KING'S College LONDON

Air quality in London

London Air Quality Network
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IMAGE: FRANCISBOOTH.COM

Main contact
London Air Quality Network
Environmental Research Group
King's College London
4th Floor
Franklin-Wilkins Building
150 Stamford Street
London SE1 9NH
020 7848 4019
erg@kcl.ac.uk

Credits
Written by Gary Fuller and Louise Meston
Cover image (bottom) by francisbooth.com
Designed by the Corporate Design Unit
King's College London
design@kcl.ac.uk

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Introduction

The measurements detailed in this report result from a team effort, undertaken by staff who are dedicated and committed to their work.

The Environmental Research Group

Director of the Environmental Research Group
Professor Frank Kelly

Air quality monitoring
Jon Alexander
Timothy Baker
Ben Barratt
Hima Chouhan
Gary Fuller*
David Green
Andrew Grieve
Paul Johnson
Daniel Marsh
Louise Meston
Ellie Norris
Karin Nilsdotter
Max Priestman
Ana Rowan
Anja Tremper

Air quality modelling
Sean Beevers*
David Dajnak
Stephen Hedley
Nutthida Kitwiroon
Hrishi Mittal
Cathryn Tonne
Emily Westmoreland

Emissions
Joanne Best
Stephen Hedley*
Stephen Inch

Finance
Maria Lavender*

Computing
Robert Hepburn*
Sam Hope-Evans
Olufemi Kilani
Ian Troughton

Administration
Adina Beck
Valentina Lotti*
Wendy Rowlands

**Suggested first point of contact within each team.*

Contents

Foreword

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

Welcome to the thirteenth annual report of the London Air Quality Network (LAQN). This publication provides a strategic overview of air pollution across London during 2005 and as such, is important as a stand-alone document for comparison with other cities, as well as part of the ongoing annual air pollution record for London. The report provides a vital resource for anyone interested in air quality, especially those who are working at local and national levels, and for individuals developing policies to help reduce the level of air pollution in the UK.

The information in this report originates not only from the LAQN, managed by the Air Quality Monitoring group and led by Gary Fuller at King's College London, but is enhanced by input from the Environmental Research Group's (ERG) Air Quality Management team. The combined and complementary expertise of the individuals in these groups is further evident in the LAQN website **www.londonair.org.uk**. The latter contains summaries of air pollution across the LAQN and a number of tools to allow the user to analyse and plot data. The major make-over of the site during 2006 and the more recent addition of 3D visualisation and RSS feeds have received very positive feedback and now, more than ever, the site represents an essential resource for all those interested in air pollution.

2005 proved to be another challenging year for air quality since, in parallel with many other large cities around the world, London continued to experience high levels of air pollution. Traffic-related air pollution remains one of the most pressing problems in urban areas for example, in London during 2003, emissions from road transport contributed to approximately 50% of NO_x emissions and to 73% of emissions from particles with an aerodynamic diameter of 10 μm or smaller (PM_{10}). Moreover, evidence of adverse health effects resulting from these pollutants continues to emerge at an alarming rate. Human exposure to air pollutants in densely populated urban areas is thus high, and improvements in air quality are therefore imperative.

During the year ERG staff continued to work with experts from St George's, the London School of Hygiene & Tropical Medicine and Transport for London to assess the impact of the Congestion Charging Scheme (CCS)

in London. The work being undertaken by this interdisciplinary group of epidemiologists, toxicologists and air pollution scientists into air quality and health impacts of Europe's largest intervention in urban traffic management continues to attract international attention. The same team of investigators have also begun work in anticipation of the London-wide Low Emission Zone (LEZ). This scheme was introduced on 8 February 2008, and specifically targets the heaviest and most polluting diesel vehicles entering Greater London. Given the worldwide worries about diesel emissions and public health, especially children's health, these new initiatives certainly have the potential to provide benefit to Londoners and those who work in and visit the capital.

The purpose of air quality monitoring is not just to collect data, but also to provide information to the public so they have access to accurate, up-to-date and easy to understand information. Furthermore, it is important for policy makers and planners to enable them to make informed decisions in managing and regulating our environment. The value of the ERG networks was clearly exemplified on Sunday 11 December 2005 following a major explosion at the Buncefield depot near Hemel Hempstead in North London. The fire was the UK's largest peacetime blaze, burning at an intense heat and producing a large smoke plume that could be seen for miles. Over the immediate period following the explosion, the plume drifted south with groundings detected by ERG at sites in Hertfordshire, north London, Surrey and Sussex.

2005 also saw intense activity at the International level. The World Health Organisation (WHO), in taking into account the wealth of new evidence on the health effects of air pollutants that has accumulated in recent years, worked towards updating their air quality guidelines for PM, ozone, nitrogen dioxide and sulphur dioxide. These new guidelines are intended to replace those released in 2000, and will provide appropriate targets for a broad range of policy options for air quality management in different parts of the world.

Summary

During 2005 Air Quality Strategy (AQS) Objectives for NO_2, O_3 and PM_{10} were exceeded throughout London.

The annual mean AQS Objective for NO_2 was exceeded at all kerb and roadside monitoring sites except Thurrock 3. The annual mean NO_2 Objective was also exceeded at inner London background sites and around Heathrow. Eleven monitoring sites also breached the hourly mean Objective for NO_2.

The O_3 episodes experienced during 2003 were not repeated during 2005. The AQS Objective was, however, exceeded at suburban and background sites throughout the Home Counties and in outer London with the exception of Ealing 1 and Hillingdon AURN. Several roadside and inner London background sites attained the Objective.

The greatest PM_{10} concentrations in London were measured at sites in residential streets close to waste facilities. These sites exceeded the AQS Objective by a wide margin. The AQS Objective for PM_{10} was also exceeded at monitoring sites alongside major trunk roads. A total of 13 sites breached the EU Limit Value for PM_{10}. The Buncefield oil depot fire during December had little effect on ambient PM_{10} concentrations.

AQS Objectives for CO and SO_2 were attained throughout the LAQN.

The London Air Quality Network (LAQN) annual mean index provides a useful tool to track the changes in air pollution in the Capital relative to concentrations measured at the start of the index during 1996. During 2005 there was little change in annual mean concentrations in London; changes in the index value for all pollutants were within the range of +/-3%. However, provisional results for 2006 indicate an increase of 19% in the annual mean index for O_3 and a further increase of 3% in annual mean PM_{10}. The annual mean indices for CO, NO_2, NO_X and SO_2 all decreased during 2006.

Considering the longer-term perspective, from November 1996 to the end of 2005, the LAQN annual mean index reduced for all pollutants except O_3; the annual mean concentrations of O_3 showed a substantial increase during the period from November 1996 to the end of 2005 (+37%) and provisional measurements from 2006 suggested a further substantial increase during the year. The annual mean index for PM_{10} reached a minimum during 2000 and provisional results from 2006 suggest an increase of 8% since this time. During 2003 London experienced a series of prolonged PM_{10} episodes during the spring and summer and as a consequence many roadside sites exceeded the EU Limit Value. Despite an absence of such prolonged episodes during 2006, provisional measurements suggest that roadside PM_{10} concentrations during the year were similar to those measured during 2003.

During 2005 the LAQN continued to grow and adapt. Eleven new monitoring sites joined the network. New monitoring sites were installed in Ealing, Hammersmith & Fulham, Hillingdon, Lambeth, Reigate & Banstead, Sevenoaks and Sutton. The area covered by the network increased westwards with the addition of monitoring sites in Windsor & Maidenhead; two roadside sites operated by the local authority and a further site operated by Imperial College London. The network coverage in Surrey also increased with the inclusion of measurements from two sites in Elmbridge. New PM_{10} (FDMS) monitoring equipment was installed at Ealing 2 and an O_3 analyser was added to the site at Heathrow.

Introduction

This report details the results of air pollution measurements made during 2005 and assesses changes in London's air pollution during 2005 and 2006. Measurements have been presented with specific reference to the Air Quality Strategy (AQS) Objectives. The report also describes changes in London's air pollution from 1996 to 2006. Appendices to the report provide details of the monitoring sites in the LAQN and the air pollution concentrations measured during 2005.

The London Air Quality Network (LAQN) is a unique resource, providing robust air pollution measurements that are essential to underpin air quality management and health studies. The public face of the network, the London Air web site (**www.londonair.org.uk**), is visited by thousands of Londoners seeking hourly updated air pollution information.

The LAQN was formed in 1993 to coordinate and improve air pollution monitoring in London. Currently, 31 of London's 33 boroughs supply measurements to the network. In addition, these data are increasingly being supplemented by measurements from local authorities surrounding London, thereby providing an overall perspective of air pollution in London and the Home Counties.

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 Department of Environment, Food and Rural Affairs (DEFRA) funds King's 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. Analysis of LAQN measurements has been augmented by measurements from the directly-funded DEFRA sites in London. These six sites provide further information concerning pollution in central and west London. Measurements from DEFRA sites were provided by AEA from the National Air Quality Archive and were included within the LAQN database. Transport for London have also supported monitoring to help assess the air pollution impacts of the Congestion Charging Scheme and Low Emissions Zone.

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, measurements are validated using the best calibration and instrument performance information available at the time. Measurements are subsequently examined during the ratification process, using long-term instrument histories and the results of further quality checks. Measurements from AURN and London Standard sites are subject to UKAS accredited audits by the National Physical Laboratory (NPL) and by AEA and have traceability to National Metrological Standards. At 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 measurements in context, the uncertainty associated with each measurement has to be considered. Estimates of the uncertainty associated with air quality measurement were discussed in the 2001 LAQN Annual Report (Fuller et al, 2003). This suggested 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 was justified on the basis of both mathematical modelling and equipment performance tests.

The EU Air Quality Directives require a maximum 15% uncertainty for CO, NO_2, O_3 and SO_2 measurements at the short–term Limit Value concentrations. The European Standards Organisation (CEN) have determined a programme for the type approval for continuous CO, NO_2, O_3 and SO_2 analysers and structure for on-going field operation and quality assurance to enable this quality standard to be met (eg CEN, 2006). Manufacturers are currently submitting equipment for type approval. LAQN and AURN procedures already meet most of the CEN requirements for on-going field operation and quality assurance. At LAQN sites the additional sample line testing required by the CEN standards began in early 2007 and NPL are working to reduce the uncertainty in on-site gas cylinder certification. NPL are the only UK audit organisation to hold UKAS accreditation for on-site gas cylinder testing.

Concentration units

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 (pbb, ppm). 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 (20°C) and 101.3 kPa (1 Atmosphere), where appropriate, for comparison to the AQS Objectives, (DETR 2000c). Mass per unit volume NO_X concentrations are reported as NO_2 equivalent.

To determine measurement uncertainty associated with current LAQN instrumentation and quality standards, King's are analysing measurements from a series of LAQN instrument co-location exercises to determine between-sampler uncertainties as input into a field based assessment of measurement uncertainty.

It must be remembered a 10% or 15% uncertainty in measured concentration does not imply a 10% or 15% uncertainty in the number of breaches of a threshold standard, due to the statistical distribution of the measurements,

The uncertainty associated with the measurement of PM_{10} is more complex. PM_{10} is not a chemical compound but instead the composition of PM_{10} varies with location and time of year as well as 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 as such each produces systematically different results.

The First Daughter Directive (1999/30/EC) included Limit Values for PM_{10} and also stipulated that PM_{10} should be measured gravimetrically as laid out in EN12341 (CEN, 1998). There is, however, a conflict between the requirement to measure PM_{10} gravimetrically and the requirement for rapid public

The KCL Volatile Correction Model

During 2003, King's instigated a FDMS monitoring programme in conjunction with the London Boroughs (Green and Fuller, 2004; Green and Fuller, 2006). Arising from this programme, Green and Fuller (2006) proposed a model to correct several TEOMs in a region based on the measurements from a single FDMS. Initial tests of this hypothesis (the KCL Volatile Correction Model) proved encouraging and in 2007 DEFRA commissioned King's to carry out a detailed appraisal to inform the future PM_{10} monitoring strategy for the UK. This appraisal confirmed that the KCL Volatile Correction Model could correct TEOM measurements to meet the EU equivalence criteria. It is intended that this will form the basis of future reporting of TEOM measurements in London.

reporting due to the time between sampling, weighing and reporting the data, which can be up to 21-28 days after the sample was taken. Many EU member states therefore rely on automated techniques to measure PM_{10}.

In the UK the majority of PM_{10} measurements are made using the TEOM automated method. Due to its elevated operating temperature, the TEOM has the widely acknowledged disadvantage of driving off semi-volatile material such as ammonium nitrate and organic aerosols (Ruppecht et al, 1992; Allen et al, 1997; Salter and Parsons, 1999; Soutar et al, 1999; Green et al, 2001; Josef et al, 2001; Charron et al, 2003). A 'correction' factor of 1.3 was therefore recommended in the UK for comparison of TEOM PM_{10} measurements with the EU Directive (DETR, 1999).

Comparing the performance of the reference gravimetric technique with other PM_{10} measurement techniques is not simple. This is due to the lack of a standard reference material for airborne particulate and due to the nature of the pollutant itself; different measurement techniques have different sensitivity to both the semi-volatile constituents of PM_{10} and to the confounding effects of relative humidity. Different PM_{10} measurement techniques must therefore demonstrate that they are equivalent to the reference method in field trials (EC Working Group 2005).

During 2004 DEFRA therefore embarked upon a field trial programme to determine the equivalence of several automated and non-automated PM_{10} and $PM_{2.5}$ measurement techniques (Harrison, 2006). Several instruments proved equivalent to the European PM_{10} reference method: Partisol 2025, FDMS, Opsis SM200 Beta Attenuation Monitor (BAM), Opsis SM200 sampler (with slope and intercept correction) and the Met One Beta BAM (with slope correction). Importantly, the TEOM did not meet the equivalence criteria and is therefore not suitable for reporting PM_{10} concentrations with respect to the EU limit values. The implied need to upgrade or replace TEOMs with an equivalent automated measurement technique has significant cost implications for DEFRA, the Devolved Administrations and for local authorities. Therefore, as an interim measure DEFRA have recommended that local authorities continue to use a TEOM correction factor of 1.3 rather than requiring a large-scale equipment replacement programme.

Table 1 summarises the correction factors applied to the PM_{10} measurements presented in this report.

Method	Correction factor	Reference
TEOM	1.3	DETR 1999, Green et al 2001
Met-One BAM	0.82	Green 1999, Harrison 2006
FDMS	None	Harrison 2006
Gravimetric	None	

Table 1 PM_{10} correction factors used in this report.

Air quality during 2005

Carbon monoxide – CO

CO is produced by incomplete combustion of fuel, the major source in London being road traffic (GLA, 2005). Concentrations of CO have fallen over the last 15 years due to the widespread introduction of catalytic converters. The AQS Objective, a maximum 8-hour rolling mean of 8.6 mg m^{-3} (10 ppm), has not been exceeded at any LAQN site since 2000.

As expected, CO concentrations were higher close to busy roads but elevated levels were also measured at all site types during NO_2 and PM_{10} pollution episodes during the year. Elevated background CO was most notable during the PM_{10} and NO_2 pollution episodes of late November and December 2005. These were caused by still, calm conditions resulting in poor atmospheric dispersion. *Figure 1* shows CO concentrations during 2005 for a typical roadside site, Wandsworth 4 and a typical background site, Bexley 1. Periods of elevated CO concentrations can be clearly seen in November and December.

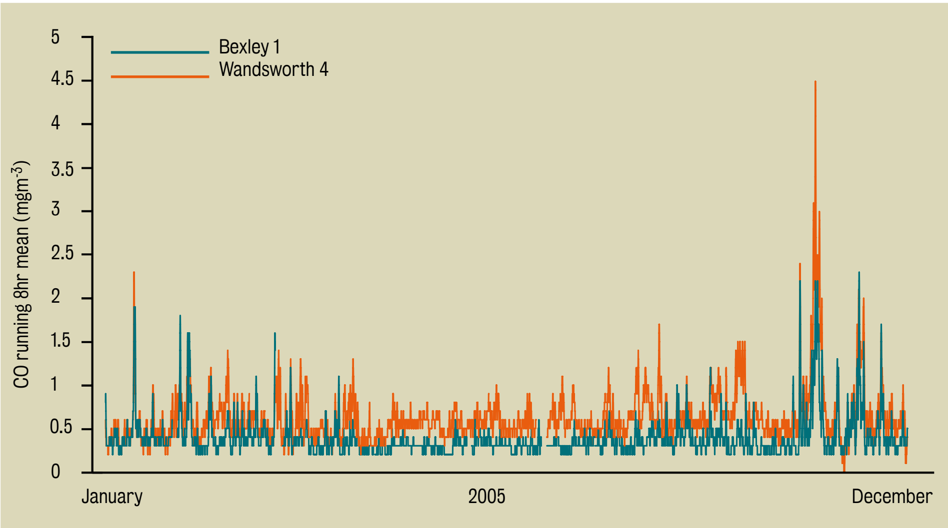

Figure 1 CO 8hr means during 2005 at the roadside site, Wandsworth 4 and the urban background site, Bexley 1.

Nitrogen dioxide – NO_2

Nitrogen oxides (NO_X), predominantly consisting of NO and NO_2 are also produced by the combustion of fossil fuels. NO_2 is the oxide of most concern, due to its effect on respiratory health. Ambient NO_2 arises from both primary and secondary sources; it is emitted directly from combustion sources and is also produced in the atmosphere by the oxidation of NO. The main sources of both NO and NO_2 in the LAQN area are vehicle exhausts and gas combustion (GLA, 2005). The majority of NO_2 is of a secondary nature but recent analysis suggests that primary NO_2 is making an increasingly important contribution to the total measured NO_2 concentrations, especially at roadside sites, as discussed in Carslaw and Beevers (2004a, 2004b, 2005a and 2005b) and Carslaw (2005).

There are two AQS Objectives for NO_2, one is based on the annual mean concentration which should not exceed 40 µg m^{-3} (21 ppb) and the second is an incident-based Objective of 200 µg m^{-3} (105 ppb), measured as an hourly mean, which should not be exceeded more than 18 times a year.

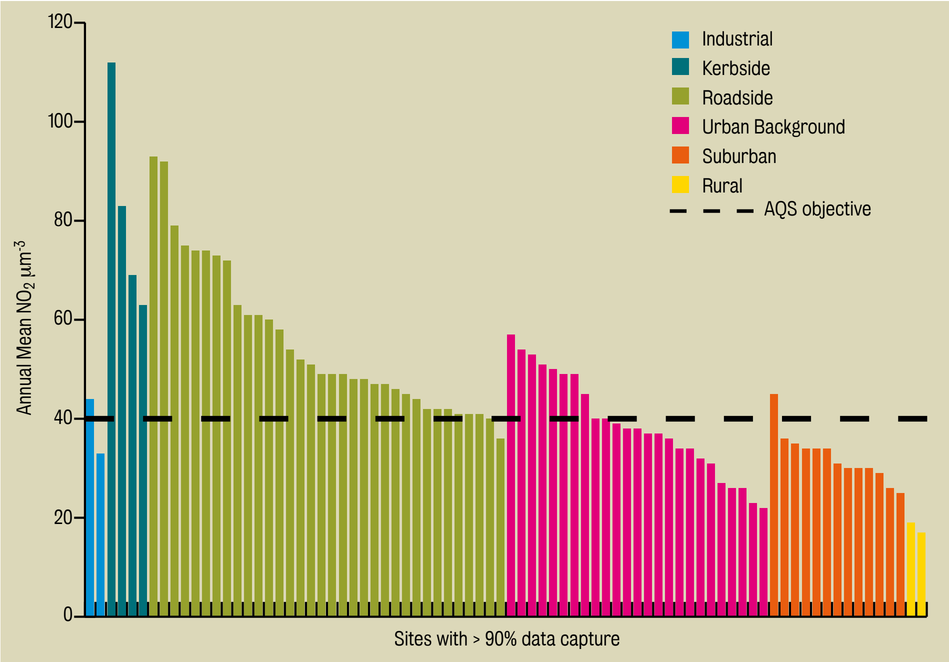

Figure 2 Annual mean NO_2 concentrations measured at LAQN sites with greater than 90% data capture. Sites have been classified by site type and ranked by annual mean concentration. The AQS Objective is also shown along with measurements from 2 rural sites in the Kent Network.

Figure 2 shows the annual mean NO_2 concentration at all LAQN sites that achieved 90% data capture during the year. NO_2 concentrations were greatest at kerbside and roadside sites and lower at background and suburban sites. The concentration difference between these classifications is particularly evident when measurements are compared to the AQS Objective; only one kerb/roadside site met the Objective whereas the Objective was met at the majority of background and suburban sites.

In addition, measurements from two rural sites in Kent were included in *Figure 2* to illustrate NO_2 outside London, away from urban areas. The increment above the rural baseline concentration illustrates the concentration due to emissions within the LAQN area. Even at background London locations, the annual mean NO_2 was substantially elevated when compared with rural concentrations; at sites exceeding the Objective over half the measured concentration arose locally. The proportion of local NO_2 was even greater at kerb/roadside sites; the mean concentration at these sites exceeded rural concentrations by more than three times. Such comparison of London to rural concentrations highlights the importance of citywide air quality management.

When comparing the sites achieving the annual mean Objective during 2005 to those in 2004, there was little change seen. Again, most roadside and kerbside sites did not achieve the Objective in 2005, the one exception being Thurrock 3 in Essex. In 2004, the annual mean was achieved at three additional outer London roadside sites that did not meet the Objective in 2005.

At urban background locations, a similar pattern was seen in 2005 to that in 2004; the annual mean Objective being exceeded at some inner London locations and at Heathrow Airport. Outer London background sites achieved the annual mean Objective.

During 2005, 11 LAQN sites failed to achieve the hourly mean Objective for NO_2.

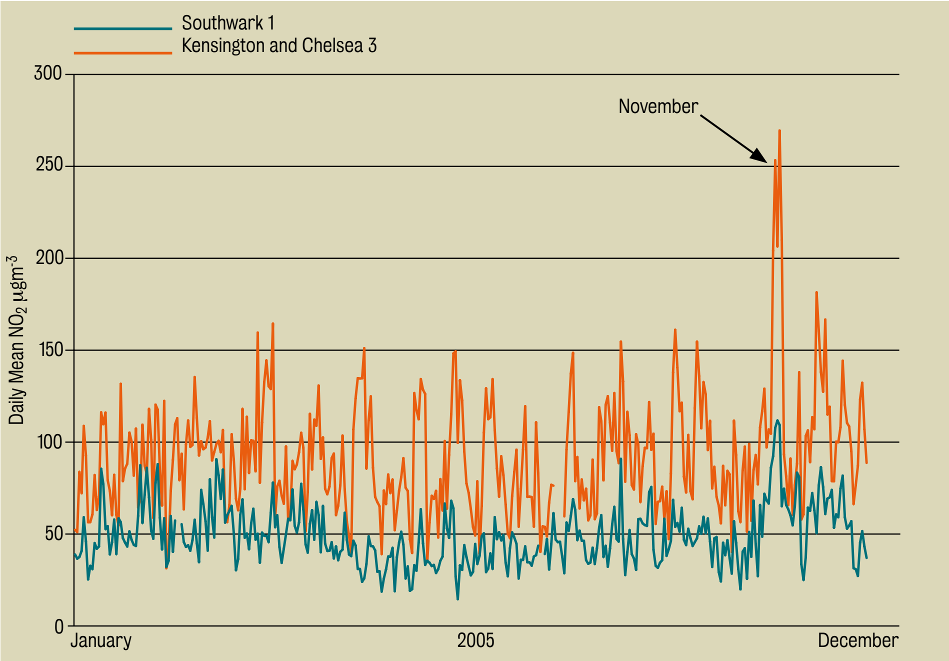

Figure 3 Daily mean NO_2 concentrations during 2005 measured at the urban background site Southwark 1 and at the roadside site, Kensington and Chelsea 3.

These included three kerbside sites: Lambeth 4, Marylebone Road and Sutton 4 which measured 3710, 844 and 189 hourly means greater than 200 µg m^{-3} (105 ppb) respectively. All other sites exceeding this Objective were at roadside locations; 23 hourly means above 200 µg m^{-3} (105 ppb) were measured at the A3 AURN site, 157 at Ealing 6, 43 at Greenwich 8, 27 at Hammersmith and Fulham 1, 21 at Islington 2,379 at Kensington and Chelsea 3, 98 at Kensington and Chelsea 4 and 22 at Lambeth 5.

No urban background, suburban or rural sites exceeded the hourly mean Objective but 10 urban background sites and one suburban site measured hourly means greater than 200 µg m^{-3} (105 ppb) compared to 9 background sites in 2004. The highest number measured was 15 at Hackney 4, closely followed by 14 at Kensington and Chelsea 1.

Figure 3 shows the daily mean NO_2 concentration at a roadside and background site in inner London. Neither site exhibited a strong seasonal dependency but concentrations at both sites showed substantial daily variation. The concentrations measured at the Southwark 1 urban background site were representative of other background locations in inner London whereas concentrations at busy roadside sites, such as Kensington and Chelsea 3 were more susceptible to local traffic sources which caused a variable concentration increment above background. As with the time series shown for CO in *Figure 1*, some of the more widespread pollution incidents during 2005 are evident at both site types, such as the poor dispersion episode during November.

Ozone – O_3

O_3 is a complex secondary pollutant. The concentrations of O_3 in London are determined by the combination of local, regional, European and global emissions and meteorological effects such as sunshine and temperature.

The involvement of sunlight in the process of O_3 formation means that levels are greater during the summer months when the hours of daylight are longer and the intensity of sunlight is stronger. O_3 pollution episodes occur during prolonged periods of warm sunny weather. In London, episodes are most severe when airflow is from the south and east due to the addition of O_3 precursors from Europe to those emitted locally. For this reason, the management of O_3 pollution is not simple and any efforts to reduce levels must be considered at a regional scale.

The AQS Objective set for O_3 is based on an 8-hour rolling mean of 100 µg m^{-3} (50 ppb) that should not be exceeded on more than 10 days per year. Due to the scavenging effect of NO, O_3 concentrations tend to be lowest near busy roads and concentrations are usually lower at inner London sites than those in outer London. The pattern of sites that met the O_3 AQS Objective was therefore very different to those that met Objectives for other pollutants. *Figure 4* shows that O_3 concentrations during 2005 were greatest in rural areas outside London with lower concentrations measured within the city. The majority of monitoring sites exceeded the AQS Objective.

Until recently, O_3 was rarely monitored at roadside sites as it was considered unlikely that roadside locations would exceed the AQS Objective. However, during the last three years, roadside O_3 monitoring has been increased with O_3 analysers being included in new roadside sites and occasionally added to existing sites. Although this additional O_3 monitoring was mainly undertaken to quantify directly emitted NO_2, two of these roadside sites did exceed the AQS Objective in 2005; the Bexley 8 site in Crayford and the Greenwich Bexley 6 site on the A2 at the border of the Greenwich and Bexley. Both O_3 analysers began monitoring during 2004.

Most non-roadside sites failed to achieve the O_3 Objective during 2005 with the following exceptions; Bloomsbury AURN, City of London 1, Ealing 1, Hillingdon AURN, Southwark 1, Wandsworth 2 and Westminster AURN. Apart from Ealing 1

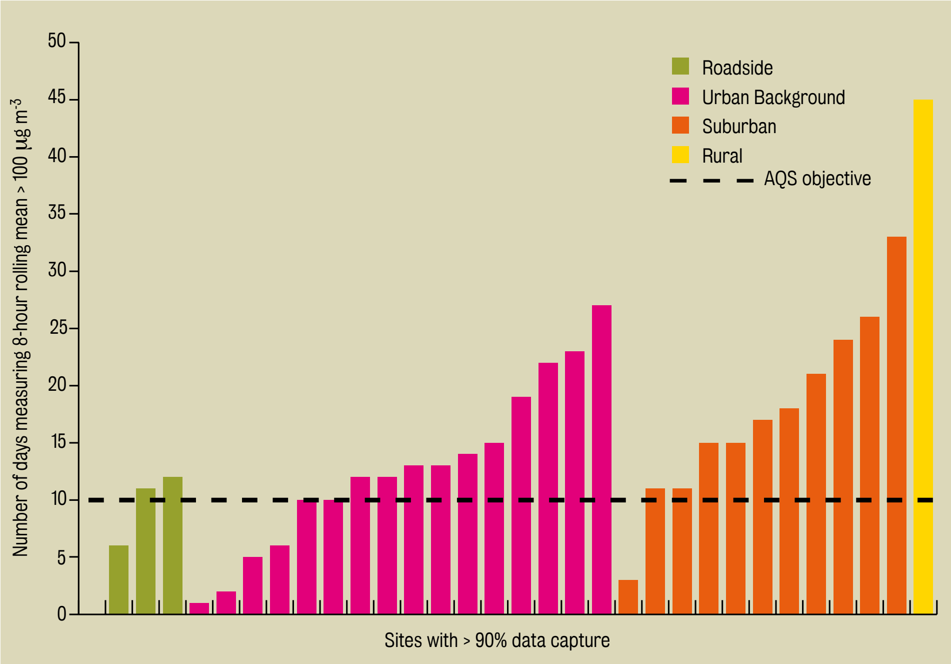

Figure 4 The number of days with maximum 8-hour rolling mean O_3 greater than 100 µg m^{-3}, compared to the AQS Objective. Sites have been classified by site type and ranked by the number of days exceeding this threshold. The AQS Objective is also shown along with measurements from the rural Stoke-Medway site in the Kent Network. Although it is possible for this Objective to be exceeded without 90% data capture, only sites with greater than 90% data capture are shown on the graph to permit accurate comparison.

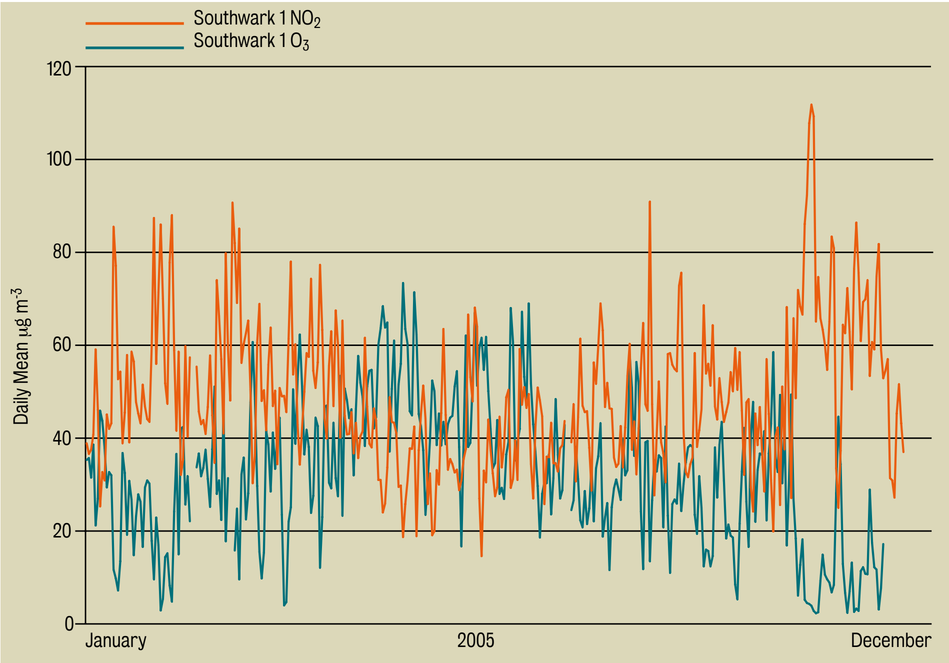

Figure 5 Daily means O_3 and NO_2 at the Southwark 1 inner London background site during 2005.

wand Hillingdon AURN, all these sites are located in inner London boroughs.

During 2003, London experienced an exceptional number of O_3 pollution episodes. Many sites had more than 40 days with 8-hour rolling mean O_3 greater than 100 µg m^{-3} and nearly all sites failed to meet the AQS Objective. This frequency of episodes was not repeated in 2004 and 2005. During 2005 most sites that failed to meet the Objective measured between 10 and 30 days with 8-hour rolling means greater than 100 µg m^{-3}.

Figure 5 shows the time series of daily mean O_3 concentrations at the inner London background site, Southwark 1, which is representative of the pattern of O_3 levels during the year at background locations. As shown in *Figure 5*, the most significant O_3 pollution episodes in 2005 took place in the early summer. The first episode occurred towards the end of May when a period of warm weather resulted in photochemical activity producing widespread 'moderate' O_3 (hourly mean concentrations greater than 50 ppb or 100 µg m^{-3}) at background sites and some sites reached the 'high' banding (hourly mean concentrations greater than 90 ppb or 180 µg m^{-3}). A further episode occurred at the end of June when calm conditions led to the build up of O_3 precursors that combined with hot sunny weather to produce 'moderate' and 'high' O_3 at background sites. Some further elevated O_3 was seen during July.

Daily mean NO_2 at Southwark 1 is also shown on *Figure 5*. The inverse relationship between O_3 and NO_2 observed in annual concentrations across the whole of the LAQN can also be seen in daily measurements at an individual site. Dips in NO_2 can be seen to coincide with spikes in O_3 and vice versa. O_3 was particularly low during periods of elevated NO_2 in November and December.

Particulate – PM_{10}

There are many sources of airborne particulate matter, both natural and anthropogenic. The PM_{10} size fraction consists mostly of particles less than 10 µm in diameter. These small particles are of most concern due to their ability to penetrate into the lungs with proven harmful health effects. PM_{10} particles also have a long residence time in the atmosphere; they can therefore accumulate during periods of poor atmospheric dispersion and can be transported over many hundreds of kilometres.

In the past, coal burning and industrial processes have been major sources of particulate matter in London but the availability of natural gas and tighter industrial emission regulations means that these sources are now less significant. Vehicle emissions, especially from diesel engines, are presently the main source of PM_{10} particulate in London (GLA, 2005). Additionally, when airflow comes from Europe, PM_{10} particles from continental sources can be detected at monitoring stations in London. One of the major events of 2005 was the explosion and subsequent fire at the Buncefield oil depot in Hertfordshire. The air pollution impacts of the fire are discussed in Chapter 7.

There are two AQS Objectives for PM_{10} particulate; one is based on an annual mean concentration which should not exceed 40 µg m^{-3} and the second is an incident based Objective of 50 µg m^{-3}, measured as a daily mean, which should not be exceeded more than 35 times per year. These Objectives are in line with the EU Stage 1 Limit Value.

The vast majority of LAQN sites met the annual mean Objective for PM_{10} particulate, as shown in *Figure 6*. However, Bexley 4 and Brent 5, which are classified as industrial sites due to their proximity to waste transfer stations, failed to meet the Objective, as did some sites at the busiest road and kerbside locations on the network. Brent 4 situated next to the North Circular, Greenwich 8 at the Woolwich Flyover and the Marylebone Road site all measured annual mean concentrations greater than 40 µg m^{-3}. This is an increase

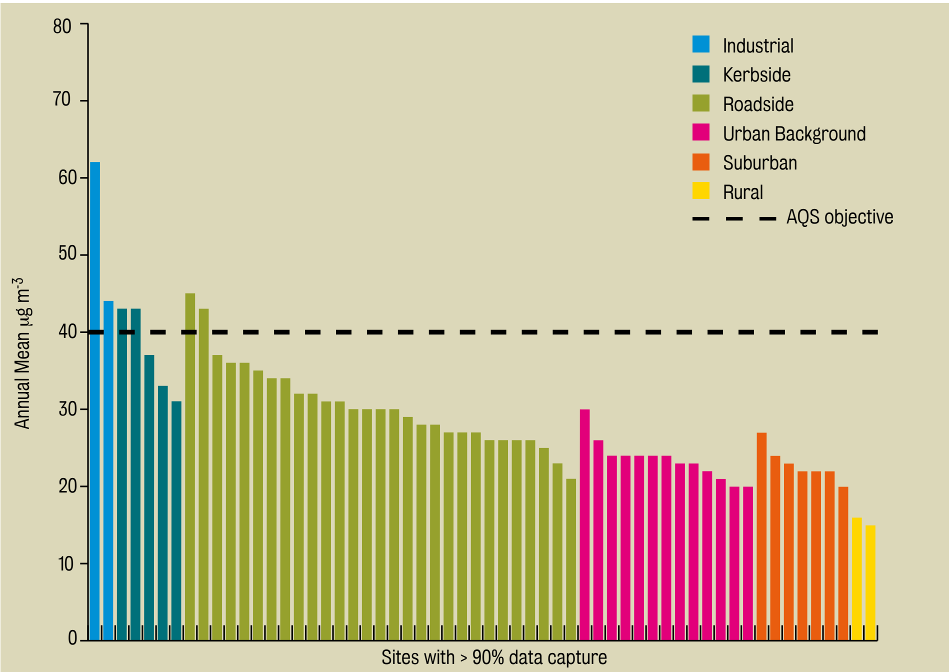

Figure 6 Annual mean PM_{10} concentrations measured at LAQN sites with data capture more than 90% data capture. Sites have been classified by according to type and ranked by concentration. The AQS Objective is shown along with measurements from measurements from two rural sites in the Kent network.

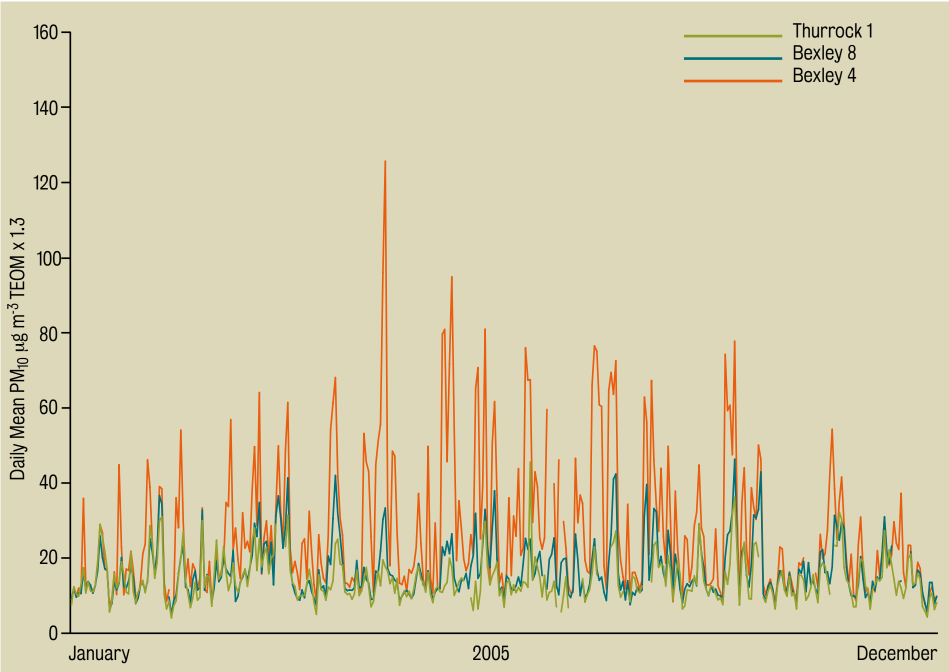

Figure 7 Daily mean PM_{10} at three east London and Essex sites; the industrial site Bexley 4, the roadside site Bexley 8 and the urban background site Thurrock 1.

in the number of sites failing to meet the annual mean Objective compared with 2004.

In addition, measurements from two rural sites in Kent were included in *Figure 6* to illustrate PM_{10} outside London, away from urban areas. When compared with concentrations measured in London, the increment above the rural baseline concentration provides an indication of the concentrations due to emissions within the LAQN area. Comparing the mean background concentration in London to that in rural areas, it is evident that around two thirds of the of the annual mean PM_{10} concentration at background sites in London was due to sources experienced in rural areas. This proportion drops to half of the PM_{10} mean concentration measured at kerb and roadside sites. These proportions are higher than those for NO_2; one third of the road and kerbside NO_2 and one half of background NO_2 was from sources outside of London. The relatively high proportion of annual mean PM_{10} originating outside of London presents obvious challenges for city-wide air quality management.

The daily mean Objective was exceeded at several kerb and roadside monitoring sites in addition to those that exceeded the annual mean Objective. Ealing 8, another site located near a waste transfer facility, exceeded the daily mean Objective with the greatest number of daily means exceeding 50 µg m^{-3} (230) on the network despite the fact that monitoring only began at the end of February. The daily mean Objective was also exceeded at the Camden 1 kerbside site at Swiss Cottage and at the roadside sites Hounslow 5 in Brentford close to the A4/M4 junction, Hammersmith and Fulham 1 at Hammersmith Broadway, Kensington and Chelsea 2 on Cromwell Road, Lambeth 4 on Brixton Road (BAM) and Lambeth 5 at Vauxhall (BAM). All background sites met both PM_{10} AQS Objectives. This is a similar pattern to results seen in 2004.

Figure 7 shows the daily mean PM_{10} time series measured at three different site types located in the eastern part of the LAQN area. The substantial influence of a waste transfer site and local industry can be seen in the time series of measurements at Bexley 4 where PM_{10} levels were often much greater than those measured at the roadside and background sites. In turn, the levels at the Bexley 8 roadside site were elevated above the background levels measured at Thurrock 1. A series of PM_{10} episodes were measured throughout the year including episodes during February, October, November and December.

Sulphur dioxide – SO_2

Sulphur dioxide levels in the LAQN area have fallen markedly in recent years due to the decline in coal burning and the reduction of sulphur in vehicle fuel. Peak concentrations tend to be seen in eastern boroughs such as Bexley where SO_2 pollution is sometimes detected from industry in the East Thames corridor.

All sites achieved the SO_2 AQS Objectives with ease. The most stringent Objective states that there should be no more than 35 occurrences of 15-minute means greater than 266 μg m^{-3} per year. Only one 15-minute mean greater than 266 μg m^{-3} was measured in the LAQN during 2005 which was at the Lambeth 4 site on Brixton Road. The number of 15-minute means greater than 266 μg m^{-3} measured in 2005 were fewer than in 2004.

Objectives are also set for the hourly mean SO_2 concentration which should not exceed 350 μg m^{-3} more than 24 times a year and the 24 hour mean should not exceed 125 μg m^{-3} more than 3 times a year. SO_2 concentrations at LAQN sites did not approach these levels during the year.

Although the AQS Objectives for SO_2 have not been exceeded in London since 1998 the relative importance of this pollutant may change in the future if new World Health Organisation (WHO) Guidelines are adopted within the UK. The new WHO Guidelines (WHO, 2006) recommend a significant reduction in the maximum daily mean concentration from the current 125 μg m^{-3} to an eventual 20 μg m^{-3}. During 2005, 27 out of the 44 LAQN SO_2 monitoring sites exceeded this guideline, however all sites achieved the WHO's level 1 and level 2 interim targets. Attainment of the WHO guideline would present a significant challenge to the Environment Agency and local authority regulators.

Benzene and 1,3 butadiene

The AQS Objectives for benzene and 1,3 butadiene are based on annual mean concentrations reflecting the long-term exposure concerns for these pollutants.
The annual mean AQS Objective for benzene is 5 μg m^{-3} and the AQS Objective for 1,3 butadiene is 2.25 μg m^{-3}. Benzene and 1,3 butadiene are measured by DEFRA networks at the Marylebone Road kerbside site, the Haringey 1 roadside site and the Greenwich 4 background 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.

The Buncefield oil depot fire

The explosion and subsequent fire

At 06.01 on Sunday 11 December 2005 a massive explosion occurred at the Buncefield Oil Depot near Hemel Hempstead, Hertfordshire. The explosion, which was heard many tens of km away, caused widespread damage over two kilometres from the site; 300 homes were damaged with several suffering major structural damage. Twenty business premises were destroyed and a further 60 business premises were badly damaged. Mercifully no one was killed but 60 people were injured; most injuries were minor from flying debris. The resulting fire was considered as the largest fire in peace-time Europe. Fighting the fire involved a truly UK wide effort with resources and fire-fighters being drawn from 32 fire services. At the peak of fire fighting 180 fire-fighters were at the site. The fire engulfed 21 oil storage tanks and it was estimated that around one third of the site inventory of 35 million litres of petrol, diesel and aviation fuel were consumed in the fire that burnt until Thursday 15 December. (BMIIB 2006a, 2006b, 2006c, 2007.)

The Buncefield fire has been investigated by the Buncefield Major Incident Investigation Board who published a series of reports regarding the cause of the explosion and its impact. The Board found that the initial explosion at the Buncefield Depot was caused by Tank 912 at the site being overfilled with unleaded petrol. Both the gauge and safety devices on the tank failed to indicate when the tank was full and fuel, pumped at a rate of up to 890 m^3 hour, began flowing from vents in the top of the tank, cascading down the sides and vaporising. Weather conditions were very still and a large low level vapour cloud formed. Eventually the vapour cloud met with an ignition source, thought to be the emergency generator house, and a massive explosion resulted. (BMIIB 2006d, 2007a, 2007b).

It was estimated that around 8000 tonnes of PM_{10} particulate were released during the fire, around 6% of the UK's annual emissions (Tragra et al 2006). The intense heat and low wind speeds on the first day of the fire caused the plume to rise to around 3000 m above the site. As the plume dispersed at altitude it was seen over wide areas of London and south east England and was clearly visible on satellite photographs.

Initial air quality assessment

The air quality impacts of the Buncefield fire were assessed using both bespoke and pre-existing monitoring programmes and were reported in Targra et al (2006) and Health Protection Agency (HPA) (2006). Local measurements were undertaken by the fire service, the Health and Safety Laboratory (on behalf of the HPA) and by AEA (on behalf of DEFRA). Further away from the fire the impacts of Buncefield were assessed using established monitoring programmes; the AURN and also regional monitoring networks managed by King's College London including the LAQN.

Within the King's College London operations centre rapid detection of possible groundings of the Buncefield plume were based on the characteristics of plume groundings from industrial sources of SO_2. Industrial sources typically cause short-term peaks in measured concentrations, at clusters of sites, which propagate according to the prevalent wind direction. It was additionally assumed that the plume from the Buncefield fire contained a very high ratio of PM_{10}:NO_X, in line with those from

IMAGE: CHILTERN AIR SUPPORT UNIT

previous major fires. This was later confirmed by aircraft measurements (Targra et al 2006). LAQN measurements were therefore scanned, using both manual and automated techniques, for short-term peaks in PM_{10} concentration that:

- were not linked to peaks in NO_X
- affected more than one monitoring site
- were consistent with the prevalent wind direction

Several PM_{10} peaks were identified and those initially linked to the Buncefield fire are shown in *Table 2*. Suspected incidents were divided into four geographical areas and time periods.

The plume from the fire did not result in **widespread** high or moderate pollution concentrations.

On the evening of Sunday 11 and early in the morning of Monday 12 December, the smoke from the fire was detected at monitoring sites in parts of east Surrey and Sussex causing PM_{10} particulate concentrations to reach 'moderate' levels in Horsham and Lewes, though it is possible that local coal burning contributed to concentrations measured at Lewes. The plume was also detected at monitoring sites in north London and St Albans but concentrations here remained 'low'.

On the evening of Tuesday 13 December, PM_{10} particulate from the fire was detected at the Barnet 2 background site and on the morning of Wednesday 14, PM_{10} particulate from the fire was detected at the Watford 1 site. In both cases concentrations remained 'low'.

Throughout the period of the fire 'moderate' PM_{10} particulate was measured at several roadside sites in London. This was due to road transport sources and was not directly related to the smoke from the oil depot fire. 'Moderate' PM_{10} concentrations were also measured at the Chichester 1 site in Sussex but these were found to be due to nearby road resurfacing.

Incident	Date	Time of max concentrations	Area	Site	Max 15 min mean concentrations
					µg m-3 TEOM *1.3
A	11 Dec	16.15	Surrey & Sussex	Mole Valley 3 – Dorking	156
A	11 Dec	17.45	Surrey & Sussex	R'gate & Bans 1 – Horley	133
A	11 Dec	19.15	Surrey & Sussex	Lewes 2	217
A	11 Dec	22.45	Surrey & Sussex	Horsham 2	290
B	11 Dec	20.30	Hertfordshire	St Albans – Fleetville	133
C	11 Dec	18h-19h	North London	Haringey 2 – Priory Pk*	102
C	11 Dec	18.45	North London	Haringey 1 – Tottenham	122
C	11 Dec	19.15	North London	Islington 2 – Holloway Rd	137
C	11 Dec	02.30	North London	Brent 5 – Neasden	130
D	14 Dec	03.00	North London	Barnet 2	98
D	14 Dec	07.30	Hertfordshire	Watford	114

Table 2 Peak PM_{10} concentrations initially linked to the Buncefield fire. *Measurements from Haringey 2 were made using a Met-One BAM and were multiplied by 0.83 to produce a gravimetric equivalent concentration (Harrison 2006) akin to that from TEOM *1.3.

Although the peak 15-minute mean concentrations listed in *Table 2* were notably elevated, these peaks were of short duration and their contribution to a daily mean concentration (for EU Limit Value comparison) was minor. A detailed assessment of the impacts of the Buncefield plume is being undertaken at King's using PM_{10} source apportionment to differentiate between the impacts of the Buncefield plume grounding and PM_{10} from other sources. Preliminary results suggest that contribution of the Buncefield plume towards the daily mean PM_{10} concentration ranged from around 2 (+/-1) or 3 (+/-1) µg m^{-3} TEOM *1.3 in incidents B and C, up to 9 (+/-3) µg m^{-3} TEOM *1.3 during incident D and reached 21 (+/-9) µg m^{-3} TEOM *1.3 in incident A at Horsham. These concentrations were considerably less than the EU Limit Value concentration of 50 µg m^{-3} TEOM *1.3. The Buncefield incident was also modelled by Webster et al (2006) using the Met Office NAME model and by Vautaud et al (2007) using the CHIMERE regional model. Both studies concluded that the ground level impacts of the fire were minimised by a combination of favourable meteorology and the intensity the fire which lead to a very buoyant plume.

IMAGE: FRANCISBOOTH.COM

Relative results 1996 to 2006

Measurements of air pollution concentrations from November 1996 to the end of 2006 were analysed to place the results from 2005 in context. 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. The changes in index, relative to November 1996, are shown in *Table 3*.

	% Change during 2005	% Change during 2006	% Change Nov 1996 to 2005	% Change Nov 1996 to 2006
CO	-3	-6	-56	-63
NO_2	-1	-2	-14	-15
NO_X	2	-4	-37	-42
O_3	3	19	37	56
PM_{10}	1	3	-28	-25
SO_2	-3	-1	-74	-74

Table 3 Percentage changes in the annual mean index for each pollutant relative to November 1996. Changes have been rounded to the nearest whole number.

During 2005 there was little change in annual mean concentrations; changes in all pollutants were within the range of +/-3% as seen in *Table 3*. This also shows the results from provisional measurements made during 2006. During 2006, the annual mean concentrations of air pollutants exhibited greater change than in 2005; most notable was a 19% rise in mean O_3 concentration, a 6% decrease in mean CO and a 3% increase in mean PM_{10}.

Considering the longer-term perspective, from November 1996 to the end of 2005, the LAQN annual mean index reduced for all pollutants except O_3. The greatest reductions were achieved in annual mean concentrations of SO_2 (-74%) and CO (-56%), with lesser reductions exhibited by PM_{10} (-28%) and NO_X (-42%). Despite the 37% reduction in NO_X concentration, the annual mean concentration of NO_2 showed a lesser decrease (-14%) over the same period. Worryingly, the annual mean concentrations of O_3 showed a substantial increase during the period from November 1996 to the end of 2005 (+37%) and provisional measurements from 2006 suggested a further substantial increase during the year. Although O_3 is not included in Local Air

LAQN annual mean Index

Measurements from a range of site types were used to derive the LAQN annual mean index. However, due to measurement availability, different sites were used for each pollutant. The sites used in the index were revised in 2004 and again in 2005 to reflect the changing availability of pollution measurements. This was to ensure that the index for each pollutant was based on measurement sites with the longest datasets and to represent the range of pollution concentrations experienced in the network. Six long-term sites were used for the PM_{10} calculation, seven for CO, O_3 and SO_2, and 16 for NO_X and NO_2. It should be noted that measurements during 2006 were provisional and subject to ratification.

IMAGE: FRANCISBOOTH.COM

Quality Management (DEFRA, 2003), due to its regional nature, the continued measurement of O_3 is essential to quantify the changes in the concentration of this pollutant and to support the understanding of changes in the concentrations of NO_2.

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 annual mean values for each pollutant shown in *Figure 8* and *Figure 9* allow the concentration changes during 2005 and 2006 to be viewed in the context of changes in pollution concentrations over the previous ten years.

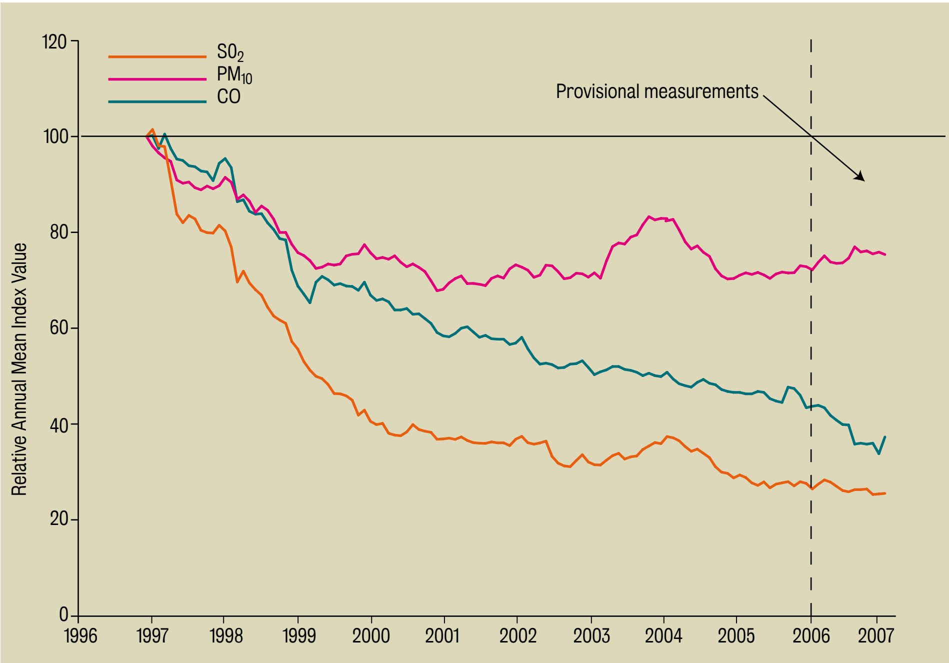

Figure 8 Relative annual mean concentrations of CO, PM_{10} and SO_2.

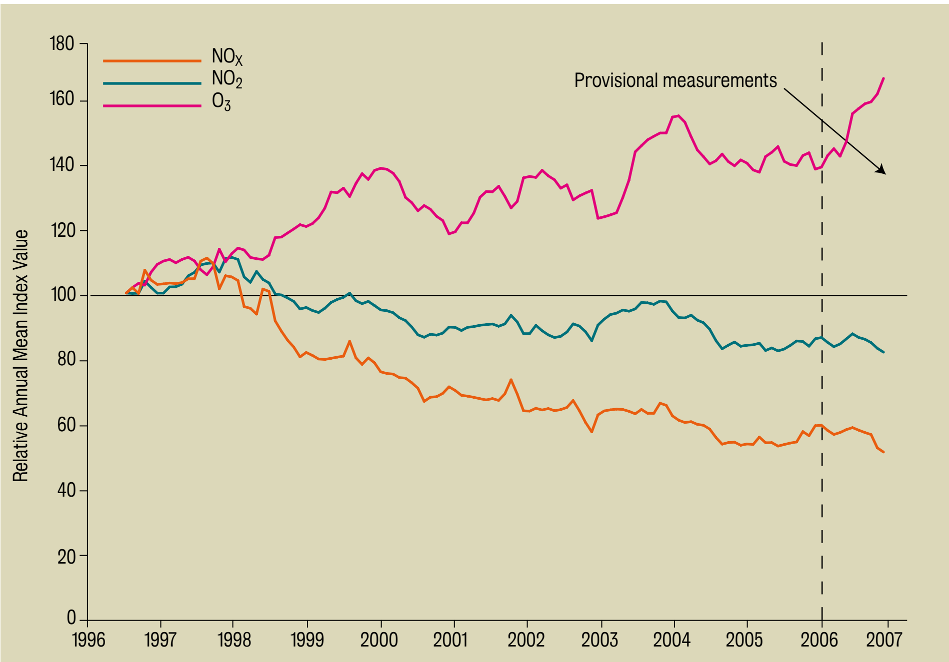

Figure 9 Relative annual mean concentrations of NO_X, O_3 and NO_2

Figure 8 shows that the decline in the mean concentration of CO measured during 2005 and 2006 was part of a continuing reduction apparent over the whole period of the index. Although the mean concentration of SO_2 reduced by 63% over the period of the index, the majority of this reduction was achieved prior to 2000 with a more modest rate of decline since this time. Mean concentrations of PM_{10} also reduced over the period of the index and by the end of 2006 the annual mean concentration of PM_{10} was at 75% of the November 1996 value. However PM_{10} concentrations reached a minimum during 2000 and have increased by 7% since this time; a gradual increase in mean PM_{10} concentrations was apparent even if the pollution events of 2003 were excluded.

Figure 9 shows the annual mean value of the LAQN indexes for NO_X, NO_2 and O_3. The steady reductions in the annual mean concentration of NO_X as a result of technological changes in the vehicle fleet has not resulted in a commensurate reduction in the mean concentration of NO_2. Although mean concentrations of NO_X reduced by 42% over the period of the index, the mean concentration of NO_2 only reduced by 15%. Over the period of the index the mean concentration of NO_2 showed considerable variability with concentrations at the end of 2003 returning to within 2% of their 1996 value. The lesser reduction in mean NO_2 concentration, when compared to reductions in NO_X concentration, illustrates the challenges of controlling the concentrations of this mainly secondary pollutant. The annual mean O_3 increased by 56% over the period of the index. The annual mean concentration of O_3 has been clearly affected by pollution incidents, such as those during 2003 and 2006 in addition to an underlying upwards trend.

Primary tail pipe emissions of NO_2

Local management of NO_2 focuses on reducing total emissions of NO_X. The majority of NO_X is emitted as NO, which is then oxidised to NO_2 in the atmosphere. The concentration of NO_2 is therefore limited by the oxidising capacity of the atmosphere. This is especially the case at roadside locations. However, NO_2 can also be emitted directly from vehicle exhausts without the need for atmospheric oxidation. The importance of primary emissions of NO_2 has been highlighted by a series of papers by Carslaw and Beevers (2004a, 2004b, 2005a and 2005b) that quantified the contribution of primary emissions of NO_2 to the total NO_2 concentration measured at roadside locations in London during 2000 to 2002. Further, Carslaw (2005) estimated that primary emissions of NO_2 ranged between 3% and 24% of the emissions of NO_X, with the directly emitted NO_2 being responsible for 21% of the annual mean NO_2 concentration (median estimate). Carslaw (2005) suggested that the proportion of directly emitted NO_2 at many roadside sites increased between 1997 and 2003, which masked underlying reductions in NO_2 being achieved as a consequence of NO_X reduction. Carslaw (2005) and AQEG (2006) suggested that the increase in primary emissions of NO_2 may be due to the installation of diesel particulate filters, changes to the engine management systems on diesel vehicles and the increased proportion of diesel vehicles in the passenger car fleet. It is expected that stricter NO_X controls on new vehicles will out-compete recent increases in primary NO_2 emissions leading to future reductions in primary NO_2 emissions.

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 concentrations 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.

Nitrogen dioxide – NO_2

Figure 10 compares the annual mean NO_2 at three different types of location in London using a sample of LAQN sites. 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. All location types exhibited fluctuations due to regional pollution episodes, for example, those during in autumn 1997 and, to a lesser extent, the photochemical episodes during 2003. All site types exhibited a reduction in mean NO_2 concentration until late 2002 and concentrations have been relatively stable since. Mean NO_2 concentrations were relatively stable during 2005 and 2006 with inner London sites continuing to exceed the objective by a wide margin.

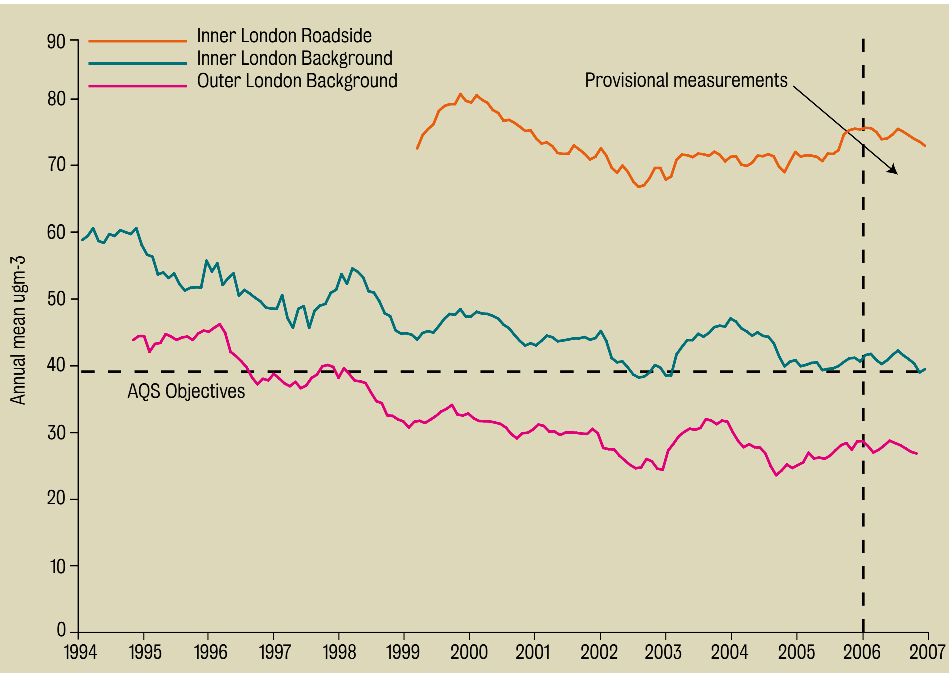

Figure 10 Annual Mean NO_2 at different site types in London.

Particulate – PM_{10}

Figure 11 shows the annual number of days with mean PM_{10} concentrations above 50 $\mu g\ m^{-3}$ (TEOM*1.3) at three different types of location.

The long-term measurements at inner London background sites are available since late 1994. These exhibited a downward trend from around 50 days above 50 $\mu g\ m^{-3}$ (TEOM*1.3) in 1995 to around 10 days in 2002. The similar downward trend at all site

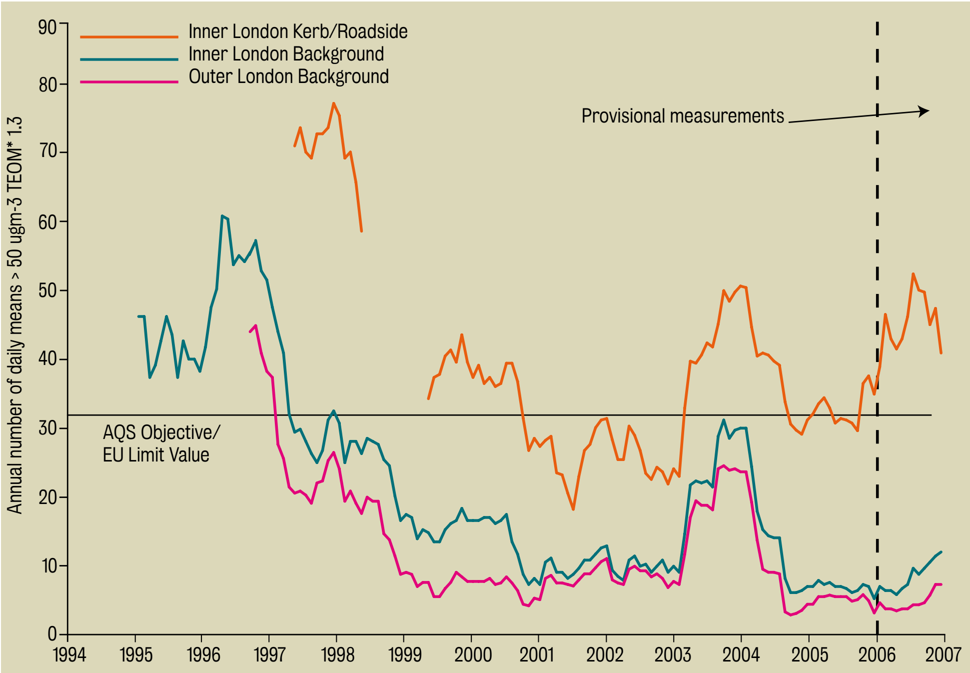

Figure 11 Annual number of days when mean PM_{10} exceeded 50 µg m^{-3} (TEOM*1.3)

types reflected a reduction in primary PM_{10} emissions from within London and a reduction of regional concentrations of secondary 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 µg m^{-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 µg m^{-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 µg m^{-3} (TEOM*1.3) included the primary episode of autumn 1997, which caused a deterioration in PM_{10} concentrations, and the unsettled weather in late 2000 which lead to an improvement. Inner London background sites consistently achieved the Objective since 1998. The number of daily means above 50 µg m^{-3} (TEOM*1.3) measured at outer London background 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 µg m^{-3} (TEOM*1.3) at the kerb/roadside sites in inner London followed a similar trend to background, albeit with additional days due to local traffic emissions. Inner London kerb/roadside sites generally achieved the Objective between 2000 and 2002. The measurements shown in *Figure 11* also show the impact of the PM_{10} episodes in 2003. Compared to 2002, background sites measured around 20 additional daily means above 50 µg m^{-3} (TEOM*1.3) during 2003, with kerb/roadside sites in inner London measuring around 30 such additional days. By the end of 2003, many road and kerbside TEOM sites in London had exceeded the AQS Objective.

IMAGE: FRANCISBOOTH.COM

The PM_{10} pollution events during 2003 were not repeated during 2004 and thus the annual number of days with mean PM_{10} greater than 50 µg m^{-3} (TEOM*1.3) reduced during the year. By the end of 2004, the annual number of days with mean PM_{10} greater than 50 µg m^{-3} (TEOM*1.3) at background sites in inner and outer London was comparable to that measured at the start of 2001. However, the PM_{10} measurements at inner London kerb and roadside sites did not exhibit comparable reductions to those measured at background locations. Although PM_{10} at inner London kerb and roadside sites reduced during 2004, the annual number of days with mean PM_{10} greater than 50 µg m^{-3} (TEOM*1.3) at the end of the year was close to the Objective and above that measured at the start of 2001. The number of days with mean PM_{10} above 50 µg m^{-3} (TEOM*1.3) remained relatively stable during 2005. Provisional measurements during 2006 indicated a substantial increase in the annual number of days with mean PM_{10} above 50 µg m^{-3} (TEOM*1.3) at inner London roadside sites, which returned to 2003 levels by mid-2006. The pollution episodes during 2003 were caused by an influx of PM_{10} from outside London that clearly affected all site types. Such an explanation cannot account for the elevated concentrations measured during 2006; these mainly affected roadside sites and were therefore due to emissions from road transport within London. An increase in the concentration of PM_{10} from primary sources within London was also suggested by Fuller and Green (2006) who considered measurements up to the end of 2004. This is clearly raises important questions for local and city-wide air quality management in London.

Measurements at Marylebone Road are not shown in *Figure 11* but have been in the range 70-167 days per year since the site was installed and showed variations due to local events such as building works, changes in road layout and increases in local primary emissions (Fuller et al, 2002, Fuller and Green, 2004, 2006).

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IMAGE: FRANCISBOOTH.COM

Appendix 1: LAQN monitoring sites

Site Name	Opening Date	Closing Date	Type	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data quality
A3 - AURN	Mar-97		R	y	y			T		**A
Barking & Dag'ham 1 - Rush Green	Nov-99		S		y	y				**
Barking & Dag'ham 2 - Scrattons Farm	Sep-93		S					T		**
Barnet 1 - Tally Ho Corner	Dec-98		K		y			T		**
Barnet 2 - Finchley	Aug-00		U		y			T		**
Barnet 3 - Strawberry Vale	Aug-00	May-02	U		y			T		**
Bexley 1 - Slade Green	May-94		S	y	y	y	y	T		**A
Bexley 2 - Belvedere	Jan-98		S		y			T		**
Bexley 3 - Thamesmead	Jan-98		S						T	**
Bexley 4 - Erith	Apr-99		I		y			T		**
Bexley 5 - Bedonwell	Oct-99	Apr-04	S	y	y	y				**
Bexley 7 - Thames Rd North	Apr-04		R		y		y	TF	T	**
Bexley 8 - Thames Rd South	Apr-04		R		y		y	T	T	**
Bloomsbury - AURN	Jan-92		U	y	y	y	y	T	T	**A
Brent 1 - Kingsbury	Jan-96		S	y	y	y	y	T		**A
Brent 2 - Ikea	Jun-01	Jun-03	R		y	y		T		**
Brent 3 - Harlesden	Oct-01		R		y	y		T		**
Brent 4 - Ikea	Jun-03		R		y	y		T		**
Brent 5- Neasden Lane	Feb-04		I		y			T		**
Brentwood 1 - Town Hall	Aug-95		U		y					**
Bromley 1 - Rent office	Jan-93	Jan-96	U	y	y		y			**
Bromley 5 - Biggin Hill	Apr-96		S				y			**
Bromley 7 - Central	Jul-98		R	y	y			B		*/**AA
Camden 1 - Swiss Cottage	Apr-96		K		y			T		**AA
Camden 3 - Shaftesbury Avenue	Apr-00		R		y			T		**
Castle Point 1 - Town Centre	May-96		U		y	y				**
City of London 1 - Senator House	Oct-01		U		y	y	y			*
Croydon 2 - Purley Way	Aug-94		R		y					**
Croydon 3 - Thornton Heath	Jun-97		S				y	T		**
Croydon 4 - George Street	Sep-99		R		y	y		T		**
Croydon 5 - Norbury	Oct-00		K		y					**
Croydon 6 - Euston Road	Jan-01		S		y					**
Crystal Palace 1 - C Palace Parade	Sep-99		R	y	y	y		T		**
Ealing 1 - Ealing Town Hall	Mar-95		U		y	y	y			**
Ealing 2 - Acton Town Hall	Sep-96		R	y	y		y	TF	T	**
Ealing 6 - Hangar Lane	Aug-03		R		y					**
Ealing 7 - Southall	Jul-04		U		y			T		**
Ealing 8 - Horn Lane	Feb-05		I					T		**
Ealing 9 - Court Way, Acton	Apr-05		R		y					**
Ealing Mobile 4 - Hamilton Road	Nov-98	Mar-99	R		y	y		T		**
Ealing Mobile 5 - Southall	Mar-99	Jun-01	R		y	y		T		**
Enfield 1 - Bushhill Park	Jun-95		S		y					**

Site Name	Opening Date	Closing Date	Type	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data quality
Enfield 2 - Church Street	Dec-97		R	y	y			B		**
Enfield 3 - Salisbury School Ponders End	Nov-98		U	y	y	y	y	B		**
Enfield 4 - Derby Road, Upper Edmonton	Feb-00		R		y	y		B		**
Enfield 5 - A406 Bowes Road	Jul-04		R					T		**
Greenwich 10 - A206, Burrage Grove	Oct-04		R		y			T		**
Greenwich 12 - Millennium Village	Aug-04		U		y			F	F	**
Greenwich 4 - Eltham	Jan-94		S		y	y	y	T		**AA
Greenwich 5 - Trafalgar Road	Nov-96		R		y			T		**
Greenwich 7 - Blackheath	Mar-02		R		y			T		**
Greenwich 8 - Woolwich Flyover	Jul-04		R		y			T		**
Greenwich 9 - Westhorne Ave	Oct-04		R		y			F	F	**
Greenwich Bexley 6 - A2 Falconwood	Oct-00		R		y		y	T	T	**
Hackney 4 - Clapton	Oct-93		U	y	y		y		T	*/**AA
Hackney 6 - Old Street	May-00		R		y			T		**
Hammersmith & Fulham 1 - H'smith B'dway	Aug-99		R		y	y		T		**
Hammersmith & Fulham 2 - Brook Green	Jul-03		U		y			T		**
Hammersmith & Fulham 3 - Scrubs Lane	Mar-05	Oct-05	K		y			T		**
Haringey 1 - Town Hall	Nov-94		R		y	y		T		**/**AA
Haringey 2 - Priory Park	Mar-96		S		y		y	B		**/**AA
Haringey 3 - Bounds Green	Jun-99	Mar-01	R		y	y		B		**
Harlington - AURN	Jan-04		U	y	y		y	T		**A
Harrow 1 - Stanmore	Apr-99		U		y	y			T	**
Harrow 2 - North Harrow	Jun-03		R		y			T		**
Havering 1 - Rainham, A1306	Dec-95		R		y					**
Havering 2 - Harold Hill	Mar-98	Nov-00	S					B		**
Havering 3 - Romford	Dec-98		R		y			T		**
Heathrow Airport	Jan-99		U		y	y	y	T		**A
Hillingdon - AURN	Aug-96		S	y	y	y	y	T		**A
Hillingdon 1 - South Ruislip	Jan-94		R		y			T		**
Hillingdon 2 - Hillingdon Hospital	Sep-02		R		y			T		**
Hillingdon 3 - Oxford Avenue	Mar-05		R		y			T		**
Hounslow 1 - Brentford	Apr-93	Jan-03	R	y	y		y			**AA
Hounslow 2 - Cranford	Jan-99		S		y	y	y	T		**
Hounslow 3 - Brentford	Mar-99	Jan-03	R					T		**
Hounslow 4 - Chiswick High Rd	Aug-99		R		y	y		T		**
Hounslow 5 - Brentford Roadside	Jun-03		R	y	y			T		**/**AA
Islington 1 - Upper Street	May-94		U		y			T		**
Islington 2 - Holloway Road	Jul-00		R	y	y			T		**

Site Name	Opening Date	Closing Date	Type	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data quality
Kens & Chelsea 1 - North Kensington	Mar 95		U	y	y	y	y	TFG		**AA
Kens & Chelsea 2 - Cromwell Rd	May 98		R	y	y	y		T		**/**A
Kens & Chelsea 3 - Knightsbridge	Mar 00		R		y					**
Kens & Chelsea 4 - King's Rd	Sep 00		R		y					**
Kens & Chelsea 5 - Earl's Court Road	May 02		R					G		**
Kingston 1 - Chessington	Jan 96		S				y			**
Kingston 2 - Town Centre	Apr 96	Jun 00	R		y			T		**
Lambeth 1 - Christchurch Road	Sep 00		R		y	y		B		*
Lambeth 2 - Vauxhall Cross	Dec 01	Jul 03	R		y	y		B		*
Lambeth 3 - Loughborough Junct	Dec 01		U		y	y		B		*
Lambeth 4 - Brixton Road	Dec 03		K		y	y		B		*
Lambeth 5 Vauxhall Cross	Feb 05		R		y	y		B		*
Lewisham 1 - Catford	Aug 96		U		y	y	y			**AA
Lewisham 2 - New Cross	Mar 02		R		y	y		T		**
Marylebone Rd	May 97		K	y	y	y	y	TF G*2	T	**AA
Mole Valley 1 - Leatherhead	Apr 96	Feb-99	RU		y	y		T		**
Mole Valley 2 - Lower Ashtead	Apr 97		S		y			T		**
Mole Valley 3 - Dorking	Oct-01		U		y			T		**
Reading AURN - New Town	Oct-03		U	y	y	y	y	T		**A
Redbridge 1 - Perth Terrace	Nov-99		U		y		y	B		*
Redbridge 2 - Ilford Broadway	Dec-99	Jun-03	K	y	y					*
Redbridge 3 - Fullwell Cross	Nov-99		K		y			B		*
Redbridge 4 - Gardner Close	Nov-99		R	y	y	y		B		*
Redbridge 5 - A406 Woodford	Nov-03		R	y	y			B		*
Reigate and Banstead 1 - Horley	Jul-00		S		y			T		**
Reigate and Banstead 2 - Horley South	Aug-03		S		y					**
Reigate and Banstead 3 - Poles Lane	Feb-05		RU		y		y			**
Richmond 1 - Castlenau	Jun-00		R		y			T		**
Richmond 2 - Barnes Wetlands	Mar-01		S		y		y	T		**
Sevenoaks 2 - Background	Jan-98		U	y	y	y	y	T		**
Sevenoaks 3 - Bat & Ball	Aug-05		R		y			T		**
Southwark 1 - Elephant & Castle	Mar-93		U	y	y	y	y	T		*/**AA
Southwark 2 - Old Kent Road	May-94		R	y	y	y		T		*/**AA
Sutton 1 - Town Centre	Apr-95	Apr-02	R	y	y	y		T		**AA
Sutton 2 - North Cheam	Apr-95	May-02	U		y					**
Sutton 3 - Carshalton	May-95		S		y		y			**
Sutton 4 - Wallington	Jul-02		K		y			T		**
Sutton 5 - Beddington Lane	Dec-05		I		y			T		**
Teddington - AURN	Aug-96		S		y	y	y			**A
Thurrock 1 - Grays	Jan-95		U	y	y	y	y	T		**A
Thurrock 2 - Purfleet	May-03		R		y					**
Thurrock 3 - Stanford	Aug-03		R		y			T		**

Site Name	Opening Date	Closing Date	Type	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data quality
Tower Hamlets 1 - Poplar	Jan-94		U		y	y	y	T		**
Tower Hamlets 2 - Mile End Rd	Mar-94		R	y	y					**AA
Tower Hamlets 3 - Bethnal Green	Oct-99		U		y			T		**
Waltham Forest - Chingford	Jul-03		R		y	y		T		**
Waltham Forest 1 - Dawlish Road	Jul-98		U		y	y		T		**
Waltham Forest 2 - Mobile	Jul-98	Oct-01	R		y	y		T		*
Wandsworth 1 - Garett Lane	Jan-95	Feb-96	R							**
Wandsworth 2 - Town Hall	Oct-94		U	y	y	y	y			**/**AA
Wandsworth 3 - Roehampton	Oct-94	Nov-00	RU			y	y			**
Wandsworth 4 - High Street	Jan-98		R	y	y			T		**
West London - AURN	Jan-87		U	y	y					**A
Westminster - AURN	Jul-01		U	y	y	y	y			**A
Windsor & Maidenhead 1 - Maidenhead	Mar-05		R		y					**
Windsor & Maidenhead 2 - Windsor	Feb-05		R		y					**
Windsor & Maidenhead 3 - Ascot IC	Oct-05		RU		y		y			**

Key

T TEOM
B Beta Attenuation
G Gravimetric
F FDMS
AA Affiliated to UK AURN. Final data set published by DEFRA
A AURN DEFRA funded. Final data set published by DEFRA
* Locality Standard
** Traceability to National Standards

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

Appendix 2: Network changes during 2005

← The **Bexley 3** monitoring site reopened in September and is now operated by the neighbouring London Borough of Greenwich. The site measures $PM_{2.5}$ only.

→ **Ealing 8** is an industrial site, monitoring PM_{10} particulate in Horn Lane in Acton; a residential roadside location. The site opened in February. It is affected by local sources of PM_{10} particulate and is not representative of other areas within the Borough. It forms part of an investigation of PM_{10} around a nearby a waste transfer station and aggregates handing yard.

← NO_2 monitoring began in April at the roadside site, **Ealing 9**, which is located at Court Way in Acton. The site is intended to measure the local impact of air pollution from the nearby A40.

← Air quality measurements are newly available from two sites operated by Elmbridge Borough Council in Surrey. The council have been running, **Elmbridge 1** (upper left), an urban background site at Bell Farm in Hersham since 2001 and a new roadside site, **Elmbridge 2** (lower left) was installed at Esher High Street in September 2005. Elmbridge 1 monitors PM_{10} particulate, NO_2, CO, SO_2 and O_3 and Elmbridge 2 monitors NO_2 only. The publication of the meaurements from these sites within the Londonair website is a significant enhancement to the publicly available information on air quality in Surrey.

→ The **Hammersmith & Fulham 3** site was set up at Scrubs Lane on a temporary basis as a result of concerns over elevated pollution levels caused by local industry, including a waste transfer station and a metal recycling plant. The site operated from March to October 2005 and measured PM_{10} particulate and NO_2.

← Hillingdon added to their air quality monitoring programme with a new site, **Hillingdon 3** in February 2005. Initially planned to run for around two years, the site measures NO_2 and PM_{10} particulate and is intended to quantify pollution levels from the nearby Heathrow Airport and busy roads such as the A4.

→ The **Lambeth 5** site opened at Vauxhall Cross in February 2005 close to the location of the former Lambeth 2 site. Lambeth 5 is a roadside site located in the middle of a traffic island close to a public transport interchange.

← The **Reigate & Banstead 3** rural site was the first site to be set up by a local authority outside its boundary. The site measures NO_2 and O_3. Reigate & Banstead 3 forms part of an overall strategy comprising four sites to investigate NO_2 levels in the Gatwick area; Reigate and Banstead 3 is located to the south west of the airport, Reigate & Banstand 1 and 2 are located in Horley to the north east and Crawley 2 (part of the Sussex Air Network) lies to the south east of Gatwick.

A new roadside site, **Sevenoaks 3**, was installed to investigate pollution from the Bat and Ball junction. The site measures NO_2 and PM_{10}. It was istalled in August .

Sutton 5 was opened in December due to concerns about air pollution from industrial facilities affecting residential areas of Beddington Lane. The site measures PM_{10} and NO_2.

The LAQN has extended westwards with the addition of three new continuous monitoring sites in the Royal Borough of Windsor and Maidenhead in Berkshire. Two roadside NO_2 sites have been set up by the borough council; **Windsor & Maidenhead 1** in Maidenhead and **Windsor & Maidenhead 2** in Windsor. The third site, **Windsor & Maidenhead 3** is owned and operated by Imperial College London as a research facility. This site measures NO_2 and O_3 in a rural area near Ascot.

➔ Ealing Borough Council upgraded the **Ealing 2** site at Acton Town Hall in 2005. A PM_{10} FDMS has been installed alongside the existing PM_{10} and $PM_{2.5}$ TEOMs and a new O_3 analyser was also installed. The site is now one of the most comprehensive in the LAQN and will provide essential measurements to support the operation of FDMS instruments in London and also to monitor changes in the emissions from primary NO_2 from road traffic.

🡐 An O_3 analyser was added to the **Heathrow Airport** site in March. O_3 measurements will support the understanding of NO_2 arising from airport emissions.

Appendix 3: Detailed results

CO				
Site	**Type**	**Data Capture %**	**Max 8h mean < 8.6 $\mu g\ m^{-3}$**	**Achieved?**
A3 AURN	R	97	0	YES
Bexley 1	S	97	0	YES
Bloomsbury AURN	U	92	0	YES
Brent 1	S	56	0	NA
Bromley 7	R	46	0	NA
Crystal Palace 1	R	90	0	YES
Ealing 2	R	93	0	YES
Elmbridge 1	U	82	0	NA
Enfield 2	R	99	0	YES
Enfield 3	U	89	0	NA
Hackney 4	U	95	0	YES
Harlington AURN	U	99	0	YES
Heathrow Airport	U	98	0	YES
Hillingdon AURN	S	89	0	NA
Hounslow 5	R	83	0	NA
Islington 2	R	98	0	YES
Kens and Chelsea 1	U	96	0	YES
Kens and Chelsea 2	R	94	0	YES
Marylebone Rd	K	98	0	YES
Reading AURN	U	81	0	NA
Redbridge 4	R	94	0	YES
Redbridge 5	R	96	0	YES
Richmond 21	R	35	0	NA
Richmond 25	R	35	0	NA
Sevenoaks 2	U	95	0	YES
Southwark 1	U	96	0	YES
Southwark 2	R	92	0	YES
Thurrock 1	U	94	0	YES
Tower Hamlets 2	R	88	0	NA
Wandsworth 2	U	86	0	NA
Wandsworth 4	R	98	0	YES
West London AURN	U	93	0	YES
Westminster AURN	U	52	0	NA

NO_x		
Site	**Type**	**Annual mean NO_x μgm^{-3} (IAS NO_2)**
A3 AURN	R	164
Barking & Dagenham 1	S	52
Barnet 1	K	176
Barnet 2	U	65
Bexley 1	S	65
Bexley 2	S	55
Bexley 4	I	73
Bexley 7	R	99
Bexley 8	R	93
Bloomsbury AURN	U	107
Brent 1	S	57
Brent 3	R	115
Brent 4	R	287
Brent 5	I	131
Brentwood 1	U	48
Bromley 7	R	89
Camden 1	K	200
Camden 3	R	172
Castle Point 1	U	40
City of London 1	U	91
Croydon 2	R	154
Croydon 4	R	127
Croydon 5	K	194
Croydon 6	S	71
Crystal Palace 1	R	129
Ealing 1	U	75
Ealing 2	R	143
Ealing 6	R	331
Ealing 7	U	57

NO_x		
Site	**Type**	**Annual mean NO_x μgm^{-3} (IAS NO_2)**
Ealing 9	R	89
Elmbridge 1	U	52
Elmbridge 2	R	168
Enfield 1	S	61
Enfield 2	R	83
Enfield 3	U	59
Enfield 4	R	111
Greenwich 10	R	113
Greenwich 12	U	69
Greenwich 4	S	48
Greenwich 5	R	107
Greenwich 7	R	129
Greenwich 8	R	242
Greenwich 9	R	113
Greenwich Bexley 6	R	119
Hackney 4	U	95
Hackney 6	R	147
Haringey 1	R	93
Haringey 2	S	57
Harlington AURN	U	73
Harrow 1	U	44
Harrow 2	R	123
Havering 1	R	91
Havering 3	R	97
Heathrow Airport	U	121
Hillingdon 1	R	121
Hillingdon 2	R	81
Hillingdon 3	R	93
Hillingdon AURN	S	109

NO_x		
Site	Type	Annual mean NO_x μgm^{-3} (IAS NO_2)
Hounslow 2	S	69
Hounslow 4	R	178
Hounslow 5	R	153
H'smith and Fulham 1	R	214
H'smith and Fulham 2	U	67
H'smith and Fulham 3	K	119
Islington 1	U	77
Islington 2	R	184
Kens and Chelsea 1	U	69
Kens and Chelsea 2	R	194
Kens and Chelsea 3	R	234
Kens and Chelsea 4	R	232
Lambeth 1	R	131
Lambeth 3	U	67
Lambeth 4	K	612
Lambeth 5	R	184
Lewisham 1	U	107
Lewisham 2	R	149
Marylebone Rd	K	305
Mole Valley 2	S	44
Mole Valley 3	U	46
Reading AURN	U	42
Redbridge 1	U	67
Redbridge 3	K	158
Redbridge 4	R	107
Redbridge 5	R	131
Reigate and Banstead 1	S	50
Reigate and Banstead 2	S	63
Reigate and Banstead 3	RU	28

NO_x		
Site	Type	Annual mean NO_x μgm^{-3} (IAS NO_2)
Richmond 1	R	87
Richmond 2	S	54
Richmond 21	R	63
Richmond 23	R	26
Richmond 25	R	97
Sevenoaks 2	U	38
Sevenoaks 3	R	99
Southwark 1	U	91
Southwark 2	R	143
Sutton 3	S	52
Sutton 4	K	202
Sutton 5	I	125
Teddington AURN	S	44
Thurrock 1	U	67
Thurrock 2	R	206
Thurrock 3	R	85
Tower Hamlets 1	U	61
Tower Hamlets 2	R	153
Tower Hamlets 3	U	93
Waltham Forest 1	U	63
Waltham Forest 3	R	65
Wandsworth 2	U	119
Wandsworth 4	R	95
West London AURN	U	87
Westminster AURN	U	87
Windsor and Maidenhead 1	R	137
Windsor and Maidenhead 2	R	123
Windsor and Maidenhead 3	RU	44

NO_2						
Site	**Type**	**Data capture %**	**Annual Mean < 40 $\mu g\ m^{-3}$**	**Annual mean achieved?**	**No more than 18 occurrences of hourly mean > = 200 $\mu g\ m^{-3}$ (104.6ppb)**	**Hourly mean achieved?**
A3 AURN	R	98	61	NO	23	NO
Barking & Dagenham 1	S	98	30	YES	0	YES
Barnet 1	K	81	74	NA	4	NA
Barnet 2	U	98	37	YES	2	YES
Bexley 1	S	95	36	YES	0	YES
Bexley 2	S	95	31	YES	0	YES
Bexley 4	I	96	33	YES	0	YES
Bexley 7	R	84	40	NA	0	NA
Bexley 8	R	95	41	NO	0	YES
Bloomsbury AURN	U	94	57	NO	1	YES
Brent 1	S	89	33	NA	0	NA
Brent 3	R	73	53	NA	2	NA
Brent 4	R	83	69	NA	9	NA
Brent 5	I	99	44	NO	0	YES
Brentwood 1	U	92	31	YES	0	YES
Bromley 7	R	95	49	NO	1	YES
Camden 1	K	85	76	NA	17	NA
Camden 3	R	81	75	NA	2	NA
Castle Point 1	U	98	26	YES	0	YES
City of London 1	U	85	51	NA	2	NA
Croydon 2	R	90	49	NO	2	YES
Croydon 4	R	79	60	NA	5	NA
Croydon 5	K	99	69	NO	4	YES
Croydon 6	S	93	34	YES	1	YES
Crystal Palace 1	R	90	52	NO	1	YES
Ealing 1	U	99	39	YES	0	YES
Ealing 2	R	93	58	NO	6	YES
Ealing 6	R	88	93	NA	157	NO
Ealing 7	U	96	34	YES	0	YES
Ealing 9	R	66	40	NA	0	NA
Elmbridge 1	U	81	29	NA	0	NA
Elmbridge 2	R	28	56	NA	0	NA
Enfield 1	S	96	35	YES	0	YES
Enfield 2	R	95	42	NO	0	YES
Enfield 3	U	90	32	YES	0	YES
Enfield 4	R	98	48	NO	1	YES
Greenwich 10	R	99	51	NO	2	YES
Greenwich 12	U	99	34	YES	0	YES
Greenwich 4	S	84	29	NA	0	NA

NO_2						
Site	**Type**	**Data capture %**	**Annual Mean < 40 µg m^{-3}**	**Annual mean achieved?**	**No more than 18 occurrences of hourly mean > = 200 µg m^{-3} (104.6ppb)**	**Hourly mean achieved?**
Greenwich 5	R	95	48	NO	0	YES
Greenwich 7	R	93	47	NO	0	YES
Greenwich 8	R	96	75	NO	43	NO
Greenwich 9	R	97	44	NO	0	YES
Greenwich Bexley 6	R	99	41	NO	0	YES
Hackney 4	U	97	49	NO	15	YES
Hackney 6	R	98	63	NO	2	YES
Haringey 1	R	97	42	NO	1	YES
Haringey 2	S	97	34	YES	0	YES
Harlington AURN	U	99	38	YES	1	YES
Harrow 1	U	99	27	YES	0	YES
Harrow 2	R	98	45	NO	0	YES
Havering 1	R	94	40	NO	0	YES
Havering 3	R	98	41	NO	3	YES
Heathrow Airport	U	97	53	NO	1	YES
Hillingdon 1	R	78	46	NA	4	NA
Hillingdon 2	R	87	39	NA	0	NA
Hillingdon 3	R	72	37	NA	0	NA
Hillingdon AURN	S	93	45	NO	0	YES
Hounslow 2	S	87	38	NA	0	NA
Hounslow 4	R	99	72	NO	15	YES
Hounslow 5	R	99	49	NO	3	YES
H'smith and Fulham 1	R	90	74	NO	27	NO
H'smith and Fulham 2	U	97	40	NO	0	YES
H'smith and Fulham 3	K	57	41	NA	3	NA
Islington 1	U	93	45	NO	0	YES
Islington 2	R	99	74	NO	21	NO
Kens and Chelsea 1	U	96	40	NO	14	YES
Kens and Chelsea 2	R	93	79	NO	9	YES
Kens and Chelsea 3	R	99	93	NO	379	NO
Kens and Chelsea 4	R	99	92	NO	98	NO
Lambeth 1	R	74	56	NA	0	NA
Lambeth 3	U	89	39	NA	0	NA
Lambeth 4	K	75	228	NA	3710	NO
Lambeth 5	R	84	84	NA	22	NO
Lewisham 1	U	99	51	NO	3	YES
Lewisham 2	R	79	57	NA	6	NA
Marylebone Rd	K	97	112	NO	844	NO
Mole Valley 2	S	99	26	YES	0	YES

NO_2						
Site	**Type**	**Data capture %**	**Annual Mean < 40 $\mu g\ m^{-3}$**	**Annual mean achieved?**	**No more than 18 occurrences of hourly mean > = 200 $\mu g\ m^{-3}$ (104.6ppb)**	**Hourly mean achieved?**
Mole Valley 3	U	99	26	YES	0	YES
Reading AURN	U	95	23	YES	0	YES
Redbridge 1	U	95	36	YES	0	YES
Redbridge 3	K	94	63	NO	8	YES
Redbridge 4	R	94	47	NO	0	YES
Redbridge 5	R	93	54	NO	0	YES
Reigate and Banstead 1	S	98	29	YES	0	YES
Reigate and Banstead 2	S	97	34	YES	0	YES
Reigate and Banstead 3	RU	72	19	NA	0	NA
Richmond 1	R	98	42	NO	4	YES
Richmond 2	S	93	30	YES	0	YES
Richmond 21	R	39	30	NA	0	NA
Richmond 23	R	11	17	NA	0	NA
Richmond 25	R	45	40	NA	0	NA
Sevenoaks Background	U	93	22	YES	0	YES
Sevenoaks Roadside	R	37	38	NA	0	NA
Southwark 1	U	98	49	NO	0	YES
Southwark 2	R	99	60	NO	1	YES
Sutton 3	S	92	30	YES	0	YES
Sutton 4	K	97	83	NO	189	NO
Sutton 5	I	5	55	NA	0	NA
Teddington AURN	S	94	25	YES	0	YES
Thurrock 1	U	84	35	NA	0	NA
Thurrock 2	R	94	73	NO	12	YES
Thurrock 3	R	99	36	YES	0	YES
Tower Hamlets 1	U	98	38	YES	0	YES
Tower Hamlets 2	R	99	61	NO	1	YES
Tower Hamlets 3	U	71	47	NA	0	NA
Waltham Forest 1	U	99	37	YES	0	YES
Waltham Forest 3	R	78	31	NA	0	NA
Wandsworth 2	U	96	54	NO	10	YES
Wandsworth 4	R	97	46	NO	2	YES
West London AURN	U	94	50	NO	1	YES
Westminster AURN	U	82	48	NA	0	NA
Windsor and Maidenhead 1	R	74	51	NA	0	NA
Windsor and Maidenhead 2	R	82	49	NA	0	NA
Windsor and Maidenhead 3	RU	21	22	NA	0	NA

O_3				
Site	**Type**	**Data capture %**	**No more than 10 days where maximum rolling 8 hr mean > = 100 $\mu g\ m^{-3}$ (50ppb)**	**Achieved?**
Bexley 1	S	97	11	NO
Bexley 7	R	98	6	YES
Bexley 8	R	98	12	NO
Bloomsbury AURN	U	91	1	YES
Brent 1	S	96	24	NO
Bromley 5	S	97	26	NO
City of London 1	U	94	2	YES
Croydon 3	S	99	18	NO
Ealing 1	U	99	10	YES
Ealing 2	R	57	2	NA
Elmbridge 1	U	23	0	NA
Enfield 3	U	93	19	NO
Greenwich 4	S	98	15	NO
Greenwich Bexley 6	R	99	11	NO
Hackney 4	U	78	15	NO
Haringey 2	S	99	21	NO
Harlington AURN	U	99	12	NO
Heathrow Airport	U	75	10	NA
Hillingdon AURN	S	92	3	YES
Hounslow 2	S	66	11	NO
Kens and Chelsea 1	U	98	13	NO
Kingston 1	S	97	11	NO
Lewisham 1	U	99	14	NO
Marylebone Rd	K	98	0	YES
Reading AURN	U	96	22	NO
Redbridge 1	U	98	12	NO
Reigate and Banstead 3	RU	83	6	NA
Richmond 2	S	99	17	NO
Richmond 21	R	39	0	NA
Richmond 23	R	12	7	NA
Richmond 25	R	45	2	NA
Sevenoaks 2	U	94	23	NO
Southwark 1	U	96	5	YES
Sutton 3	S	99	15	NO
Teddington AURN	S	99	33	NO
Thurrock 1	U	94	13	NO
Tower Hamlets 1	U	99	27	NO
Wandsworth 2	U	97	6	YES
Westminster AURN	U	96	10	YES
Windsor and Maidenhead 3	RU	22	0	NA

PM_{10}						
Site	**Type**	**Data capture %**	**Annual mean less than 40 µg m^{-3}**	**Annual mean achieved?**	**No more than 35 days where daily mean > = 50 µg m^{-3}**	**Daily mean achieved?**
A3 AURN	R	98	31	YES	20	YES
Barking & Dagenham 2	S	29	26	NA	5	NA
Barnet 1	K	70	27	NA	6	NA
Barnet 2	U	98	24	YES	8	YES
Bexley 1	S	70	23	NA	2	NA
Bexley 2	S	83	23	NA	6	NA
Bexley 2 (FDMS)	S	52	25	NA	12	NA
Bexley 4	I	98	44	NO	105	NO
Bexley 7	R	81	30	NA	20	NA
Bexley 7 (FDMS)	R	75	26	NA	24	NA
Bexley 8	R	98	27	YES	28	YES
Bloomsbury AURN	U	94	26	YES	5	YES
Brent 1	S	83	21	NA	3	NA
Brent 3	R	83	30	NA	17	NA
Brent 4	R	91	43	NO	86	NO
Brent 5	I	96	62	NO	180	NO
Bromley 7	R	62	22	NA	8	NA
Camden 1	K	97	37	YES	54	NO
Camden 3	R	91	34	YES	23	YES
Croydon 3	S	97	24	YES	3	YES
Croydon 4	R	88	29	NA	11	NA
Crystal Palace 1	R	90	28	YES	7	YES
Ealing 2	R	89	29	NA	20	NA
Ealing 2 (FDMS)	R	30	28	NA	11	NA
Ealing 7	U	95	23	YES	5	YES
Ealing 8	I	84	84	NA	230	NO
Elmbridge 1	U	39	20	NA	1	NA
Enfield 2	R	95	21	YES	16	YES
Enfield 3	U	87	22	NA	7	NA
Enfield 4	R	91	31	YES	32	YES
Enfield 5	R	84	31	NA	27	NA
Greenwich 10	R	97	26	YES	9	YES
Greenwich 12 (FDMS)	U	1	15	NA	0	NA
Greenwich 4	S	78	22	NA	4	NA
Greenwich 5	R	97	26	YES	8	YES
Greenwich 7	R	98	30	YES	22	YES
Greenwich 8	R	99	45	NO	120	NO
Greenwich 9 (FDMS)	R	70	26	NA	25	NA
Greenwich Bexley 6	R	98	30	YES	31	YES
Hackney 6	R	92	34	YES	23	YES
Haringey 1	R	95	25	YES	5	YES
Haringey 2	S	95	23	YES	13	YES
Harlington AURN	U	85	25	NA	3	NA
Harrow 1	U	99	20	YES	1	YES
Harrow 2	R	97	29	YES	18	YES
Havering 3	R	95	23	YES	4	YES
Heathrow Airport	U	98	30	YES	24	YES

PM$_{10}$						
Site	**Type**	**Data capture %**	**Annual mean less than 40 $\mu g\ m^{-3}$**	**Annual mean achieved?**	**No more than 35 days where daily mean > = 50 $\mu g\ m^{-3}$**	**Daily mean achieved?**
Hillingdon 1	R	81	28	NA	15	NA
Hillingdon 2	R	85	24	NA	3	NA
Hillingdon 3	R	72	24	NA	3	NA
Hillingdon AURN	S	96	27	YES	10	YES
Hounslow 2	S	94	22	YES	3	YES
Hounslow 4	R	99	30	YES	25	YES
Hounslow 5	R	92	37	YES	56	NO
H'smith and Fulham 1	R	95	36	YES	41	NO
H'smith and Fulham 2	U	97	24	YES	6	YES
H'smith and Fulham 3	K	57	36	NA	30	NA
Islington 1	U	90	24	YES	4	YES
Islington 2	R	98	35	YES	34	YES
Kens and Chelsea 1	U	99	24	YES	6	YES
Kens and Chelsea 1 (FDMS)	U	88	24	NA	19	NA
Kens and Chelsea 1 (partisol)	U	82	29	NA	26	NA
Kens and Chelsea 2	R	97	36	YES	39	NO
Kens and Chelsea 5 (partisol)	K	93	43	NO	81	NO
Lambeth 1	R	90	28	YES	24	YES
Lambeth 3	U	83	23	NA	16	NA
Lambeth 4	K	81	43	NA	78	NO
Lambeth 5	R	68	71	NA	176	NO
Lewisham 2	R	99	30	YES	24	YES
Marylebone Rd	K	96	43	NO	118	NO
Marylebone Rd (FDMS)	K	93	33	YES	39	NO
Marylebone Rd (partisol)	K	87	44	NA	85	NO
Marylebone Road (KFG)	K	85	40	NA	69	NO
Mole Valley 2	S	99	20	YES	1	YES
Mole Valley 3	U	96	22	YES	4	YES
Reading AURN	U	97	21	YES	2	YES
Redbridge 1	U	71	24	NA	14	NA
Redbridge 3	K	67	35	NA	35	NA
Redbridge 4	R	95	32	YES	33	YES
Redbridge 5	R	93	27	YES	21	YES
Reigate and Banstead 1	S	98	22	YES	3	YES
Richmond 1	R	99	26	YES	6	YES
Richmond 2	S	99	22	YES	4	YES
Richmond 21	R	38	26	NA	4	NA
Richmond 23	R	12	22	NA	0	NA
Richmond 25	R	43	26	NA	3	NA
Sevenoaks 2	U	90	20	YES	0	YES

PM_{10}						
Site	Type	Data capture %	Annual mean less than 40 $\mu g\ m^{-3}$	Annual mean achieved?	No more than 35 days where daily mean > = 50 $\mu g\ m^{-3}$	Daily mean achieved?
Sevenoaks 3	R	38	27	NA	5	NA
Southwark 1	U	75	26	NA	2	NA
Southwark 2	R	99	32	YES	26	YES
Sutton 4	K	95	31	YES	14	YES
Sutton 5	I	6	30	NA	1	NA
Thurrock 1	U	94	23	YES	5	YES
Thurrock 3	R	99	26	YES	10	YES
Tower Hamlets 1	U	95	24	YES	7	YES
Tower Hamlets 3	U	86	25	NA	5	NA
Waltham Forest 1	U	86	24	NA	0	NA
Waltham Forest 3	R	77	26	NA	5	NA
Wandsworth 4	R	95	27	YES	16	YES

$PM_{2.5}$		
Site	Data capture %	Annual Mean μgm^{-3}
Bexley 1	99	11
Bexley 2	84	12
Bexley 3	30	12
Bexley 7	94	13
Bexley 8	95	13
Bloomsbury AURN	94	13
Ealing 2	97	15
Greenwich 12	95	19
Greenwich 9	68	18
Greenwich Bexley 6	99	13
Hackney 4	97	14
Kens and Chelsea 1 (partisol)	94	20
Marylebone Rd	97	19
Marylebone Rd (partisol)	83	28

SO_2				
Site	Type	Data Capture %	No more than 35 occurrences of 15 mins mean > = 266 $\mu g\ m^{-3}$	Achieved?
Barking & Dagenham 1	S	84	0	NA
Bexley 1	S	97	0	YES
Bloomsbury AURN	U	94	0	YES
Brent 1	S	95	0	YES
Brent 3	R	85	0	NA
Brent 4	R	85	0	NA
Castle Point 1	U	95	0	YES
City of London 1	U	92	0	YES
Croydon 4	R	86	0	NA
Crystal Palace 1	R	88	0	NA
Ealing 1	U	95	0	YES
Elmbridge 1	U	57	0	NA
Enfield 3	U	87	0	NA
Enfield 4	R	96	0	YES
Greenwich 4	S	94	0	YES
Haringey 1	R	99	0	YES
Harrow 1	U	98	0	YES
Havering 3	R	99	0	YES
Hillingdon	S	96	0	YES
Hounslow 2	S	83	0	NA
Hounslow 4	R	99	0	YES
H'smith and Fulham 1	R	78	0	NA
Kens and Chelsea 1	U	99	0	YES
Kens and Chelsea 2	R	95	0	YES
Lambeth 1	R	64	0	NA
Lambeth 3	U	99	0	YES
Lambeth 4	K	93	1	YES
Lambeth 5	R	53	0	NA
Lewisham 1	U	97	0	YES
Lewisham 2	R	100	0	YES
Marylebone Rd	K	98	0	YES
Reading AURN	U	70	0	NA
Redbridge 4	R	94	0	YES
Richmond 21	R	39	0	NA
Richmond 23	R	11	0	NA
Richmond 25	R	44	0	NA
Sevenoaks 2	U	95	0	YES
Southwark 1	U	98	0	YES
Southwark 2	R	98	0	YES
Teddington AURN	S	99	0	YES
Thurrock 1	U	94	0	YES
Thurrock 3	R	99	0	YES
Tower Hamlets 1	U	99	0	YES
Tower Hamlets 3	U	77	0	NA
Waltham Forest 1	U	87	0	NA
Waltham Forest 3	R	76	0	NA
Wandsworth 2	U	78	0	NA
Westminster AURN	U	95	0	YES

Appendix 4: Air quality strategy objectives

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 $\mu g\ m^{-3}$ (1 ppb)	Running Annual Mean	31 Dec 2010
1, 3 Butadiene	2.25 $\mu g\ m^{-3}$ (1 ppb)	Running Annual Mean	31 Dec 2003
Carbon Monoxide	10 $mg\ m^{-3}$ (8.6 ppb)	Running 8 hour mean	31 Dec 2003
Lead	0.5 $\mu g\ m^{-3}$ 0.25 $\mu g m^{-3}$	Annual Mean Annual Mean	31 Dec 2003 31 Dec 2008
Nitrogen Dioxide (provisional)	200 $\mu g\ m^{-3}$ (105 ppb) not to be exceeded more than 18 times a year	1 hour mean	31 Dec 2005
	40 $\mu g\ m^{-3}$ (21 ppb)	Annual Mean	31 Dec 2005
Particles (PM_{10})	50 $\mu g/m^{-3}$ not to be exceeded more than 35 times a year	24 hour mean	31 Dec 2004
	40 $\mu g\ m^{-3}$	Annual Mean	31 Dec 2004
Sulphur Dioxide	350 $\mu g\ m^{-3}$ (132 ppb) not to be exceeded more than 24 times a year	1 hour mean	31 Dec 2004
	125 $\mu g\ m^{-3}$ (47 ppb) not to be exceeded more than 3 times a year	24 hour mean	31 Dec 2004
	266 $\mu g\ m^{-3}$ (100 ppb) not to be exceeded more than 35 times a year	15 minute mean	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		Date to be achieved by
	Concentration	Measured as	
Objectives for the protection of human health			
Ozone (provisional)	100 $\mu g\ m^{-3}$ (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 $\mu g\ m^{-3}$ (16 ppb)	Annual mean	31 Dec 2000
Sulphur Dioxide	20 $\mu g\ m^{-3}$ (8 ppb)	Annual mean	31 Dec 2000
	20 $\mu g\ m^{-3}$ (8 ppb)	Winter mean (1 Oct-31 March)	31 Dec 2000

DETR 2000a, 2000b.

London Air Quality Network
Environmental Research Group
King's College London
4th Floor
Franklin-Wilkins Building
150 Stamford Street
London SE1 9NH
020 7848 4019
erg@kcl.ac.uk
www.londonair.org.uk

£35