input from ERG's Air Quality Management Group. The combined and complementary expertise of the individuals in these groups is also evident in the new LAQN website www.londonair.org.uk. This excellent resource has summaries of air pollution across the LAQN and a number of tools to allow the user to analyse and plot data. We hope that the website will be of benefit to all those with an interest in air quality.

2003 will be seen as a memorable year for air pollution in the UK. Previous such years include 1952 when the so called Great Smog led to the Clean Air Act, 1991 when a winter time pollution incident caused unprecedented background NO_2 concentrations and 1996 when a spring time PM_{10} episode coincided with new evidence of the health effects of this pollutant. The pollution events in each of these years have challenged the accepted scientific and regulatory understanding of air pollution.

The August 'heat-wave' in 2003 resulted in the highest concentration of ozone since 1990 and this has been associated with up to 800 excess deaths in England and Wales. Furthermore, a series of PM_{10} episodes led to widespread breach of the 2005 EU Limit Value at roadside sites across London. In this respect, PM_{10} concentrations in London have showed no improvement since the turn of the century with concentrations (with respect to the EU Limit Value) returning to levels measured during 1998. Probably of equal importance, NO_2 concentrations rose at almost all measurement sites. At the end of 2003 the LAQN annual mean index for NO_2 was just 2% below its initial value in November 1996 despite reductions of 29% in the annual mean NO_X. Underlying this London-wide increase in NO_2, increases in NO_2 concentration at specific roadside sites raise important new questions regarding our understanding of the behaviour of this pollutant.

The importance of 2003, in air pollution terms, is further underlined by the introduction of London's Congestion Charging Scheme on the 17th February. Although not specifically designed to abate air pollution, the scheme is a unique and bold urban traffic management initative that has attracted international interest amongst air pollution scientists, epidemiologists and policy makers. Recently, the US Health Effects Institute (HEI) announced the funding of a project to quantify the air pollution and health changes arising from the scheme. The KCL led project, brings together expertise from St. Georges Hospital, the London School of Hygiene & Tropical Medicine and Transport for London. This interdisciplinary group of epidemiologists, toxicologists and air pollution scientists will provide new insights into the air pollution and health impacts of Europe's largest experiment in urban traffic management.

Air pollution in 2003 was also notable with respect to the timetable for the Air Quality Strategy (AQS) and EU Directives. During 2003, AQS Objectives and EU Limit values for 2004/5 were widely exceeded. With little time before the 2004/5 attainment date of these Objectives and Limit Values, the measurements in 2003 suggest a risk of further breaches in 2004 and beyond. This report does contain some encouraging information, but fundamentally, it highlights how much more must be done at all levels, from the individual, local councils and Government, to combat the problem of air pollution in London.

SUMMARY

Gary Fuller – Head of Air Quality Monitoring

During 2003 the UK experienced a series of air pollution episodes that caused the Air Quality Strategy (AQS) Objectives for PM_{10}, NO_2 and O_3 to be exceeded throughout London and South East England.

Particles: The main PM_{10} episodes were measured during February, March, April and August, with lesser incidents measured during September and November. The first 5 episodes were mainly caused by secondary PM_{10} from distant sources, with summer episodes also being linked to photochemistry. The November episode was associated with Guy Fawkes Night. Roadside sites measured additional PM_{10} from local traffic, which caused additional incidents not measured at background sites. The incidents during 2003 reversed the established trend of improving PM_{10}, with levels returning to those experienced during 1998. As a consequence of these PM_{10} episodes, the incident-based AQS Objective for PM_{10} was exceeded at kerbside and roadside sites in inner London and at several such sites in outer London. PM_{10} at background sites was largely below the Objective.

Ozone: The O_3 season during 2003 was exceptionally long and the hot summer weather caused the highest concentrations measured in the 10 year history of the London Air Quality Network (LAQN). The O_3 Objective was exceeded at all sites except Marylebone Road.

Nitrogen Dioxide: All roadside and kerbside sites exceeded the NO_2 annual mean Objective. The annual mean Objective was also exceeded at background sites in inner, north-east and west London. Several roadside and kerbside sites exceeded the hourly mean Objective; some outer London sites exceeded the hourly mean Objective for the first time
.

The annual mean concentration index increased for all pollutants during 2003. The largest increases were exhibited by NO_2 (8%), PM_{10} (11%) and O_3 (16%). These changes differ markedly from the decreasing trends in air pollution seen in London over the previous 7 years when annual mean concentrations of all pollutants, except O_3, decreased during the period November 1996 to the end of 2003. The greatest reductions in annual mean concentration were exhibited by SO_2 (63%) and CO (50%). A lesser reduction was achieved for PM_{10} (25%) and NO_X (29%). Despite the 29% reduction in NO_X concentration, the annual mean concentration of NO_2 at the end of 2003 was only 2% below its value during November 1996

This report does not extend to a through analysis of air pollution during 2003. Such analysis will only emerge over the next few years. It does, however, provide information to support these future analyses and, with ratified measurements, updates our preliminary report for 2003 published early in 2004. In addition, this report contains the preliminary source apportionment of PM_{10} during the year along with additional analysis that places 2003 in the context of air pollution measurements during the last 10 years.

Even now, early in 2005, the air pollution measurements in 2003 leave many unanswered questions. Within KCL, on-going work with respect to direct NO_2 emissions is making an important contribution to our understanding of why this pollution increased during the year.

INTRODUCTION

During 2003, the UK experienced a series of pollution episodes that caused the Air Quality Strategy (AQS) Objectives to be exceeded throughout London. The pollution episodes measured during 2003 present massive challenges to air quality managers with little time remaining before the AQS Objectives need to be met in 2005. During February 2004 a preliminary annual report for 2003 was published to allow provisional measurements to be rapidly incorporated into the air quality management process. This final report contains ratified measurements of air pollution during 2003 and additional analysis.

Measurements have been analysed with specific reference to the AQS Objectives which are detailed in Appendix 4. Full details of the sites in the London Air Quality Network (LAQN) are presented in Appendix 1 and the detailed monitoring results are presented in Appendix 3.

The LAQN was formed in 1993 to coordinate and improve air pollution monitoring in London. Currently, 30 London boroughs are supplying data to the LAQN. Increasingly, these data are being supplemented by measurements from local authorities surrounding London, thereby providing an overall perspective of air pollution in South East England. The LAQN is operated and managed by the Environmental Research Group (ERG) at King's College London. Each borough funds air quality monitoring in its own area. The core LAQN activities are funded by the ERG itself. The Department of Environment, Food and Rural Affairs (DEFRA) funds the ERG to operate the Marylebone Road site and to maintain 14 of the LAQN sites as affiliate sites to the UK Automatic Urban and Rural Network (AURN). This DEFRA support assists the operation of the overall LAQN. Further monitoring sites have been supported by Transport for London to provide measurements to inform the assessment of the Congestion Charging Scheme.

Analysis of LAQN measurements has been augmented by measurements from the directly-funded DEFRA sites in London. These 6 sites, listed in Appendix 2, provide further information concerning pollution in central and west London. Measurements from DEFRA sites were provided by AEAt plc from the National Air Quality Archive and included within the LAQN database.

To understand air pollution in London it is necessary to understand air pollution in the surrounding area and vice-versa. To support this understanding the LAQN also includes sites in Essex, Kent and Surrey. A more complete picture of air pollution in South East England can be obtained from the combined results of the LAQN, the Kent Air Quality Monitoring Network (KAQMN), the Hertfordshire and Bedfordshire Air Pollution Monitoring Network (HBAPMN) and the Sussex Air Quality Steering Group (SAQSG) network. Measurements from these networks are available from the ERG.

Hourly updated measurements from the LAQN and neighbouring networks are published by the ERG on the Internet at:

www.londonair.org.uk

AIR QUALITY MEASUREMENTS

Air quality measurements in the LAQN are made using a range of continuous air quality monitoring equipment. Measurements are subject to two quality assurance processes. Initially, data are validated using the best calibration and instrument performance information available at the time. Measurements are retrospectively examined during the ratification process, using long-term instrument histories and the results of further quality checks. Sites are classified into three quality standards. Measurements from sites affiliated to the AURN and London Standard sites have traceabilty to National Metrological Standards, whereas for the Locality Standard sites there is insufficient information to demonstrate such traceability.

No scientific measurement is absolutely accurate or absolutely precise. The combination of accuracy and precision is termed the uncertainty. In order to place results in context, the uncertainty associated with each result has to be considered. Estimates of the uncertainty associated with air quality measurement are discussed in the 2001 LAQN Annual Report (ERG, 2003). This suggests that a working uncertainty of around 10% (2σ) should be considered when discussing high values and long-term averages of CO, NO_2 and SO_2 measured at London Standard sites. This is justified on the basis of both mathematical modelling and equipment performance tests. However, due to the statistical distribution of the data, a 10% uncertainty in measurements does not imply a 10% uncertainty in the number of breaches of a threshold standard.

The uncertainty associated with the measurement of PM_{10} is more complex since the results obtained are highly dependent on the measurement method used. PM_{10} poses many measurement challenges. Rather than comprising a single, defined chemical compound, like CO or SO_2 for example, the composition of PM_{10} varies with location, time of year and during episodes. PM_{10} can be considered to comprise: primary particulates (mainly emitted from local sources), secondary particulates (mainly from distant sources), and coarse particulates whose origin can be local or further afield. The variation in composition affects each measurement technique differently and therefore each measurement technique produces systematically different results. The EU Daughter Directive is based on a 'gravimetric' method where PM_{10} is collected on a filter that is then weighed in a laboratory (CEN, 1998). There is ample evidence to suggest that the most common measurement methodology employed in the UK, the Tapered Element Oscillating Microbalance (TEOM), produces a result lower than the 'gravimetric' method (APEG, 1999; Green *et al* 2000). DETR (1999) suggested that a correction factor of 1.3 be applied to TEOM results for comparison to the AQS Objective.

Beta Attenuation Monitors (BAM) are also used to measure PM_{10} in the LAQN. Research at Marylebone Road (Green, 1999) sought to compare the results from TEOM, 'gravimetric' and BAM instruments. The BAM instrument tested produced higher results than the 'gravimetric' method at this location during the test period. However, no correction factor has been applied to the BAM measurements.

The Air Quality Regulations (DETR 2000b) specify Objectives in terms of mass per unit volume for all pollutants. However, continuous gas analysers and the calibration standards used are measured in terms of mixing ratio. These are two entirely different bases of measurement with conversion between them being dependent on temperature and pressure conditions. Conversions have been made based on 293 K and 101.3 kPa, where appropriate, for comparison to the AQS Objectives, (DETR 2000c). Mass per unit volume NO_X concentrations are reported at NO_2 equivalent.

The final data sets for the AURN sites are published by the DEFRA.

AIR QUALITY DURING 2003

Air Pollution Episodes

A series of distinct air pollution episodes during the year have been identified. These are discussed below for each pollutant and for ease of cross-reference a consistent labelling scheme has been adopted throughout this report. The labelling scheme is based on PM_{10} episodes during the year.

CO

CO emissions within the LAQN area are dominated by road transport sources. All sites met the AQS Objective of 10 mgm^{-3} (8.6 ppm) as a rolling 8 hour mean. CO is a primary pollutant and its temporal distribution is easier to understand than that for NO_2, O_3 or PM_{10}. CO concentrations are determined by emission rates and dispersion only, and are therefore generally highest during the winter months when atmospheric dispersion is weakest. This is evident in Figure 1 which shows the temporal distribution of CO during the year as measured at the roadside site Wandsworth 4.

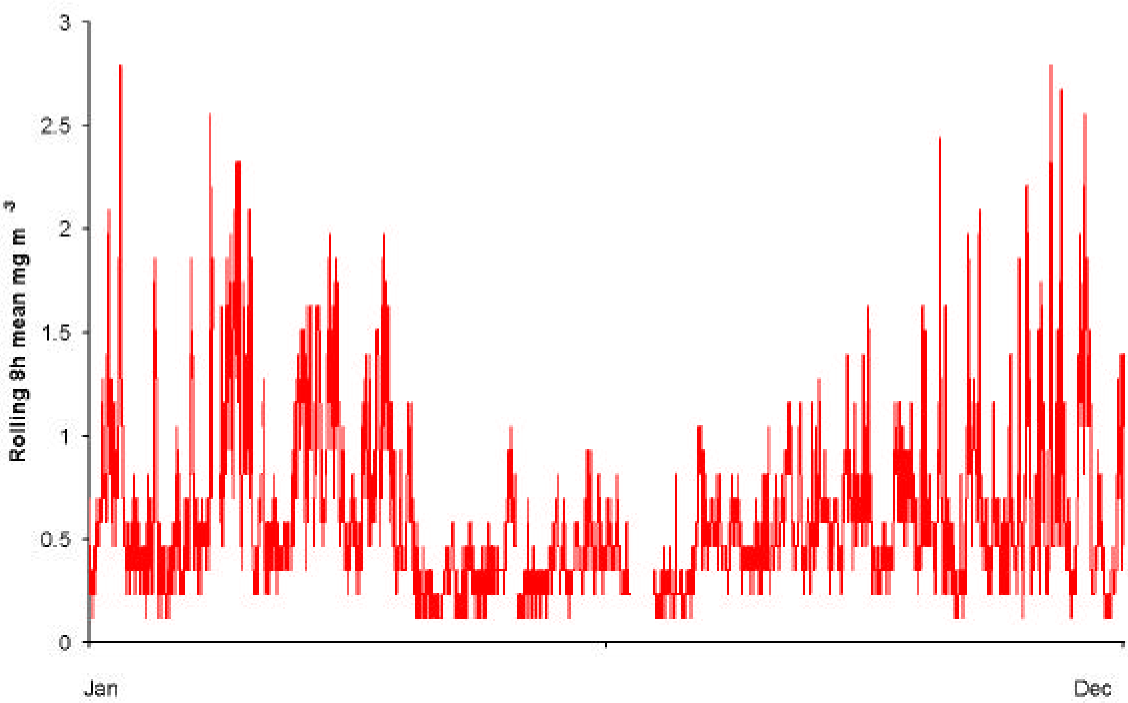

Figure 1 Rolling 8h mean CO at Wandsworth 4

NO_2

NO_2 is largely a secondary pollutant formed by the oxidation of NO. In the LAQN area, road transport is the dominant source of NO_X. This is reflected in the spatial distribution of NO_2, with the greatest annual mean concentrations being measured near roads and in central London locations. Lower concentrations are observed in background and suburban areas.

2003 Results

The AQS stipulates two Objectives for NO_2: an annual mean of 40 μgm^{-3} (21 ppb) and an incident-based Objective of 200 μgm^{-3} (105 ppb), as an hourly mean, not to be exceeded more than 18 times per year.

During 2003, the annual mean NO_2 Objective was exceeded at all kerbside and roadside monitoring sites. This Objective was also exceeded at background sites in inner London. The area where background sites exceeded the Objective extended beyond inner London to include Redbridge 1 in the north-east, and Heathrow Airport, Hillingdon (AURN) and Hounslow 2 in the west.

All permanent kerbside sites measured hourly mean concentrations above 200 μgm^{-3} (105 ppb) during the year. The incident-based Objective for NO_2 was exceeded at the kerbside sites Barnet 1, Marylebone Road, Lambeth 4, Redbridge 2 and Sutton 4. The Objective was also exceeded at the roadside sites Hammersmith & Fulham 1, Hounslow 4, Kensington & Chelsea 3 and Kensington & Chelsea 4. This is the first time that Barnet 1, Sutton 4 and Hounslow 4 have exceeded this Objective.

The temporal distribution of NO_2 throughout the year is illustrated in Figure 2, which shows measurements from the roadside site Hillingdon 1. Hourly mean NO_2 exceeded 200 μgm^{-3} (105 ppb) during the winter and also approached this concentration during the summertime episode D. Wintertime incidents are caused by poor pollutant dispersion; those episodes measured at Hillingdon 1 in November and December were typical. During these episodes elevated primary PM_{10} was also measured; the late November episode coincided with PM_{10} episode G and the December episode coincided with roadside PM_{10} episode 4. During these wintertime incidents, peak NO_2 concentrations are normally measured during the morning when pollution dispersion is weakest. Summertime incidents are caused by the increased oxidising capacity of the atmosphere during O_3 episodes; the NO_2 peaks during mid April and early August are examples of this behaviour and also coincide with PM_{10} episodes C and D. During summertime incidents, the peak NO_2 concentration normally occurs in the evening as solar radiation decreases. These summertime incidents may not be easily amenable to control by reduction of local NO_X emissions.

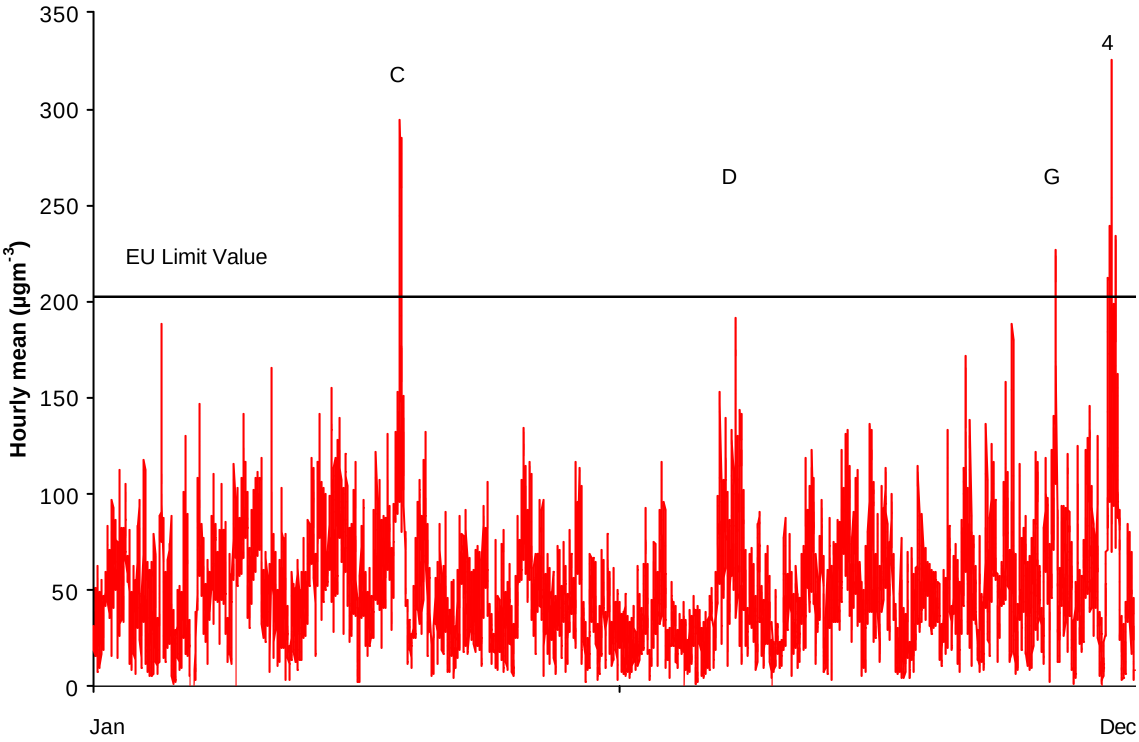

Figure 2 Hourly mean NO_2 at Hillingdon 1

O_3

O_3 is a seasonal pollutant with the highest concentrations being measured during the summer months. It is also a regional pollutant, with episodes extending over many hundreds of kilometres. O_3 exhibits local variation caused by the scavenging effect of NO close to NO_X emission sources, at the roadside for example. Health-based standards are rarely exceeded at roadside and kerbside sites and O_3 monitoring is not generally undertaken in these locations. However, roadside monitoring of O_3 can lead to a better understanding of the mechanisms that determine roadside NO_2 concentrations (e.g. Clapp and Jenkins, 2001 and Carslaw and Beevers, 2004) and for this reason further O_3 monitoring at roadside sites in London would be encouraged.

The AQS has an Objective of 100 μgm^{-3} (50 ppb), measured as a rolling 8 hour mean, which should not be exceeded on more than 10 days per year. The greatest concentrations of O_3 are generally measured at sites on the edge of London and in the Home Counties. During the 3 years 2000 to 2002, the majority of sites in outer London and the Home Counties exceeded the Objective, whilst many sites in inner and west London met the Objective. During 2000 to 2002, outer London sites typically experienced around 20 to 30 days per year with peak concentrations above 100 μgm^{-3}, measured as a rolling 8 hour mean. During 2003, several sites measured over 40 days above 100 μgm^{-3}, expressed as a rolling 8 hour mean; almost double the number of days measured annually during 2000 to 2002. During 2003 the AQS Objective was exceeded at all O_3 measurement sites in London except the kerbside site Marylebone Road.

The temporal distribution of O_3 during the year is illustrated in Figure 3 which shows the mean of measurements at the suburban sites Enfield 3 and Kingston 1. During 2003, London experienced the longest 'O_3 season' (defined in terms of 'moderate' O_3) and also the highest concentrations measured in the 10 year history of the LAQN. The 'season' began on 23rd March (the earliest measured in 10 years) and finished on the relatively late date of the 21st September. On the 6th August the hourly mean O_3 reached 262 μgm^{-3} (131 ppb) at Enfield 3; this is the highest concentration measured in the 10 year history of the LAQN and the highest concentration measured in the UK since 1990. During early August 2003 many sites measured concentrations above 240 µgm^{-3}. These concentrations are, however, around half those measured during the summer of 1976. (PORG 1993). The PM_{10} episodes A to G and 1 to 4 are also labelled in Figure 3. The elevated O_3 concentrations during PM_{10} episodes B to E and 1 and 2 can be clearly seen, as can the very low O_3 concentrations during the primary pollution episode 4.

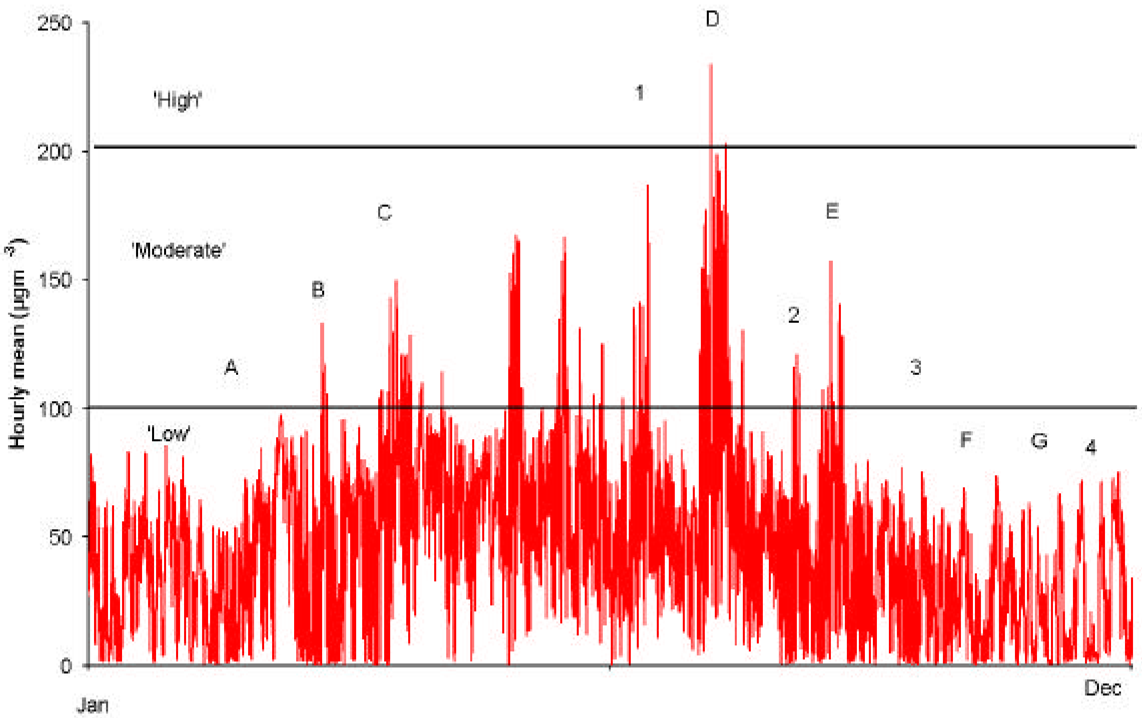

Figure 3 Hourly mean O_3; the mean of measurements at Enfield 3 and Kingston 1

PM_{10}

There are two AQS Objectives for PM_{10}: an incident-based Objective of 50 µgm^{-3}, measured as a daily mean not to be exceeded on more than 35 days per year, and an annual mean Objective of 40 µgm^{-3}. These Objectives are in line with the EU Daughter Directive Stage 1 Limit Value.

During 2003, London experienced a series of PM_{10} episodes. The temporal distribution of PM_{10} during the year is illustrated by measurements from Kensington & Chelsea 1, a typical inner London background site, and is shown in Figure 4. Figure 4 shows 7 distinct episodes during the year when the daily mean exceeded 50 µgm^{-3} (TEOM*1.3). These episodes are labelled A to G.

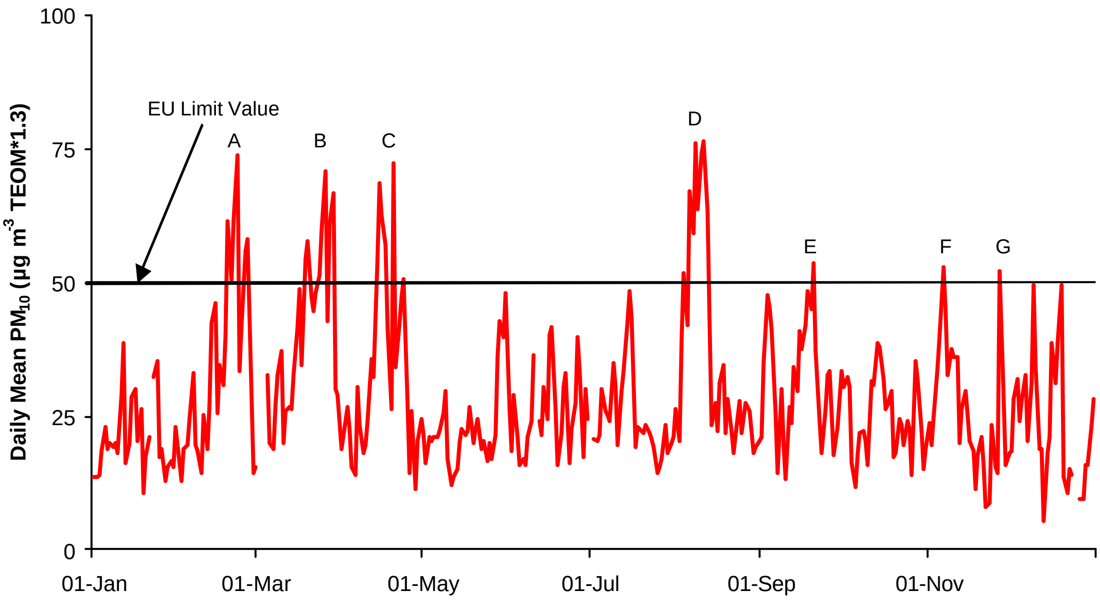

Figure 4 Daily Mean PM_{10} at Kensington and Chelsea 1

As a consequence of the episodes shown in Figure 4, the incident-based PM_{10} AQS Objective was exceeded at kerbside and roadside TEOM sites in inner London and at several such sites in outer London. The highest number of daily means above 50 µgm^{-3} at TEOM sites was measured at the Marylebone Road kerbside site (161 days) and at the Bexley 4 roadside site (131 days); the latter site was regularly affected by PM_{10} arising from vehicles accessing nearby industrial facilities. All background and suburban TEOM sites met the incident-based Objective except those affected by additional PM_{10} from local sources: Barking & Dagenham 2, Heathrow Airport, Tower Hamlets 1 and Thurrock 1. The annual mean Objective of 40 µgm^{-3} was exceeded at the kerbside TEOM site Marylebone Road and at the roadside TEOM site Bexley 4.

The incident-based Objective was exceeded at all BAM sites irrespective of location. The greatest number of daily means above 50 µgm^{-3} was measured at the roadside sites Enfield 4 (131 days), Lambeth 1 (115 days) and Enfield 2 (81 days). The annual mean Objective was also exceeded at the roadside BAM sites Enfield 2, Enfield 4, Lambeth 1 and Redbridge 4.

'Gravimetric' measurements of PM_{10} indicate that the incident-based Objective was exceeded at the Marylebone Road kerbside site (96 days) and at the roadside site Kensington and Chelsea 5 (91 days). These data support the conclusion from TEOM measurements; that the incident-based Objective was exceeded alongside roads in central and inner London. The 'gravimetric' measurements from the inner London background Kensington & Chelsea 1 exceeded 50 µgm^{-3} on 32 days, supporting the conclusion from TEOM measurements that the Objective was not widely exceeded at background locations in London.

Preliminary PM_{10} Source Apportionment

To understand the causes of the 2003 episodes it is necessary to apportion the measured PM_{10} according to source. ERG's PM_{10} modelling methodology is described fully in Fuller *et al*, 2002. The ERG model divides PM_{10} by source through analysis of measurements of annual mean NO_X, PM_{10} and $PM_{2.5}$ across a network of monitoring sites. PM_{10} is identified as arising from three source components: primary (associated with NO_X), secondary (mainly the $PM_{2.5}$ not associated with NO_X but also containing some coarse particulate) and natural (coarse component not associated with NO_X). Here, coarse PM is defined as $PM_{10} – PM_{2.5}$. The daily mean secondary and natural components are assumed to be invariant across London. For the preliminary analysis of 2003, the model was used in a reduced form with mean secondary and natural components being derived from a single background site in Bexley. Total daily mean PM_{10} concentrations at other locations were then calculated by adding the secondary and natural PM_{10} to primary PM_{10} derived from NO_X at each location. This preliminary analysis does not contain sufficient information to apportion PM_{10} on each day of the year; specifically, apportionment is not possible for short periods during late March and early June.

Figure 5 shows the source apportionment of PM_{10} measured at Kensington & Chelsea 1, with episodes labelled A to G. During episodes A to E, PM_{10} was dominated by secondary particulate brought into London from continental sources. The imported secondary PM_{10} is present in the $PM_{2.5}$ fraction, as expected. Imported secondary PM_{10} is also evident in the coarse (PM_{10} - $PM_{2.5}$) fraction; this is especially the case in the first part of episode C. Episodes B to E were associated with photo-chemical activity as indicated by elevated concentrations of ground-level O_3. Episode D was dominated by secondary PM_{10} and coincided with record-breaking temperatures and the highest ground-level O_3 concentrations measured since 1990. Episode F was caused by Guy Fawkes Night bonfires and fireworks. The source apportionment method is not accurate at this time due to large local sources of particulate that are not also sources of NO_X. The preliminary source apportionment underestimates the PM_{10} concentration during episode G in Figure 4 and the modelled daily mean does not exceed 50 μgm^{-3} (TEOM*1.3) at this time.

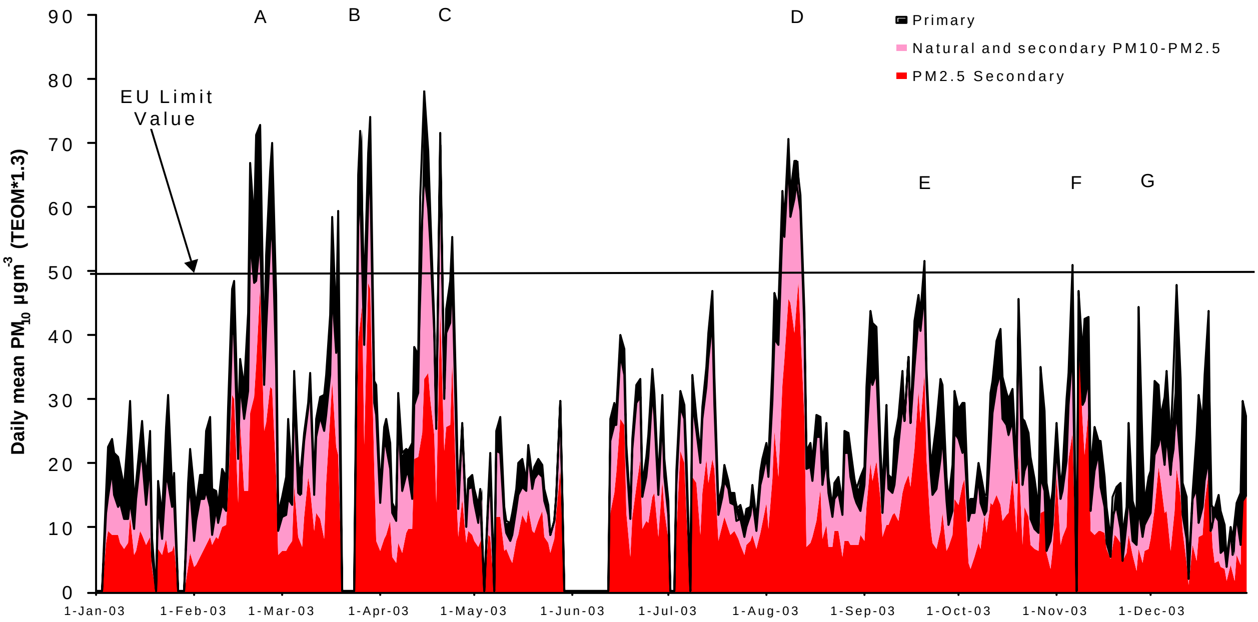

Figure 5 Source apportioned daily mean PM_{10} at the inner London background site Kensington & Chelsea 1

Figure 6 shows the source apportionment of PM_{10} measured at Kensington & Chelsea 2; a typical inner London roadside site. Due to its proximity to a major road, the site experienced more primary PM_{10} than the nearby Kensington and Chelsea 1 background site. This additional primary PM_{10} increased the impact of episodes A to E, with causing additional daily means above 50 μgm^{-3} (TEOM*1.3). The additional primary PM_{10} also led to 4 further episodes not measured at the background site; these are labelled 1 to 4 in Figure 6. Episodes 1 to 3 were caused by a mixture of local primary and secondary particulate. Episode 4 was dominated by local primary sources and is a classic winter-time pollution episode occurring in poor dispersion conditions. As expected, during such winter-time episodes, elevated NO_2 and very low levels of O_3 were also measured during episode 4 as shown in Figure 2 and Figure 3.

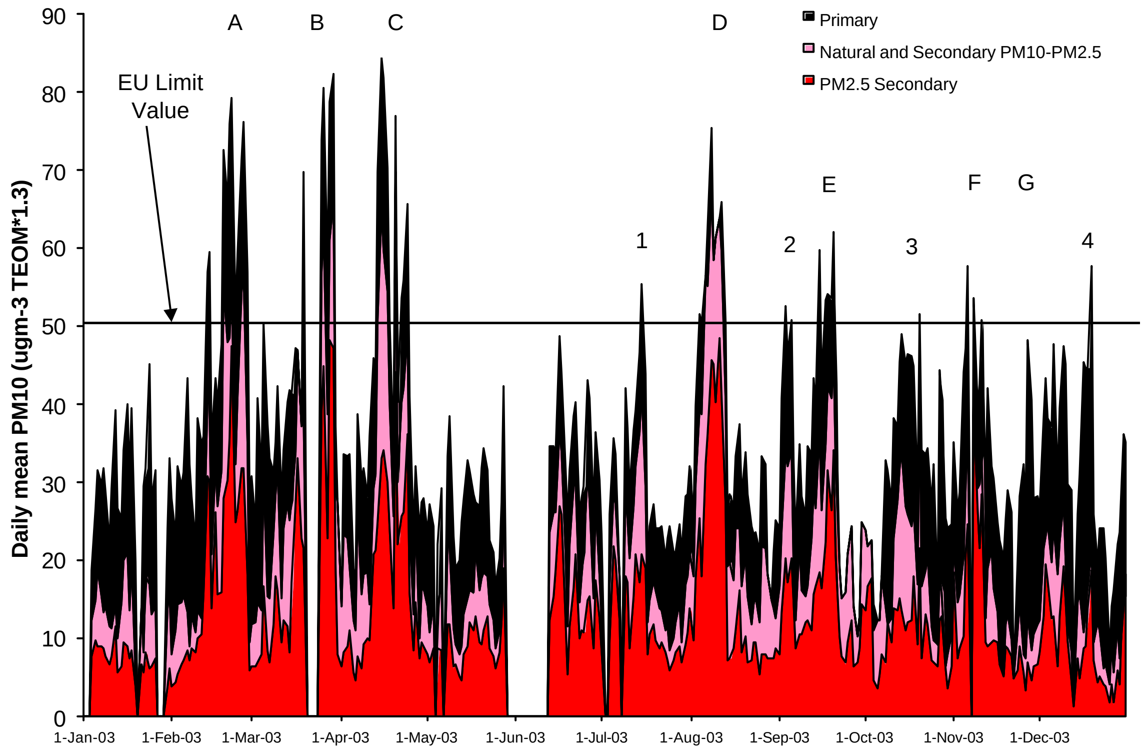

Figure 6 Source apportioned daily mean PM_{10} at the inner London roadside site Kensington & Chelsea 2

SO_2

The distribution of SO_2 concentrations is influenced by both road traffic and industrial point sources. Road traffic sources are the main factor influencing annual mean concentrations, whereas industrial point sources produce short-term high values due to plume grounding. The annual mean concentrations of SO_2 do not vary to any large degree over the network.

The AQS Objective for SO_2 is based on 35 breaches of a 15 minute mean of 266 µgm^{-3} (100 ppb). This was not approached at any site in the network, although Brent 1, Bexley 1, Enfield 3, Hounslow 2, Lewisham 1, Lewisham 2, and Thurrock 1 measured 15 minute means in excess of 266 µgm^{-3}. The AQS also has an hourly mean Objective of 350 µgm^{-3} (132 ppb) which should not be exceeded on more than 24 occasions per year. A single hourly mean above 350 µgm^{-3} was measured at Thurrock 1.

The temporal distribution of SO_2 during the year is illustrated by measurements from three sites in south-east London and is shown in Figure 7. SO_2 incidents in London are mainly caused by plume grounding from large industry located in the East Thames area and are, therefore, associated with easterly winds. Pollution from continental sources is also transported into London by easterly winds and, therefore, SO_2 incidents often occur at the same time as secondary PM_{10} and O_3 episodes. This is evident in Figure 7 which shows elevated SO_2 during PM_{10} episodes A to D, and 1 and 3.

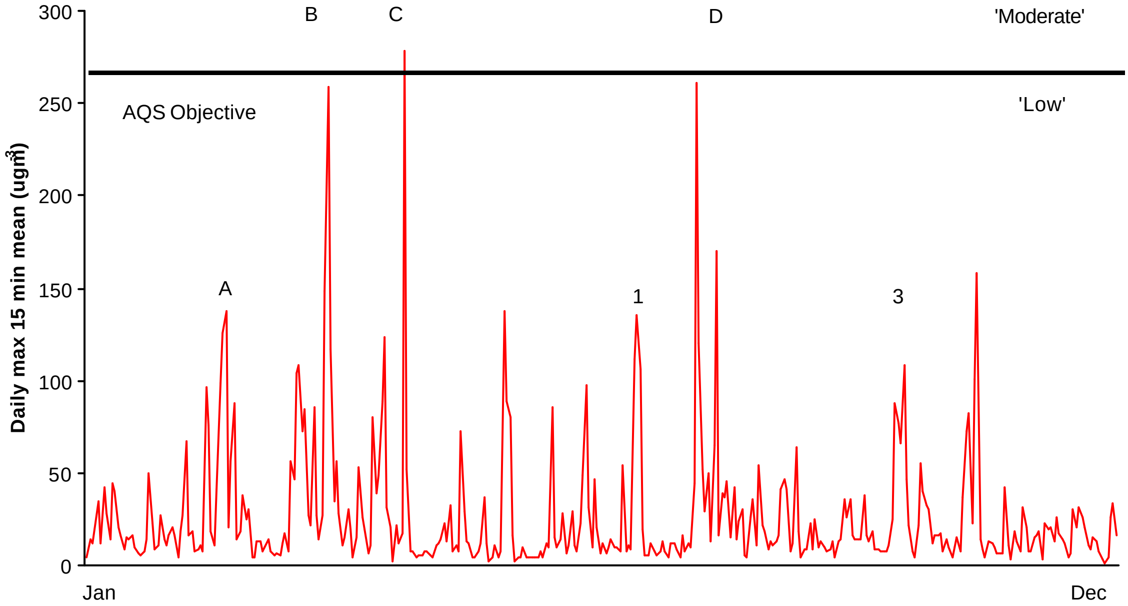

Figure 7 Daily maximum 15 minute mean SO2 from Lewisham 1, Lewisham 2 and Crystal Palace.

Benzene and 1,3 Butadiene

Benzene and 1,3 butadiene are measured by DEFRA networks at the Marylebone Road kerbside site and at the Haringey 1 roadside site. Benzene and 1,3 butadiene are also measured at the Tower Hamlets 2 roadside site. All sites met the AQS Objectives for these pollutants.

MEDIUM-TERM CHANGES IN AIR POLLUTION IN LONDON

Relative Results 1996 to 2004

Data from November 1996 to December 2004 were analysed to place the results from 2003 in context. Annual means were utilised in an attempt to eliminate seasonal effects. To provide a perspective across the network as a whole, the mean from a sample of long-term sites was averaged to produce a LAQN mean. The LAQN network mean was set to 100 for each pollutant as at November 1996, thereby creating an index to illustrate relative change. Measurements from a range of site types were used to derive the index. However, due to measurement availability, different sites were used for each pollutant. Four long-term sites were used for the PM_{10} calculation, five for CO, six for O_3 and SO_2, and 12 for NO_X and NO_2. The three long-term monitoring sites in Sutton closed during May 2002. These were replaced in the index by sites in similar locations: Bexley 2, Crystal Palace, Greenwich Bexley 6 and Haringey 2. It should be noted that measurements during 2004 are provisional and subject to ratification. The changes in index, relative to November 1996, are shown in Table 1.

	Change during 2003 (%)	Change during 2004* (%)	Change Nov 1996 to Dec 2003 (%)	Change Nov 1996 to Dec 2004* (%)
CO	+1	-5	-50	-55
NO_X	+5	-10	-29	-39
NO_2	+8	-12	-2	-14
O_3	+16	-9	+42	+33
PM_{10}	+11	-7	-25	-32
SO_2	+5	-8	-63	-75

Table 1 Changes in LAQN annual mean index (* measurements during 2004 are provisional)

Table 1 shows that the annual mean concentration of all pollutants increased during 2003; the largest increases were exhibited by NO_2 (8%), PM_{10} (11%) and O_3 (16%), relative to their respective annual mean concentrations measured during November 1996.

Despite the air pollution incidents during 2003, Table 1 also shows that the LAQN annual mean index reduced for all pollutants except O_3 during the period November 1996 to the end of 2003. The greatest reductions were achieved in annual mean concentrations of SO_2 (63%) and CO (50%), with lesser reductions exhibited by PM_{10} (25%) and NO_X (29%). Despite the 29% reduction in NO_X concentration, the annual mean concentration of NO_2 only showed a slight decrease (2%) during the period November 1996 to the end of 2003. This will be disappointing to air quality managers and illustrates the challenges of controlling the concentrations of this secondary pollutant. Although local management of NO_2 focuses on the emissions of NO_X, the concentration of NO_2 is also determined by the capacity of the atmosphere to oxidise NO to NO_2. In this respect, concentrations of NO_2 and O_3 are linked. (e.g. Clapp and Jenkins, 2001). Other important determinants of NO_2 concentrations include direct emissions of NO_2 (Carslaw and Beevers, 2004) and other substances that can oxidise NO to NO_2. Annual mean concentrations of O_3 show a substantial increase in the period from November 1996 to the end of 2003 (42%).

Table 1 also shows the results from provisional measurements made during 2004. Measurements from 2004 suggest that air quality improved during the year and the annual mean concentration reduced for all pollutants. Changes in the LAQN annual mean index from November 1996 to the end of 2004 are also presented in Table 1.

Further insight into the relative changes in the concentration of air pollution in London can be gained from the time series of the annual mean values of the index for each pollutant. To produce a time series, the annual mean value of the index for each pollutant was calculated at monthly intervals from November 1996. The mean value for a particular date represented that for the preceding 12 months;

for example, the value calculated for November 1996 represented the mean between November 1995 and November 1996. The values of the index are shown in Figure 8 and Figure 9.

Figure 8 shows an overall fall of around 39% in the annual mean NO_X concentration over the period November 1996 to December 2004. This is the result of reduced NO_X emissions due to technological changes in the vehicle fleet. The effects of pollution incidents during October and November 1997 are clearly reflected in the NO_X concentration; causing a rise in annual mean index at this time and a consequential fall during winter 1998 as this incident drops from the rolling annual mean. Similar incidents are apparent during November 1999 and January 2002.

The annual mean O_3 index in Figure 8 shows an overall rise of 33% from November 1996 to December 2004. As a consequence of the photochemical episodes during 2003, the annual mean O_3 index reached a peak of 147% during spring 2004.

From November 1996 to December 2004 the annual mean NO_2 index reduced by 14%. This reduction is not, however, consistent and fluctuations in annual mean NO_2 show influences of changes in annual mean NO_X and annual mean O_3. The annual mean NO_2 index showed a relative increase from November 1996 to November 1998, due in part to pollution incidents during autumn 1997. Despite reductions in annual mean NO_2 during 1998, the index returned to its original value again at the end of 1999. The index then reduced by 10% in 2000, during unsettled weather at this time, and was relatively stable during 2001 and 2002. However, the annual mean concentration of NO_2 rose during 2003 and by the end of year the NO_2 concentration index was within 2% of its value during November 1996. At this stage it is not possible to determine if the 12% decline in the annual mean NO_2 index during 2004 will herald a longer-term decline, or if the decline in the annual mean NO_2 index during 2004 simply reflects the annual fluctuation exhibited by this pollutant.

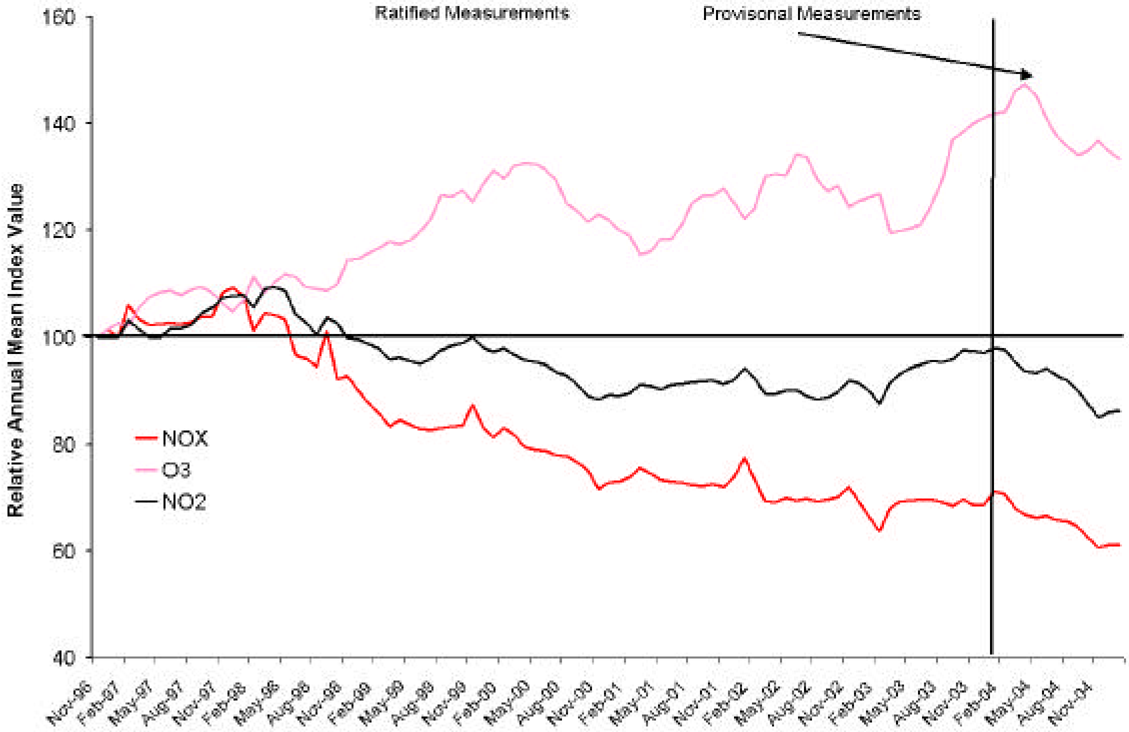

Figure 8 Relative Annual Mean Concentration of O_3, NO_X and NO_2

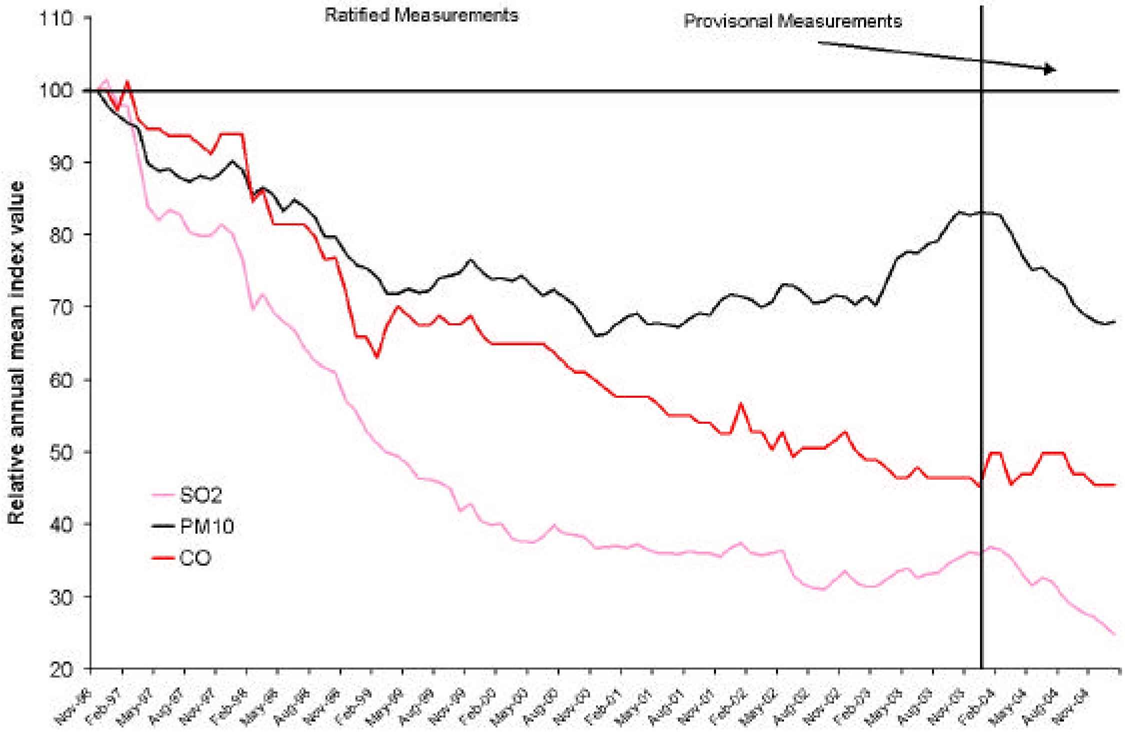

Figure 9 Relative Annual Mean Concentrations of CO, PM_{10} and SO_2

The annual mean concentrations of CO and SO_2 declined by 55% and 75% respectively from November 1996 to the end of 2004. Figure 9 shows that annual mean CO and SO_2 indices fell relatively rapidly from November 1996 to 1999. However, from the start of 2000, the rate of change in annual mean CO and SO_2 has been more modest. During 2003, the annual mean SO_2 concentration increased by 5%. This SO_2 increase was in part due to more frequent easterly winds bringing pollution from industry to the east of London into the capital. However, provisional measurements of SO_2 during 2004 show a decline of 12%.

Figure 9 also shows the annual mean PM_{10} index, which declined steadily from November 1996 to the end of 2000 and then rose at a rate of 3% per year through to spring 2003. The increase in the annual mean PM_{10} index during 2003 reflected a series of PM_{10} episodes during the year. Over the period November 1996 to the end of 2004, the annual mean PM_{10} concentration decreased by 32%.

Progress towards the attainment of AQS Objectives

The LAQN annual mean index is effective at showing the relative change in annual mean concentration. However, the LAQN annual mean index does not show concentration relative to the AQS Objectives or progression towards the attainment of these Objectives. Progress towards the attainment of the AQS Objectives for PM_{10} and NO_2 is discussed below.

NO_2

Figure 10 compares the annual mean NO_2 at 3 different types of location in London using a sample of LAQN sites. All location types showed an overall reduction and exhibited fluctuations due to the same factors; for example, the pollution episodes in Autumn 1997 and, to a lesser extent, the photochemical episodes during 2003. Annual mean concentrations at typical background sites in outer London have been below the AQS Objective since 1998, whereas those at typical roadside and background sites in inner London have been consistently above the Objective.
During 2003, annual mean NO_2 increased by an average of 5 μgm^{-3} (14%) at background sites. This analysis is based on a sample of 11 background sites; 5 in outer London and 6 in inner London. In

Figure 10 the sample inner London kerb/roadside sites (5 sites) show a average increase of 2 µgm^{-3} (3%). However, the mean results from these sample sites masks substantial variations at individual roadside sites. Annual mean concentrations at the Marylebone Road kerbside site (not included in the analysis in Figure 10) increased by 27 µgm^{-3} (33%), offsetting the improvements brought about by the installation of a bus lane during August 2001. Other roadside sites measuring large increases in annual mean NO_2 during 2003 include Kensington and Chelsea 4 (14 µgm^{-3}/ 17%) and Hounslow 4 (24 µgm^{-3} / 41%). In contrast several roadside sites measured very small changes in annual mean NO_2; these include Camden 3 (1.5 µgm^{-3}/ 2%) and Kensington and Chelsea 2 (3.5 µgm^{-3}/ 5%). Additionally, a slight reduction in NO_2 concentration (-1.4 µgm^{-3}/ -2%) was measured at the Islington 2 roadside site. The range of increases in roadside annual mean NO_2 suggests that local changes in emissions are responsible. The increases in annual mean NO_2 are not reflected in changes in annual mean NO_X. The nature and cause of these local changes is currently subject to investigation.

Figure 10 Annual mean NO_2

PM_{10}

Figure 11 shows the annual number of daily mean PM_{10} measurements above 50 µgm^{-3} (TEOM*1.3) at three different types of location. The long-term measurements at inner London background sites exhibit a downward trend from around 50 days above 50 µgm^{-3} (TEOM*1.3) in 1995 to around 10 days in 2002. The similar downward trend of all site types reflects a reduction in secondary and primary PM_{10} emissions, whilst the convergence in the number of daily means above 50 µgm^{-3} (TEOM*1.3) illustrates the reduction in traffic emissions of primary PM_{10}.

During 1995 typical inner London background sites exceeded the Objective, which implied a widespread breach of this Objective throughout London. The situation deteriorated in Spring 1996 due to the substantial secondary episode at this time. As a consequence, 76 daily means above 50 µgm^{-3} (TEOM*1.3) were measured in inner London during the year ending April 1996; more than double the 2005 Objective of 35 days. A repetition of such an episode would clearly provide significant challenges for air quality management. The additional days above 50 μgm^{-3} (TEOM*1.3) caused by the Spring 1996 episode left the running count in Spring 1997. Other events affecting the number of daily means above 50 μgm^{-3} (TEOM*1.3) included the primary episode of Autumn 1997 and the unsettled weather in late 2000. Inner London background sites have consistently achieved the Objective since 1998. The number of daily means above 50 μgm^{-3} (TEOM*1.3) measured at outer London sites was only marginally less than those measured in inner London. A larger difference can be seen between the background and kerb/roadside sites in inner London than between outer and inner London background sites.

The number of daily means above 50 μgm^{-3} (TEOM*1.3) at the kerb/roadside in inner London followed a similar trend to background, albeit with additional days due to local traffic emissions. Inner London roadside sites have generally achieved the Objective since 2000. Measurements at Marylebone Road are not shown in Figure 11, but have been in the range 70–160 days per year and show variations in part due to local events such as building works.

The measurements shown in Figure 11 reflect the impact of the PM_{10} episodes in 2003. Compared to 2002, background sites measured around 20 additional daily means above 50 μgm^{-3} (TEOM*1.3) during 2003, with kerb/roadside sites in inner London measuring around 30 such additional days. The results presented in Figure 11 are means calculated from a sample of sites within each site type and therefore mask individual site variations. By the end of 2003, many road and kerbside TEOM sites in London had exceeded the 2005 AQS Objective. The majority of inner London background TEOM sites did not exceed the Objective; the exception being Tower Hamlets 1 where building works may have caused additional local PM_{10}. Regrettably, measurements from the TEOM at the Bloomsbury AURN site were not available due to an equipment fault. Sufficient TEOM measurements of central London background conditions were therefore not available to determine if the Objective was exceeded in this area. Substituting measurements from the background site Kensington & Chelsea 1 for the missing measurements at Bloomsbury provides a conservative estimate of at least 33 daily means above 50 μgm^{-3} (TEOM*1.3) for the Bloomsbury site. There is hence a possibility that background locations in central London exceeded this Objective.

Provisional measurements suggest that the PM_{10} pollution events during 2003 were not repeated during 2004 and thus the annual count of days with mean PM_{10} greater than 50 μgm^{-3} (TEOM*1.3) reduced. By the end of 2004, the annual count of days with mean PM_{10} greater than 50 μgm^{-3} (TEOM*1.3) at background sites in inner and outer London was comparable to that measured at the start of 2001. The PM_{10} measurements at inner London kerb and roadside sites did not exhibit the magnitude of the reduction measured at background locations. Although PM_{10} at inner London kerb and roadside sites reduced during 2004, the annual count of days with mean PM_{10} greater than 50 μgm^{-3} (TEOM*1.3) at the end of 2004 was close to the EU Limit Value and above that measured at the start of 2001.

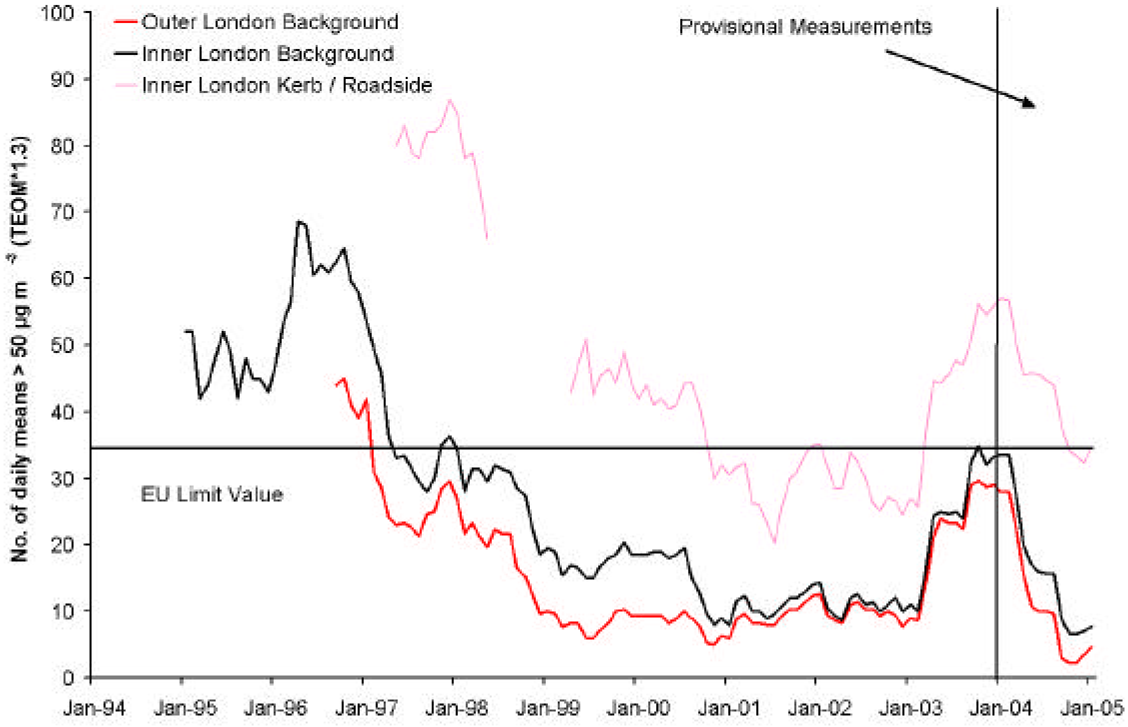

Figure 11 Annual number of days when daily mean PM_{10} exceeded 50 μgm^{-3} (TEOM*1.3)

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APPENDIX 1: LAQN MONITORING SITES

A 1.0 Network Changes

Twelve new monitoring sites joined the LAQN during the year. These are shown in Figure 10 to Figure 20.

Figure 12 The Brent 4 site that joined the LAQN during June as a replacement for Brent 2. The site is located on the A406 around 300 m from the location of Brent 2. The site monitors NO_X, SO_2 and PM_{10} (TEOM).

Figure 13 The Hillingdon 2 site that became fully operational during April. The site monitors NO_X and PM_{10} (TEOM) at a roadside location close to Hillingdon Hospital.

Figure 14 The Waltham Forest 3 site that joined the network during July. The site is located in a roadside location in Chingford and measures NO_X, SO_2 and PM_{10} (TEOM).

Figure 15 The Ealing 6 site that joined the LAQN during August. The site monitors NO_X and is located close to housing façades at Hanger Lane.

Figure 16 The Harrow 2 site that joined the LAQN during June. The site is located in a roadside location and monitors NO_X and PM_{10} (TEOM).

Figure 17 The Hammersmith & Fulham 2 background site that joined the LAQN during July. The site monitors NO_X and PM_{10} (TEOM).

Figure 18 The Hounslow 5 roadside site that replaced Hounslow 1 during August. The site is located beside the A4 and M4 and monitors CO, NO_X and PM_{10} (TEOM).

Figure 19 The Lambeth 4 roadside site that joined the LAQN in December. The site measures NO_X, SO_2 and PM_{10} (BAM) alongside the A23 in Brixton.

Figure 20 The Reigate and Banstead 2 NO_X site that joined the LAQN during August. The site is located in a suburban area immediately adjacent to Gatwick Airport. The site forms part of a larger monitoring programme, which also includes Reigate and Banstead 1, and aims to quantify NO_2 around the airport.

Figure 21 The Thurrock 2 roadside site that measures NO_X. The site joined the LAQN during May.

Figure 22 The Thurrock 3 roadside site joined the LAQN during August and measures NO_X, SO_2 and PM_{10} (TEOM).

Figure 23 The Redbridge 5 site also joined the LAQN during 2003. The site was installed in November as a replacement for Redbridge 2 that closed during April. The site measures CO, NO_X and PM_{10} (BAM).

A.1.1 Details of Monitoring Sites

The following tables detail the pollution monitoring sites in the LAQN at the end of 2003. The start date of each site is shown along with the pollutants monitored and the data quality. In some cases a monitoring site was not operating during the 12 month period. The availability of data from a site is indicated in the data column in the tables below.

Sites are classified according to their location:

- Kerbside sites are those with sampling locations within 1 m of the kerbside and with a sampling height of 3 m or less.
- Roadside sites are those with sampling locations within 1-5 m of the roadside and with a sampling height of 3 m or less.
- Urban background sites are located to represent pollution conditions in the centre of an urban area. Sampling locations are away from the influence of individual pollution sources; 25 m from major roads for example.
- Suburban sites are typical of residential locations on the edge of a built-up area. Sampling locations are away from the influence of individual pollution sources; 25 m from major roads for example.
- Industrial sites are situated to assess air pollution from specific industrial locations.

A.1.1 Kerbside Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Barnet 1	**Dec 98**		●			**T**		**Yes**	**
Bromley 4	**Feb 96**	**Closed Jul 98**							
Camden 1	**Apr 96**		●			**T**		**Yes**	** A1
Marylebone Road	**Jun 97**	●	●	●	●	**T Gx2**	**T**	**Yes**	** A1
Redbridge 2	**Dec 99**	●	●					**Yes**	*
Redbridge 3	**Dec 99**		●			**B**		**Yes**	*
Richmond 5	**Feb 01**	**Closed Aug 01**							
Sutton 4	**Jul 02**		●			**T**		**Yes**	**

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, * Locality Standard, ** Traceability to National Standards
A= Affiliated to UK AURN- final data set published by DEFRA

A.1.2 Roadside Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Brent 2	Jun 01	Closed Sep 02							
Brent 3	Dec 01		●	●		T		Yes	**
Brent 4	Jun 03		●	●		T		Yes	**
Bromley 7	July 98	●	●			B		Yes	*/** A
Camden 3	Apr 00		●			T		Yes	**
Croydon 2	Sept 94		●					Yes	**
Croydon 4	Sept 99		●	●		T		Yes	**
Croydon 5	Oct 00		●					Yes	**
Crystal Palace	Oct 99	●	●	●		T		Yes	**
Ealing 2	Sept 96	●	●			T	T	Yes	**
Ealing 4	Dec 98	Closed Mar 99							
Ealing 5	Mar 99	Closed Jun 01							
Ealing 6	Aug 03		●					Yes	**
Enfield 2	Jan 98	●	●			B		Yes	**
Enfield 4	Mar 00		●	●		B		Yes	**
Greenwich 5	Sept 97		●			T		Yes	**
Greenwich 7	Mar 02		●			T		Yes	**
Greenwich Bexley 6	Oct 00		●			T	T	Yes	**
Hams & Fulham 1	Aug 99		●	●		T		Yes	**
Hackney 6	Nov 02		●			T		Yes	**
Haringey 1	Dec 94		●	●		T		Yes	** A
Haringey 3	Apr 99	Closed Mar 01							
Harrow 2	Jun 03		●			T		Yes	**
Havering 1	Dec 95		●					Yes	**
Havering 3	Dec 98		●	●		T		Yes	**
Hillingdon 1	Sept 99		●			T		Yes	**
Hillingdon 2	Sept 02		●			T		Yes	**
Hounslow 1	Apr 93	Closed Dec 02							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A= Affiliated to UK AURN- final data set published by DEFRA

A.1.2 Roadside Sites (continued)

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Hounslow 3	Mar 99	Closed Nov 02							
Hounslow 4	Aug 99		●	●		T		Yes	**
Hounslow 5	Aug 03	●	●			T		Yes	**
Islington 2	Jul 00	●	●			T		Yes	**
Ken & Chelsea 2	May 98					T		Yes	**
Ken & Chelsea 3	Mar 00		●					Yes	**
Ken & Chelsea 4	Sep 00		●					Yes	**
Ken & Chelsea 5	May 02					G		Yes	*
Kingston 2	Apr 96		●			T		No	
Lambeth 1	Sep 00		●	●		B		Yes	*
Lambeth 2	Dec 01		●	●		B		Yes	*
Lambeth 4	Dec 03		●	●		B		Yes	*
Redbridge 4	Dec 99	●	●	●		B		Yes	*
Redbridge 5	Nov 03	●	●			B		Yes	*
Richmond 1	Jun 00		●			T		Yes	**
Southwark 2	Oct 94	●	●	●		T		Yes	*/** A
Sutton 1	May 95	Closed May 02							
Thurrock 2	May 03		●					Yes	**
Thurrock 3	Aug 03		●	●		T		Yes	**
Tower Hamlets 2	Mar 94	●	●					Yes	** A
Wandsworth 1	Sept 94	Closed Mar 96							
Wandsworth 4	Feb 98	●	●			T		Yes	**
Waltham Forest 3	Jul 03		●	●		T		Yes	**
Westminster 2	Jun 95	Last data 95							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A= Affiliated to UK AURN- final data set published by DEFRA

A.1.3 Urban Background Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Barnet 2	Aug 00		●			T		Yes	**
Barnet 3	Aug 00	Closed Mar 02							
Brent 1	Aug 95	●	●	●	●	T		Yes	* A
Bromley 1	Jan 93	Closed Feb 96							
Castle Point	May 96		●	●				Yes	**
City of London 1	Oct 01		●	●	●			Yes	*
Croydon 3	May 97				●	T		Yes	**
Ealing 1	Mar 95	(●)	●	●	●			Yes	**
Enfield 3	Nov 98	●	●	●	●	B		Yes	**
Greenwich 4	Sept 93		●	●	●	T		Yes	** A
Hackney 4	Oct 93	●	●		●		T	Yes	*/** A
Hams & Fulham 2	Aug 03		●			T		Yes	**
Heathrow Airport	Mar 99	●	●			T		Yes	*
Hillingdon (O)	Oct 94	Last Data Apr 95							
Ken & Chelsea 1	Mar 95	●	●	●	●	TG	G	Yes	** A
Islington 1	Sep 94	(●)	●			T		Yes	**
Lambeth 3	Dec 01		●	●		B		Yes	*
Lewisham 1	Jan 95		●	●	●			Yes	** A
Mole Valley 3	Oct 01		●			T		Yes	**
Redbridge 1	Dec 99		●		●	B		Yes	*
Sevenoaks 2	Feb 98	●	●	●	●	T		Yes	**
Southwark 1	Mar 93	●	●	●	●	T		Yes	*/** A
Thurrock 1	Feb 95	●	●	●	●	TG		Yes	* A
Tower Hamlets 1	Jan 94		●	●	●	T		Yes	**
Tower Hamlets 3	Oct 99		●	●		T		Yes	**
Waltham Forest 1	Jul 98		●	●		T		Yes	**
Wandsworth 2	Oct 94	●	●	●	●			Yes	** A
Westminster 1	Jan 93	Last Data 96							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, * Locality Standard, ** Traceability to National Standards
A = final data set published by DEFRA

A.1.4 Suburban Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Bark & Dag 1	**Sep 93**		●	●				**Yes**	**
Bark & Dag 2	**Oct 99**					**T**		**Yes**	**
Bexley 1	**Jan 93**	●	●	●	●	**T**		**Yes**	*A
Bexley 2	**Jan 98**		●			**T**	**T**	**Yes**	**
Bexley 3	**Jan 98**					**T**	**T**	**Yes**	**
Bexley 5	**Nov 99**	●	●	●				**Yes**	**
Brentwood 1	**Aug 95**		●					**Yes**	**
Bromley 5	**Mar 96**				●			**Yes**	**
Croydon 6	**Jan 01**		●					**Yes**	**
Enfield 1	**Jul 95**		●					**Yes**	**
Haringey 2	**Apr 96**		●		●	**B**		**Yes**	**A
Havering 2	**Apr 98**	**Closed Nov 00**							
Harrow 1	**Apr 99**		●	●		**T**		**Yes**	**
Hounslow 2	**Apr 99**		●	●	●	**T**		**Yes**	**
Kingston 1	**Mar 96**				●			**Yes**	**
Mole Valley 2	**Apr 97**		●			**T**		**Yes**	**
Reigate & Bans 1	**Jul 00**		●			**T**		**Yes**	**
Reigate & Bans 2	**Aug 03**		●					**Yes**	**
Richmond 2	**Apr 01**		●		●	**T**		**Yes**	**
Sutton 2	**May 95**	**Closed May 02**							
Sutton 3	**May 95**	**Closed May 02**							
Wandsworth 3	**Oct 94**	**Closed Nov 00**							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A= Affiliated to UK AURN- final data set published by DEFRA.

A.1.5 Rural Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Mole Valley 1	**Mar 96**	**Closed Mar 99**							
S'oaks Scudders H	**Sept 95**	**Closed Sept 97**							

A.1.6 Industrial Site

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Bexley 4	**May 99**					**T**		**Yes**	**

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards A= Affiliated to UK AURN- final data set published by DEFRA.

Deployments of the Richmond mobile site (Richmond 3+) are not individually listed.

APPENDIX 2: DEFRA DIRECTLY FUNDED SITES

A.2.0 Roadside Sites

	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$
A3	●	●			T	
Cromwell Rd	●	●	●		#	

A.2.1 Background Sites

	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$
Bloomsbury	●	●	●	●	T	T
Hillingdon	●	●	●	●	T	
Teddington		●	●	●		
Westminster	●	●	●	●	G	
West London	●	●				

 # Reported as LAQN site Kensington & Chelsea 2.
T = TEOM. G = Gravimetric.

APPENDIX 3: MONITORING RESULTS

Monitoring results have been compared to the AQS Objectives and the UK Air Quality Information System descriptors. Many AQS Objectives require data representative of the whole year. If insufficient data are available, then comparison with the Objective is not possible. This, for example, may be the case for sites installed during the year or those that experienced serious and prolonged instrument failure. A data capture Objective of 90% is recommended in LAQM.TG(02) (DEFRA 2002) in line with EU Directive requirements. The UK Air Quality Information System for PM_{10} only applies to TEOM measurements.

A.3.1 Carbon Monoxide

Carbon Monoxide	Type	Capture Rate (%)	Days Moderate and Above
A3	R	97	0
Bexley 1	U	94	0
Bexley 5	S	28	0
Bloomsbury	U	93	0
Brent 1	U	97	0
Bromley 7	R	76	0
Crystal Palace 1	R	96	0
Ealing 2	R	96	0
Enfield 2	R	86	0
Enfield 3	U	95	0
Hackney 4	U	95	0
Heathrow Airport	U	93	0
Hillingdon	S	95	0
Hounslow 5	R	34	0
Islington 2	R	97	0
Kens and Chelsea 1	U	92	0
Kens and Chelsea 2	R	88	0
Marylebone Rd	K	98	0
Redbridge 2	K	31	0
Redbridge 4	R	93	0
Redbridge 5	R	10	0
Richmond 11	K	15	0
Richmond 13	R	22	0

Carbon Monoxide	Type	Capture Rate (%)	Days Moderate and Above
Richmond 15	R	51	0
Sevenoaks 2	U	96	0
Southwark 1	U	97	0
Southwark 2	R	38	0
Thurrock 1	U	98	0
Tower Hamlets 2	R	98	0
Wandsworth 2	U	90	0
Wandsworth 4	R	96	0
West London	U	95	0
Westminster	U	97	0

Carbon Monoxide	Type	No occurrences of rolling 8hr mean >=10mgm $^{-3}$ (8.6ppb)	Achieved
A3	R	0	YES
Bexley 1	U	0	YES
Bexley 5	S	0	NA
Bloomsbury	U	0	YES
Brent 1	U	0	YES
Bromley 7	R	0	NA
Crystal Palace 1	R	0	YES
Ealing 2	R	0	YES
Enfield 2	R	0	NA
Enfield 3	U	0	YES
Hackney 4	U	0	YES
Heathrow Airport	U	0	YES
Hillingdon	S	0	YES
Hounslow 5	R	0	NA
Islington 2	R	0	YES
Kens and Chelsea 1	U	0	YES
Kens and Chelsea 2	R	0	NA
Marylebone Rd	K	0	YES
Redbridge 2	K	0	NA
Redbridge 4	R	0	YES
Redbridge 5	R	0	NA

Carbon Monoxide	Type	No occurrences of rolling 8hr mean >=10mgm $^{-3}$ (8.6ppb)	Achieved
Richmond 11	K	0	NA
Richmond 13	R	0	NA
Richmond 15	R	0	NA
Sevenoaks 2	U	0	YES
Southwark 1	U	0	YES
Southwark 2	R	0	NA
Thurrock 1	U	0	YES
Tower Hamlets 2	R	0	YES
Wandsworth 2	U	0	YES
Wandsworth 4	R	0	YES
West London	U	0	YES
Westminster	U	0	YES

A.3.2 Nitrogen Oxides

Nitrogen Oxides	Type	Capture Rate (%)
A3	R	80
Barking & Dagenham 1	S	98
Barnet 1	K	85
Barnet 2	U	84
Bexley 1	U	88
Bexley 2	S	97
Bexley 5	S	96
Bloomsbury	U	67
Brent 1	U	95
Brent 3	R	77
Brent 4	R	34
Brentwood 1	U	96
Bromley 7	R	97
Camden 1	K	43
Camden 3	R	97
Castle Point 1	U	98
City of London 1	U	89
Croydon 2	R	95
Croydon 4	R	84
Croydon 5	K	98
Croydon 6	S	99
Crystal Palace 1	R	97
Ealing 1	U	87
Ealing 2	R	94
Ealing 6	R	5
Enfield 1	S	99
Enfield 2	R	90
Enfield 3	U	95
Enfield 4	R	99
Greenwich 4	U	97
Greenwich 5	R	99
Greenwich 7	R	90

Nitrogen Oxides	Type	Capture Rate (%)
Greenwich Bexley 6	R	93
Hackney 4	U	91
Hackney 6	R	83
Haringey 1	R	88
Haringey 2	S	86
Harrow 1	U	91
Harrow 2	R	48
Havering 1	R	95
Havering 3	R	84
Heathrow Airport	U	95
Hillingdon	S	82
Hillingdon 1	R	99
Hillingdon 2	R	45
Hounslow 2	S	94
Hounslow 4	R	88
Hounslow 5	R	41
H'smith and Fulham 1	R	84
H'smith and Fulham 2	U	16
Islington 1	U	98
Islington 2	R	100
Kens and Chelsea 1	U	94
Kens and Chelsea 2	R	93
Kens and Chelsea 3	R	98
Kens and Chelsea 4	R	98
Lambeth 1	R	95
Lambeth 2	R	48
Lambeth 3	U	99
Lambeth 4	K	3
Lewisham 1	U	99
Lewisham 2	R	100
Marylebone Rd	K	94
Mole Valley 2	S	97
Mole Valley 3	U	98

Nitrogen Oxides	Type	Capture Rate (%)
Redbridge 1	U	99
Redbridge 2	K	31
Redbridge 3	K	87
Redbridge 4	R	83
Redbridge 5	R	10
Reigate and Banstead 1	S	99
Reigate and Banstead 2	S	18
Richmond 1	R	96
Richmond 11	K	12
Richmond 13	R	14
Richmond 15	R	49
Richmond 2	S	99
Sevenoaks 2	U	96
Southwark 1	U	73
Southwark 2	R	91
Sutton 4	K	96
Teddington	U	95
Thurrock 1	U	93
Thurrock 2	R	56
Thurrock 3	R	35
Tower Hamlets 1	U	99
Tower Hamlets 2	R	97
Tower Hamlets 3	U	94
Waltham Forest 1	U	84
Waltham Forest 3	R	41
Wandsworth 2	U	91
Wandsworth 4	R	94
West London	U	96
Westminster	U	69

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 µgm^{-3}
A3	R	97	185
Barking & Dagenham 1	S	28	54
Barnet 1	K	98	188
Barnet 2	U	37	71
Bexley 1	U	35	67
Bexley 2	S	33	63
Bexley 5	S	27	52
Bloomsbury	U	53	100
Brent 1	U	31	60
Brent 3	R	62	119
Brent 4	R	161	308
Brentwood 1	U	28	53
Bromley 7	R	42	80
Camden 3	R	83	159
Castle Point 1	U	20	38
City of London 1	U	51	98
Croydon 2	R	75	143
Croydon 4	R	64	123
Croydon 5	K	121	232
Croydon 6	S	38	73
Crystal Palace 1	R	60	115
Ealing 1	U	43	81
Ealing 2	R	89	169
Ealing 6	R	198	378
Enfield 1	S	32	61
Enfield 2	R	49	94
Enfield 3	U	31	60
Enfield 4	R	62	118
Greenwich 4	U	31	58
Greenwich 5	R	56	106
Greenwich 7	R	76	145
Greenwich Bexley 6	R	86	164
Hackney 4	U	56	107

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 µgm^{-3}
Hackney 6	R	82	157
Haringey 1	R	61	116
Haringey 2	S	33	64
Harrow 1	U	28	53
Harrow 2	R	66	126
Havering 1	R	48	91
Havering 3	R	57	109
Heathrow Airport	U	69	133
Hillingdon	S	67	129
Hillingdon 1	R	73	139
Hillingdon 2	R	42	80
Hounslow 2	S	47	90
Hounslow 4	R	102	195
Hounslow 5	R	94	179
H'smith and Fulham 1	R	131	250
H'smith and Fulham 2	U	30	57
Islington 1	U	42	80
Islington 2	R	97	185
Kens and Chelsea 1	U	39	74
Kens and Chelsea 2	R	100	191
Kens and Chelsea 3	R	126	241
Kens and Chelsea 4	R	137	262
Lambeth 1	R	68	131
Lambeth 2	R	71	135
Lambeth 3	U	35	67
Lambeth 4	K	268	511
Lewisham 1	U	61	117
Lewisham 2	R	81	154
Marylebone Rd	K	164	313
Mole Valley 2	S	23	45
Mole Valley 3	U	26	50
Redbridge 1	U	38	72
Redbridge 2	K	175	335

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 μgm^{-3}
Redbridge 3	K	79	151
Redbridge 4	R	69	132
Redbridge 5	R	100	190
Reigate and Banstead 1	S	26	50
Reigate and Banstead 2	S	46	88
Richmond 1	R	51	97
Richmond 11	K	90	172
Richmond 13	R	63	119
Richmond 15	R	64	122
Richmond 2	S	31	58
Sevenoaks 2	U	22	43
Southwark 1	U	45	87
Southwark 2	R	83	158
Sutton 4	K	94	179
Teddington	U	23	44
Thurrock 1	U	36	68
Thurrock 2	R	105	201
Thurrock 3	R	61	116
Tower Hamlets 1	U	36	68
Tower Hamlets 2	R	95	181
Tower Hamlets 3	U	37	71
Waltham Forest 1	U	37	72
Waltham Forest 3	R	44	85
Wandsworth 2	U	63	120
Wandsworth 4	R	59	114
West London	U	48	92
Westminster	U	43	81

A.3.3 Nitrogen Dioxide

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
A3	R	80	2
Barking & Dagenham 1	S	98	0
Barnet 1	K	85	0
Barnet 2	U	84	0
Bexley 1	U	88	0
Bexley 2	S	97	0
Bexley 5	S	96	0
Bloomsbury	U	67	0
Brent 1	U	95	0
Brent 3	R	77	0
Brent 4	R	34	0
Brentwood 1	U	96	0
Bromley 7	R	97	0
Camden 1	K	43	0
Camden 3	R	97	0
Castle Point 1	U	98	0
City of London 1	U	89	0
Croydon 2	R	95	0
Croydon 4	R	84	0
Croydon 5	K	98	2
Croydon 6	S	99	0
Crystal Palace 1	R	97	0
Ealing 1	U	87	0
Ealing 2	R	94	0
Ealing 6	R	5	0
Enfield 1	S	99	0
Enfield 2	R	90	0
Enfield 3	U	95	0
Enfield 4	R	99	0
Greenwich 4	U	97	0
Greenwich 5	R	99	0
Greenwich 7	R	90	0

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
Greenwich Bexley 6	R	93	0
Hackney 4	U	91	0
Hackney 6	R	83	0
Haringey 1	R	88	0
Haringey 2	S	86	0
Harrow 1	U	91	0
Harrow 2	R	48	0
Havering 1	R	95	0
Havering 3	R	84	0
Heathrow Airport	U	95	0
Hillingdon	S	82	0
Hillingdon 1	R	99	2
Hillingdon 2	R	45	0
Hounslow 2	S	94	0
Hounslow 4	R	88	4
Hounslow 5	R	41	0
H'smith and Fulham 1	R	84	1
H'smith and Fulham 2	U	16	0
Islington 1	U	98	0
Islington 2	R	100	0
Kens and Chelsea 1	U	94	0
Kens and Chelsea 2	R	93	0
Kens and Chelsea 3	R	98	11
Kens and Chelsea 4	R	98	0
Lambeth 1	R	95	1
Lambeth 2	R	48	0
Lambeth 3	U	99	0
Lambeth 4	K	3	8
Lewisham 1	U	99	0
Lewisham 2	R	100	0
Marylebone Rd	K	94	8
Mole Valley 2	S	97	0
Mole Valley 3	U	98	0

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
Redbridge 1	U	99	0
Redbridge 2	K	31	31
Redbridge 3	K	87	0
Redbridge 4	R	83	0
Redbridge 5	R	10	0
Reigate and Banstead 1	S	99	0
Reigate and Banstead 2	S	18	0
Richmond 1	R	96	0
Richmond 11	K	12	0
Richmond 13	R	14	0
Richmond 15	R	49	0
Richmond 2	S	99	0
Sevenoaks 2	U	96	0
Southwark 1	U	73	0
Southwark 2	R	91	0
Sutton 4	K	96	0
Teddington	U	95	0
Thurrock 1	U	93	0
Thurrock 2	R	56	1
Thurrock 3	R	35	0
Tower Hamlets 1	U	99	0
Tower Hamlets 2	R	97	0
Tower Hamlets 3	U	94	0
Waltham Forest 1	U	84	0
Waltham Forest 3	R	41	0
Wandsworth 2	U	91	0
Wandsworth 4	R	94	0
West London	U	96	0
Westminster	U	69	0

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40µgm $^{-3}$	Achieved
A3	R	38	73	NA
Barking & Dagenham 1	S	16	32	YES
Barnet 1	K	39	74	NA
Barnet 2	U	20	38	NA
Bexley 1	U	20	37	NA
Bexley 2	S	19	37	YES
Bexley 5	S	18	35	YES
Bloomsbury	U	29	56	NA
Brent 1	U	18	34	YES
Brent 3	R	27	52	NA
Brent 4	R	31	59	NA
Brentwood 1	U	19	36	YES
Bromley 7	R	22	42	NO
Camden 1	K	34	65	NA
Camden 3	R	36	70	NO
Castle Point 1	U	14	26	YES
City of London 1	U	30	58	NA
Croydon 2	R	29	55	NO
Croydon 4	R	29	56	NA
Croydon 5	K	39	74	NO
Croydon 6	S	20	38	YES
Crystal Palace 1	R	26	49	NO
Ealing 1	U	22	43	NA
Ealing 2	R	32	62	NO
Ealing 6	R	48	91	NA
Enfield 1	S	18	35	YES
Enfield 2	R	24	45	NO
Enfield 3	U	17	33	YES
Enfield 4	R	27	52	NO
Greenwich 4	U	20	37	YES
Greenwich 5	R	26	50	NO
Greenwich 7	R	31	58	NO
Greenwich Bexley 6	R	29	55	NO

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40µgm^{-3}	Achieved
Hackney 4	U	26	50	NO
Hackney 6	R	34	64	NA
Haringey 1	R	27	52	NA
Haringey 2	S	19	37	NA
Harrow 1	U	16	30	YES
Harrow 2	R	23	45	NA
Havering 1	R	23	44	NO
Havering 3	R	22	43	NA
Heathrow Airport	U	31	58	NO
Hillingdon	S	28	53	NA
Hillingdon 1	R	26	50	NO
Hillingdon 2	R	21	40	NA
Hounslow 2	S	27	52	NO
Hounslow 4	R	43	82	NA
Hounslow 5	R	27	52	NA
H'smith and Fulham 1	R	48	92	NA
H'smith and Fulham 2	U	20	38	NA
Islington 1	U	25	48	NO
Islington 2	R	36	69	NO
Kens and Chelsea 1	U	23	44	NO
Kens and Chelsea 2	R	39	75	NO
Kens and Chelsea 3	R	49	93	NO
Kens and Chelsea 4	R	51	98	NO
Lambeth 1	R	31	59	NO
Lambeth 2	R	34	65	NA
Lambeth 3	U	22	42	NO
Lambeth 4	K	88	167	NA
Lewisham 1	U	29	55	NO
Lewisham 2	R	35	67	NO
Marylebone Rd	K	56	107	NO
Mole Valley 2	S	14	27	YES
Mole Valley 3	U	15	29	YES
Redbridge 1	U	21	41	NO

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40µgm^{-3}	Achieved
Redbridge 2	K	71	136	NA
Redbridge 3	K	33	63	NA
Redbridge 4	R	29	55	NA
Redbridge 5	R	29	56	NA
Reigate and Banstead 1	S	16	31	YES
Reigate and Banstead 2	S	20	37	NA
Richmond 1	R	25	48	NO
Richmond 11	K	29	56	NA
Richmond 13	R	27	52	NA
Richmond 15	R	26	50	NA
Richmond 2	S	19	37	YES
Sevenoaks 2	U	13	25	YES
Southwark 1	U	25	48	NA
Southwark 2	R	35	67	NO
Sutton 4	K	37	70	NO
Teddington	U	15	28	YES
Thurrock 1	U	20	38	YES
Thurrock 2	R	39	74	NA
Thurrock 3	R	22	42	NA
Tower Hamlets 1	U	22	42	NO
Tower Hamlets 2	R	35	66	NO
Tower Hamlets 3	U	23	44	NO
Waltham Forest 1	U	21	40	NA
Waltham Forest 3	R	20	38	NA
Wandsworth 2	U	33	62	NO
Wandsworth 4	R	27	52	NO
West London	U	29	55	NO
Westminster	U	26	50	NA

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm^{-3} (104.6ppb)	Achieved
A3	R	16	NA
Barking & Dagenham 1	S	0	YES
Barnet 1	K	23	NO
Barnet 2	U	0	NA
Bexley 1	U	0	NA
Bexley 2	S	0	YES
Bexley 5	S	0	YES
Bloomsbury	U	0	NA
Brent 1	U	3	YES
Brent 3	R	6	NA
Brent 4	R	0	NA
Brentwood 1	U	0	YES
Bromley 7	R	0	YES
Camden 1	K	2	NA
Camden 3	R	3	YES
Castle Point 1	U	0	YES
City of London 1	U	0	NA
Croydon 2	R	5	YES
Croydon 4	R	0	NA
Croydon 5	K	17	YES
Croydon 6	S	0	YES
Crystal Palace 1	R	2	YES
Ealing 1	U	0	NA
Ealing 2	R	3	YES
Ealing 6	R	6	NA
Enfield 1	S	0	YES
Enfield 2	R	0	YES
Enfield 3	U	0	YES
Enfield 4	R	3	YES
Greenwich 4	U	0	YES
Greenwich 5	R	0	YES

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm $^{-3}$ (104.6ppb)	Achieved
Greenwich 7	R	0	YES
Greenwich Be xley 6	R	2	YES
Hackney 4	U	5	YES
Hackney 6	R	0	NA
Haringey 1	R	0	NA
Haringey 2	S	0	NA
Harrow 1	U	0	YES
Harrow 2	R	6	NA
Havering 1	R	1	YES
Havering 3	R	0	NA
Heathrow Airport	U	0	YES
Hillingdon	S	0	NA
Hillingdon 1	R	18	YES
Hillingdon 2	R	7	NA
Hounslow 2	S	1	YES
Hounslow 4	R	85	NO
Hounslow 5	R	0	NA
H'smith and Fulham 1	R	110	NO
H'smith and Fulham 2	U	0	NA
Islington 1	U	0	YES
Islington 2	R	5	YES
Kens and Chelsea 1	U	0	YES
Kens and Chelsea 2	R	6	YES
Kens and Chelsea 3	R	239	NO
Kens and Che lsea 4	R	50	NO
Lambeth 1	R	1	YES
Lambeth 2	R	0	NA
Lambeth 3	U	0	YES
Lambeth 4	K	92	NO
Lewisham 1	U	1	YES
Lewisham 2	R	10	YES
Marylebone Rd	K	464	NO

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm^{-3} (104.6ppb)	Achieved
Mole Valley 2	S	0	YES
Mole Valley 3	U	0	YES
Redbridge 1	U	1	YES
Redbridge 2	K	465	NO
Redbridge 3	K	15	NA
Redbridge 4	R	1	NA
Redbridge 5	R	0	NA
Reigate and Banstead 1	S	0	YES
Reigate and Banstead 2	S	0	NA
Richmond 1	R	0	YES
Richmond 11	K	0	NA
Richmond 13	R	0	NA
Richmond 15	R	2	NA
Richmond 2	S	0	YES
Sevenoaks 2	U	0	YES
Southwark 1	U	0	NA
Southwark 2	R	1	YES
Sutton 4	K	39	NO
Teddington	U	0	YES
Thurrock 1	U	1	YES
Thurrock 2	R	4	NA
Thurrock 3	R	0	NA
Tower Hamlets 1	U	0	YES
Tower Hamlets 2	R	6	YES
Tower Hamlets 3	U	0	YES
Waltham Forest 1	U	7	NA
Waltham Forest 3	R	0	NA
Wandsworth 2	U	8	YES
Wandsworth 4	R	0	YES
West London	U	0	YES
Westminster	U	0	NA

A.3.4 Ozone

Ozone	Type	Capture Rate (%)	Days moderate and above
Bexley 1	U	97	56
Bloomsbury	U	82	25
Brent 1	U	90	53
Bromley 5	S	90	56
City of London 1	U	86	37
Croydon 3	S	88	43
Ealing 1	U	99	39
Enfield 3	U	85	55
Greenwich 4	U	92	47
Hackney 4	U	96	39
Haringey 2	S	93	46
Hillingdon	S	98	33
Hounslow 2	S	76	63
Kens and Chelsea 1	U	99	45
Kingston 1	S	99	64
Lewisham 1	U	98	27
Marylebone Rd	K	96	6
Redbridge 1	U	99	39
Richmond 11	K	15	0
Richmond 13	R	22	4
Richmond 15	R	56	21
Richmond 2	S	99	64
Sevenoaks 2	U	98	79
Southwark 1	U	98	46
Teddington	U	99	73
Thurrock 1	U	97	55
Tower Hamlets 1	U	98	62
Wandsworth 2	U	90	25
Westminster	U	95	32

Ozone	Type	No more than 10 days where maximum rolling 8hr mean >=100µgm $^{-3}$ (50ppb)	Achieved
Bexley 1	U	33	NO
Bloomsbury	U	16	NO
Brent 1	U	39	NO
Bromley 5	S	42	NO
City of London 1	U	25	NO
Croydon 3	S	32	NO
Ealing 1	U	23	NO
Enfield 3	U	40	NO
Greenwich 4	U	31	NO
Hackney 4	U	22	NO
Haringey 2	S	36	NO
Hillingdon	S	19	NO
Hounslow 2	S	43	NO
Kens and Chelsea 1	U	29	NO
Kingston 1	S	50	NO
Lewisham 1	U	17	NO
Marylebone Rd	K	3	YES
Redbridge 1	U	29	NO
Richmond 11	K	0	NA
Richmond 13	R	1	NA
Richmond 15	R	13	NO
Richmond 2	S	49	NO
Sevenoaks 2	U	59	NO
Southwark 1	U	35	NO
Teddington	U	49	NO
Thurrock 1	U	40	NO
Tower Hamlets 1	U	42	NO
Wandsworth 2	U	12	NO
Westminster	U	19	NO

A.3.5 PM_{10}

PM_{10}	Type	Instrument	Capture Rate (%)	Days moderate and above
A3	R	T	96	29
Barking & Dage nham 2	S	T	97	28
Barnet 1	K	T	94	21
Barnet 2	U	T	98	9
Bexley 1	U	T	96	23
Bexley 2	S	T	96	23
Bexley 3	S	T	13	0
Bexley 4	I	T	98	136
Bloomsbury	U	T	58	8
Brent 1	U	T	95	11
Brent 3	R	T	78	23
Brent 4	R	T	40	25
Bromley 7	R	B	52	NA
Camden 1	K	T	99	22
Camden 3	R	T	97	40
Croydon 3	S	T	91	9
Croydon 4	R	T	86	15
Crystal Palace 1	R	T	95	2
Ealing 2	R	T	99	36
Enfield 2	R	B	90	NA
Enfield 3	U	B	90	NA
Enfield 4	R	B	94	NA
Greenwich 4	U	T	99	22
Greenwich 5	R	T	98	23
Greenwich 7	R	T	92	30
Greenwich Bexley 6	R	T	94	36
Hackney 6	R	T	78	28
Haringey 1	R	T	98	18
Haringey 2	S	B	94	NA
Harrow 1	U	T	93	8
Harrow 2	R	T	52	10
Havering 3	R	T	85	9

PM_{10}	Type	Instrument	Capture Rate (%)	Days moderate and above
Heathrow Airport	U	T	96	25
Hillingdon	S	T	89	18
Hillingdon 1	R	T	93	25
Hillingdon 2	R	T	60	12
Hounslow 2	S	T	96	10
Hounslow 4	R	T	75	26
Hounslow 5	R	T	55	15
H'smith and Fulham 1	R	T	85	31
H'smith and Fulham 2	U	T	<1	0
Islington 1	U	T	97	12
Islington 2	R	T	85	36
Kens and Chelsea 1	U	T	98	19
Kens and Chelsea 1	U	G	88	NA
Kens and Chelsea 2	R	T	88	30
Kens and Chelsea 5	R	G	97	NA
Lambeth 1	R	B	93	NA
Lambeth 2	R	B	44	NA
Lambeth 3	U	B	97	NA
Lambeth 4	K	B	2	NA
Lewisham 2	R	T	82	33
Marylebone Rd	K	T	99	93
Marylebone Rd	K	G (Partisol)	86	NA
Marylebone Rd	K	G (KFG)	60	NA
Mole Valley 2	S	T	99	8
Mole Valley 3	U	T	87	12
Redbridge 1	U	B	93	NA
Redbridge 3	K	B	70	NA
Redbridge 4	R	B	95	NA
Redbridge 5	R	B	11	14
Reigate and Banstead 1	S	T	98	9
Richmond 1	R	T	96	16
Richmond 11	K	T	15	5
Richmond 13	R	T	22	11

PM_{10}	Type	Instrument	Capture Rate (%)	Days moderate and above
Richmond 15	R	T	44	12
Richmond 2	S	T	98	20
Sevenoaks 2	U	T	99	6
Southwark 1	U	T	99	20
Southwark 2	R	T	66	40
Sutton 4	K	T	99	24
Thurrock 1	U	T	98	30
Thurrock 1	U	G	64	NA
Thurrock 3	R	T	32	0
Tower Hamlets 1	U	T	96	29
Tower Hamlets 3	U	T	93	14
Waltham Forest 1	U	T	69	4
Waltham Forest 3	R	T	43	7
Wandsworth 4	R	T	95	30

Instrument type; T = TEOM, B = BAM, G = 'Gravimetric'.

PM_{10}	Type	Instrument	No more than 35 days where daily mean >=50µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
A3	R	T	43	NO
Barking & Dagenham 2	S	T	44	NO
Barnet 1	K	T	45	NO
Barnet 2	U	T	25	YES
Bexley 1	U	T	33	YES
Bexley 2	S	T	28	YES
Bexley 3	S	T	0	NA
Bexley 4	I	T	131	NO
Bloomsbury	U	T	14	NA
Brent 1	U	T	25	YES
Brent 3	R	T	37	NO
Brent 4	R	T	41	NO
Bromley 7	R	B	15	NA
Camden 1	K	T	48	NO
Camden 3	R	T	69	NO
Croydon 3	S	T	14	YES
Croydon 4	R	T	32	NA
Crystal Palace 1	R	T	17	YES
Ealing 2	R	T	61	NO
Enfield 2	R	B	81	NO
Enfield 3	U	B	39	NO
Enfield 4	R	B	131	NO
Greenwich 4	U	T	26	YES
Greenwich 5	R	T	33	YES
Greenwich 7	R	T	55	NO
Greenwich Bexley 6	R	T	47	NO
Hackney 6	R	T	40	NO
Haringey 1	R	T	34	YES
Haringey 2	S	B	57	NO
Harrow 1	U	T	16	YES
Harrow 2	R	T	20	NA
Havering 3	R	T	26	NA

PM_{10}	Type	Instrument	No more than 35 days where daily mean >=50µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Heathrow Airport	U	T	39	NO
Hillingdon	S	T	32	NA
Hillingdon 1	R	T	41	NO
Hillingdon 2	R	T	18	NA
Hounslow 2	S	T	22	YES
Hounslow 4	R	T	49	NO
Hounslow 5	R	T	28	NA
H'smith and Fulham 1	R	T	54	NO
H'smith and Fulham 2	U	T	0	NA
Islington 1	U	T	29	YES
Islington 2	R	T	58	NO
Kens and Chelsea 1	U	T	29	YES
Kens and Chelsea 1	U	G	32	NA
Kens and Chelsea 2	R	T	56	NO
Lambeth 1	R	B	115	NO
Lambeth 2	R	B	45	NO
Lambeth 3	U	B	69	NO
Lambeth 4	K	B	4	NA
Lewisham 2	R	T	47	NO
Marylebone Rd	K	T	161	NO
Marylebone Rd	K	G (Partisol)	86	NO
Marylebone Rd	K	G (KFG)	60	NO
Mole Valley 2	S	T	15	YES
Mole Valley 3	U	T	21	NA
Redbridge 1	U	B	61	NO
Redbridge 3	K	B	80	NO
Redbridge 4	R	B	85	NO
Redbridge 5	R	B	9	NA
Reigate and Banstead 1	S	T	16	YES
Richmond 1	R	T	29	YES
Richmond 11	K	T	7	NA
Richmond 13	R	T	19	NA
Richmond 15	R	T	23	NA

PM_{10}	Type	Instrument	No more than 35 days where daily mean >=50µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Richmond 2	S	T	34	YES
Sevenoaks 2	U	T	14	YES
Southwark 1	U	T	32	YES
Southwark 2	R	T	52	NO
Sutton 4	K	T	37	NO
Thurrock 1	U	T	40	NO
Thurrock 1	U	G	49	NO
Thurrock 3	R	T	7	NA
Tower Hamlets 1	U	T	43	NO
Tower Hamlets 3	U	T	27	YES
Waltham Forest 1	U	T	16	NA
Waltham Forest 3	R	T	10	NA
Wandsworth 4	R	T	46	NO

Instrument type; T = TEOM, B = BAM, G = 'Gravimetric'.

PM_{10}	Type	Instrument	Annual Mean less than $40\mu gm^{-3}$ (TEOM *1.3, BAM *1)	Achieved
A3	R	T	33	YES
Barking & Dagenham 2	S	T	32	YES
Barnet 1	K	T	33	YES
Barnet 2	U	T	26	YES
Bexley 1	U	T	27	YES
Bexley 2	S	T	27	YES
Bexley 3	S	T	21	NA
Bexley 4	I	T	46	NO
Bloomsbury	U	T	30	NA
Brent 1	U	T	26	YES
Brent 3	R	T	34	NA
Brent 4	R	T	41	NA
Bromley 7	R	B	28	NA
Camden 1	K	T	35	YES
Camden 3	R	T	39	YES
Croydon 3	S	T	26	YES
Croydon 4	R	T	32	NA
Crystal Palace 1	R	T	27	YES
Ealing 2	R	T	34	YES
Enfield 2	R	B	41	NO
Enfield 3	U	B	29	YES
Enfield 4	R	B	51	NO
Greenwich 4	U	T	27	YES
Greenwich 5	R	T	29	YES
Greenwich 7	R	T	35	YES
Greenwich Bexley 6	R	T	32	YES
Hackney 6	R	T	36	NA
Haringey 1	R	T	29	YES
Haringey 2	S	B	35	YES
Harrow 1	U	T	24	YES
Harrow 2	R	T	31	NA
Havering 3	R	T	27	NA

PM_{10}	Type	Instrument	Annual Mean less than 40µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Heathrow Airport	U	T	31	YES
Hillingdon	S	T	30	NA
Hillingdon 1	R	T	31	YES
Hillingdon 2	R	T	31	NA
Hounslow 2	S	T	27	YES
Hounslow 4	R	T	36	NA
Hounslow 5	R	T	36	NA
H'smith and Fulham 1	R	T	37	NA
H'smith and Fulham 2	U	T	35	NA
Islington 1	U	T	28	YES
Islington 2	R	T	38	NA
Kens and Chelsea 1	U	T	28	YES
Kens and Chelsea 1	U	G	28	NA
Kens and Chelsea 2	R	T	39	NA
Lambeth 1	R	B	46	NO
Lambeth 2	R	B	46	NA
Lambeth 3	U	B	37	YES
Lambeth 4	K	B	80	NA
Lewisham 2	R	T	37	NA
Marylebone Rd	K	T	48	NO
Marylebone Rd	K	G (Partisol)	45	NA
Marylebone Rd	K	G (KFG)	39	NA
Mole Valley 2	S	T	24	YES
Mole Valley 3	U	T	27	NA
Redbridge 1	U	B	35	YES
Redbridge 3	K	B	44	NA
Redbridge 4	R	B	41	NO
Redbridge 5	R	B	40	NA
Reigate and Banstead 1	S	T	26	YES
Richmond 1	R	T	28	YES
Richmond 11	K	T	34	NA
Richmond 13	R	T	36	NA
Richmond 15	R	T	35	NA

PM_{10}	Type	Instrument	Annual Mean less than 40µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Richmond 2	S	T	28	YES
Sevenoaks 2	U	T	23	YES
Southwark 1	U	T	30	YES
Southwark 2	R	T	39	NA
Sutton 4	K	T	34	YES
Thurrock 1	U	T	30	YES
Thurrock 1	U	G	35	NA
Thurrock 3	R	T	28	NA
Tower Hamlets 1	U	T	31	YES
Tower Hamlets 3	U	T	29	YES
Waltham Forest 1	U	T	25	NA
Waltham Forest 3	R	T	27	NA
Wandsworth 4	R	T	32	YES

Instrument type; T = TEOM, B = BAM, G = 'Gravimetric'.

A.3.6 $PM_{2.5}$

$PM_{2.5}$	Type	Instrument	Capture Rate (%)	Annual Mean µgm $^{-3}$
Bexley 2	S	T	98	14
Bexley 3	S	T	99	13
Ealing 2	R	T	28	13
Greenwich Bexley 6	R	T	98	17
Hackney 4	U	T	52	16
Marylebone Rd	K	T	93	18

Instrument type; T = TEOM.

A.3.7 Sulphur Dioxide

Sulphur Dioxide	Type	Capture Rate (%)	Days moderate and above
Barking & Dagenham 1	S	98	0
Bexley 1	U	91	1
Bexley 5	S	96	0
Bloomsbury	U	94	0
Brent 1	U	96	0
Brent 3	R	77	0
Brent 4	R	32	0
Castle Point 1	U	98	0
City of London 1	U	71	0
Croydon 4	R	94	0
Crystal Palace 1	R	77	0
Ealing 1	U	92	0
Enfield 3	U	90	2
Enfield 4	R	96	0
Greenwich 4	U	98	0
Haringey 1	R	91	0
Harrow 1	U	91	0
Havering 3	R	84	0
Hillingdon	S	98	0
Hounslow 2	S	95	1
Hounslow 4	R	88	0
H'smith and Fulham 1	R	81	0
Kens and Chelsea 1	U	99	0
Kens and Chelsea 2	R	88	0
Lambeth 1	R	94	0
Lambeth 2	R	48	0
Lambeth 3	U	99	0
Lambeth 4	K	3	0
Lewisham 1	U	99	1
Lewisham 2	R	96	1
Marylebone Rd	K	96	0
Redbridge 4	R	94	0

Sulphur Dioxide	Type	Capture Rate (%)	Days moderate and above
Richmond 11	K	15	0
Richmond 13	R	20	0
Richmond 15	R	46	0
Sevenoaks 2	U	98	0
Southwark 1	U	98	0
Southwark 2	R	90	0
Teddington	U	99	0
Thurrock 1	U	91	5
Thurrock 3	R	35	0
Tower Hamlets 1	U	99	0
Tower Hamlets 3	U	85	0
Waltham Forest 1	U	70	0
Waltham Forest 3	R	29	0
Wandsworth 2	U	92	0
Westminster	U	69	0

Sulphur Dioxide	Type	No more than 35 occurrences of 15min mean >=266µgm $^{-3}$ (100ppb)	Achieved
Barking & Dagenham 1	S	0	YES
Bexley 1	U	1	YES
Bexley 5	S	0	YES
Bloomsbury	U	0	YES
Brent 1	U	0	YES
Brent 3	R	0	NA
Brent 4	R	0	NA
Castle Point 1	U	0	YES
City of London 1	U	0	NA
Croydon 4	R	0	YES
Crystal Palace 1	R	0	NA
Ealing 1	U	0	YES
Enfield 3	U	2	YES
Enfield 4	R	0	YES
Greenwich 4	U	0	YES
Haringey 1	R	0	YES
Harrow 1	U	0	YES
Havering 3	R	0	NA
Hillingdon	S	0	YES
Hounslow 2	S	1	YES
Hounslow 4	R	0	NA
H'smith and Fulham 1	R	0	NA
Kens and Chelsea 1	U	0	YES
Kens and Chelsea 2	R	0	NA
Lambeth 1	R	0	YES
Lambeth 2	R	0	NA
Lambeth 3	U	0	YES
Lambeth 4	K	0	NA
Lewisham 1	U	2	YES
Lewisham 2	R	1	YES
Marylebone Rd	K	0	YES

Sulphur Dioxide	Type	No more than 35 occurrences of 15min mean >=266μgm^{-3} (100ppb)	Achieved
Redbridge 4	R	0	YES
Richmond 11	K	0	NA
Richmond 13	R	0	NA
Richmond 15	R	0	NA
Sevenoaks 2	U	0	YES
Southwark 1	U	0	YES
Southwark 2	R	0	YES
Teddington	U	0	YES
Thurrock 1	U	9	YES
Thurrock 3	R	0	NA
Tower Hamlets 1	U	0	YES
Tower Hamlets 3	U	0	NA
Waltham Forest 1	U	0	NA
Waltham Forest 3	R	0	NA
Wandsworth 2	U	0	YES
Westminster	U	0	NA

A3.8 Benzene

Benzene	Type	Capture Rate (%)	Annual Mean ppb	Annual Mean μgm^{-3}	Achieved
Haringey 1	R	Not Known	0.6	2.9	YES
Marylebone Road	K	91	0.7	3.3	YES
Tower Hamlets 2	R	78	0.7	3.3	NA

A3.9 1,3 Butadiene

Benzene	Type	Capture Rate (%)	Annual Mean ppb	Annual Mean μgm^{-3}	Achieved
Marylebone Road	K	92	0.3	0.6	YES
Tower Hamlets 2	R	88	0.2	0.4	NA

APPENDIX 4: AIR QUALITY STRATEGY OBJECTIVES & UK AIR QUALITY INFORMATION SYSTEM

The following Objectives are set out in the Air Quality Regulations 2000 for the purposes of Local Air Quality Management.

Pollutant	Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	5 μgm^{-3} (1 ppb)	Running Annual Mean	31 Dec 2010
1, 3 Butadiene	2.25 μgm^{-3} (1 ppb)	Running Annual Mean	31 Dec 2003
Carbon Monoxide	10 mgm^{-3} (8.6 ppb)	Running 8 hour mean	31 Dec 2003
Lead	0.5 μgm^{-3} 0.25 μgm^{-3}	Annual Mean Annual Mean	31 Dec 2003 31 Dec 2008
Nitrogen Dioxide (provisional)	200 μgm^{-3} (105 ppb) not to be exceeded more than 18 times a year 40 μgm^{-3} (21 ppb)	1 hour mean Annual Mean	31 Dec 2005 31 Dec 2005
Particles (PM_{10})	50 $\mu g/m^3$ not to be exceeded more than 35 times a year 40 μgm^{-3}	24 hour mean Annual Mean	31 Dec 2004 31 Dec 2004
Sulphur Dioxide	350 μgm^{-3} (132 ppb) not to be exceeded more than 24 times a year 125 μgm^{-3} (47 ppb) not to be exceeded more than 3 times a year 266 μgm^{-3} (100 ppb) not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31 Dec 2004 31 Dec 2004 31 Dec 2005

The following Objectives are not included in the Air Quality Regulations 2000 for the purposes of Local Air Quality Management.

Pollutant	Objective: Concentration	Objective: Measured as	Date to be achieved by
Objectives for the protection of human health			
Ozone (provisional)	100 μgm^{-3} (50 ppb) not to be exceeded more than 10 times per year	Daily maximum of running 8 hour mean	31 Dec 2005
Objectives for the protection of vegetation and ecosystems			
Nitrogen Oxides (assuming NO_X is taken as NO_2)	30 μgm^{-3} (16 ppb)	Annual mean	31 Dec 2000
Sulphur Dioxide	20 μgm^{-3} (8 ppb) 20 μgm^{-3} (8 ppb)	Annual Mean Winter Mean (1 Oct- 31 Mar)	31 Dec 2000 31 Dec 2000

DETR, 2000; The Air Quality Strategy for England, Scotland, Wales and Northern Ireland – A consultation Document.

DETR, 2000; Air Quality Regulations 2000.

DEFRA, 2002; Report on the Review of the National Air Quality Strategy; Proposals to Amend the Strategy.

The 'descriptors' applied to air pollution concentrations are defined by the UK Air Quality Information system.

Pollutant / Band	LOW	MODERATE	HIGH	VERY HIGH
Sulphur Dioxide	below 100ppb, averaged over 15 minutes	100ppb, averaged over 15 minutes	200ppb, averaged over 15 minutes	400ppb, averaged over 15 minutes
Ozone	below 50ppb, as an 8 hour running average and below 50ppb averaged over one hour	50ppb, as an 8 hour running average or 50ppb averaged over one hour	90 ppb, averaged over one hour	180 ppb, averaged over one hour
Carbon Monoxide	below 10 ppm, as an 8 hour running average	10 ppm, as an 8 hour running average	15 ppm, as an 8 hour running average	20 ppm, as an 8 hour running average
Nitrogen Dioxide	below 150 ppb, averaged over one hour	150 ppb, averaged over one hour	300 ppb, averaged over one hour	400 ppb, averaged over one hour
PM_{10} Particles (by TEOM)	below 50 ug/m^3, as a 24 hour running average	50 ug/m^3, as a 24 hour running average	75 ug/m^3, as a 24 hour running average	100 ug/m^3, as a 24 hour running average