Report

UK air quality modelling for annual reporting 2004 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC

Report to The Department for Environment, Food and Rural Affairs, Welsh Assembly Government, the Scottish Executive and the Department of the Environment for Northern Ireland

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Executive Summary

Directive 96/62/EC on Ambient Air Quality Assessment and Management (the Framework Directive) establishes a framework under which the EU sets limit values or target values for the concentrations of specified air pollutants. Directive 1999/30/EC (the first Daughter Directive) sets the limit values to be achieved for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particles and lead. Directive 2000/69/EC (the second Daughter Directive) set limits to be achieved for benzene and carbon monoxide. Directive 2002/3/EC (the third daughter directive) sets targets and long term objectives to be achieved for ozone.

2004 is the forth year for which an annual air quality assessment for the first Daughter Directive pollutants is required and the second year for which an annual air quality assessment has been undertaken for the second Daughter Directive pollutants. 2004 is the first year for which an annual air quality assessment has been undertaken for the third Daughter Directive. A questionnaire has been completed for submission to the EU containing the results of this air quality assessment. The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the limit values set out in the Directives. Air quality modelling has been carried out to supplement the information available from the UK national air quality monitoring networks.

The accompanying technical report (Bush et al, 2005) contains a summary of key results from the questionnaire for ozone (covered by the third daughter directive) and additional technical information on the modelling methods that have been used to assess ozone concentrations throughout the UK.

This report provides a summary of key results from the questionnaire for pollutants included in the first and second daughter directives and additional technical information on the modelling methods that have been used to assess SO_2, NO_2 and NO_x, PM_{10}, benzene and CO concentrations throughout the UK. This includes:

- Details of modelling methods where they differ from modelling methods used in 2003
- Information on the verification of the models used and comparisons with data quality objectives
- Detailed modelling results and comparison with limit values.

Maps of background concentrations of SO_2, NO_2, PM_{10}, benzene and CO in 2004 on a 1 km x 1 km grid have been prepared. Maps of roadside concentrations of NO_2, PM_{10}, benzene and CO have been prepared for a total of 9937 urban major road links (A-roads and motorways) across the UK.

The dominant contributions to measured SO_2 concentrations in the UK are typically from major point sources such as power stations and refineries, particularly in terms of high percentile concentrations. Emissions of SO_2 from point sources were therefore modelled in some detail. Area sources have been modelled using a dispersion kernel approach. For NO_2, NO_x, PM_{10}, benzene and CO there are also important contributions to ambient concentrations from area sources, particularly traffic; therefore a slightly different modelling approach has been adopted. The area source contribution has been modelled using a kernel-based area source model, which has been calibrated empirically using measurement data. Roadside concentrations of NO_2, NO_x, PM_{10}, benzene and CO have been estimated by adding a roadside increment to the modelled background concentrations. This roadside increment has been calculated using road link emission estimates and dispersion coefficients derived empirically from roadside monitoring data.

The UK has been divided into 43 zones for air quality assessment. There are 28 agglomeration zones (large urban areas) and 15 non-agglomeration zones. The status of the zones in relation to the limit values for all of the first and second Daughter Directive pollutants have been listed and reported to the EU in the questionnaire. The status has been determined from a combination of monitoring data and model results. The results of this assessment are summarised in Table E1 in terms of exceedences of limit values + margins of tolerance (LV + MOT) and limit values (LV). Table E2 contains details of exceedences of old directives.

Table E1 Summary results of air quality assessment for 2004

Pollutant	Averaging time	Number of zones exceeding limit value + margin of tolerance	Number of zones exceeding limit value[1]
SO_2	1-hour	1 zone modelled (Eastern)	1 zone modelled (Eastern)
SO_2	24-hour[2]	none	none
SO_2	annual[3]	n/a	none
SO_2	winter[3]	n/a	none
NO_2	1-hour[4]	1 zone measured (Greater London Urban Area)	1 zone measured (Greater London Urban Area)
NO_2	annual	34 zones (6 measured + 28 modelled)	39 zones (9 measured + 30 modelled)
NO_x	annual[3]	n/a	none
PM_{10}	24-hour (Stage 1)	19 zones (1 measured + 18 modelled)	27 zones (2 measured + 25 modelled)
PM_{10}	Annual (Stage 1)	1 zone modelled (Greater London Urban Area)	2 zones (1 measured, London + 1 modelled, West Midlands Urban Area)
PM_{10}	24-hour[5] (Stage 2)	n/a	15 zones (15 measured)
PM_{10}	annual[6] (Stage 2)	32 zones (3 measured + 29 modelled)	41 zones (26 measured + 15 modelled)
Lead	annual	none	none
Benzene	annual	none	none
CO	8-hour	none	none

[1] Includes zones exceeding LV + MOT
[2] No MOT defined, LV + MOT = LV
[3] No MOT defined for vegetation and ecosystem LVs, which are already in force
[4] No modelling for 1-hour LV
[5] Stage 2 indicative LV, no MOT defined for 24-hour stage 2 LV, no modelling for 24-hour stage 2 LV
[6] Stage 2 indicative LV

Table E2. Exceedences of old Directives

Pollutant	Directive	Averaging time	Concentration ($\mu g\ m^{-3}$)
NO_2	85/203/EEC	1-hour 98%ile	233 (measured at London Marylebone Road)

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Appendices

1 Introduction

1.1 THE FRAMEWORK AND FIRST AND SECOND DAUGHTER DIRECTIVES

Directive 96/62/EC on Ambient Air Quality Assessment and Management (the Framework Directive (Council Directive 96/62/EC)) establishes a framework under which the EU sets limit values or target values for the concentrations of specified air pollutants in ambient air. Directive 1999/30/EC (the first Daughter Directive, AQDD1 (Council Directive 1999/30/EC)) sets the limit values to be achieved for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particles and lead. Directive 2000/69/EC (the second Daughter Directive, AQDD2) sets out the limit values to be achieved for benzene and carbon monoxide. Directive 2002/3/EC (the third Daughter Directive, AQDD3) sets target values and long-term objectives to be achieved for ozone.

Air quality modelling has been carried out to supplement the information available from the UK national air quality monitoring networks and contribute to the assessments required by the Framework and subsequent Daughter Directives as discussed in Stedman et al (2005).

1.2 THIS REPORT

The first and second Daughter Directives make provision for an annual air quality assessment for SO_2, NO_x, NO_2, PM_{10}, benzene and CO. 2004 is the first year for which an annual air quality assessment is required for ozone as specified in the third Daughter Directive. This report provides a summary of key results from the questionnaire for SO_2, NO_x, NO_2, PM_{10}, benzene and CO and additional information on the modelling methods that have been used to assess concentrations throughout the UK. Where modelling methods have remained unchanged from the methods used in the 2003 annual assessment as described in Stedman et al (2005), reference has been made to this report and only changes in the method are described in detail.

Sections 2 to 6 describe the modelling methods used for estimation of SO_2, NO_2, PM_{10}, benzene and CO. These include:

- Details of changes to modelling methods from the 2003 modelling described in Stedman et al (2005)
- Information on the verification of the models used and comparisons with data quality objectives
- Detailed modelling results.

The ozone air quality assessment is covered in a separate technical report (Bush et al, 2005)

The status of zones in relation to the limit values for the AQDD1 and AQDD2 pollutants have been listed and reported to the EU in the questionnaire and copies of these lists are included in Section 7. The status has been determined from a combination of monitoring data and model results. Section 7 also includes a comparison of the results of similar assessments carried out for the calendar years 2003, 2002 and 2001 (Stedman et al, 2005, Stedman et al, 2003, Stedman et al, 2002).

1.3 PRELIMINARY ASSESSMENTS AND DEFINITION OF ZONES

The preliminary assessment carried out for AQDD1 (Bush, 2000) defined a set of zones to be used for air quality assessment in the UK. The boundaries of some zones and agglomerations have been modified for the 2004 reporting based on 2001 census and urban area data. The updated zones and agglomerations map for the UK is presented in figure 1.1. Table 1.1 contains details of area, population and urban road length contained in each zone and agglomeration

Figure 1.1. UK zones and agglomerations for 2004

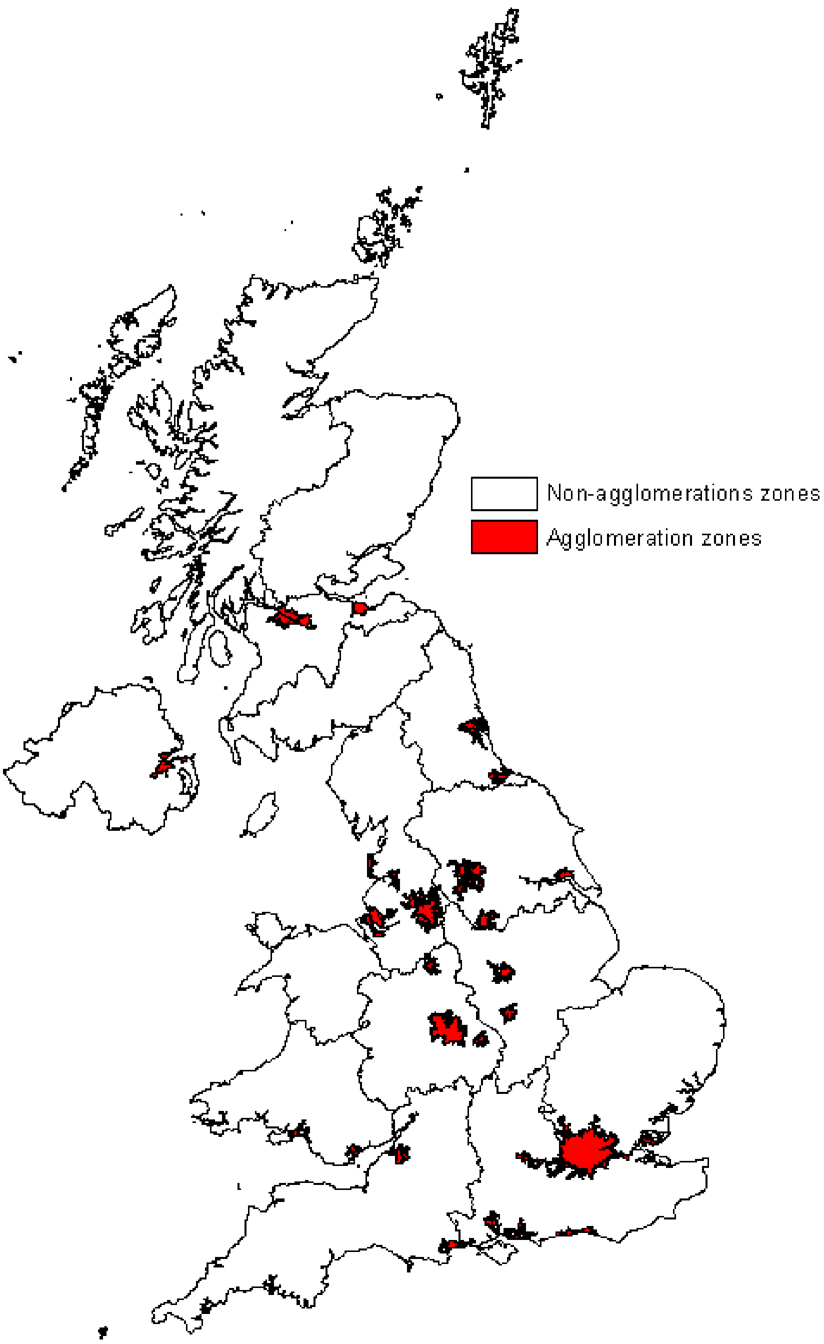


Table 1.1 Zones for AQDD1 reporting

Zone	Zone code	Ag or nonag*	Population	Area (km^2)	Number of urban road links	Length of urban road links (km)
Greater London Urban Area	UK0001	ag	8278251	1628	2016	1890.1
West Midlands Urban Area	UK0002	ag	2284093	594	400	565.4
Greater Manchester Urban Area	UK0003	ag	2244931	557	567	664.7
West Yorkshire Urban Area	UK0004	ag	1499465	363	288	424.1
Tyneside	UK0005	ag	879996	217	176	210.0
Liverpool Urban Area	UK0006	ag	816216	184	271	215.3
Sheffield Urban Area	UK0007	ag	640720	165	112	158.1
Nottingham Urban Area	UK0008	ag	666358	169	131	136.3
Bristol Urban Area	UK0009	ag	551066	142	122	118.6
Brighton/Worthing/Littlehampton	UK0010	ag	461181	97	54	84.3
Leicester Urban Area	UK0011	ag	441213	102	71	92.8
Portsmouth Urban Area	UK0012	ag	442252	91	52	72.6
Teesside Urban Area	UK0013	ag	365323	111	59	74.1
The Potteries	UK0014	ag	362403	91	109	123.8
Bournemouth Urban Area	UK0015	ag	383713	113	54	71.2
Reading/Wokingham Urban Area	UK0016	ag	369804	97	70	84.4
Coventry/Bedworth	UK0017	ag	336452	76	31	34.9
Kingston upon Hull	UK0018	ag	301416	80	40	52.3
Southampton Urban Area	UK0019	ag	304400	77	57	65.1
Birkenhead Urban Area	UK0020	ag	319675	88	65	63.9
Southend Urban Area	UK0021	ag	269415	64	33	49.8
Blackpool Urban Area	UK0022	ag	261088	63	49	65.7
Preston Urban Area	UK0023	ag	264601	58	35	45.8
Glasgow Urban Area	UK0024	ag	1168270	366	190	301.5
Edinburgh Urban Area	UK0025	ag	452194	117	61	103.2
Cardiff Urban Area	UK0026	ag	327706	72	42	53.1
Swansea Urban Area	UK0027	ag	270506	84	30	68.3
Belfast Metropolitan Urban Area	UK0028	ag	580276	193	29	244.2
Eastern	UK0029	nonag	4850132	19113	628	897.2
South West	UK0030	nonag	3980991	23506	473	678.2
South East	UK0031	nonag	6016677	18645	885	1354.8
East Midlands	UK0032	nonag	3084598	15491	413	658.2
North West & Merseyside	UK0033	nonag	2826622	13149	574	976.4
Yorkshire & Humberside	UK0034	nonag	2514947	14787	357	709.6
West Midlands	UK0035	nonag	2271650	12192	360	559.2
North East	UK0036	nonag	1269803	8282	205	271.1
Central Scotland	UK0037	nonag	1813314	9305	223	346.6
North East Scotland	UK0038	nonag	1001499	18587	137	233.5
Highland	UK0039	nonag	380062	38269	11	34.5
Scottish Borders	UK0040	nonag	254690	11145	37	58.5
South Wales	UK0041	nonag	1578773	12221	214	367.1
North Wales	UK0042	nonag	720022	8368	80	152.1
Northern Ireland	UK0043	nonag	1104991	13579	126	787.0
Total			59211755	242698	9937	14217.6

* ag = agglomeration zone, nonag = non-agglomeration zone

1.4 MONITORING SITES

The monitoring stations operating during 2004 for the purpose of AQDD1 and AQDD2 are listed in Table A1.1 in Appendix 1. This information is included in form 3 of the questionnaire. Not all sites had sufficient data capture during 2003 for data to be reported. The data quality objective (DQO) for AQDD1 and AQDD2 measurements is 90 % data capture. We have, however, included all measurements with at least 75 % data capture in the analysis in order to ensure that we can make maximum use of data from the monitoring sites operational during 2004 for reporting purposes. Table A1.2 in Appendix 1 lists the data capture for sites operational during 2004.

1.5 LIMIT VALUES AND MARGINS OF TOLERANCE

The limit values (LV) and limit values + margins of tolerance (LV + MOT) included in AQDD1 and AQDD2 are listed in Tables 1.2 to 1.7. Stage 1 limit values for achievement by 2005 and indicative stage 2 limit values for achievement by 2010 have been set for PM_{10}. The limit value + margin of tolerance varies from year to year from the date the Directives came into force until the date by which the limit value is to be met. Values for 2004 are listed in Tables 1.2 to 1.7. Where no margin of tolerance has been defined the limit value + margin of tolerance is effectively the same as the limit value. There are no margins of tolerance for the ecosystem and vegetation limit values because these limit values are already in force. The stage 2 annual mean limit value + margin of tolerance for PM_{10} is 30 $\mu g\ m^{-3}$ from 2001 until 2005.

All exceedences of the limit value must be reported to the EU. Exceedences of the limit value + margin of tolerance (or limit value if no limit value + margin of tolerance has been set) also must be reported to the EU and trigger a requirement for the preparation of a 'plan and programme' for attaining the limit value within the specified time limit specified by the relevant Directive and a report to the EU on this 'plan and programme'.

Table 1.2. Limit values for SO_2

	Averaging period	**LV**	**LV + MOT 2004**	**Date by which LV is to be met**
1. Hourly LV for the protection of human health	1 hour	350 $\mu g\ m^{-3}$, not to be exceeded more than 24 times a calendar year	380 $\mu g\ m^{-3}$, not to be exceeded more than 24 times a calendar year	1 January 2005
2. Daily LV for the protection of human health	24 hour	125 $\mu g\ m^{-3}$, not to be exceeded more than 3 times a calendar year	N/A	1 January 2005
3. LV for the protection of ecosystems	Calendar year and winter	20 $\mu g\ m^{-3}$	N/A	19 July 2001

Table 1.3. Limit values for NO_2 and NO_x

	Averaging period	**LV**	**LV + MOT 2004**	**Date by which LV is to be met**
1. Hourly LV for the protection of human health	1 hour	200 $\mu g\ m^{-3}$ NO_2 not to be exceeded more	260 $\mu g\ m^{-3}$, NO_2 not to be exceeded more	1 January 2010

		than 18 times a calendar year	than 18 times a calendar year	
2. Annual LV for the protection of human health	Calendar year	40 μg m^{-3} NO_2	52 μg m^{-3}, NO_2	1 January 2010
3. LV for the protection of vegetation	Calendar year	30 μg m^{-3} NO_x, as NO_2	N/A	19 July 2001

Table 1.4a. Limit values for PM_{10} (Stage 1)

	Averaging period	LV	LV + MOT 2004	Date by which LV is to be met
1. 24-hour LV for the protection of human health	24 hour	50 μg m^{-3} not to be exceeded more than 35 times a calendar year	55 μg m^{-3} not to be exceeded more than 35 times a calendar year	1 January 2005
2. Annual LV for the protection of human health	Calendar year	40 μg m^{-3}	42 μg m^{-3}	1 January 2005

Table 1.4b. Indicative limit values for PM_{10} (Stage 2)

	Averaging period	LV	LV + MOT 2004	Date by which LV is to be met
1. 24-hour LV for the protection of human health	24 hour	50 μg m^{-3} not to be exceeded more than 7 times a calendar year	N/A	1 January 2010
2. Annual LV for the protection of human health	Calendar year	20 μg m^{-3}	30 μg m^{-3}	1 January 2010

Table 1.5. Limit values for lead

	Averaging period	LV	LV + MOT 2004	Date by which LV is to be met
Annual LV for the protection of human health	Calendar year	0.5 μg m^{-3}	0.6 μg m^{-3}	1 January 2005

Table 1.6. Limit values for benzene

	Averaging period	LV	LV + MOT 2004	Date by which LV is to be met
Annual LV for the protection of human health	Calendar year	5 $\mu g\ m^{-3}$	10 $\mu g\ m^{-3}$	1 January 2010

Table 1.7. Limit values for CO

	Averaging period	LV	LV + MOT 2004	Date by which LV is to be met
8-hour LV for the protection of human health	Maximum daily 8-hour mean	10 $mg\ m^{-3}$	12 $mg\ m^{-3}$	1 January 2005

1.6 DATA QUALITY OBJECTIVES FOR MODELLING RESULTS AND MODEL VERIFICATION

A description of data quality objectives set in AQDD1 and how assessment of success in meeting these objectives has been carried out for 2003 is given in Stedman et al (2005). For 2004 reporting, a similar method has been followed. Details of verification sites (i.e. sites only used in the verification process and not in calibrating the model) are given in Appendix 2.

1.7 AIR QUALITY MODELLING

The approaches to modelling SO_2, NO_2, NO_x, benzene and CO for 2004 closely follow the methods for the 2003 modelling set out in Stedman et al (2005). This report describes the main changes to these methods for the 2004 modelling. Emissions estimates used in calculating pollutant concentrations have been taken from the National Atmospheric Emissions Inventory (Dore et al, 2004).

The dominant contributions to measured SO_2 concentrations in the UK are typically from major point sources such as power stations and refineries, particularly in terms of high percentile concentrations. Emissions of SO_2 from point sources were therefore modelled in some detail. Area sources have been modelled using a dispersion kernel approach. For NO_2, NO_x, PM_{10}, benzene and CO there are also important contributions to ambient concentrations from area sources, particularly traffic, therefore a slightly different modelling approach has been adopted. The area source contribution has been modelled using a kernel-based area source model, which has been calibrated empirically using measurement data. Roadside concentrations of NO_2, NO_x, PM_{10}, benzene and CO have been estimated by adding a roadside increment to the modelled background concentrations. This roadside increment has been calculated using road link emission estimates and dispersion coefficients derived empirically from roadside monitoring data.

The method for modelling PM_{10} has been significantly revised from the 2003 mapping. A more detailed description of this method is given in section 4. The method used for the calibration of maps for comparison with the ecosystem and vegetation limit values has also been revised and is described in the relevant sections.

2 SO_2

2.1 INTRODUCTION

Maps of annual mean, winter mean, 99.73 percentile of hourly mean SO_2 concentrations and 99.18 percentile of daily mean SO_2 concentrations have been calculated using methods based on those described by Abbott and Vincent (1999). The percentile concentrations presented here correspond to the number of allowed exceedences of the 1-hour and 24-hour limit values for SO_2. Emissions from point and area sources have been modelled separately. Emissions from larger point sources were modelled explicitly using the dispersion model ADMS 3.2. Emissions from smaller point sources and area sources were modelled using 1 km x 1 km emission grids and a dispersion kernel approach. The large and small point source modelling procedure is detailed in Stedman et al 2004. Emissions profiles for the power stations in England and Wales were provided by the Environment Agency. These profiles are used in modelling work undertaken by the power station operators as part of their requirements air quality management responsiblities. The emission profiles are derived using procedures agreed by the power generators and the Environment Agency.

The emissions from the point sources are modelled using the randomising feature within the 10^{o} wind sectors. This removes the pronounced "frills" at significant distances from the emission sources that were apparent in last year's report.

Emissions from point sources for 2004 were obtained from the Environment Agency. Area emissions were based on the 2003 NAEI emissions scaled to 2004 by linearly interpolating between 2003 emissions and 2005 projected emissions.

A number of receptor areas were defined, which together covered the UK. Each receptor area was 150 km x 150 km. For larger point sources (sources with emissions ≥500 tonnes per year) all sources within the receptor area and sources in the adjoining 150 km x 150 km squares were assumed to influence concentrations within the receptor area. Concentrations were calculated on a regular 5 km x 5 km grid using ADMS 3.2 and sequential meteorological data for 2004 from Waddington. This approach ensures that the combined impact of several sources on ambient high percentile concentrations is estimated correctly (it is not possible to add together the percentiles from different sources at an individual receptor because the percentiles are unlikely to correspond to the same hour of the year).

The contribution to ambient annual mean SO_2 concentration from emissions from small point sources and area sources were calculated using dispersion kernel based models (Stedman et al, 2005).

The contributions to annual mean and high percentile concentrations from the different sources were then summed and calibrated as described below. The map of winter mean SO_2 concentrations was derived from the annual mean map using a factor of 1.32, the averge ratio between the 2003-2004 winter means and 2004 annual means measured at Rural SO_2 monitoring sites.

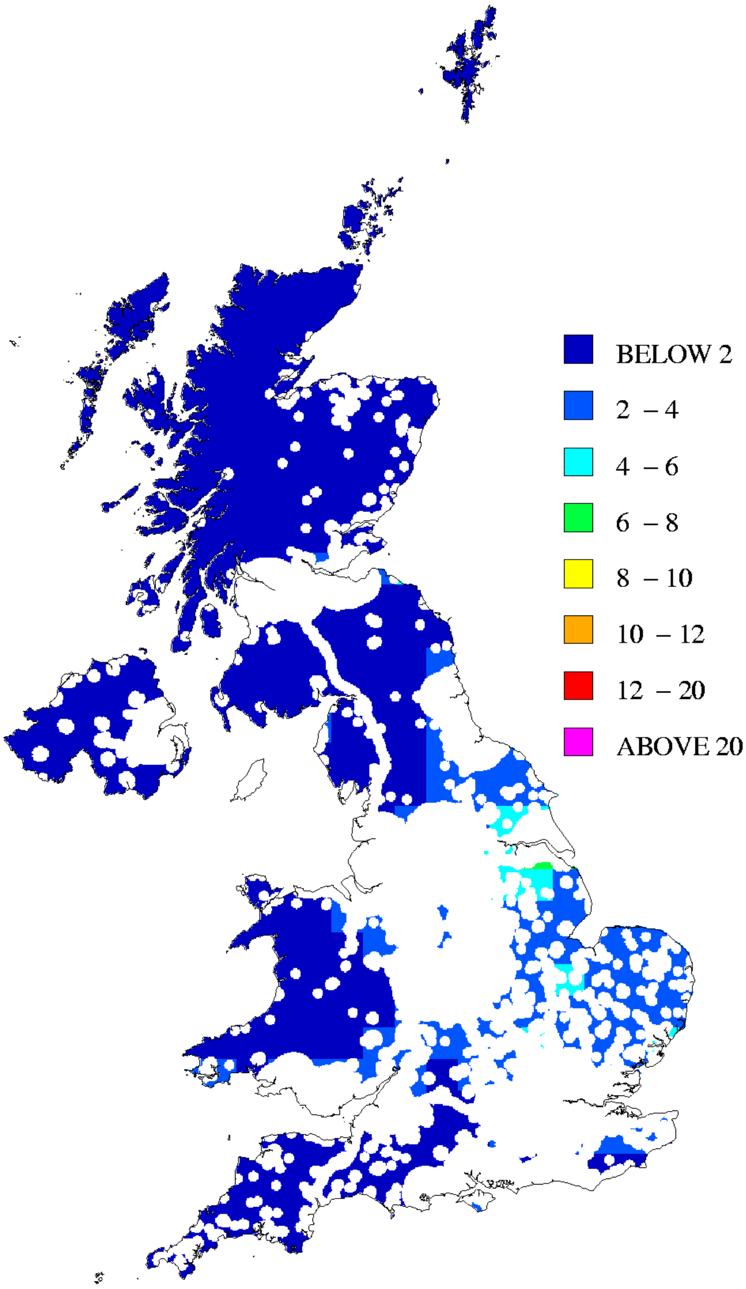
A different method was used to calculate the high percentile concentrations in Northern Ireland, where the dominant source for peak SO_2 concentrations is domestic emissions (see section 3.2).

2.2 MAPS OF WINTER AND ANNUAL MEAN CONCENTRATIONS

A map of annual mean SO_2 concentration for 2004 in ecosystem areas is shown in Figure 2.1.

This map has been calculated by removing non-vegetation areas from the background SO_2 map and calculating the zonal mean of the 1 km^2 grid squares for a 30km^2 grid. Mean concentrations on a 30 km^2 grid have been used to prevent the influence of any urban area appearing unrealistically large on adjacent vegetation areas. Thus the modelled concentrations in vegetation areas should be representative of approximately 1000km^2 as specified in Directive 1999/30/EC for monitoring sites used to assess concentrations for the vegetation limit value.

Figure 2.1. Annual mean SO_2 concentration, 2004 ($\mu g\ m^{-3}$) in ecosystem areas



Measured annual mean SO_2 concentrations were used to calibrate the annual mean SO_2 model output, as described in Stedman et al, 2005. The only calibration that took place was the generation of bias adjustment factors. These are derived by regression analysis. These factors are shown in Table 2.1.

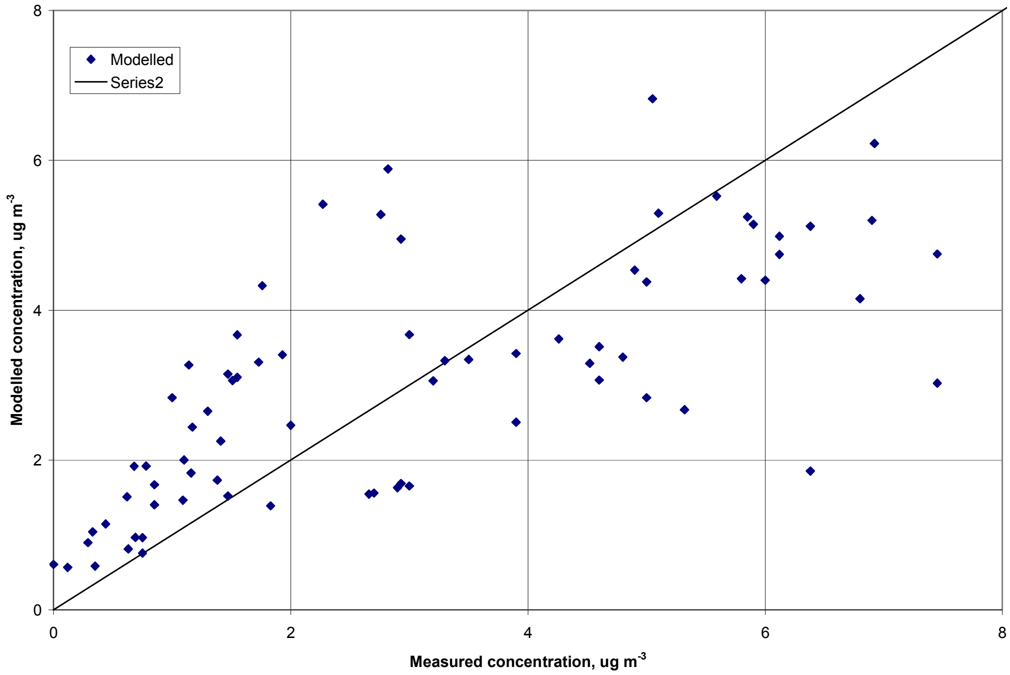
Table 2.1 Calibration coefficients for annual mean model

	Points coefficient	Area coefficient	Constant $\mu g\ m^{-3}$
Annual mean	0.80	1	0.55

Measured concentrations from Rural SO_2 Monitoring Network sites (Lawrence, *pers comm*, 2005), rural, suburban and industrial sites in the national automatic monitoring networks and rural automatic monitoring sites maintained by the electricity generating companies were used to calibrate the model. A list of the sites maintained by the electricity generating companies is included in Appendix 2. The calibration plot for 2004 is shown in Figure 2.2. Linear regression analysis of modelled and measured concentrations at rural monitoring sites was carried out to establish the values of the coefficient and constant in the following equation:

Annual average = Modelled Area and Small Point Sources + 0.80 × Modelled Part A + 0.55

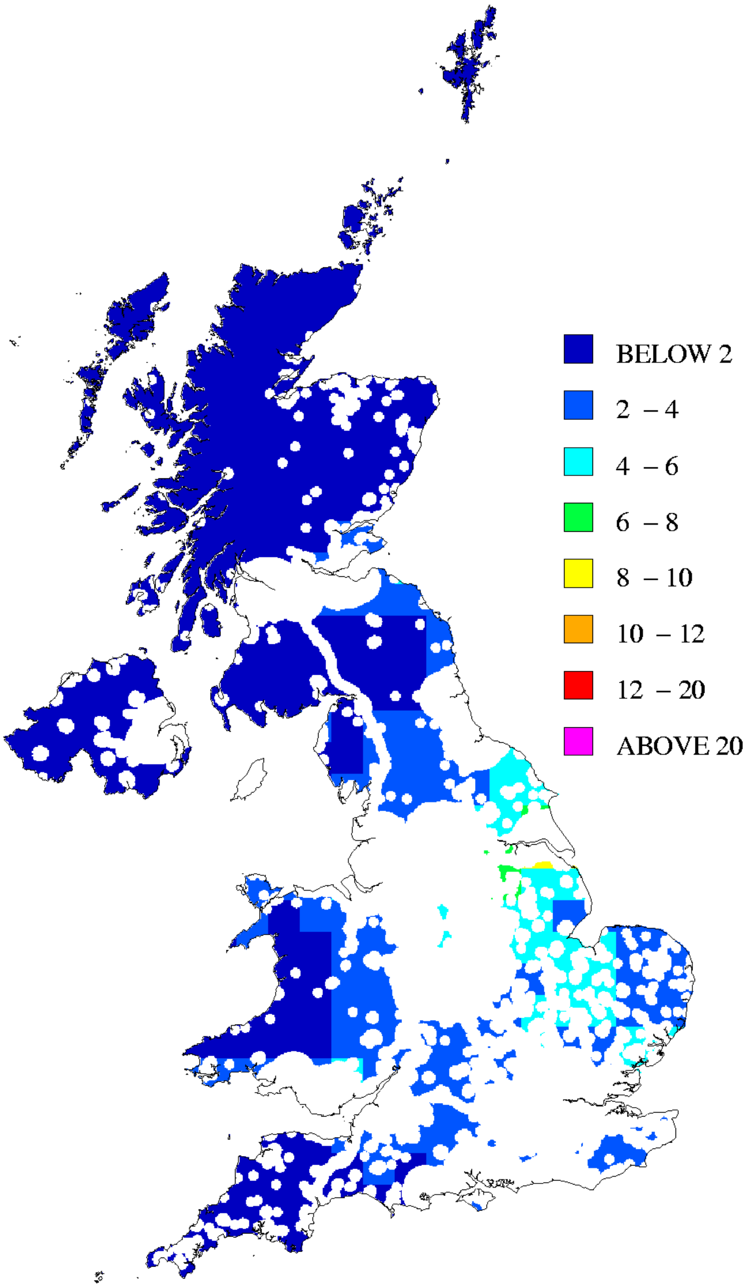
Figure 2.2. Calibration plot for 2004 annual mean SO_2 concentration



The 2004 maps do not include a spatially varying residual component. In previous studies (Stedman et al, 2005 and earlier) this residual component was derived by subtraction of the modelled concentration from concentrations measured at the sampling sites and then interpolating onto a 1 km grid. For previous years, the final modelled concentration at the sampling sites was consequently equal to exactly the measured concentration. However, this introduced additional uncertainty at increasing distance from the sampling site, the new approach is therefore a more robust modelling methodology.

A map of winter mean SO_2 concentrations for the period October 2003 to March 2004 has also been calculated and is shown in Figure 2.3. This map was calculated by multiplying the annual mean map for 2004 by 1.32, the average ratio between the 2003-2004 winter means and 2004 annual means measured at Rural SO_2 monitoring sites.

Figure 2.3. Winter mean SO_2 concentration, 2002-2003 ($\mu g\ m^{-3}$) in ecosystem areas



2.3 MAPS OF PERCENTILE CONCENTRATIONS FOR COMPARISON WITH THE 1-HOUR AND 24-HOUR LIMIT VALUES

Maps of 99.73 percentile of 1-hour mean and 99.18 percentile of 24-hour mean SO_2 concentration in 2004 are shown in Figures 2.4 and 2.5 and were calculated for comparison with the 1-hour and 24-hour limit values for SO_2.

Figure 2.4. 99.73 percentile of 1-hour mean SO_2 concentration, 2004 ($\mu g\ m^{-3}$)

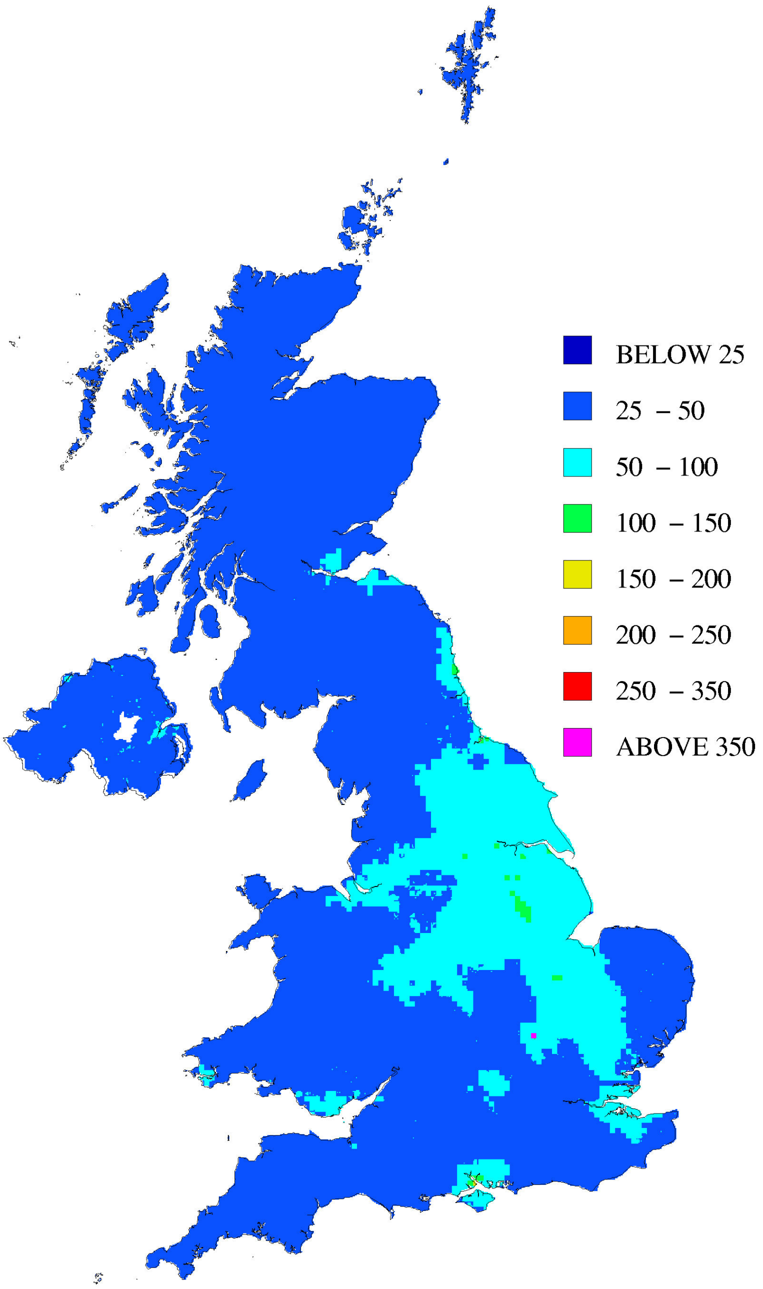
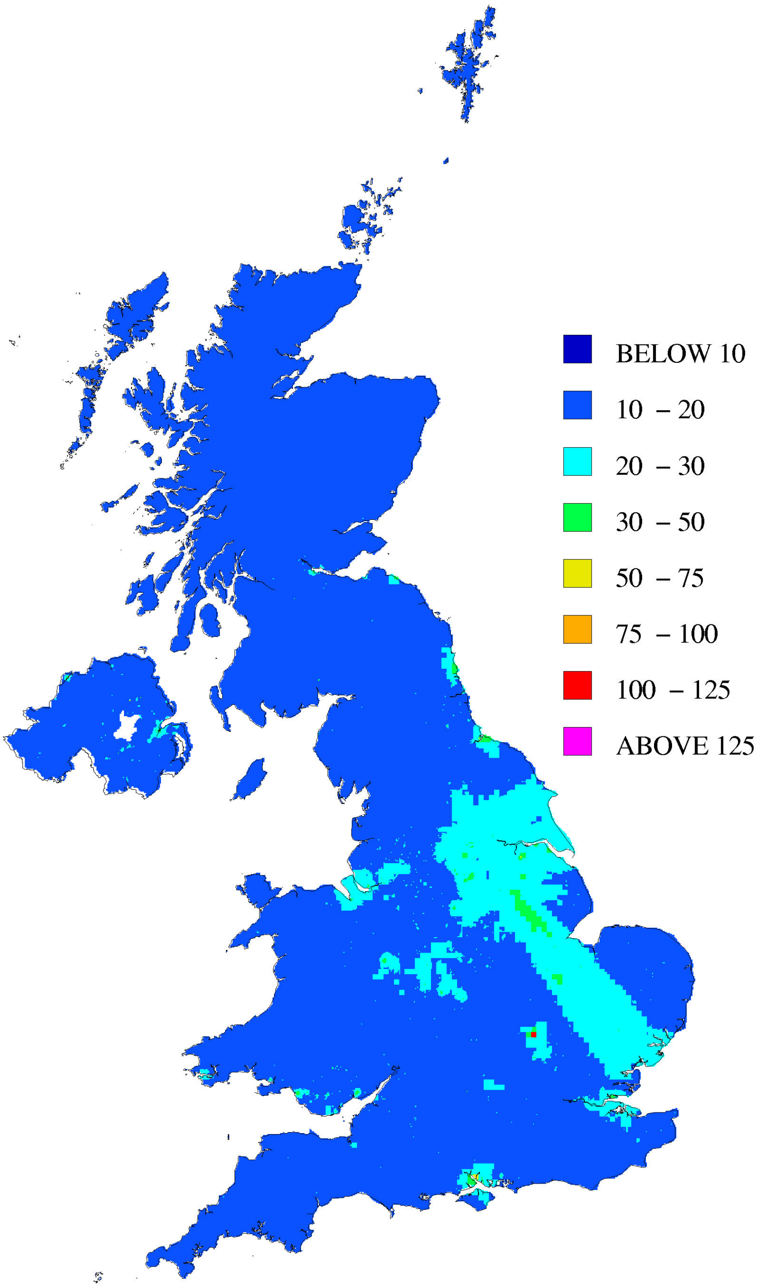


Figure 2.5. 99.18 percentile of 24-hour mean SO_2 concentration, 2004 ($\mu g\ m^{-3}$)



Measured concentrations from the national automatic monitoring networks and rural automatic monitoring sites maintained by the electricity generating companies were used to calibrate the percentile models, as described in Stedman et al, 2005. The calibration plots for the 99.73 percentile of hourly mean concentrations and 99.18 percentile of daily means are presented in Figures 2.6 and 2.7, respectively. The only calibration that took place was the generation of bias adjustment factors. These are derived by regression analysis. These factors are shown in Table 2.2.

Table 2.2 Calibration coefficients for percentile models

Metric	Points coefficient	Area coefficient	Constant $\mu g\ m^{-3}$
P9918	0.61	1	11.25
P9973	0.58	1	25.63

Figure 2.6. Calibration plot for 2004 99.73 percentile of 1-hour mean SO_2 concentrations

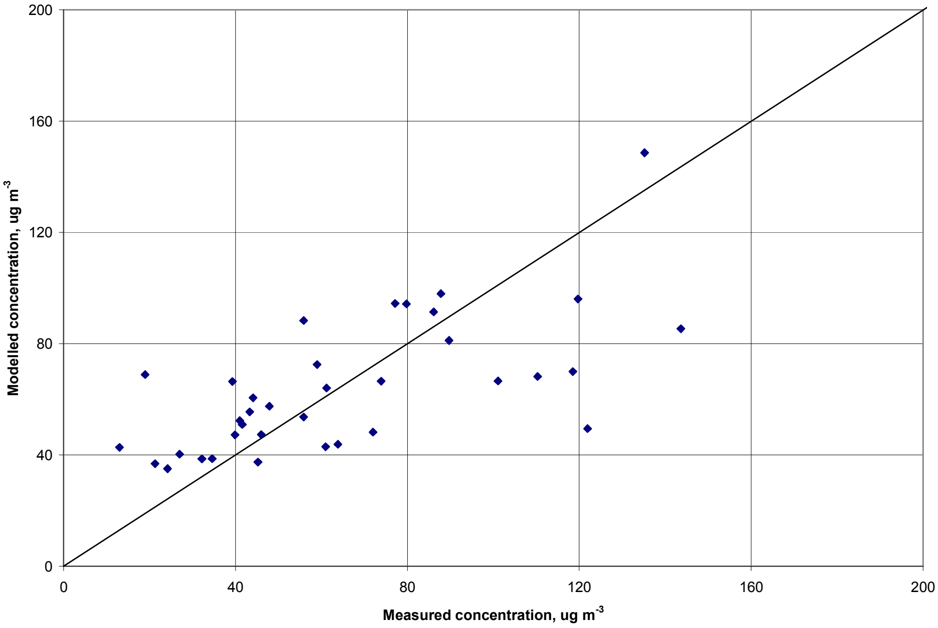
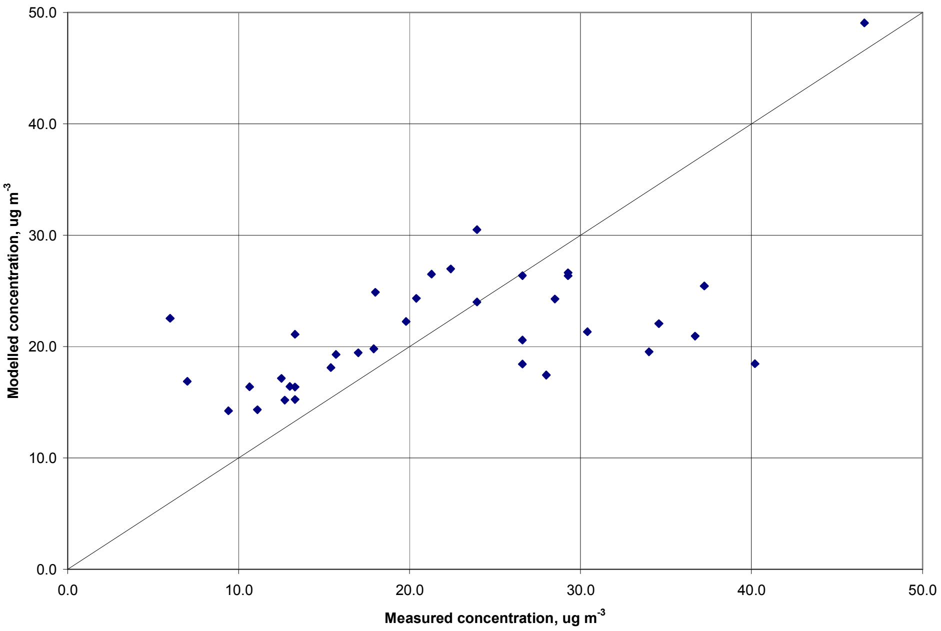


Figure 2.7. Calibration plot for 2004 99.18 percentile of 24-hour mean SO_2 concentrations



An alternative method was used to predict the high percentile concentrations in Northern Ireland from the annual mean map and is described in detail in Stedman et al, 2005. This was required because area sources, predominately emissions from domestic coal fires, make a more significant contribution to observed high percentile concentrations in Northern Ireland than in the rest of the United Kingdom. Conversely, the smaller number of point sources in Northern Ireland means that these sources make a smaller contribution to the observed high percentile concentrations.

The equations used to derive the high percentile maps are:

Predicted 99.73 %ile in Northern Ireland = 2.3 × Modelled Annual Mean + 40.9

Predicted 99.18 %ile in Northern Ireland = 1.9 × Modelled Annual Mean + 13.17

2.4 VERIFICATION OF MAPPED VALUES

Figures 2.8, 2.9 and 2.10 show comparisons of modelled and measured annual mean, 99.73 percentile of 1-hour means and 99.18 percentile of 24-hour means SO_2 concentrations in 2004 at monitoring site locations in the UK. Both the national network sites used to calibrate the models and the verification sites are shown. The 'calibration sites' include the electricity generating company sites and selected AURN sites. Urban background, centre and roadside AURN sites not used in the calibration process are also presented along with 'verification sites' that include ad-hoc monitoring sites and netcen's Calibration Club monitoring sites. A complete list of the AURN sites used are presented in Table A1.1 in the Appendices. Details of verification sites are presented in Table A2.1 and the sites maintained by the electricity generating companies are listed in Table A2.2. Lines representing y = x – 30 % and y = x + 30% and y = x – 50 % and y = x + 50% are also shown (the AQDD1 data quality objective for modelled annual mean and percentile SO_2 concentrations respectively).

Figure 2.8. Verification of annual mean SO_2 model 2004

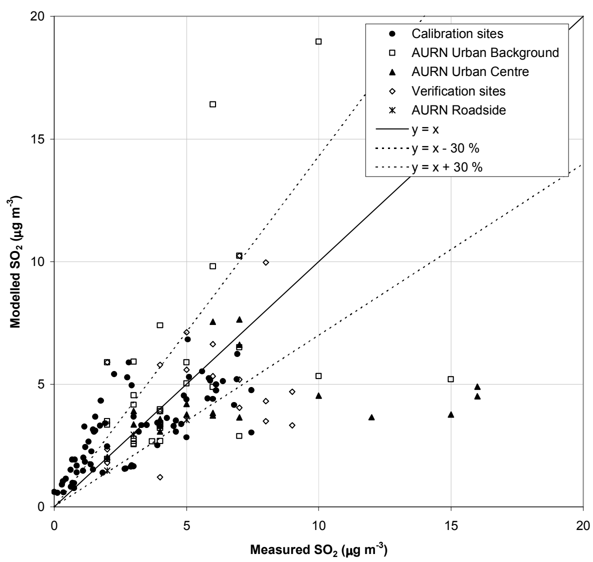


Figure 2.9. Verification of 99.73 percentile of 1-hour mean SO_2 model 2004

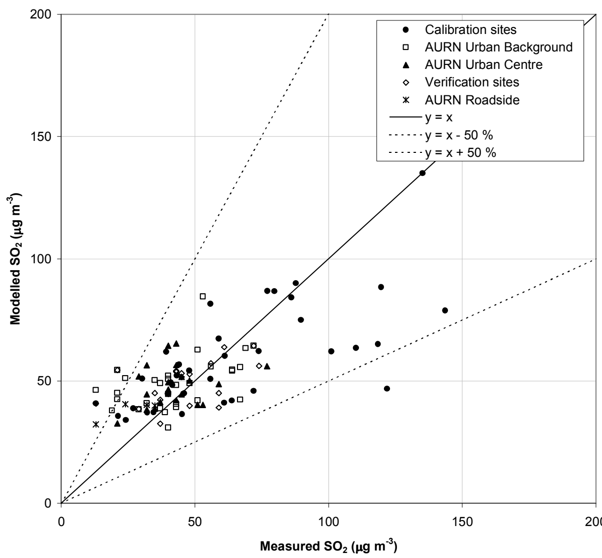
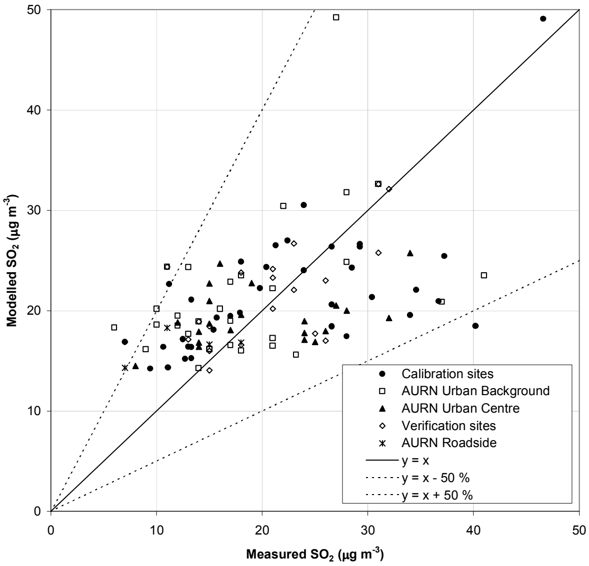


Figure 2.10. Verification of 99.18 percentile of 24-hour mean SO_2 model 2004



The agreement between modelled and measured high percentile SO_2 concentrations is much better than for annual means. Summary statistics for the comparison between modelled and measured SO_2 concentrations and the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Tables 2.3, 2.4 and 2.5.

Table 2.3. Summary statistics for comparison between modelled and measured annual mean concentrations of SO_2 at background sites

	Mean of measurements (µg m^{-3})	Mean of model estimates (µg m^{-3})	r^2	% of sites outside DQO of ±30%	Number of sites
National Network	3.8	3.6	0.23	34%	96[a]
Verification Sites	5.5	4.8	0.14	55%	20

a. includes measurement data from sites in Defra's AURN and Rural Acid Rain Monitoring Network

Table 2.4 Summary statistics for comparison between modelled and measured 99.73 percentile of 1-hour mean concentrations of SO_2 at background sites

	Mean of measurements (µg m^{-3})	Mean of model estimates (µg m^{-3})	r^2	% of sites outside DQO of ±50%	Number of sites
National Network	41.5	45.5	0.21	11%	61[b]
Verification Sites	45.4	49.2	0.42	10%	20

b. includes measurement data from sites in Defra's AURN only

Table 2.5 Summary statistics for comparison between modelled and measured 99.18 percentile of 24-hour mean concentrations of SO_2 at background sites

	Mean of measurements ($\mu g\ m^{-3}$)	Mean of model estimates ($\mu g\ m^{-3}$)	r^2	% of sites outside DQO of ±50%	Number of sites
National Network	18.5	19.1	0.14	8%	61[b]
Verification Sites	20.3	21.5	0.42	10%	20

b. includes measurement data from sites in Defra's AURN only

2.5 DETAILED COMPARISON OF MODELLING RESULTS WITH LIMIT VALUES

The modelling results, in terms of a comparison of modelled concentrations with the hourly and daily limit value for each zone, are summarised in Table 2.6. These data have also been presented in form 19a of the questionnaire. The SO_2 annual and winter mean limit value for the protection of ecosystems was not exceeded in ecosystem areas in any of the non-agglomeration zones in 2004. This limit value does not apply in agglomeration zones, according to the definition in the Directive (see Section 1.3). Method A in Table 2.6 refers to the modelling method described in this report.

Table 2.6 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

Zone	*Zone code*	*Above LV for health (1hr mean)*				*Above LV for health (24hr mean)*			
		Area		*Population exposed*		*Area*		*Population exposed*	
		km^2	*Method*	*Number*	*Method*	*km^2*	*Method*	*Number*	*Method*
Greater London Urban Area	UK0001	0	A	0	A	0	A	0	A
West Midlands Urban Area	UK0002	0	A	0	A	0	A	0	A
Greater Manchester Urban Area	UK0003	0	A	0	A	0	A	0	A
West Yorkshire Urban Area	UK0004	0	A	0	A	0	A	0	A
Tyneside	UK0005	0	A	0	A	0	A	0	A
Liverpool Urban Area	UK0006	0	A	0	A	0	A	0	A
Sheffield Urban Area	UK0007	0	A	0	A	0	A	0	A
Nottingham Urban Area	UK0008	0	A	0	A	0	A	0	A
Bristol Urban Area	UK0009	0	A	0	A	0	A	0	A
Brighton/Worthing/Littlehampton	UK0010	0	A	0	A	0	A	0	A
Leicester Urban Area	UK0011	0	A	0	A	0	A	0	A
Portsmouth Urban Area	UK0012	0	A	0	A	0	A	0	A
Teesside Urban Area	UK0013	0	A	0	A	0	A	0	A
The Potteries	UK0014	0	A	0	A	0	A	0	A
Bournemouth Urban Area	UK0015	0	A	0	A	0	A	0	A
Reading/Wokingham Urban Area	UK0016	0	A	0	A	0	A	0	A
Coventry/Bedworth	UK0017	0	A	0	A	0	A	0	A
Kingston upon Hull	UK0018	0	A	0	A	0	A	0	A
Southampton Urban Area	UK0019	0	A	0	A	0	A	0	A
Birkenhead Urban Area	UK0020	0	A	0	A	0	A	0	A
Southend Urban Area	UK0021	0	A	0	A	0	A	0	A
Blackpool Urban Area	UK0022	0	A	0	A	0	A	0	A
Preston Urban Area	UK0023	0	A	0	A	0	A	0	A
Glasgow Urban Area	UK0024	0	A	0	A	0	A	0	A
Edinburgh Urban Area	UK0025	0	A	0	A	0	A	0	A
Cardiff Urban Area	UK0026	0	A	0	A	0	A	0	A
Swansea Urban Area	UK0027	0	A	0	A	0	A	0	A
Belfast Urban Area	UK0028	0	A	0	A	0	A	0	A
Eastern	UK0029	25	A	3864	A	0	A	0	A
South West	UK0030	0	A	0	A	0	A	0	A
South East	UK0031	0	A	0	A	0	A	0	A
East Midlands	UK0032	0	A	0	A	0	A	0	A
North West & Merseyside	UK0033	0	A	0	A	0	A	0	A
Yorkshire & Humberside	UK0034	0	A	0	A	0	A	0	A
West Midlands	UK0035	0	A	0	A	0	A	0	A
North East	UK0036	0	A	0	A	0	A	0	A
Central Scotland	UK0037	0	A	0	A	0	A	0	A
North East Scotland	UK0038	0	A	0	A	0	A	0	A
Highland	UK0039	0	A	0	A	0	A	0	A
Scottish Borders	UK0040	0	A	0	A	0	A	0	A
South Wales	UK0041	0	A	0	A	0	A	0	A
North Wales	UK0042	0	A	0	A	0	A	0	A
Northern Ireland	UK0043	0	A	0	A	0	A	0	A

3 NO_2/NO_x

3.1 INTRODUCTION

Annual mean concentrations of NO_X and NO_2 have been modelled for the UK for 2004 at background and roadside locations. Maps of annual mean NO_2 concentrations for these locations in 2004 are presented in Figures 3.1 and 3.2. The modelling methods used here closely follow those used for mapping annual mean concentrations of NO_X and NO_2 for 2003 (see Stedman et al, 2005). Changes to this method for 2004 modelling are described below.

First a map of NO_x concentrations from all sources is calculated. This map was then used to calculate a map of NO_2 concentrations for comparison with the limit values for the protection of human health and a map of NO_x concentrations in vegetation areas for comparison with the limit value for the protection of vegetation.

The modelling presented in this report for NO_x and NO_2 has been restricted to estimation of annual mean concentrations for comparison with the annual mean limit values. No attempt has been made to model hourly concentrations for comparison with the 1-hour limit value. The annual mean limit value is expected to be more stringent than the 1-hour limit value in the majority of situations (AQEG, 2004).

Figure 3.1. Annual mean background NO_2 concentration, 2004 ($\mu g\ m^{-3}$)

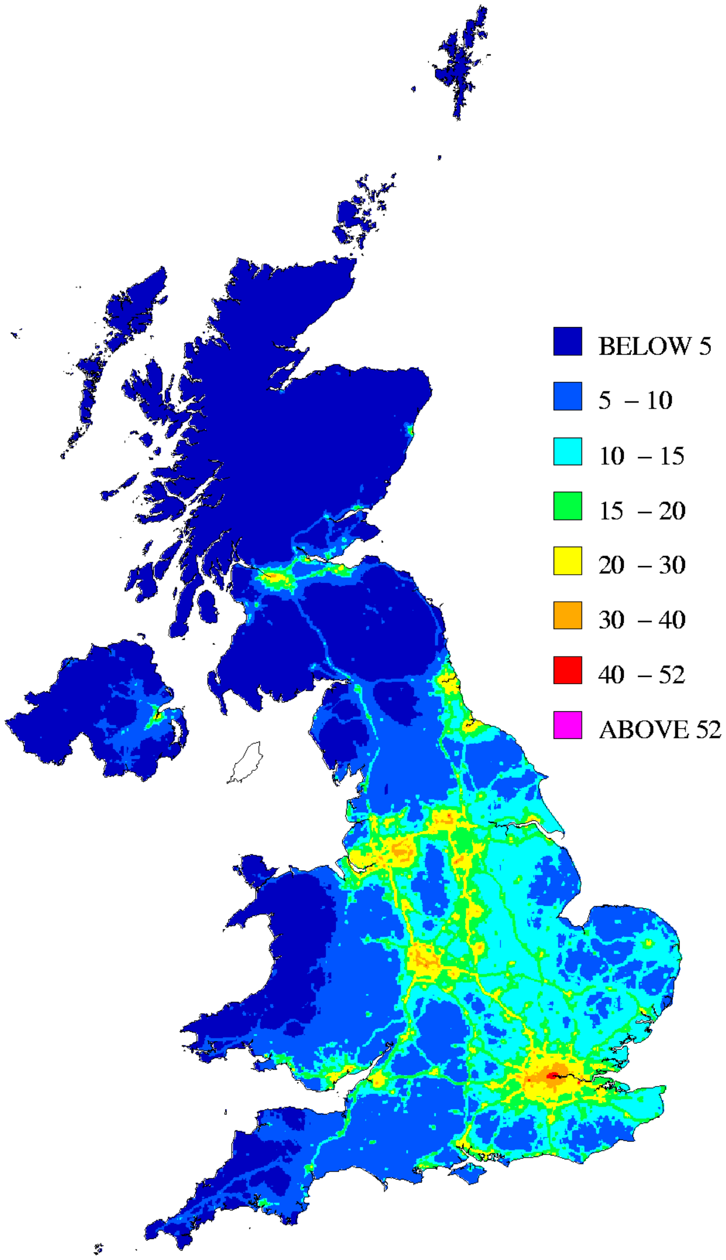
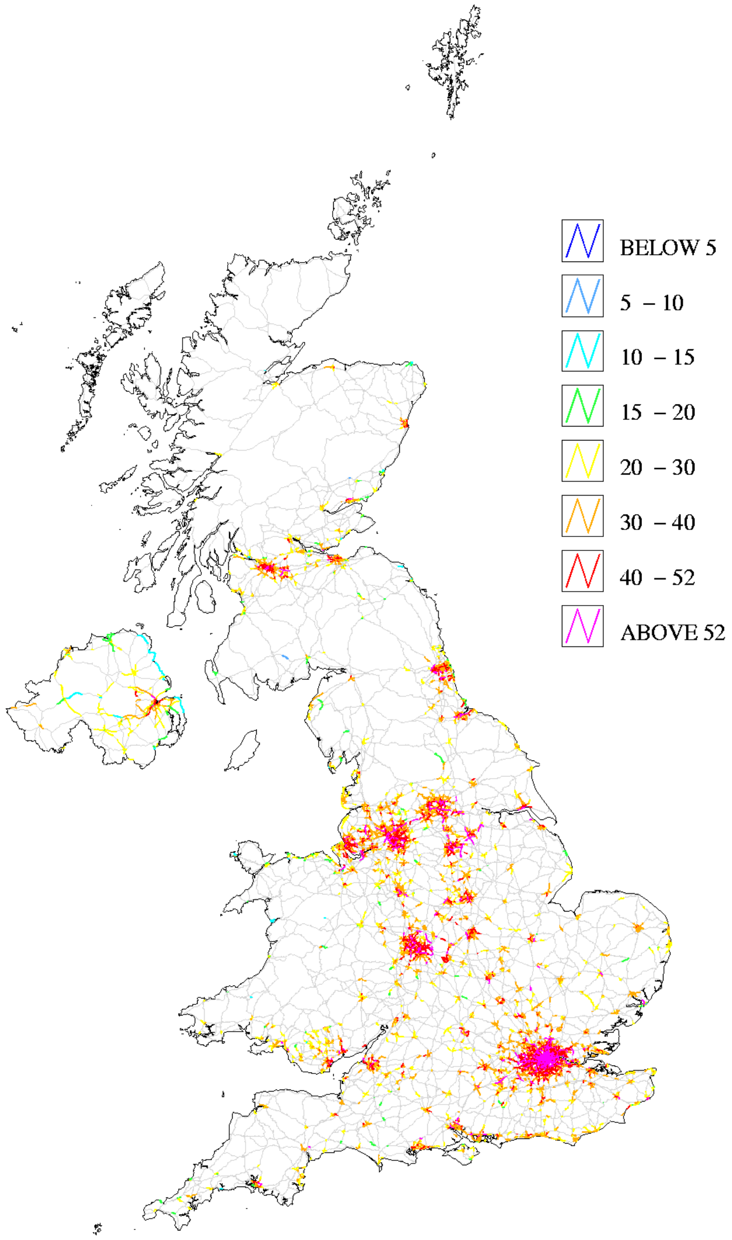
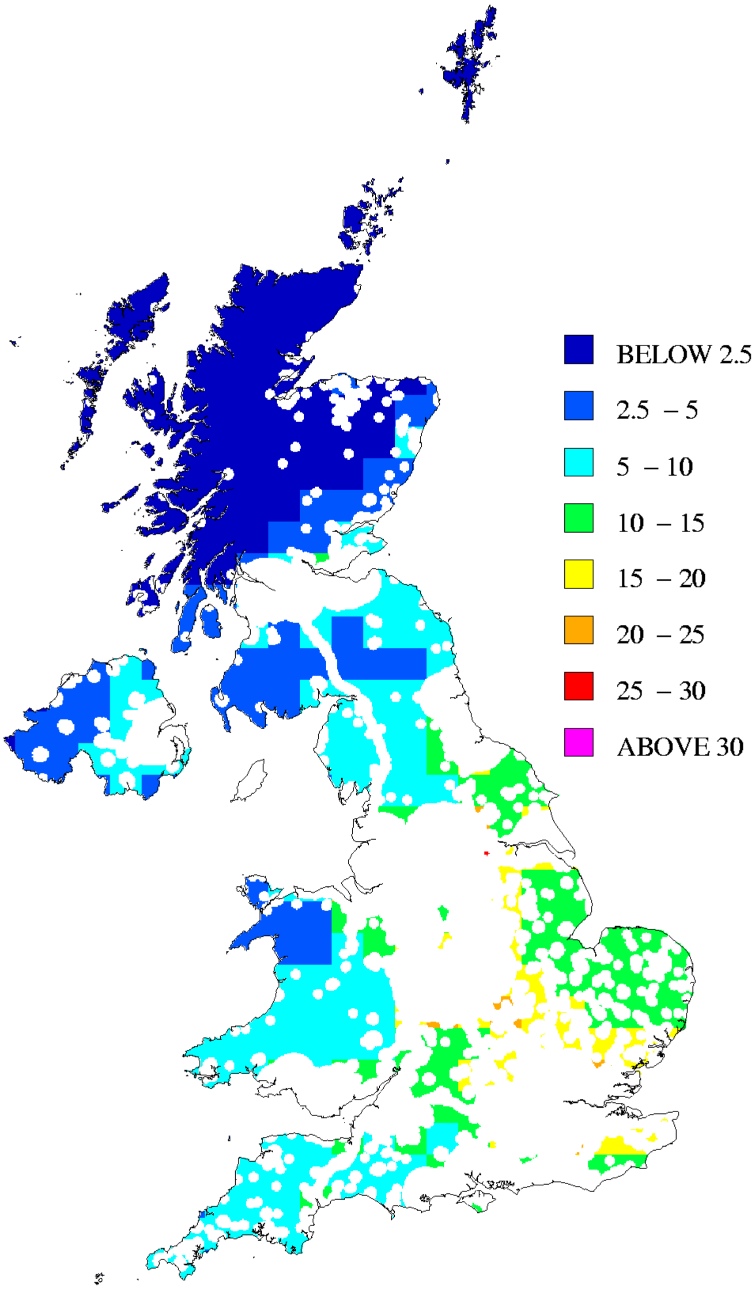


Figure 3.2. Urban major roads, annual mean roadside NO_2 concentration, 2004 ($\mu g\ m^{-3}$)



A map of annual mean NO_x concentrations in vegetation areas is presented in Figure 3.3. This map has been calculated by removing non-vegetation areas from the background NO_x map and calculating the zonal mean of the 1 km^2 grid squares for a 30km^2 grid. Mean concentrations on a 30 km^2 grid have been used to prevent the influence of any urban area appearing unrealistically large on adjacent vegetation areas. Thus the modelled concentrations in vegetation areas should be representative of approximately 1000km^2 as specified in Directive 1999/30/EC for monitoring sites used to assess concentrations for the vegetation limit value.

Figure 3.3. Annual mean Rural NO_x concentration, 2004 ($\mu g\ m^{-3}$, as NO_2)



3.2 CONTRIBUTIONS FROM LARGE POINT SOURCES

Contributions to ground level annual mean NO_X concentrations from large point sources (those with annual emission greater than 500 tonnes) in the 2003 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 3.2) and sequential meteorological data for 2004 from Waddington. A total of 169 large point sources were modelled for NO_X.

The method used for modelling concentrations from large point sources in 2004 closely follows the method used in 2003, further details of which are given in Stedman et al (2005).

3.3 CONTRIBUTIONS FROM SMALL POINT SOURCES

Contributions from NO_x point sources with less than 500 tonnes per annum emissions in the 2003 NAEI were modelled using the small points model described in Stedman et al (2005).

3.4 CONTRIBUTIONS FROM RURAL BACKGROUND CONCENTRATIONS

Rural annual mean background NO_x concentrations have been estimated using:

- NO_x measurements at 9 selected rural AURN sites
- NO_x estimated from NO_2 measurements at twenty rural NO_2 diffusion tube sites from the Acid Deposition Monitoring Network (Lawrence, *pers comm 2005*)

Rural NO_x was estimated from rural NO_2 at diffusion tube sites by dividing by 0.7835 (the average value of the NO_x/NO_2 ratio measured at rural automatic monitoring sites). Measurements have been then been corrected to remove the contribution from point source and local area sources to avoid double counting these contributions later in the modelling process. The correction procedure is as follows:

Corrected rural background ($\mu g\ m^{-3}$) *= Uncorrected rural background* ($\mu g\ m^{-3}$) *– (A + B + C)*

Where: A = an estimate of the contribution from area source components, derived using the area source model empirical coefficients from the 2003 modelling (Stedman et al, 2005).
B = sum of contributions from large point sources in 2003 modelling
C = sum of contributions from small point sources in 2003 modelling

Automatic sites, where available have been used in preference to diffusion tubes as these are considered to be more accurate. 2004 is the first year for which sufficient automatic sites are available for this to be possible. These measures have been established as a result of Directive 2002/3/EC relating to ozone in ambient air.

A bi-linear interpolation of corrected rural measurement data has been used to map regional background concentrations throughout the UK.

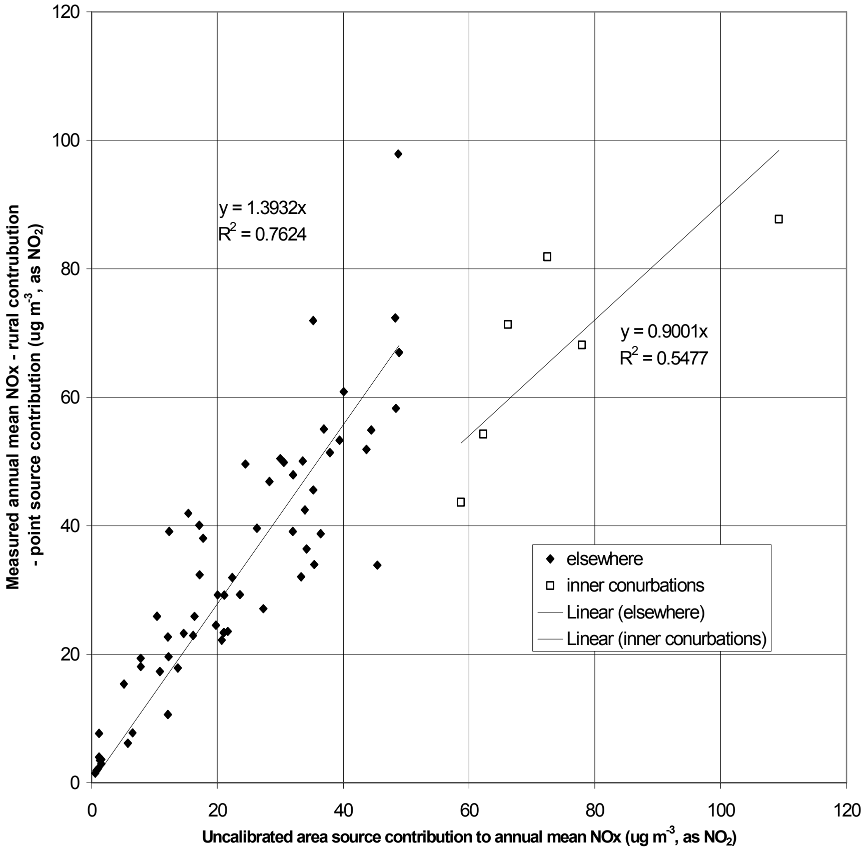
3.5 CONTRIBUTIONS FROM AREA SOURCES

Figure 3.4 shows the calibration of the NO_X area source model. Calibration of the area source model in 2004 follows the same method as in 2003 (see Stedman et al, 2005) with the following differences:

- Monitoring data from background sites for 2004 has been used.
- 2004 dispersion kernels have been used. These have been constructed using hourly sequential meteorological data from Heathrow in 2004, using the method described in Stedman et al (2005). Note that the derivation of empirical calcibration factors ensures that the calibrated results of the area source model are relatively insensitive to the choice of met data.
- Manchester has been reclassified as 'elsewhere' for the 2004 calibration and modelling. This is because Figure 3.4 shows that the monitoring sites in

Manchester fit more closely with sites classified as 'elsewhere' rather than 'inner conurbations'.

Figure 3.4. Calibration of area source NO_x model 2004 ($\mu g\ m^{-3}$, as NO_2)



3.6 ROADSIDE CONCENTRATIONS

Calibration of the NO_x roadside increment model is shown in figure 3.5. Roadside concentrations of annual mean NO_x for 2004 have been modelled using a similar method to the 2003 modelling with the following differences:

- Estimates of NO_x emissions from major road links have been taken from the 2004 NAEI
- Monitoring data from roadside sites for 2004 has been used.
- Adjustment factors applied to motorways to account for dispersion from vehicles travelling along a road have been lowered from those used in the 2003 modelling because the model otherwise overestimates concentrations on less busy motorways especially in Northern Ireland. The adjustment factors used in modelling NO_X in 2004 are illustrated in figure 3.6.

Figure 3.5. Calibration of NO_x roadside increment model

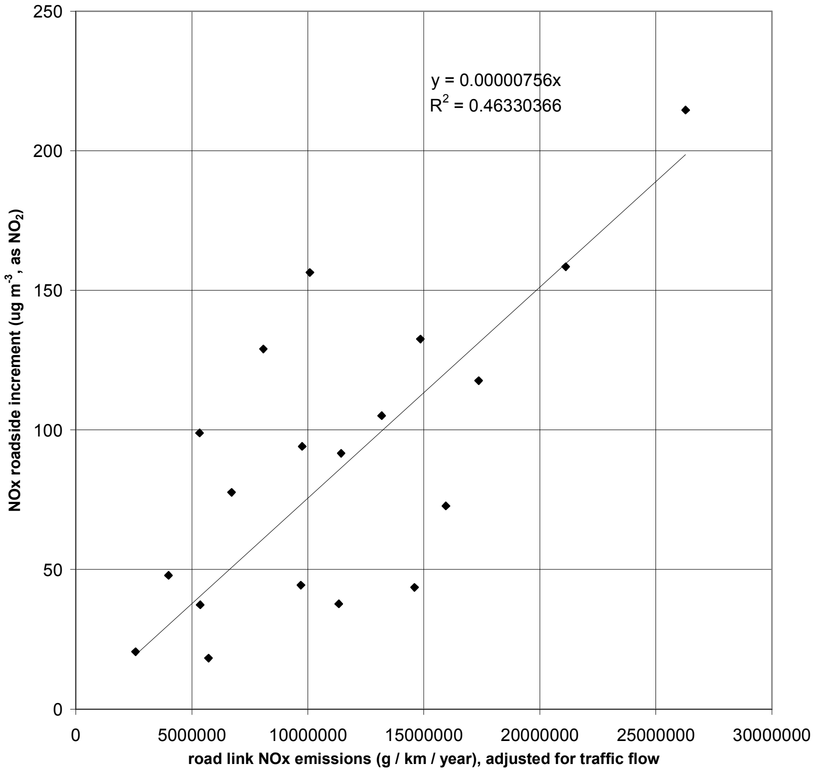
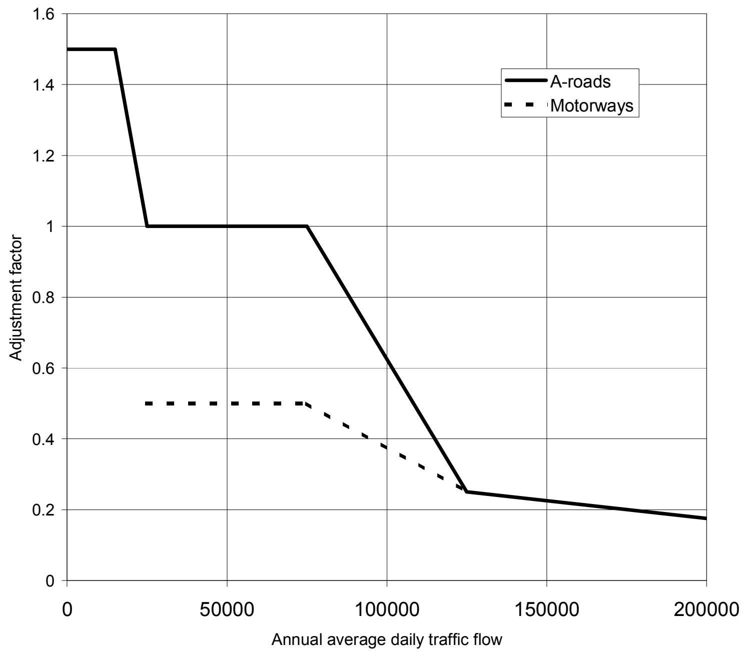


Figure 3.6 The adjustment factors applied to road link emissions



3.7 EMPIRICAL RELATIONSHIPS BETWEEN NO_2 AND NO_X CONCENTRATIONS

The oxidant-partitioning model (Jenkin, 2004) has been used to model maps of annual mean NO_2 concentrations from modelled NO_x concentrations. NO_2 concentrations were estimated as the sum of local primary NO_2, which is estimated from the modelled NO_x concentrations, and a secondary NO_2 contribution, which is derived from an estimate of regional total oxidant as a function of modelled NO_x. A full description of how this relationship has been used is given in Stedman et al (2005).

For calculating 2004 annual mean NO_2 concentrations at background locations, 0.5 ppb has been added to the regional oxidant concentrations presented in Jenkins (2004), who considered concentrations up to 2001, because regional oxidant is thought to be increasing with time at a rate of about 0.2 ppb yr^{-1} (Derwent et al, 2005).

For calculating the roadside NO_2 concentration, 0.5 ppb has also been added to the regional oxidant concentrations presented in Jenkins (2004). Additionally, because emissions of primary NO_2 at roadside locations are thought to be increasing (Abbott, 2005), primary NO_2 used in the 2003 oxidant partitioning model has been scaled by a factor of 0.15/0.14 to increase primary NO_2 in Central London to 15% of NO_x emitted from local traffic sources. This scaling factor has also been applied across the rest of the country.

3.8 VERIFICATION OF MAPPED VALUES

Figures 3.7 and 3.8 show comparisons of modelled and measured annual mean NO_x and NO_2 concentration in 2004 at background monitoring site locations. Figure 3.9 and 3.10 show similar comparisons for roadside sites. Both the national network sites used to calibrate the models and the verification sites are shown. Lines representing y = x – 30 % and y = x + 30% are also shown (this is the AQDD1 data quality objective for modelled annual mean NO_2 and NO_x concentrations). A further discussion of data quality objectives and verification of NO_x and NO_2 is given in Stedman et al (2005)

Figure 3.7. Verification of background annual mean NO_x model 2004

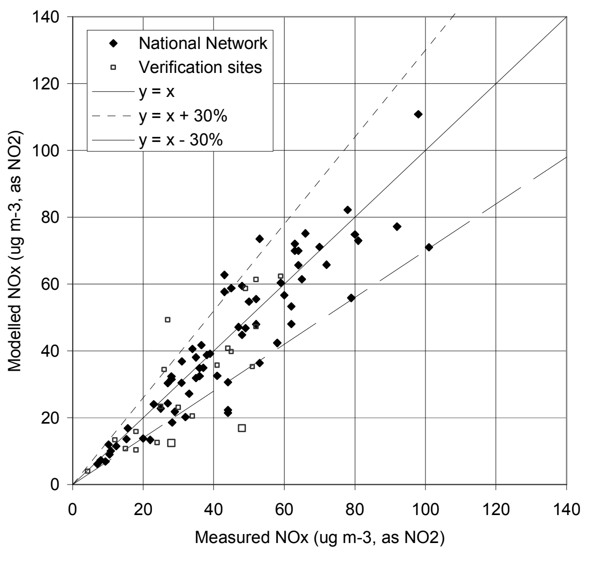


Figure 3.8. Verification of background annual mean NO_2 model 2004

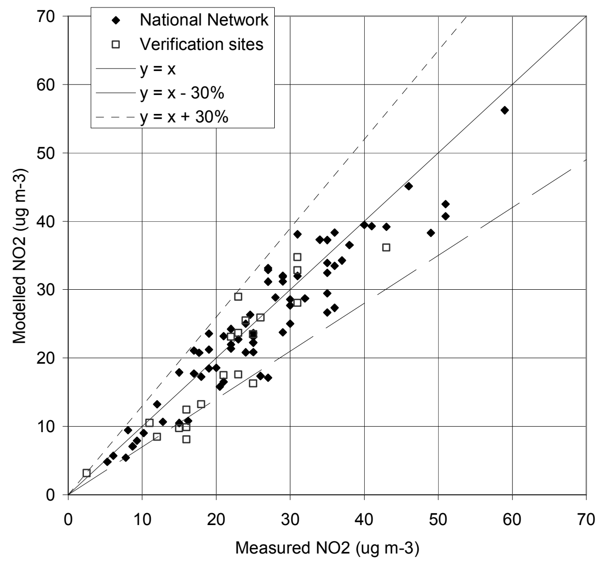


Figure 3.9. Verification of roadside annual mean NO_x model 2004

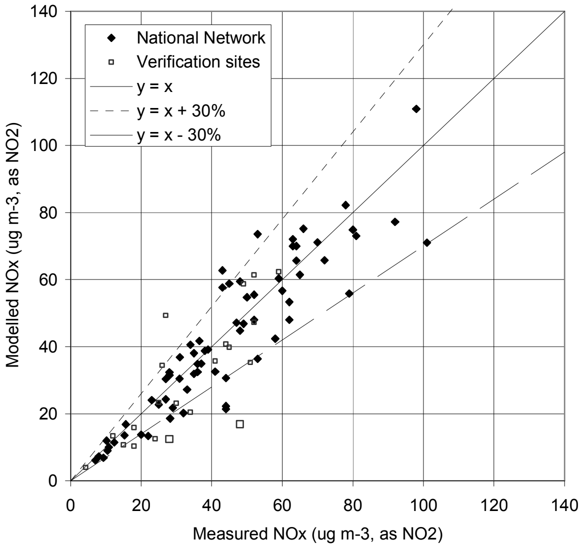
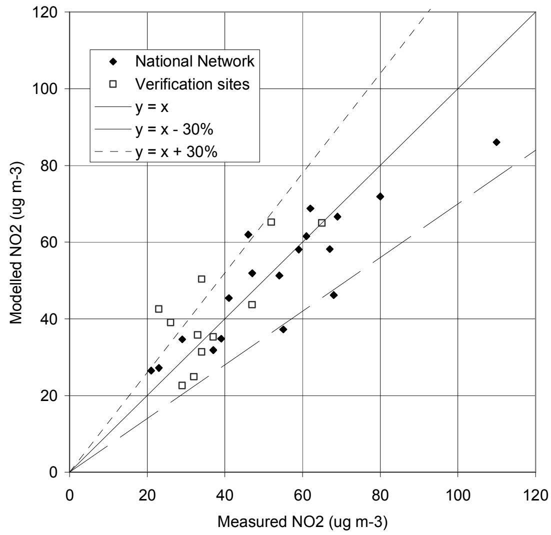


Figure 3.10. Verification of roadside annual mean NO_2 model 2004



Summary statistics for the comparison between modelled and measured NO_x and NO_2 concentrations are listed in Tables 3.2 and 3.3. The percentages of monitoring sites for which the modelled annual mean concentrations fall outside the data quality objectives is generally greater for NO_x than for NO_2, for the reasons discussed in Stedman et al (2005).

Table 3.2. Summary statistics for comparison between modelled and measured NO_x and NO_2 concentrations at background sites ($\mu g\ m^{-3}$, as NO_2)

		Mean of measurements ($\mu g\ m^{-3}$, as NO_2)	Mean of model estimates ($\mu g\ m^{-3}$, as NO_2)	r^2	% outside data quality objectives	Number of sites
National Network	**NO_x**	44.4	42.4	0.83	17.4	69
Verification Sites	**NO_x**	33.4	29.9	0.63	38.1	21
National Network	**NO_2**	26.5	25.3	0.87	7.2	69
Verification Sites	**NO_2**	21.6	19.5	0.82	19.0	21

Table 3.3. Summary statistics for comparison between modelled and measured NO_x and NO_2 concentrations at roadside sites ($\mu g\ m^{-3}$, as NO_2)

		Mean of measurements ($\mu g\ m^{-3}$, as NO_2)	Mean of model estimates ($\mu g\ m^{-3}$, as NO_2)	r^2	% outside data quality objectives	Number of sites
National Network	**NO_x**	140.2	129.7	0.66	47.4	19
Verification Sites	**NO_x**	85.6	98.2	0.48	63.6	11
National Network	**NO_2**	53.7	50.1	0.70	15.8	19
Verification Sites	**NO_2**	37.5	41.4	0.5	27.3	11

3.9 DETAILED COMPARISON OF MODELLING RESULTS WITH LIMIT VALUES

The modelling results, in terms of a comparison of modelled concentrations with the annual mean limit value by zone, are summarised in Table 3.4. These data have also been presented in form 19b of the questionnaire. The NO_x annual mean limit value for the protection of vegetation was not exceeded in vegetation areas in any of the non-agglomeration zones in 2004. This limit value does not apply in agglomeration zones, according to the definition in the Directive (see Section 1.3). Method A in this table refers to the modelling method described in this report.

Estimates of area and population exposed have been derived from the background maps only. No attempt has been made to derive estimates using maps of roadside concentrations as these maps will only apply to within approximately 10 metres from the road kerb.

Table 3.4 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II))							
- Form 19b Results of and methods used for supplementary assessment for NO_2/NO_x							
Zone	Zone code	Above LV for health (annual mean)					
		Area		Road length		Population exposed	
		km^2	Method	km	Method	Number	Method
Greater London Urban Area	UK0001	63	A	1561.1	A	549341	A
West Midlands Urban Area	UK0002	1	A	360.9	A	1526	A
Greater Manchester Urban Area	UK0003	0	A	383.9	A	0	A
West Yorkshire Urban Area	UK0004	2	A	173.4	A	2462	A
Tyneside	UK0005	0	A	85.0	A	0	A
Liverpool Urban Area	UK0006	0	A	113.5	A	0	A
Sheffield Urban Area	UK0007	2	A	111.7	A	4442	A
Nottingham Urban Area	UK0008	0	A	54.2	A	0	A
Bristol Urban Area	UK0009	0	A	51.9	A	0	A
Brighton/Worthing/Littlehampton	UK0010	0	A	8.7	A	0	A
Leicester Urban Area	UK0011	0	A	41.8	A	0	A
Portsmouth Urban Area	UK0012	0	A	13.3	A	0	A
Teesside Urban Area	UK0013	0	A	25.1	A	0	A
The Potteries	UK0014	0	A	25.7	A	0	A
Bournemouth Urban Area	UK0015	0	A	10.8	A	0	A
Reading/Wokingham Urban Area	UK0016	0	A	21.9	A	0	A
Coventry/Bedworth	UK0017	0	A	24.1	A	0	A
Kingston upon Hull	UK0018	0	A	30.8	A	0	A
Southampton Urban Area	UK0019	0	A	18.7	A	0	A
Birkenhead Urban Area	UK0020	0	A	6.0	A	0	A
Southend Urban Area	UK0021	0	A	8.3	A	0	A
Blackpool Urban Area	UK0022	0	A	0.0	A	0	A
Preston Urban Area	UK0023	0	A	6.7	A	0	A
Glasgow Urban Area	UK0024	0	A	145.8	A	0	A
Edinburgh Urban Area	UK0025	0	A	33.5	A	0	A
Cardiff Urban Area	UK0026	0	A	17.1	A	0	A
Swansea Urban Area	UK0027	0	A	0.0	A	0	A
Belfast Urban Area	UK0028	0	A	79.5	A	0	A
Eastern	UK0029	0	A	116.0	A	0	A
South West	UK0030	0	A	80.3	A	0	A
South East	UK0031	2	A	250.7	A	7502	A
East Midlands	UK0032	0	A	105.1	A	0	A
North West & Merseyside	UK0033	0	A	240.8	A	0	A
Yorkshire & Humberside	UK0034	0	A	242.0	A	0	A
West Midlands	UK0035	0	A	111.4	A	0	A
North East	UK0036	0	A	73.2	A	0	A
Central Scotland	UK0037	0	A	16.3	A	0	A
North East Scotland	UK0038	0	A	34.2	A	0	A
Highland	UK0039	0	A	0.0	A	0	A
Scottish Borders	UK0040	0	A	0.0	A	0	A
South Wales	UK0041	0	A	51.0	A	0	A
North Wales	UK0042	0	A	12.7	A	0	A
Northern Ireland	UK0043	0	A	6.8	A	0	A
Total		70		4754.1		565273	

4 PM_{10}

4.1 INTRODUCTION

Maps of annual mean PM_{10} in 2004 at background and roadside locations are shown in Figures 4.1 and 4.2. The methodology employed in modelling PM_{10} in 2004 was significantly different from previous years. Prior to 2004 modelling was undertaken in TEOM units, calibrated using TEOM measurements and then converted to a gravimetric equivalent using a factor of 1.3 for comparison with the legislative objectives. In 2004 modelling was undertaken in gravimetric units and calibrated using gravimetric measurements. A summary of the 2004 methodology is provided here with a particular emphasis given to revisions to the methods for the 2004 maps.

The aspects of the modelling method that have not changed in 2004 are fully presented in Stedman, et al 2003; and earlier reports (Stedman and Bush, 2000, Stedman, et al 2001b, Stedman, et al 2002, Stedman et al, 2003).

Figure 4.1. Annual mean background PM_{10} concentration, 2004 ($\mu g\ m^{-3}$, gravimetric)

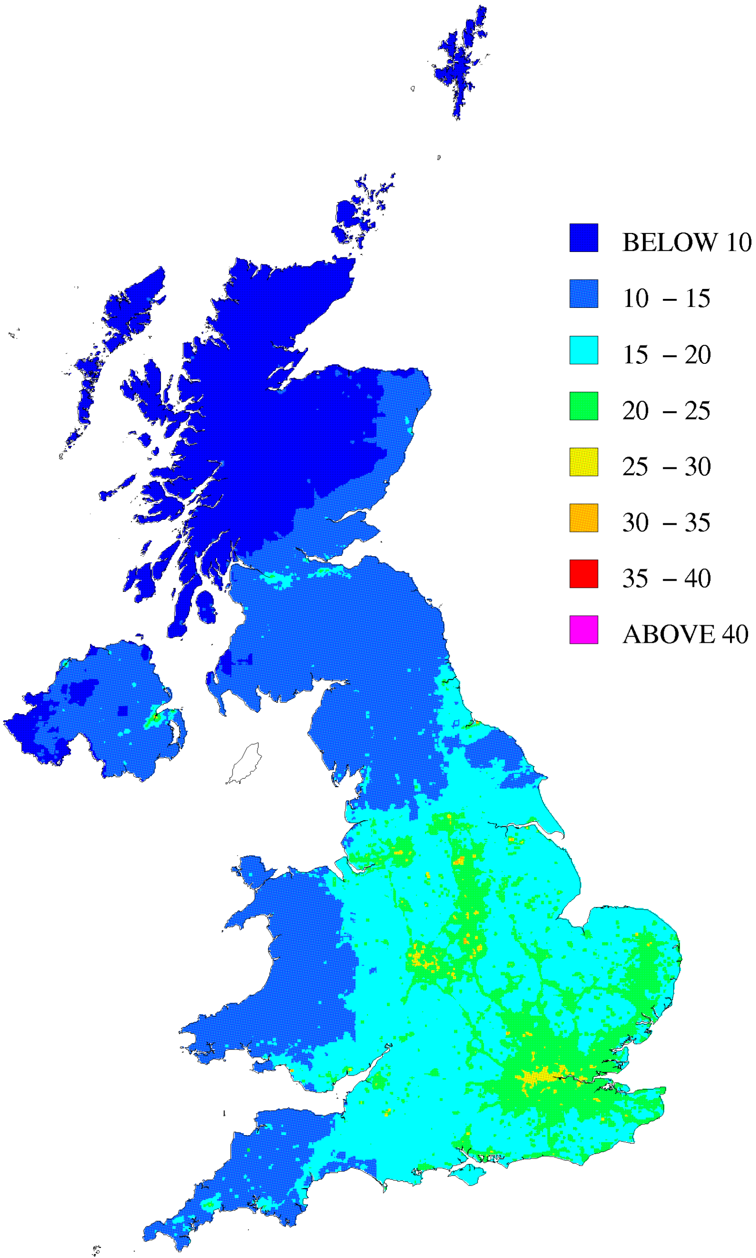
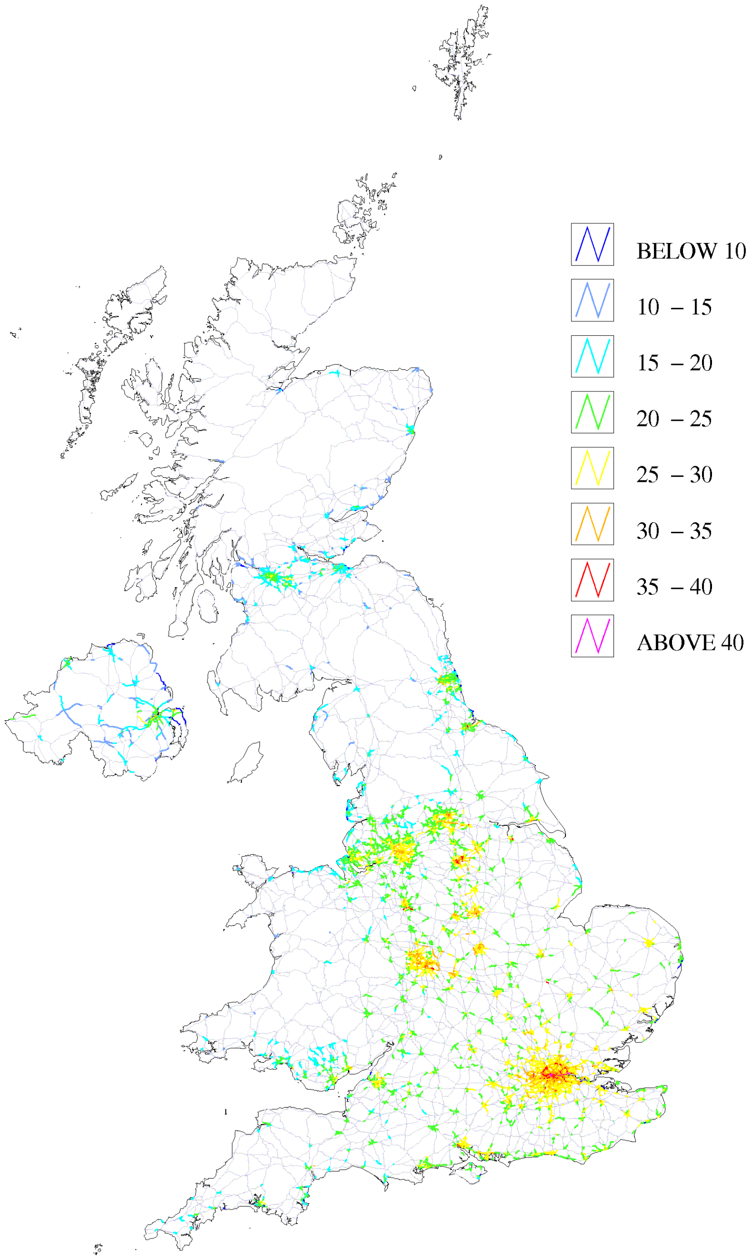


Figure 4.2. Urban major roads, annual mean roadside PM_{10} concentration, 2004 ($\mu g\ m^{-3}$, gravimetric)



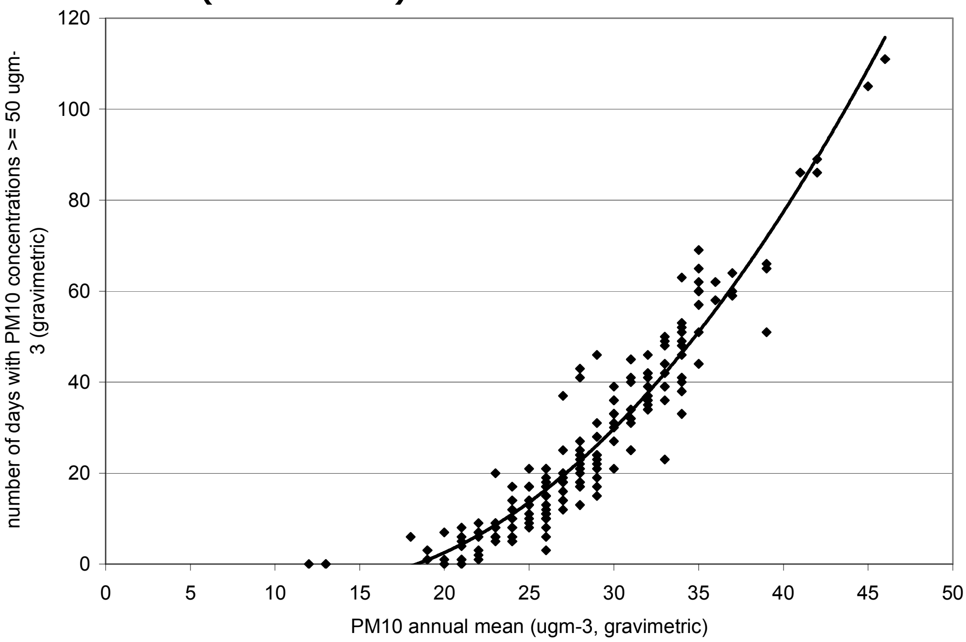
The maps of background concentrations are made up of contributions from

- Large point sources of primary particles (modelled using ADMS)
- Small point sources of primary particles (modelled using the small points model)
- Area sources of primary particles (modelled using a dispersion kernel)
- Regional primary particles (from results from the TRACK model)
- Secondary inorganic aerosol (derived by scaling measurements of SO_4, NO_3 and NH_4)
- Secondary organic aerosol (from results from the HARM model)
- Sea salt (assumed to be a constant value)
- Residual (assumed to be a constant value)

The concentrations of many of these components have been estimated separately for the fine and coarse fraction. This enables a consistent method to be adopted for estimation of PM_{10} (the sum of the fine and coarse fractions) and $PM_{2.5}$ (fine fractions only). These component pieces are then aggregated to a single 1x1 km background PM_{10} grid. An additional roadside increment is added for roadside locations.

24-hour mean concentrations have not been explicitly modelled for comparison with the 24-hour limit values. An annual mean concentration of 31.5 μg m^{-3}, gravimetric has been taken to be equivalent to 35 days with 24-hour mean concentrations greater than 50 μg m^{-3} gravimetric (the stage 1 24-hour limit value). This equivalence is derived from an analysis of monitoring data (Stedman et al, 2001b) and is reproduced Figure 4.3. The relationship between the number of days with concentrations greater than 50 μg m^{-3}, gravimetric and annual mean is less certain at lower numbers of exceedences and no attempt has been made to model exceedences of the indicative stage 2 24-hour limit value of 7 exceedences of 50 μg m^{-3}, gravimetric. In any case, the stage 2 annual mean limit value is expected to be as stringent as the stage 2 24-hour limit value (AQEG, 2005).

Figure 4.3. The relationship between the number of days with PM_{10} concentrations greater than or equal to 50 μg m^{-3} and annual mean concentration (1992 –1999)



4.2 CONTRIBUTIONS FROM SECONDARY INORGANIC AEROSOL

Prior to 2004 secondary particles were assumed to consist of sulphates and nitrates only and were estimated from measured sulphate and nitrate concentrations using scaling factors derived from the APEG receptor model (see Stedman, et al 2001a). In 2004 the methodology used was revised. A map of secondary PM_{10} particle concentrations across the UK has been calculated from rural measurements of sulphate and nitrate and ammonium concentrations by interpolation onto a 20 km x 20 km grid. Sulphate, nitrate and ammonia particle concentrations were measured on a monthly basis at 12 rural sites using a denuder method during 2004 (Tang *pers comm*. 2005).

These secondary components were then split into fine and coarse fractions using coefficients derived from a review of mass closure research carried out by Professor Dick Derwent (see Appendix 3). These secondary components were also scaled according to 'bound water' associated with the mass of water embedded within the particles. The factor for coarse nitrate is higher as this includes the mass of the counter-ion (sodium or calcium), as shown in Table 4.1.

Table 4.1 Bound water factors and fine/ coarse proportions for each of the secondary species included in the gravimetric model

Pollutant	Size fraction	Scaling factor for size fraction	Scaling factor for bound water and counter-ion mass
SO_4	**Fine**	0.94	1.279
	Coarse	0.06	1.279
NO_3	**Fine**	0.45	1.279
	Coarse	0.55	1.60
NH_4	**Fine**	0.97	1.279
	Coarse	0.03	1.279
SOA	**Fine**	0.75	1.0
	Coarse	0.25	1.0

4.3 CONTRIBUTIONS FROM SECONDARY ORGANIC AEROSOL

The secondary organic aerosol gridded input was obtained from the HARM/ELMO model (Duncan Whyatt, pers comm.). Modelled results have been compared with monitored organic carbon data at Bush Estate, Midlothian from July 2002 to July 2003. Peak summer time monthly concentrations were found to be 0.94 $\mu g\ m^{-3}$ whereas the model indicated summer time concentrations of 0.4-0.5 $\mu g\ m^{-3}$. The similarity of this modelled value with the measured annual mean at Bush prompted the scaling of the HARM/ELMO grid by a factor of 1 because the vast majority of SOA formation occurs during the summer and summer mean concentrations would therefore be expected to be about double the annual mean.

4.4 CONTRIBUTIONS FROM LARGE AND SMALL POINT SOURCES

There were 80 large point sources modelled using ADMS for 2004. The modelling methods accounting for contributions from PM_{10} point sources are described in Stedman et al 2005 and have undergone no significant change in methodology for 2004.

4.5 CONTRIBUTIONS FROM DISTANT SOURCES OF PRIMARY PARTICLES

Contributions from long-range transport of primary particles were estimated using the TRACK model (Lee, Kingdon, Jenkin and Garland, 2000). All sources within 10 km of the receptor point were excluded from the TRACK model to allow the area source model and the point source model to be nested within this long-range transport model without duplicating source contributions.

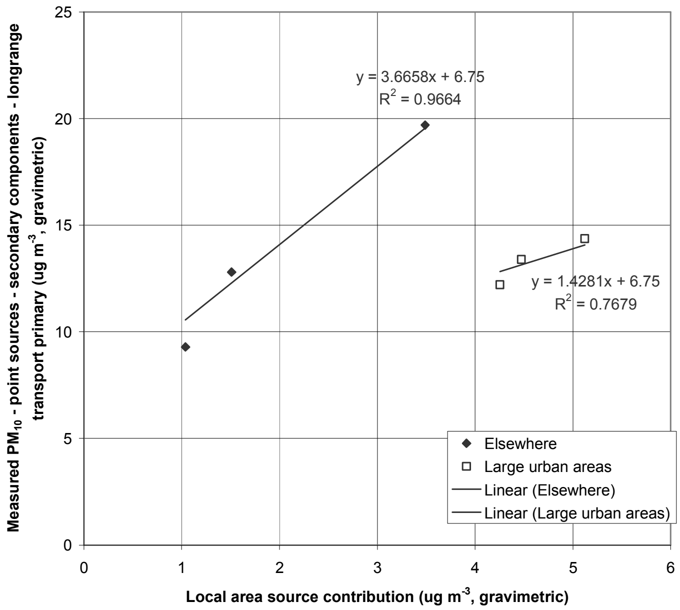
4.6 CONTRIBUTIONS FROM AREA SOURCES

Figure 4.4 shows the calibration of the PM_{10} area source model. Calibration of the area source model in 2004 follows the same method as for 2003 (see Stedman et al, 2005) with the following differences:

- Monitoring data from background sites for 2004 has been used.
- 2004 dispersion kernels have been used. These have been constructed using hourly sequential meteorological data from Heathrow in 2004.

Manchester has been reclassified as 'elsewhere' for the 2004 calibration and modelling. This is because Figure 4.4 shows that the monitoring sites in Manchester fit more closely with sites classified as 'elsewhere' rather than 'inner conurbation'.

Figure 4.4. Calibration of PM_{10} area source model 2004 (μg m^{-3}, gravimetric)



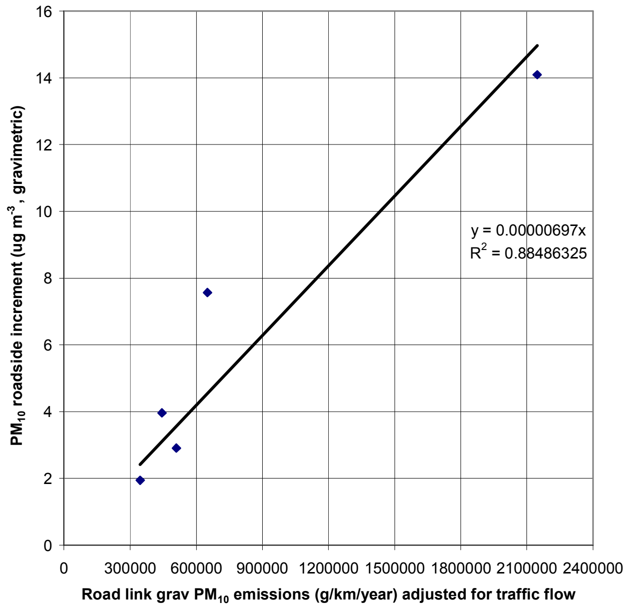
4.7 RESIDUAL (LARGELY COARSE PARTICLES)

A fine sea salt component of 0.20 μg m^{-3} and a coarse sea salt component of 0.56 was set (see Appendix 3) and assumed to apply across the UK. Emissions of coarse particles from sources such as wind blown dusts and agricultural activities are not well characterised in emission inventories and have not been modelled explicitly. A constant residual concentration of 6 μg m^{-3} was therefore added as the final contribution to total particulate matter concentration. This value was chosen to provide the best fit to the measured total concentration. The sum of this value and the sea salt contribution is close to the unforced intercept for the area source model calibration for sites outside central London and Birmingham. It is also close to the average residual obtained from the APEG receptor model (APEG 1999, Stedman et al 2001a) for gravimetric sites in 2004.

4.8 ROADSIDE CONCENTRATIONS

Modelling of roadside concentrations in 2004 was performed in the same way as in 2003 using the 2003 NEAI emissions for all major road links. These emissions were scaled to 2004 and scaled for road traffic flow before being plotted against the roadside increment (measured roadside concentration – modelled background concentration) to determine the calibration coefficient. The method is described fully in Stedman, et al 2005. The calibration of the roadside increment model for 2004 is shown in Figure 4.5

Figure 4.5. Calibration of PM_{10} roadside increment model 2004 ($\mu g\ m^{-3}$, gravimetric)



4.9 VERIFICATION OF MAPPED GRAVIMETRIC VALUES

Figures 4.6 and 4.7 show comparisons of gravimetric PM_{10} modelled and measured annual mean PM_{10} concentration in 2004 at both background and roadside monitoring site locations. There were no genuine gravimetric monitoring data outside the AURN to use to verify the model so only the national network sites used to calibrate the models are shown along with verification data for the two sites with KFG instruments operating in 2004. Lines representing y = x – 50 % and y = x + 50% are also shown because 50% is the AQDD1 data quality objective for modelled annual mean PM_{10} concentrations. Summary statistics for the comparison between modelled and measured PM_{10} concentrations are presented in Tables 4.2 and 4.3. All of the modelled values are within the data quality objectives.

Figure 4.6. Verification of background annual mean PM_{10} (gravimetric) model 2004

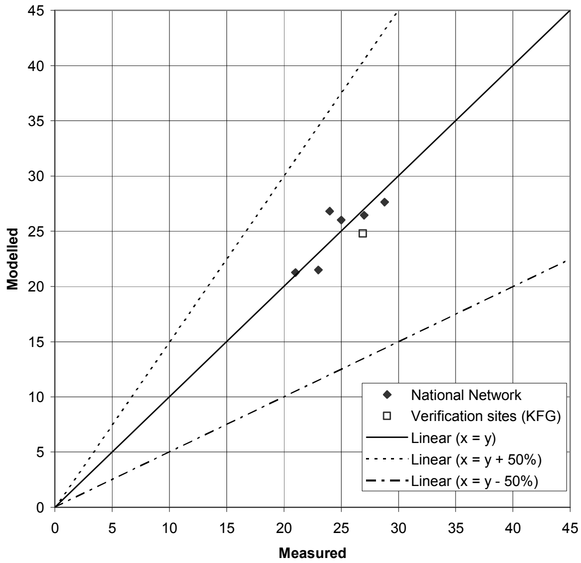


Figure 4.7. Verification of roadside annual mean PM_{10} (gravimetric) model 2004

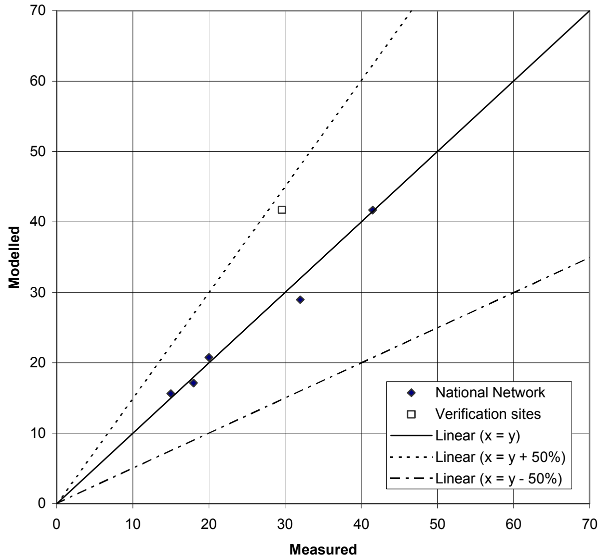


Table 4.2 Summary statistics for comparison between gravimetric modelled and measured concentrations of PM_{10} at background sites

	Mean of measurements ($\mu g\ m^{-3}$, grav)	Mean of model estimates ($\mu g\ m^{-3}$, grav)	r^2	% outside data quality objectives	Number of sites
National Network	24.8	24.9	0.7	0%	6
Verification Sites	26.9	24.8	n/a	0%	1

Table 4.3 Summary statistics for comparison between gravimetric modelled and measured concentrations of PM_{10} at roadside sites

	Mean of measurements ($\mu g\ m^{-3}$, grav)	Mean of model estimates ($\mu g\ m^{-3}$, grav)	r^2	% outside data quality objectives	Number of sites
National Network	25.3	24.8	1.0	0%	5
Verification Sites	29.6	41.7	n/a	0%	1

4.10 MAPPING OF TEOM CONCENTRATIONS

In addition to mapping PM_{10} in gravimetric units, in 2004 there was additional mapping undertaken in TEOM units. This TEOM mapping was performed to provide additional confidence in the gravimetric mapping, which is reported. The methodology for this mapping was similar to that described for the gravimetric maps but different scaling factors for the secondary components were used to account for the losses of volatile secondary components (see Table 4.4). The area source component was calibrated used TEOM measurements from the national network. Figures 4.8 and 4.9 show the TEOM background and roadside maps for 2004. Figures 4.10 and 4.11 show the calibration plots for the TEOM background and roadside area source model. Figures 4.12 and 4.13 show the verification of the TEOM model.

Figure 4.8. Annual mean background PM_{10} concentration, 2004 ($\mu g\ m^{-3}$, TEOM units)

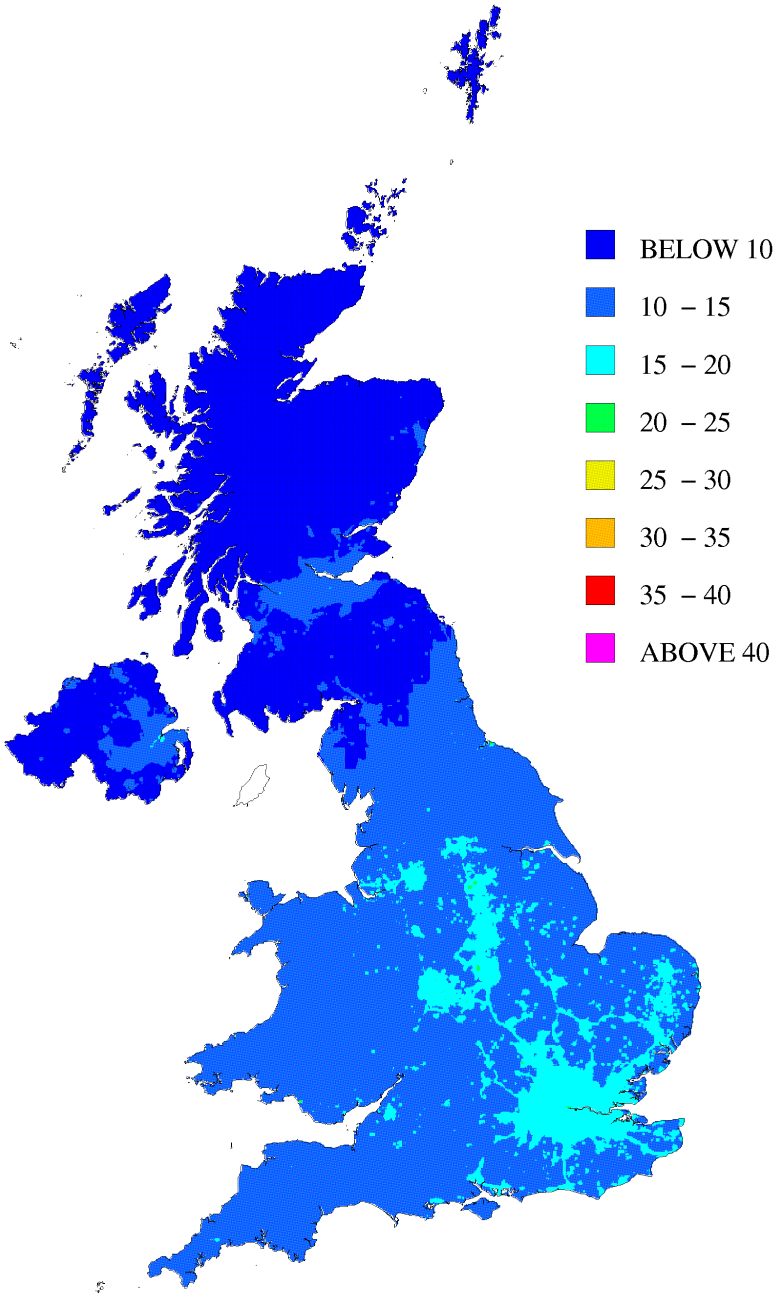


Figure 4.9. Annual mean roadside PM_{10} concentration, 2004 ($\mu g\ m^{-3}$, TEOM units)

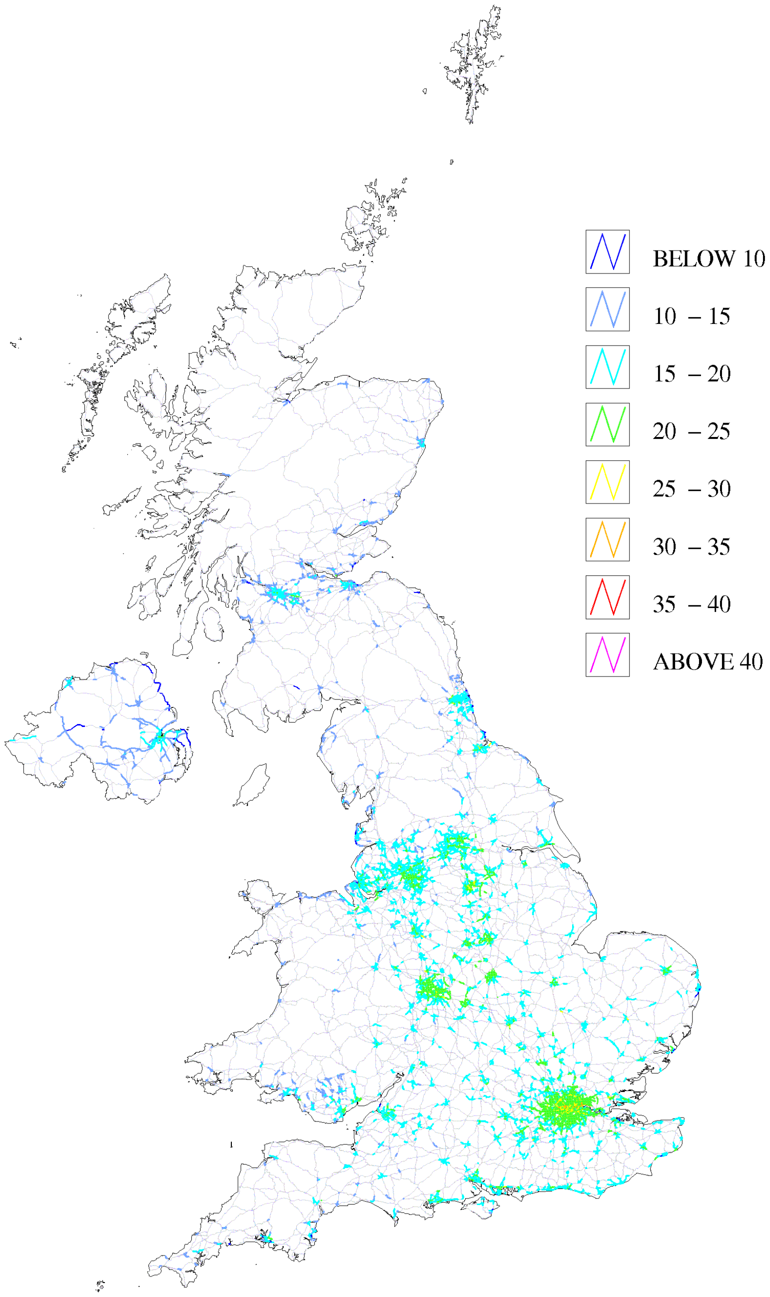


Table 4.4 Bound water factors and fine/ coarse proportions for each of the secondary species included in the TEOM model

Pollutant	Size fraction	Scaling factor for size fraction	Scaling factor for bound water and counter-ion mass
SO_4	Fine	0.94	1.00
	Coarse	0.06	1.00
NO_3	Fine	0.00	1.00
	Coarse	0.55	1.32
NH_4	Fine	0.97	0.86
	Coarse	0.03	1.00
SOA	Fine	0.75	0.00
	Coarse	0.25	0.00

Figure 4.10. Calibration of PM_{10} area source model 2004 ($\mu g\ m^{-3}$, TEOM)

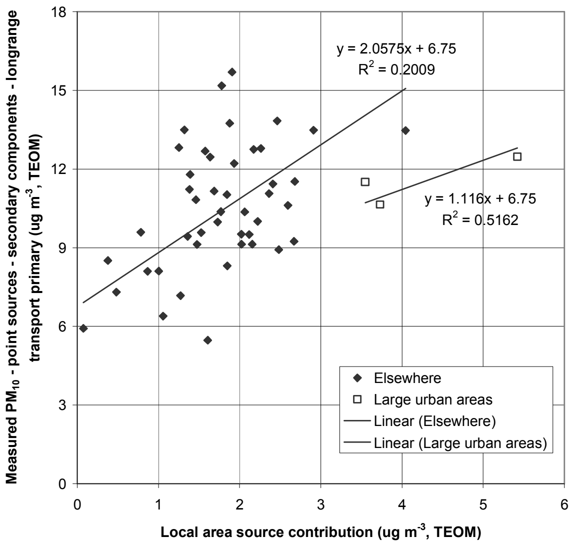


Figure 4.11. Calibration of PM_{10} roadside increment model 2004 ($\mu g\ m^{-3}$, TEOM)

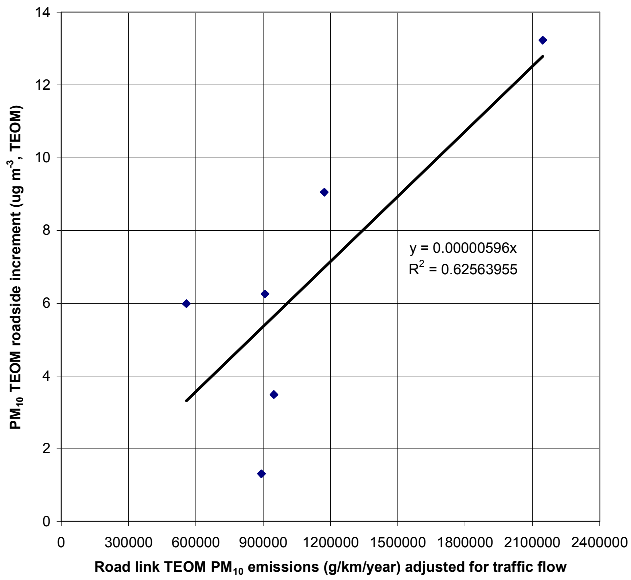


Figure 4.12. Verification of background annual mean PM_{10} (TEOM) model 2004

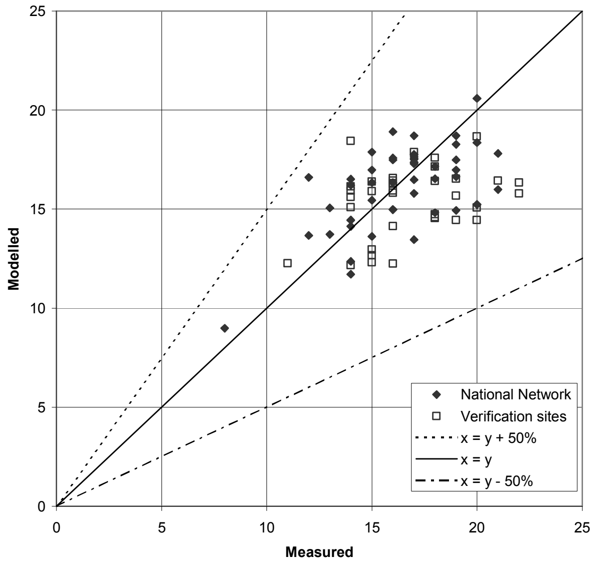


Figure 4.13. Verification of roadside annual mean PM_{10} (TEOM) model 2004

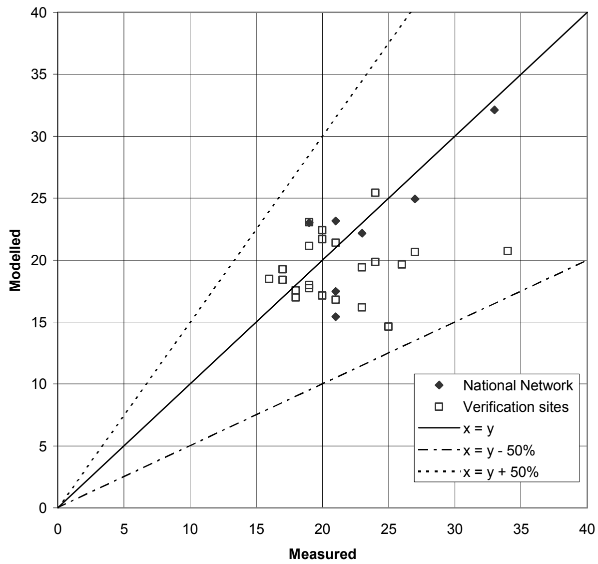


Table 4.5 Summary statistics for comparison between TEOM modelled and measured concentrations of PM_{10} at background sites

	Mean of measurements ($\mu g\ m^{-3}$, TEOM)	Mean of model estimates ($\mu g\ m^{-3}$, TEOM)	r^2	% outside data quality objectives	Number of sites
National Network	16.3	16.1	0.40	0	48
Verification Sites	17.1	15.5	0.11	0	37

Table 4.6 Summary statistics for comparison between TEOM modelled and measured concentrations of PM_{10} at roadside sites

	Mean of measurements ($\mu g\ m^{-3}$, TEOM)	Mean of model estimates ($\mu g\ m^{-3}$, TEOM)	r^2	% outside data quality objectives	Number of sites
National Network	23.6	22.6	0.64	0	7
Verification Sites	21.4	19.4	0.02	0	22

4.11 COMPARISON OF GRAVIMETRIC AND TEOM MAP

To determine whether 1.3 was an accurately representative conversion factor from TEOM to gravimetric equivalent, further analysis was undertaken to compare the resultant gravimetric and TEOM background maps. The gravimetric map was divided by the TEOM map so that each 1x1km square contained a conversion factor from gravimetric to TEOM. A population-weighted mean (based on 2001 census data) calculation was then performed on this grid to average the conversion factors over the country. The results are presented in Table 4.6.

Table 4.6 Comparison of modelled background values (population-weighted mean of gravimetric concentration/ TEOM concentration) by country)

Country/ Region	Population-weighted means across country
London	1.40
Rest of England	1.37
Scotland	1.23
Wales	1.29
Northern Ireland	1.29
UK	1.36

A population-weighted mean gravimetric/TEOM factor of 1.36 was found for the whole country. The highest values were found in London and the south east; the lowest value was in Scotland. This is because concentrations of the more volatile secondary and primary components are highest in the south east.

4.12 DETAILED COMPARISON OF MODELLING RESULTS WITH LIMIT VALUES

The modelling results, in terms of a comparison of modelled concentrations with the stage 1 and stage limit 2 values by zone, are summarised in Tables 4.7 and 4.8. These data are also presented in form 19c of the questionnaire. We have not modelled 24-hour mean concentrations for comparison with the stage 2 24-hour limit value, as discussed in Section 4.1. Method A in this table refers to the annual mean modelling methods described in this report. Method C refers to the annual mean modelling methods described in this report and the use of an annual mean threshold concentration as equivalent to the stage 1 24-hour limit value.

Estimates of area and population exposed have been derived from the background maps only. No attempt has been made to derive estimates using maps of roadside concentrations as these maps will only apply to within approximately 10 metres from the road kerb.

Table 4.7 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

- Form 19c.1 Results of and methods used for supplementary assessment for PM_{10} (Stage 1)

Zone	Zone code	Above LV (24hr mean)						Above LV (annual mean)					
		Area		Road length		Population exposed		Area		Road length		Population exposed	
		km^2	Method	km	Method	Number	Method	km^2	Method	km	Method	Number	Method
Greater London Urban Area	UK0001	0	C	464.8	C	0	C	0	A	24.0	A	0	A
West Midlands Urban Area	UK0002	0	C	100.1	C	0	C	0	A	0.4	A	0	A
Greater Manchester Urban Area	UK0003	0	C	32.5	C	0	C	0	A	0	A	0	A
West Yorkshire Urban Area	UK0004	0	C	18.5	C	0	C	0	A	0	A	0	A
Tyneside	UK0005	0	C	3.2	C	0	C	0	A	0	A	0	A
Liverpool Urban Area	UK0006	0	C	0.7	C	0	C	0	A	0	A	0	A
Sheffield Urban Area	UK0007	0	C	48.8	C	0	C	0	A	0	A	0	A
Nottingham Urban Area	UK0008	0	C	10.8	C	0	C	0	A	0	A	0	A
Bristol Urban Area	UK0009	0	C	3.3	C	0	C	0	A	0	A	0	A
Brighton/Worthing/Littlehampton	UK0010	0	C	0.0	C	0	C	0	A	0	A	0	A
Leicester Urban Area	UK0011	0	C	12.6	C	0	C	0	A	0	A	0	A
Portsmouth Urban Area	UK0012	0	C	7.1	C	0	C	0	A	0	A	0	A
Teesside Urban Area	UK0013	0	C	2.5	C	0	C	0	A	0	A	0	A
The Potteries	UK0014	0	C	9.6	C	0	C	0	A	0	A	0	A
Bournemouth Urban Area	UK0015	0	C	0.0	C	0	C	0	A	0	A	0	A
Reading/Wokingham Urban Area	UK0016	0	C	0.6	C	0	C	0	A	0	A	0	A
Coventry/Bedworth	UK0017	0	C	9.3	C	0	C	0	A	0	A	0	A
Kingston upon Hull	UK0018	0	C	3.4	C	0	C	0	A	0	A	0	A
Southampton Urban Area	UK0019	0	C	2.0	C	0	C	0	A	0	A	0	A
Birkenhead Urban Area	UK0020	0	C	0.0	C	0	C	0	A	0	A	0	A
Southend Urban Area	UK0021	0	C	1.5	C	0	C	0	A	0	A	0	A
Blackpool Urban Area	UK0022	0	C	0.0	C	0	C	0	A	0	A	0	A
Preston Urban Area	UK0023	0	C	0.0	C	0	C	0	A	0	A	0	A
Glasgow Urban Area	UK0024	0	C	0.0	C	0	C	0	A	0	A	0	A
Edinburgh Urban Area	UK0025	0	C	0.0	C	0	C	0	A	0	A	0	A
Cardiff Urban Area	UK0026	0	C	0.0	C	0	C	0	A	0	A	0	A

Table 4.7 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

- Form 19c.1 Results of and methods used for supplementary assessment for PM_{10} (Stage 1)

Zone	*Zone code*	*Above LV (24hr mean)*						*Above LV (annual mean)*					
		Area		*Road length*		*Population exposed*		*Area*		*Road length*		*Population exposed*	
		km^2	*Method*	*km*	*Method*	*Number*	*Method*	*km^2*	*Method*	*km*	*Method*	*Number*	*Method*
Swansea Urban Area	UK0027	0	C	2.3	C	0	C	0	A	0	A	0	A
Belfast Urban Area	UK0028	0	C	18.1	C	0	C	0	A	0	A	0	A
Eastern	UK0029	0	C	29.0	C	0	C	0	A	0	A	0	A
South West	UK0030	0	C	0.0	C	0	C	0	A	0	A	0	A
South East	UK0031	0	C	23.2	C	0	C	0	A	0	A	0	A
East Midlands	UK0032	0	C	20.1	C	0	C	0	A	0	A	0	A
North West & Merseyside	UK0033	0	C	0.0	C	0	C	0	A	0	A	0	A
Yorkshire & Humberside	UK0034	0	C	16.9	C	0	C	0	A	0	A	0	A
West Midlands	UK0035	0	C	23.6	C	0	C	0	A	0	A	0	A
North East	UK0036	0	C	12.1	C	0	C	0	A	0	A	0	A
Central Scotland	UK0037	0	C	0.0	C	0	C	0	A	0	A	0	A
North East Scotland	UK0038	0	C	0.0	C	0	C	0	A	0	A	0	A
Highland	UK0039	0	C	0.0	C	0	C	0	A	0	A	0	A
Scottish Borders	UK0040	0	C	0.0	C	0	C	0	A	0	A	0	A
South Wales	UK0041	0	C	1.3	C	0	C	0	A	0	A	0	A
North Wales	UK0042	0	C	0.0	C	0	C	0	A	0	A	0	A
Northern Ireland	UK0043	0	C	0.0	C	0	C	0	A	0	A	0	A

Table 4.8 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

- Form 19c.2 Results of and methods used for supplementary assessment for PM_{10} (Stage 2)

Zone	*Zone code*	*Above LV (24hr mean)*						*Above LV (annual mean)*					
		Area		*Road length*		*Population exposed*		*Area*		*Road length*		*Population exposed*	
		km^2	*Method*	*km*	*Method*	*Number*	*Method*	*km^2*	*Method*	*km*	*Method*	*Number*	*Method*
Greater London Urban Area	UK0001							1628	A	1887.8	A	7781081	A
West Midlands Urban Area	UK0002							583	A	565.4	A	2058836	A
Greater Manchester Urban Area	UK0003							455	A	660.6	A	1587934	A
West Yorkshire Urban Area	UK0004							253	A	420.7	A	835969	A
Tyneside	UK0005							31	A	168.5	A	92937	A
Liverpool Urban Area	UK0006							113	A	213.6	A	477130	A
Sheffield Urban Area	UK0007							150	A	158.1	A	485704	A
Nottingham Urban Area	UK0008							169	A	136.3	A	558935	A
Bristol Urban Area	UK0009							120	A	118.6	A	445256	A
Brighton/Worthing/Littlehampton	UK0010							91	A	82.2	A	379402	A
Leicester Urban Area	UK0011							102	A	92.8	A	374314	A
Portsmouth Urban Area	UK0012							78	A	72.6	A	331396	A
Teesside Urban Area	UK0013							42	A	74.1	A	97380	A
The Potteries	UK0014							82	A	123.0	A	250099	A
Bournemouth Urban Area	UK0015							72	A	71.2	A	251873	A
Reading/Wokingham Urban Area	UK0016							97	A	84.4	A	305786	A
Coventry/Bedworth	UK0017							76	A	34.9	A	277475	A
Kingston upon Hull	UK0018							34	A	52.3	A	109655	A
Southampton Urban Area	UK0019							76	A	65.1	A	260585	A
Birkenhead Urban Area	UK0020							14	A	54.1	A	30088	A
Southend Urban Area	UK0021							64	A	49.8	A	217874	A
Blackpool Urban Area	UK0022							0	A	14.2	A	0	A
Preston Urban Area	UK0023							18	A	45.8	A	59616	A
Glasgow Urban Area	UK0024							11	A	156.5	A	46147	A
Edinburgh Urban Area	UK0025							0	A	21.7	A	0	A
Cardiff Urban Area	UK0026							34	A	49.8	A	136371	A

Table 4.8 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II)) - Form 19c.2 Results of and methods used for supplementary assessment for PM_{10} (Stage 2)

Zone	*Zone code*	*Above LV (24hr mean)*						*Above LV (annual mean)*					
		Area		*Road length*		*Population exposed*		*Area*		*Road length*		*Population exposed*	
		km^2	*Method*	*km*	*Method*	*Number*	*Method*	*km^2*	*Method*	*km*	*Method*	*Number*	*Method*
Swansea Urban Area	UK0027							3	A	32.0	A	1991	A
Belfast Urban Area	UK0028							94	A	200.0	A	322688	A
Eastern	UK0029							8417	A	880.4	A	4209986	A
South West	UK0030							556	A	496.1	A	614116	A
South East	UK0031							6996	A	1336.2	A	4880578	A
East Midlands	UK0032							3860	A	631.1	A	2357758	A
North West & Merseyside	UK0033							721	A	707.0	A	933791	A
Yorkshire & Humberside	UK0034							1198	A	578.0	A	1091341	A
West Midlands	UK0035							1601	A	523.2	A	1312895	A
North East	UK0036							29	A	145.7	A	21612	A
Central Scotland	UK0037							16	A	30.2	A	16262	A
North East Scotland	UK0038							0	A	22.2	A	0	A
Highland	UK0039							0	A	0.0	A	0	A
Scottish Borders	UK0040							0	A	0.0	A	0	A
South Wales	UK0041							114	A	152.0	A	139193	A
North Wales	UK0042							43	A	38.1	A	19348	A
Northern Ireland	UK0043							14	A	93.8	A	30702	A

5 Benzene

5.1 INTRODUCTION

Maps of annual mean benzene concentrations at background and roadside locations in 2004 are presented in Figures 5.1 and 5.2. Annual mean Benzene concentrations in 2004 across the UK have been modelled using a similar approach to that adopted for the 2003 modelling described in detail in Stedman et al (2005). Changes to this method for 2004 modelling are described below.

Figure 5.1. Annual mean background benzene concentration, 2004 ($\mu g\ m^{-3}$)

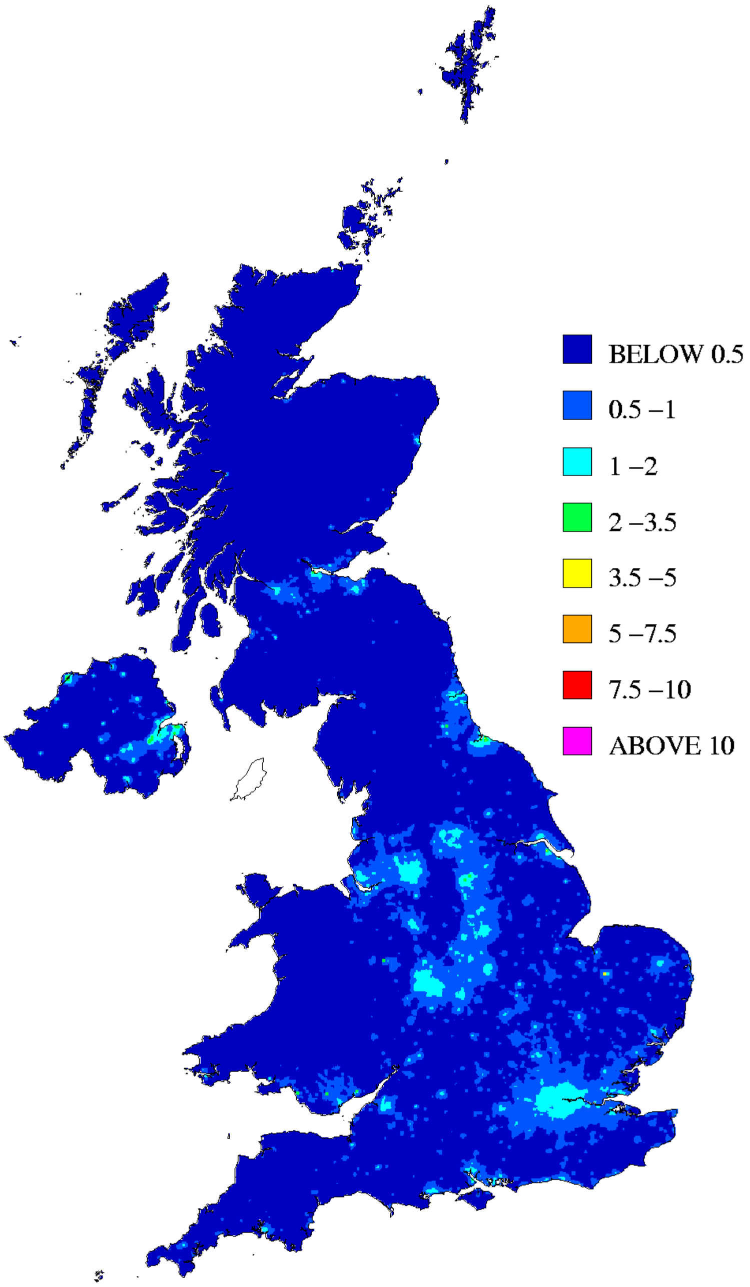
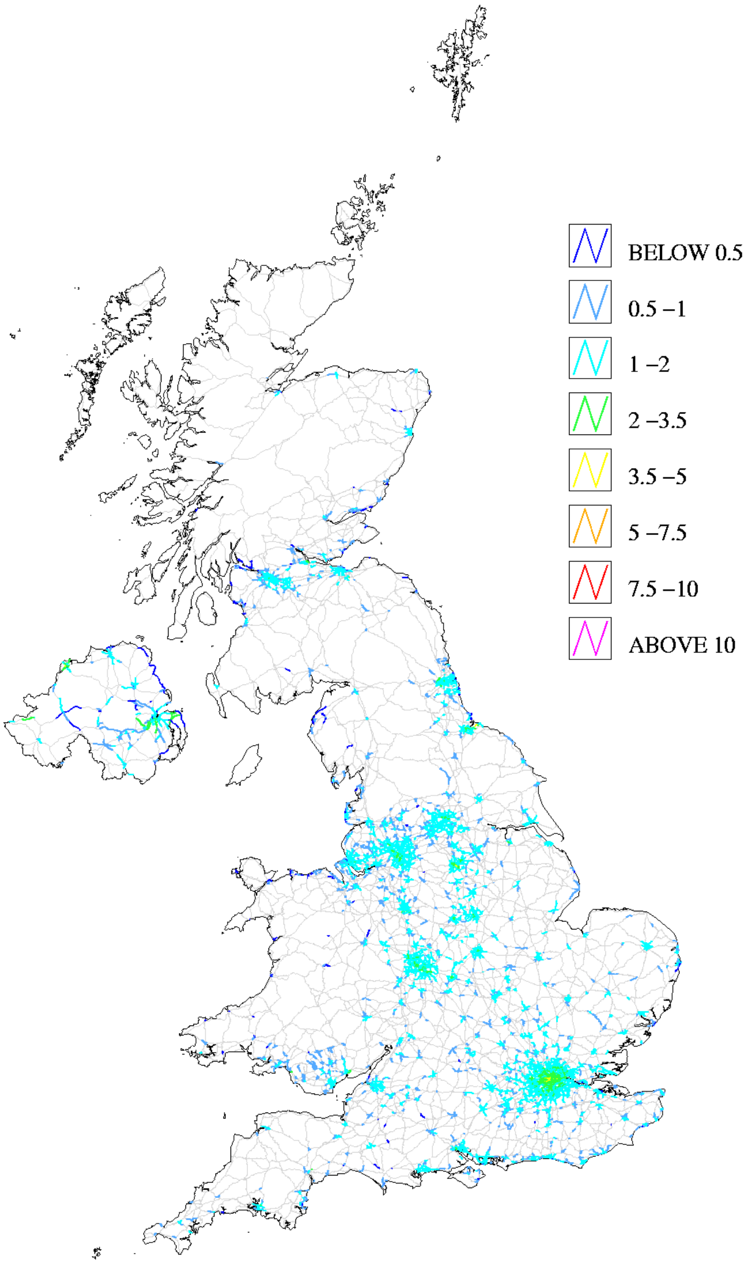


Figure 5.2. Urban major roads, annual mean roadside benzene concentration, 2004 ($\mu g\ m^{-3}$)



5.2 CONTRIBUTIONS FROM COMBUSTION POINT SOURCES

Contributions to ground level annual mean benzene concentrations from large combustion related point sources (those with annual emission greater than 5 tonnes) in the 2003 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 3.2) with sequential meteorological data for 2004 from Waddington. A total of 22 point sources were modelled.

The method used for modelling concentrations from large point sources in 2004 closely follows the method used in 2003, further details of which are given in Stedman et al (2005).

5.3 CONTRIBUTIONS FROM FUGITIVE AND PROCESS POINT SOURCES

The method used to model contributions to ambient concentrations from fugitive and process emission point sources has been revised for 2004 for that used for 2003 (Stedman et al, 2005). The emissions from these sources are not generally as well characterised in terms of exact location and release parameters as emissions from combustion sources. Separate models are used for the ‘in-square’ concentration (the concentration in the 1 x 1 km grid square that includes the source) and the concentration in surroundung grid squares (‘the out-square concentration’). The method has been revised so that an in-square concentration has been estimated by assessing the concentration resulting from unit emissions released from a volume source of dimensions 200 m by 200 m and 30 m high. The average concentration in the grid square has only been calculated for receptors outside an area 400 m by 400 m in the centre of the 1 x 1 km square so that concentrations within the boundary fence of the process have been excluded. A dispersion kernel approach similar to that adopted for the area sources was used to calculate the out-square concentrations.

5.4 CONTRIBUTIONS FROM RURAL BACKGROUND CONCENTRATIONS

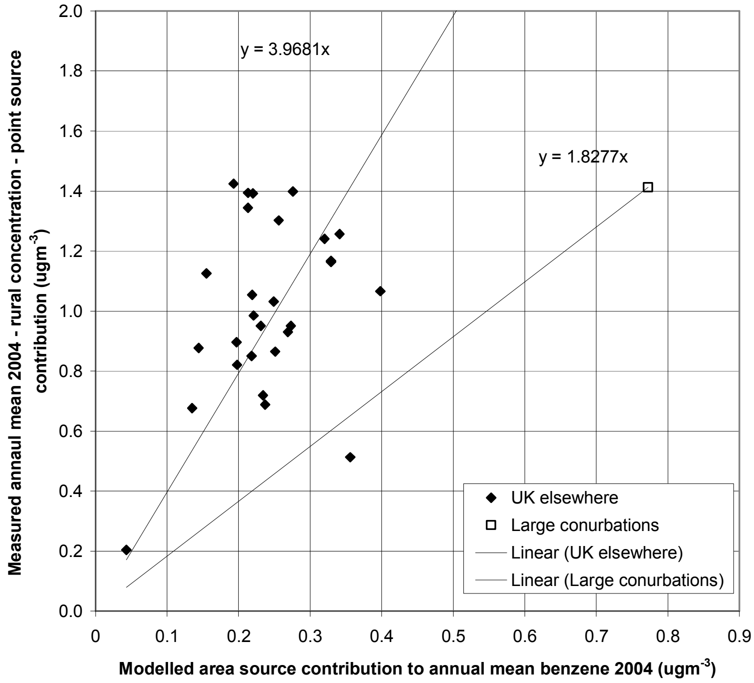
Regional rural benzene concentrations were estimated from the map of rural NO_x concentration described in section 3.4. The rural NO_x map was scaled using the ratio of measured annual mean benzene and NO_x concentrations at the rural Harwell monitoring site in 2004.

5.5 CONTRIBUTIONS FROM AREA SOURCES

Figure 5.3 shows the calibration of the benzene area source model. Calibration of the area source model in 2004 follows the same method as in 2003 for benzene (see Stedman et al, 2005) with the following differences:

- Monitoring data from background sites for 2004 has been used
- 2004 dispersion kernels have been used. These have been constructed using hourly sequential meteorological data from Heathrow in 2004,
- The ‘inner conurbations’ calibration coefficient has been calculated using London Bloomsbury, which is the only background monitoring site in an inner conurbation. However, because emissions for road transport area sources look unrealistically high compared with other locations, area source road transport emissions in inner conurbations have been scaled by a factor of 0.7.
- Grangemouth has been excluded from the calibration process because the current method of estimating point source concentrations from refineries seems to over predict somewhat at this site.

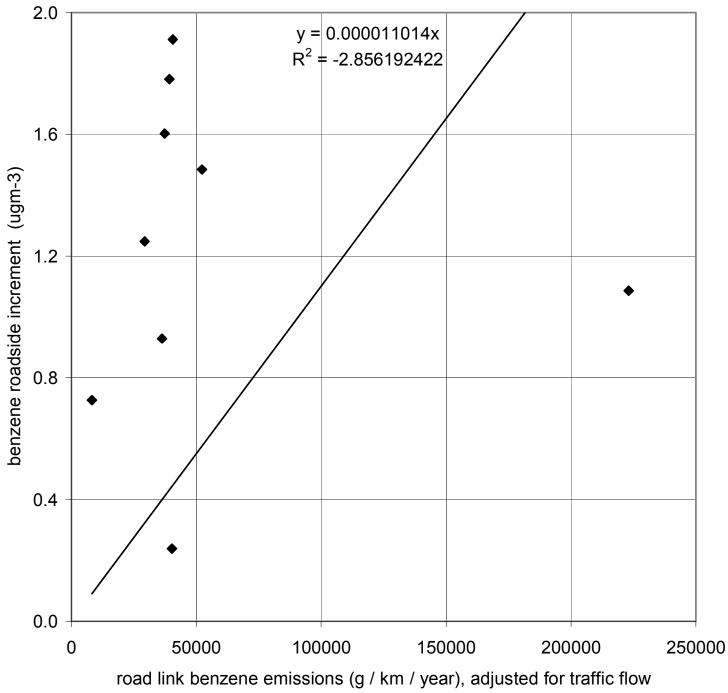
Figure 5.3. Calibration of area source benzene model 2004 ($\mu g\ m^{-3}$)



5.6 ROADSIDE CONCENTRATIONS

Calibration of the benzene roadside increment model is shown in figure 5.4. Roadside concentrations of annual mean benzene for 2004 have been modelled using a similar method to the NO_x modelling described in section 3.6.

Figure 5.4. Calibration of benzene roadside increment model



The relationship on this calibration plot is poor. This is because Marylebone road is significantly different to the other sites. This could either be as a result of its location in central London, or because it is an AURN site with automatic monitoring of benzene while the other sites on this graph are benzene pumped absorption tubes. Both methods are, however, calibrated to the same standard.

5.7 VERIFICATION OF MAPPED VALUES

Figures 5.4 and 5.5 show comparisons of the modelled and measured annual mean benzene concentrations for background and roadside locations. Lines showing $y = x - 50\%$ and $y = x + 50\%$ are included in these charts. These represent the AQDD2 data quality objective for modelled benzene concentrations.

Figure 5.4. Verification of background annual mean benzene model 2004

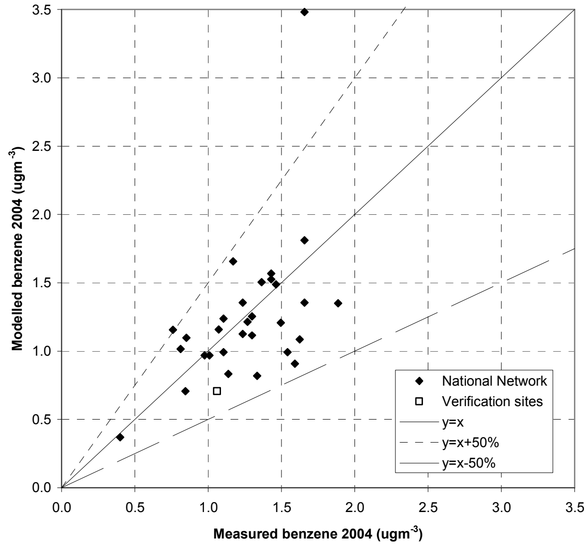
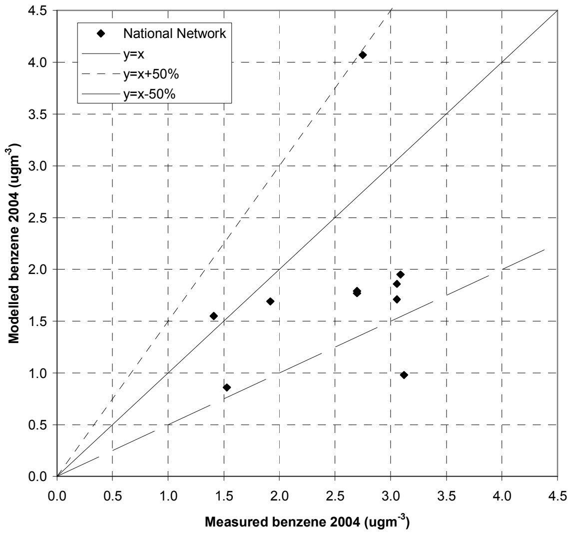


Figure 5.5. Verification of roadside annual mean benzene model 2004



Summary statistics for the comparison between modelled and measured benzene concentrations are listed in Tables 5.1 and 5.2.

Table 5.1 Summary statistics for comparison between modelled and measured benzene concentrations at background sites (μg m^{-3})

	Mean of measurements (μg m^{-3})	Mean of model estimates (μg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	1.26	1.24	0.26	7%	30
Verification site	1.06	0.71	n/a	0%	1

Table 5.2 Summary statistics for comparison between modelled and measured benzene concentrations at roadside sites (μg m^{-3})

	Mean of measurements (μg m^{-3})	Mean of model estimates (μg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	2.53	1.82	-0.01	10%	10

5.8 DETAILED COMPARISON OF MODELLING RESULTS WITH LIMIT VALUES

Modelling results for benzene have not been tabulated here because the modelled and measured benzene concentrations are below the limit value for all zones.

6 CO

6.1 INTRODUCTION

Maps of annual mean CO concentrations at background and roadside locations in 2004 are presented in Figures 6.1 and 6.2. Maps of maximum 8-hour mean CO concentrations at background and roadside locations in 2004 are presented in Figures 6.3 and 6.4.

First background and roadside maps of annual mean CO were calculated. These maps were then scaled using the relationship between measured annual mean CO concentrations and measured maximum of 8-hour concentrations from the national network. Only the maximum 8-hour mean maps are required for comparison with the AQDD2 limit value but because the annual mean maps were also prepared as an intermediate step within the modelling exercise these are also presented here.

The modelling method used here closely follows that used for mapping annual mean and maximum of 8-hour mean CO concentrations for 2003 (see Stedman et al, 2005). Changes to this method for 2004 modelling are described below.

Figure 6.1. Annual mean background CO concentration, 2004 (mg m^{-3})

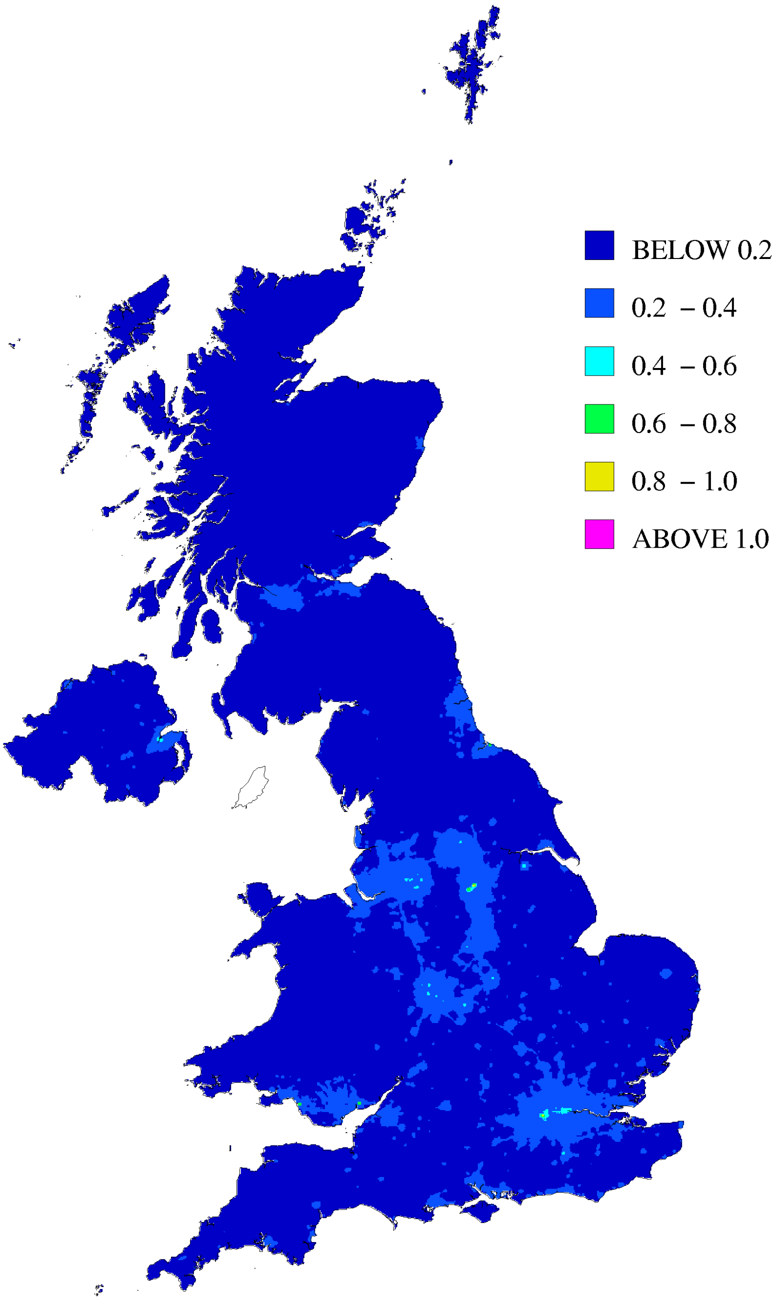


Figure 6.2. Urban major roads, annual mean roadside CO concentration, 2004 (mg m^{-3})

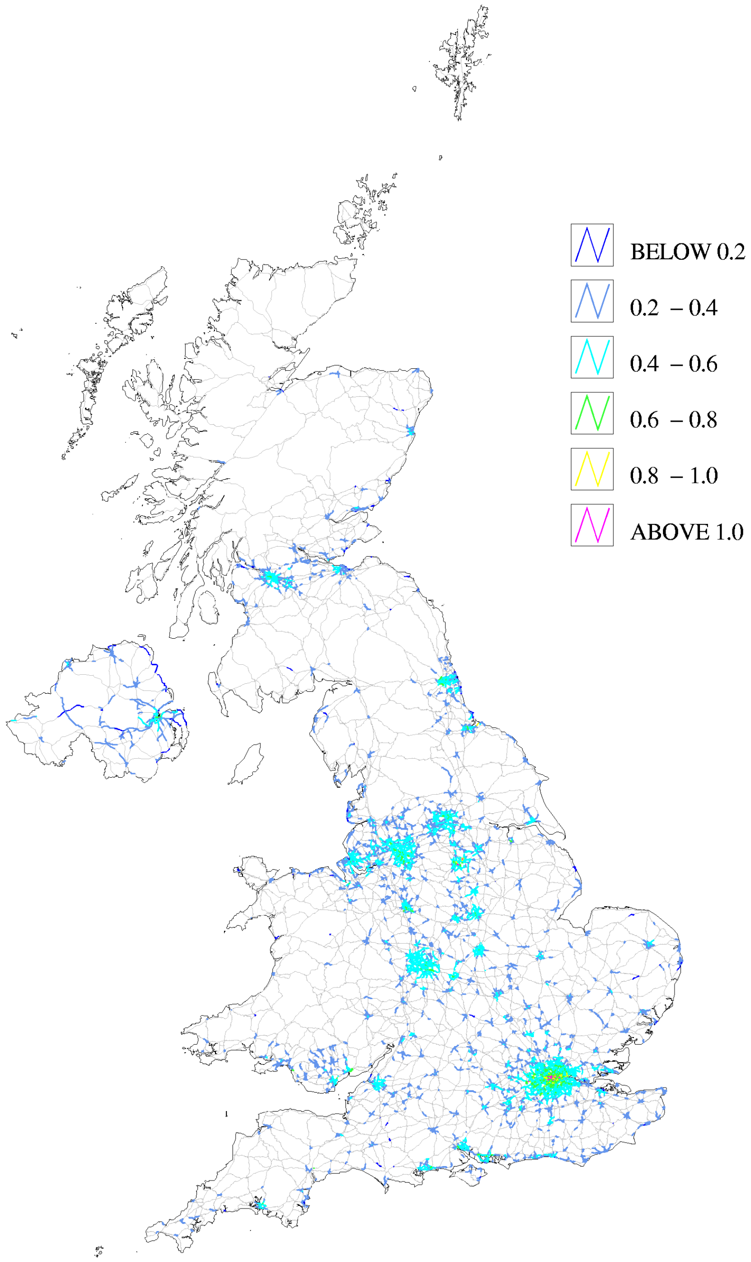


Figure 6.3. Maximum 8-hour mean background CO concentration, 2004 (mg m^{-3})

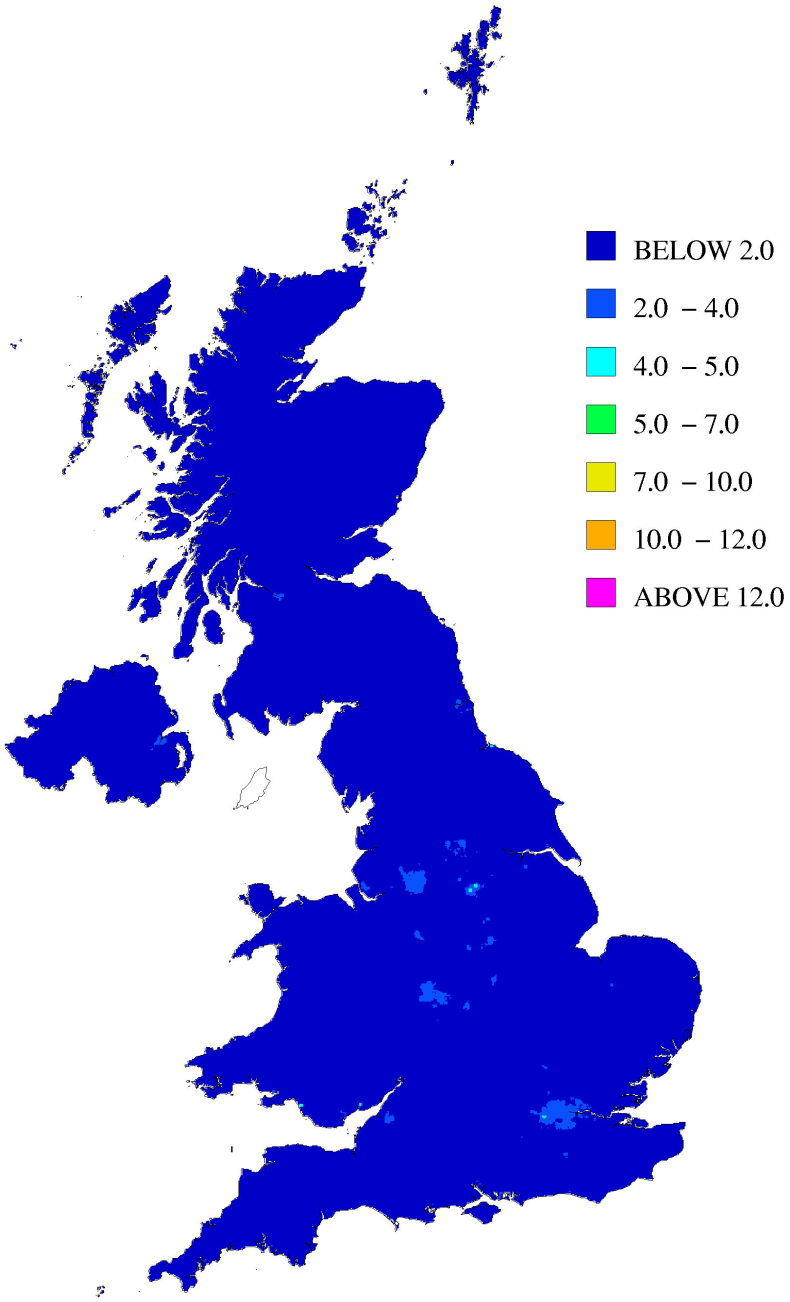
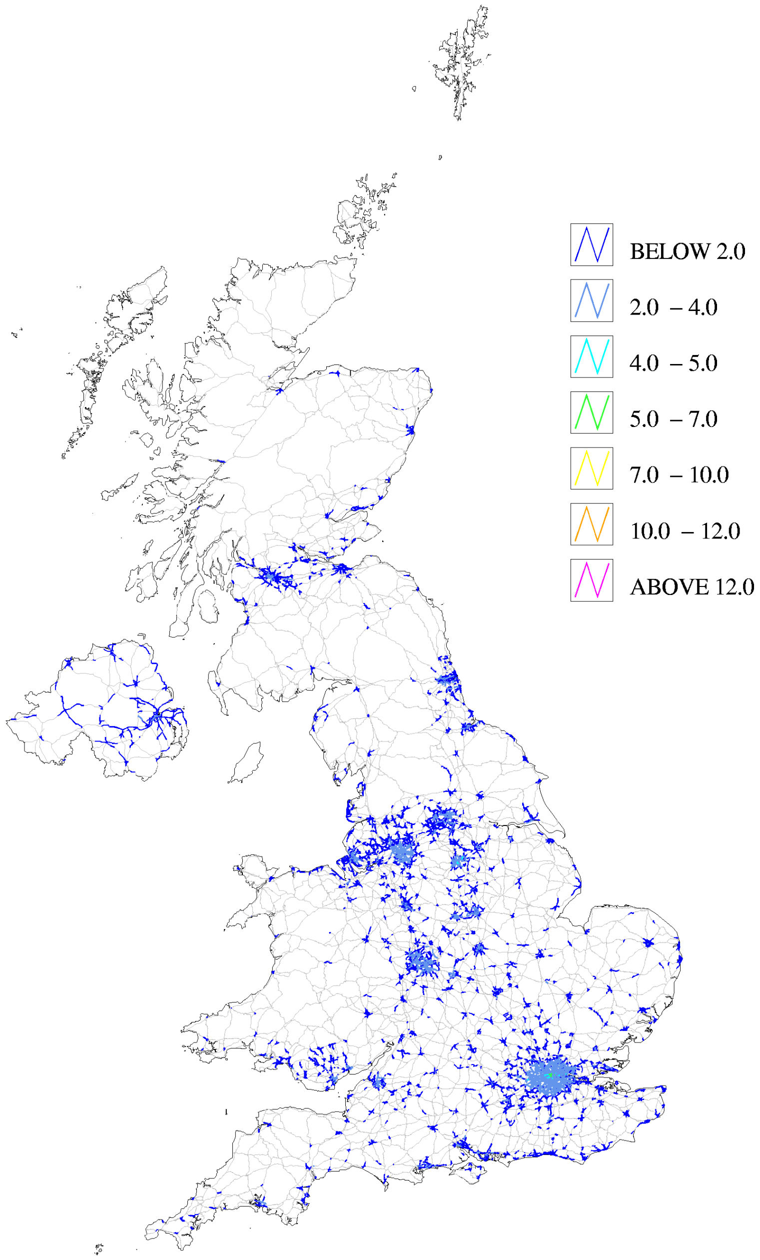


Figure 6.4. Urban major roads, maximum 8-hour mean roadside CO concentration, 2004 (mg m^{-3})



6.2 CONTRIBUTIONS FROM LARGE POINT SOURCES

Contributions to ground level annual mean CO concentrations from large point sources (those with annual emission greater than 3000 tonnes) in the 2003 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 3.2). and sequential meteorological data for 2004 from Waddington. A total of 47 point sources were modelled.

The method used for modelling concentrations from large point sources in 2004 closely follows the method used in 2003, further details of which are given in Stedman et al (2005).

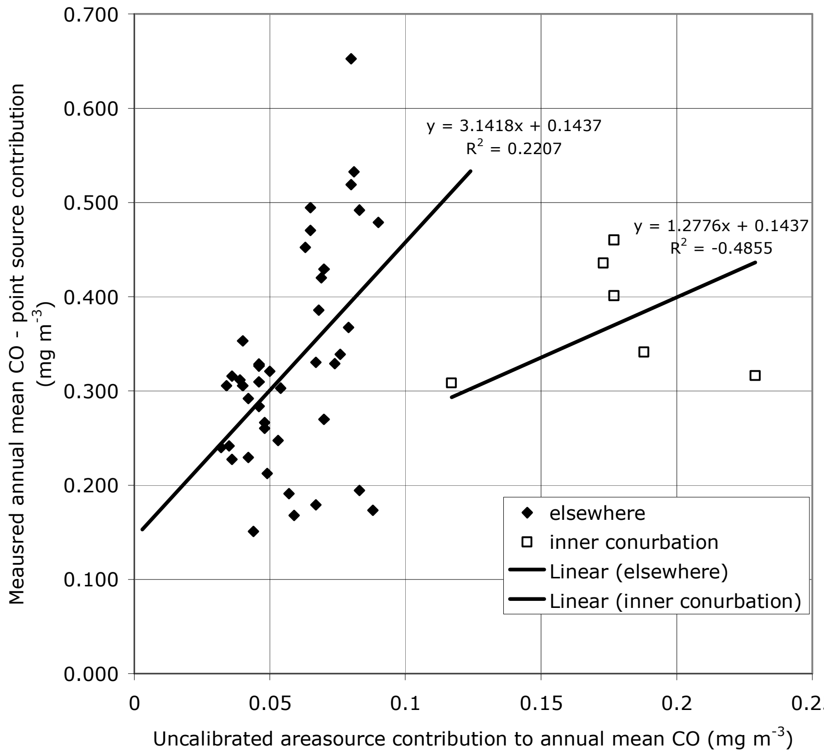
6.3 CONTRIBUTIONS FROM SMALL POINT SOURCES

Contributions to annual mean CO from CO point sources with less than 3000 tonnes per annum release in the 2003 NAEI were modelled using the small points model described in Stedman et al (2005).

6.4 CONTRIBUTIONS FROM AREA SOURCES

Figure 6.5 shows the calibration of the annual mean area source CO model for background locations.

Figure 6.5. Calibration of 2004 background annual mean CO model (mg m^{-3})



Calibration of the area source model in 2004 follows the same method as in 2003 (see Stedman et al, 2005) with the following differences:

- Monitoring data from background sites for 2004 has been used
- 2004 dispersion kernels have been used. These have been constructed using hourly sequential meteorological data from Heathrow in 2004.
- Manchester has been reclassified as 'elsewhere' in the 2004 calibration and modelling. This is because inspection of the are source calibration plot for NO_x (figure 3.4) showed that the monitoring sites in Manchester fit more closely with the sites classified as 'elsewhere' rather than 'inner conurbation'.

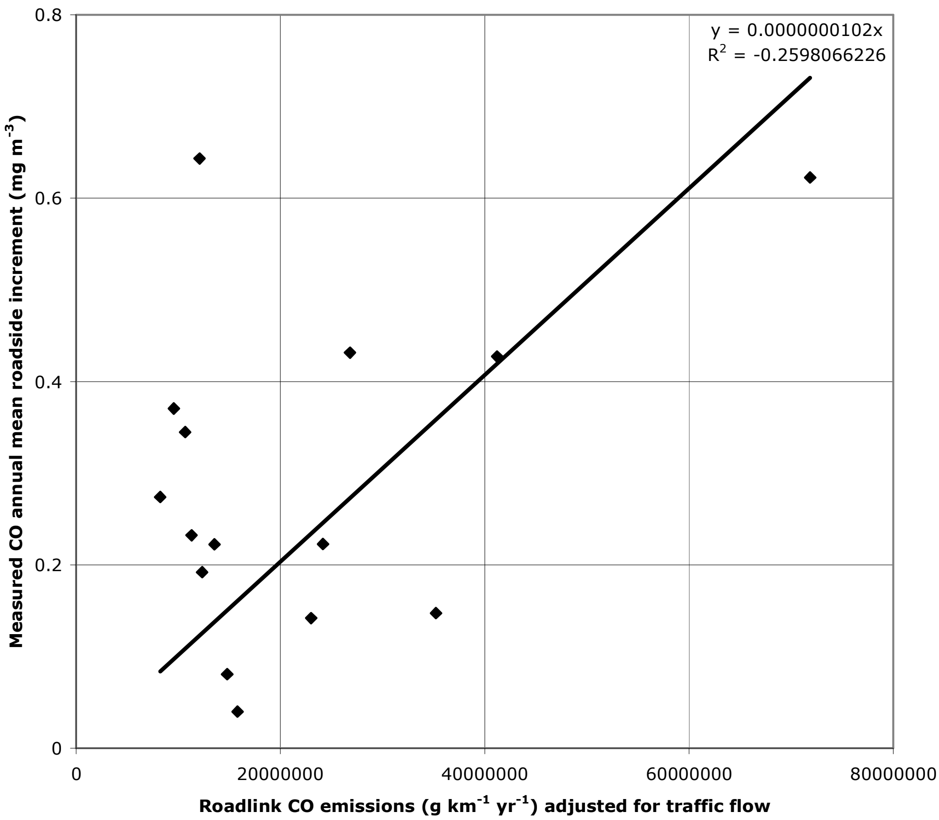
6.5 ROADSIDE ANNUAL MEAN CO CONCENTRATIONS

Calibration of the CO roadside increment model is shown in figure 6.6. Roadside concentrations of annual mean CO for 2004 have been modelled using a similar method to the 2003 modelling with the following differences:

- Estimates of CO emissions from major road links have been taken from the 2004 NAEI
- Monitoring data from roadside sites for 2004 has been used.
- Adjustment factors applied to motorways to account for dispersion from vehicles travelling along a road have been lowered from those used in the 2003 modelling as discussed in section 3.6.

It is clear that the calibration of the roadside increment model for CO is not as robust as for pollutants such as NO_x. This is likely to be due to the poor characterisation of roadlink emissions for CO, which are particularly dependent on vehicle speeds and congestion conditions.

Figure 6.6. Calibration of 2004 roadside annual mean CO model (mg m^{-3})



6.6 MODELLING THE MAXIMUM 8-HOUR MEAN CO CONCENTRATION

A map of maximum of 8-hour CO concentrations at background locations have been calculate using the annual mean CO background map and the relationship between measured annual mean concentrations and maximum 8-hour concentrations at AURN background sites, as described in Stedman et al (2005). A roadside maximum of 8-hour CO concentrations has been calculated using a similar method, but with the annual mean roadside map and data from roadside sites. The resulting calibration plots for background and roadside locations are presented in figures 6.7 and 6.8 respectively.

Figure 6.7 Calibration of 2004 background maximum 8-hour mean CO model (mg m^{-3})

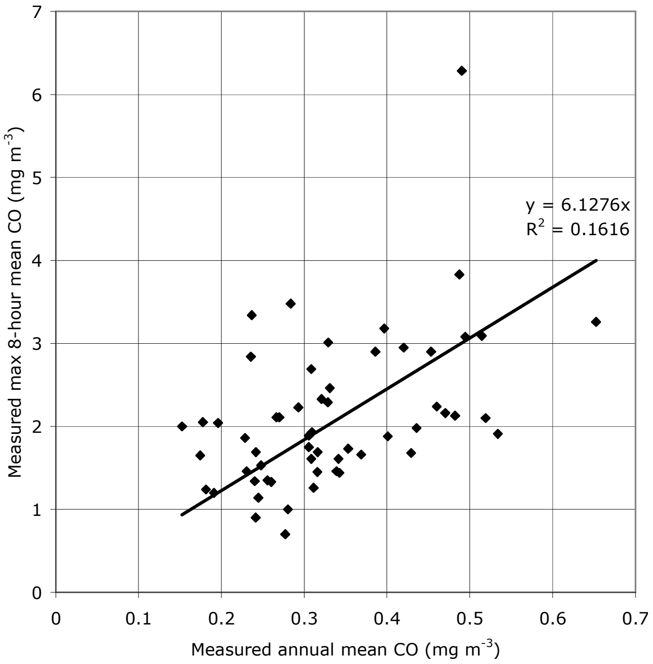
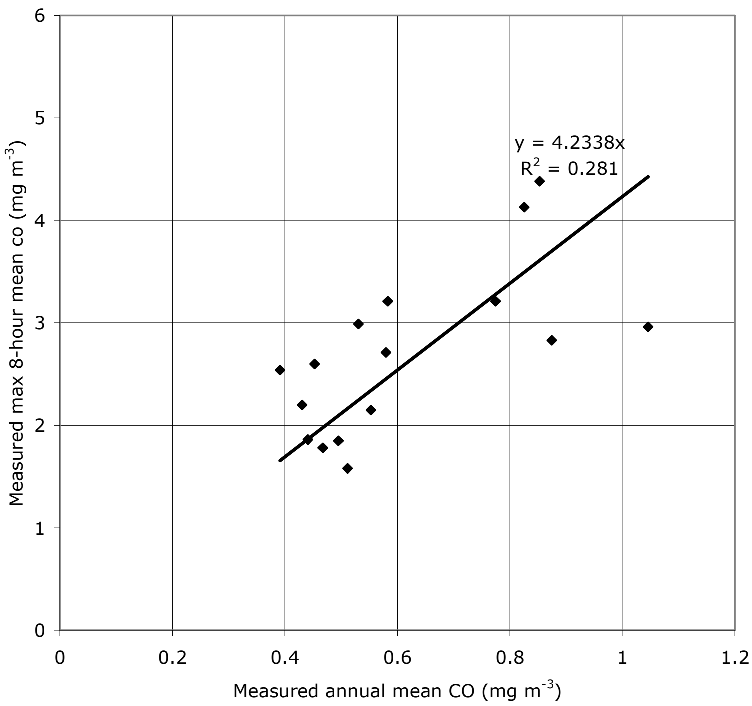


Figure 6.8. Calibration of 2004 roadside maximum 8-hour CO model (mg m^{-3})



6.7 VERIFICATION OF MAPPED VALUES

Figures 6.5 to 6.8 show comparisons of the modelled and measured annual mean and maximum 8-hour CO concentrations for background and roadside locations. The national network sites used to calibrate the models are shown in addition to the verification sites. Lines showing y = x – 50% and y = x + 50% are included in these charts – these represent the AQDD2 data quality objective for modelled carbon monoxide concentrations. Summary statistics for the comparison between modelled and measured carbon monoxide concentrations are listed in Tables 6.1 to 6.4.

Figure 6.5. Verification of background annual mean CO model 2004

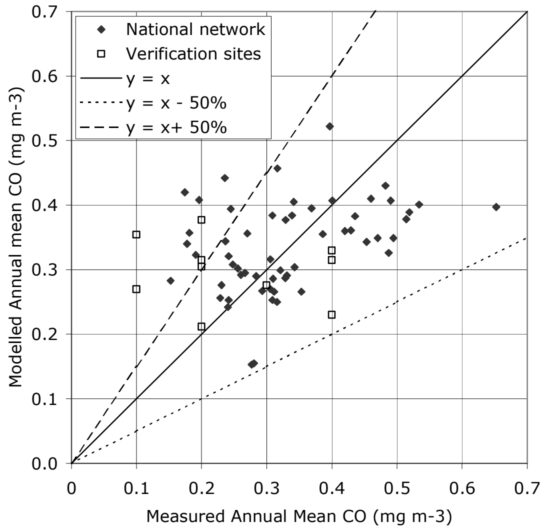


Figure 6.6. Verification of background maximum 8-hour mean CO model 2004

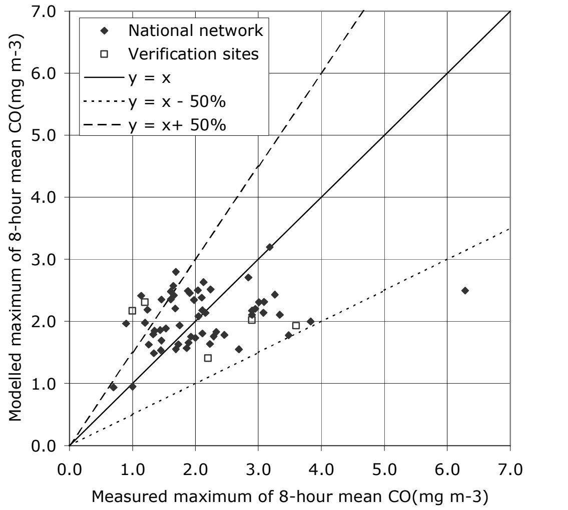


Figure 6.7. Verification of roadside annual mean CO model 2004

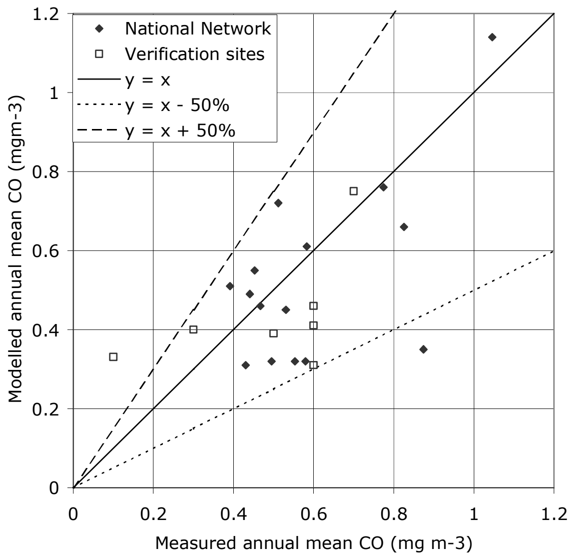


Figure 6.8. Verification of roadside maximum 8-hour mean CO model 2004

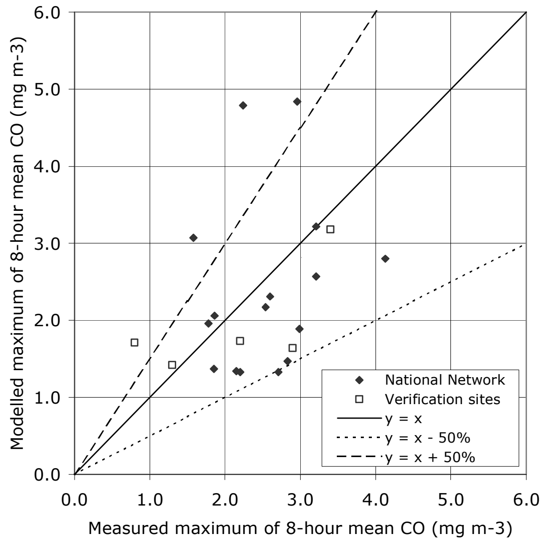


Table 6.1. Summary statistics for comparison between modelled and measured annual mean CO concentrations at background sites (mg m^{-3})

	Mean of measurements (mg m^{-3})	Mean of model estimates (mg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	0.33	0.34	0.14	14.0	57
Verification Sites	0.25	0.30	0.03	50.0	10

Table 6.2. Summary statistics for comparison between modelled and measured maximum 8-hour mean CO concentrations at background sites (mg m^{-3})

	Mean of measurements (mg m^{-3})	Mean of model estimates (mg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	2.11	2.06	0.12	15.8	57
Verification Sites	2.18	1.97	0.15	40.0	5

Table 6.3. Summary statistics for comparison between modelled and measured annual mean CO concentrations at roadside sites (mg m^{-3})

	Mean of measurements (mg m^{-3})	Mean of model estimates (mg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	0.60	0.53	0.37	6.3	16
Verification Sites	0.49	0.28	0.28	14.3	7

Table 6.4. Summary statistics for comparison between modelled and measured maximum 8-hour mean CO concentrations at roadside sites (mg m^{-3})

	Mean of measurements (mg m^{-3})	Mean of model estimates (mg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	2.55	2.41	0.04	25.0	16
Verification Sites	2.12	1.82	0.459	20.0	5

6.8 DETAILED COMPARISON OF MODELLING RESULTS WITH LIMIT VALUES

Modelling results for CO have not been tabulated here because the modelled and measured CO concentrations are below the limit value for all zones.

7 Lists of zones in relation to Limit Values and Margins of Tolerance

7.1 RESULTS FOR 2004

The tables included in this section are from form 8 of the questionnaire. Exceedence (or otherwise of the limit vale (LV) and limit value plus margin of tolerance (LV + MOT) where this exists are indicated by a 'y' for measured exceedences and with an 'm' for modelled exceedences. If both measurements and model estimates show that a threshold has been exceeded then the measurements are regarded as the primary basis for compliance status and 'y' is therefore used. An 'm' in the columns marked >LV + MOT or ≤LV + MOT; > LV indicates that modelled concentrations were higher than measured concentrations or on rare occasions that measurements were not available for that zone and modelled values were therefore used. Modelled concentration may be higher than measured concentrations because the modelling studies provide estimates of concentrations over the entire zone. It is possible that the locations of the monitoring sites do not correspond to the location of the highest concentration in the zone. There may, for example, be no roadside monitoring sites in a zone. An 'm' in the columns marked ≤LV indicates that measurements were not available for that zone and modelled values were therefore used. A 'n' indicates that the limit value is not applicable for that zone. The ecosystem and vegetation limit values, for example, do not apply in agglomeration zones. A blank cell indicates that no assessment has been made.

The results of the air quality assessments for SO_2, NO_2 and NO_x, PM_{10}, lead, benzene and CO are listed in Tables 7.1 to 7.6. The relationship between the number of days with PM_{10} concentrations greater than 50 $\mu g\ m^{-3}$ and annual means is less certain than the Stage 2 24-hour LV as discussed in section 4.1. This is why we have not attempted to model exceedences of this LV. In Tables 7.3, however we have assumed that a modelled exceedence of the Stage 1 24-hour LV implies an exceedences of the Stage 2 24-hour LV.

Table 7.1. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8a List of zones in relation to limit value exceedences for SO_2

Zone	Zone code	LV for health (1hr mean)			LV for health (24hr mean)		LV for ecosystems (annual mean)		LV for ecosystems (winter mean)	
		>LV+ MOT	≤LV+MOT; >LV	≤LV	>LV	≤LV	>LV	≤LV	>LV	≤LV
Greater London Urban Area	UK0001			y		y		n		n
West Midlands Urban Area	UK0002			y		y		n		n
Greater Manchester Urban Area	UK0003			y		y		n		n
West Yorkshire Urban Area	UK0004			y		y		n		n
Tyneside	UK0005			y		y		n		n
Liverpool Urban Area	UK0006			y		y		n		n
Sheffield Urban Area	UK0007			y		y		n		n
Nottingham Urban Area	UK0008			y		y		n		n
Bristol Urban Area	UK0009			y		y		n		n
Brighton/Worthing/Littlehampton	UK0010			y		y		n		n
Leicester Urban Area	UK0011			y		y		n		n
Portsmouth Urban Area	UK0012			y		y		n		n
Teesside Urban Area	UK0013			y		y		n		n
The Potteries	UK0014			y		y		n		n
Bournemouth Urban Area	UK0015			y		y		n		n
Reading/Wokingham Urban Area	UK0016			y		y		n		n
Coventry/Bedworth	UK0017			y		y		n		n
Kingston upon Hull	UK0018			y		y		n		n
Southampton Urban Area	UK0019			y		y		n		n
Birkenhead Urban Area	UK0020			y		y		n		n
Southend Urban Area	UK0021			y		y		n		n
Blackpool Urban Area	UK0022			m		m		n		n
Preston Urban Area	UK0023			y		y		n		n

Table 7.1. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8a List of zones in relation to limit value exceedences for SO_2

Zone	Zone code	LV for health (1hr mean)			LV for health (24hr mean)		LV for ecosystems (annual mean)		LV for ecosystems (winter mean)	
		>LV+ MOT	≤LV+MOT; >LV	≤LV	>LV	≤LV	>LV	≤LV	>LV	≤LV
Glasgow Urban Area	UK0024			y		y		n		n
Edinburgh Urban Area	UK0025			y		y		n		n
Cardiff Urban Area	UK0026			y		y		n		n
Swansea Urban Area	UK0027			y		y		n		n
Belfast Urban Area	UK0028			y		y		n		n
Eastern	UK0029	m				y		m		m
South West	UK0030			y		y		m		m
South East	UK0031			y		y		y		y
East Midlands	UK0032			y		y		y		y
North West & Merseyside	UK0033			m		m		m		m
Yorkshire & Humberside	UK0034			y		y		m		m
West Midlands	UK0035			y		y		m		m
North East	UK0036			y		y		m		m
Central Scotland	UK0037			y		y		m		m
North East Scotland	UK0038			y		y		m		m
Highland	UK0039			m		m		m		m
Scottish Borders	UK0040			m		m		m		m
South Wales	UK0041			y		y		y		y
North Wales	UK0042			y		y		m		m
Northern Ireland	UK0043			y		y		m		m

Table 7.2. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8b List of zones in relation to limit value exceedences for NO_2/NOx

Zone	Zone code	LV for health (1hr mean)			LV for health (annual mean)			LV for vegetation	
		>LV+MOT	≤LV+MOT; >LV	≤LV	>LV+MOT	≤LV+MOT; >LV	≤LV	>LV	≤LV
Greater London Urban Area	UK0001	y			y				n
West Midlands Urban Area	UK0002			y	m				n
Greater Manchester Urban Area	UK0003			y	y				n
West Yorkshire Urban Area	UK0004			y	m				n
Tyneside	UK0005			y	m				n
Liverpool Urban Area	UK0006			y	m				n
Sheffield Urban Area	UK0007			y	m				n
Nottingham Urban Area	UK0008			y	m				n
Bristol Urban Area	UK0009			y	y				n
Brighton/Worthing/Littlehampton	UK0010			y	m				n
Leicester Urban Area	UK0011			y	m				n
Portsmouth Urban Area	UK0012			y	m				n
Teesside Urban Area	UK0013			y	m				n
The Potteries	UK0014			y	m				n
Bournemouth Urban Area	UK0015			y		m			n
Reading/Wokingham Urban Area	UK0016			y	m				n
Coventry/Bedworth	UK0017			y		m			n
Kingston upon Hull	UK0018			y	m				n
Southampton Urban Area	UK0019			y	m				n
Birkenhead Urban Area	UK0020			y		m			n
Southend Urban Area	UK0021			y	m				n
Blackpool Urban Area	UK0022			y			y		n
Preston Urban Area	UK0023			y		m			n
Glasgow Urban Area	UK0024			y	y				n
Edinburgh Urban Area	UK0025			y	m				n
Cardiff Urban Area	UK0026			y	m				n
Swansea Urban Area	UK0027			y			y		n
Belfast Urban Area	UK0028			y	m				n

Table 7.2. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8b List of zones in relation to limit value exceedences for NO_2/NOx

Zone	Zone code	LV for health (1hr mean)			LV for health (annual mean)			LV for vegetation	
		>LV+MOT	≤LV+MOT; >LV	≤LV	>LV+MOT	≤LV+MOT; >LV	≤LV	>LV	≤LV
Eastern	UK0029			y	m				m
South West	UK0030			y	y				y
South East	UK0031			y	y				y
East Midlands	UK0032			y	m				m
North West & Merseyside	UK0033			y	m				m
Yorkshire & Humberside	UK0034			y	m				m
West Midlands	UK0035			y	m				m
North East	UK0036			y	m				m
Central Scotland	UK0037			y	m				m
North East Scotland	UK0038			y	m				m
Highland	UK0039			y			y		m
Scottish Borders	UK0040			y			y		m
South Wales	UK0041			y	m				y
North Wales	UK0042			y	m				y
Northern Ireland	UK0043			y		m			m

Table 7.3. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8c List of zones in relation to limit value exceedences for PM_{10}

Zone	Zone code	LV (24hr mean) Stage 1			LV (annual mean) Stage 1			LV (24hr mean) Stage 2		LV (annual mean) Stage 2		
		>LV+ MOT	≤LV+ MOT; >LV	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV	≤LV+ MOT; >LV	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV
Greater London Urban Area	UK0001	y			y			y		y		
West Midlands Urban Area	UK0002	m				m		m		m		
Greater Manchester Urban Area	UK0003	m					y	y		m		
West Yorkshire Urban Area	UK0004	m					y	y		m		
Tyneside	UK0005		m				y	m		m		
Liverpool Urban Area	UK0006		m				y	y		m		
Sheffield Urban Area	UK0007	m					y	m		m		
Nottingham Urban Area	UK0008	m					y	m		m		
Bristol Urban Area	UK0009	m					y	y		m		
Brighton/Worthing/Littlehampton	UK0010			y			y	y		y		
Leicester Urban Area	UK0011	m					y	m		m		
Portsmouth Urban Area	UK0012	m					y	m		m		
Teesside Urban Area	UK0013	m					y	m		m		
The Potteries	UK0014	m					y	m		m		
Bournemouth Urban Area	UK0015			y			y	y		m		
Reading/Wokingham Urban Area	UK0016		m				y	m		m		
Coventry/Bedworth	UK0017		m				y	m		m		
Kingston upon Hull	UK0018		m				y	m		m		
Southampton Urban Area	UK0019	m					y	m		m		
Birkenhead Urban Area	UK0020			y			y		y		m	
Southend Urban Area	UK0021		m				y	m		m		

Table 7.3. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8c List of zones in relation to limit value exceedences for PM_{10}

Zone	Zone code	LV (24hr mean) Stage 1			LV (annual mean) Stage 1			LV (24hr mean) Stage 2		LV (annual mean) Stage 2		
		>LV+ MOT	≤LV+ MOT; >LV	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV	≤LV+ MOT; >LV	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV
Blackpool Urban Area	UK0022			y			y		y		y	
Preston Urban Area	UK0023			y			y		y		m	
Glasgow Urban Area	UK0024			y			y	y			y	
Edinburgh Urban Area	UK0025			y			y		y		m	
Cardiff Urban Area	UK0026			y			y		y		y	
Swansea Urban Area	UK0027		y				y	y		y		
Belfast Urban Area	UK0028		m				y	y		m		
Eastern	UK0029	m					y	m		m		
South West	UK0030			y			y	y		m		
South East	UK0031	m					y	m		m		
East Midlands	UK0032	m					y	y		m		
North West & Merseyside	UK0033			m			m			m		
Yorkshire & Humberside	UK0034	m					m	m		m		
West Midlands	UK0035	m					y	m		m		
North East	UK0036	m					y	y		m		
Central Scotland	UK0037			y			y		y		m	
North East Scotland	UK0038			y			y	y			m	
Highland	UK0039			y			y		y			y
Scottish Borders	UK0040			y			y		y			y
South Wales	UK0041	m					y	m		m		
North Wales	UK0042			y			y	y		m		
Northern Ireland	UK0043			y			y		y		m	

Table 7.4. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8d List of zones in relation to limit value exceedences for lead

Zone	Zone code	LV		
		>LV+MOT	≤LV+MOT; >LV	≤LV
Greater London Urban Area	UK0001			y
West Midlands Urban Area	UK0002			y
Greater Manchester Urban Area	UK0003			y
West Yorkshire Urban Area	UK0004			y
Tyneside	UK0005			y
Liverpool Urban Area	UK0006			
Sheffield Urban Area	UK0007			y
Nottingham Urban Area	UK0008			
Bristol Urban Area	UK0009			
Brighton/Worthing/Littlehampton	UK0010			
Leicester Urban Area	UK0011			
Portsmouth Urban Area	UK0012			
Teesside Urban Area	UK0013			
The Potteries	UK0014			
Bournemouth Urban Area	UK0015			
Reading/Wokingham Urban Area	UK0016			
Coventry/Bedworth	UK0017			
Kingston upon Hull	UK0018			
Southampton Urban Area	UK0019			
Birkenhead Urban Area	UK0020			
Southend Urban Area	UK0021			
Blackpool Urban Area	UK0022			
Preston Urban Area	UK0023			
Glasgow Urban Area	UK0024			y
Edinburgh Urban Area	UK0025			
Cardiff Urban Area	UK0026			y
Swansea Urban Area	UK0027			
Belfast Urban Area	UK0028			

Table 7.4. List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

- Form 8d List of zones in relation to limit value exceedences for lead

Zone	Zone code	LV		
		>LV+MOT	≤LV+MOT; >LV	≤LV
Eastern	UK0029			y
South West	UK0030			y
South East	UK0031			
East Midlands	UK0032			
North West & Merseyside	UK0033			y
Yorkshire & Humberside	UK0034			
West Midlands	UK0035			
North East	UK0036			
Central Scotland	UK0037			y
North East Scotland	UK0038			
Highland	UK0039			
Scottish Borders	UK0040			y
South Wales	UK0041			
North Wales	UK0042			
Northern Ireland	UK0043			

Table 7.5 List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8e List of zones in relation to limit value exceedences for benzene

Zone	Zone code	LV		
		>LV + MOT	≤LV+MOT; >LV	≤LV
Greater London Urban Area	UK0001			y
West Midlands Urban Area	UK0002			y
Greater Manchester Urban Area	UK0003			y
West Yorkshire Urban Area	UK0004			y
Tyneside	UK0005			y
Liverpool Urban Area	UK0006			y
Sheffield Urban Area	UK0007			y
Nottingham Urban Area	UK0008			y
Bristol Urban Area	UK0009			y
Brighton/Worthing/Littlehampton	UK0010			y
Leicester Urban Area	UK0011			y
Portsmouth Urban Area	UK0012			y
Teesside Urban Area	UK0013			y
The Potteries	UK0014			y
Bournemouth Urban Area	UK0015			y
Reading/Wokingham Urban Area	UK0016			y
Coventry/Bedworth	UK0017			y
Kingston upon Hull	UK0018			y
Southampton Urban Area	UK0019			y
Birkenhead Urban Area	UK0020			m
Southend Urban Area	UK0021			y

Table 7.5 List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8e List of zones in relation to limit value exceedences for benzene

Zone	Zone code	LV		
		>LV + MOT	≤LV+MOT; >LV	≤LV
Blackpool Urban Area	UK0022			m
Preston Urban Area	UK0023			m
Glasgow Urban Area	UK0024			y
Edinburgh Urban Area	UK0025			y
Cardiff Urban Area	UK0026			y
Swansea Urban Area	UK0027			m
Belfast Urban Area	UK0028			y
Eastern	UK0029			y
South West	UK0030			y
South East	UK0031			y
East Midlands	UK0032			y
North West & Merseyside	UK0033			y
Yorkshire & Humberside	UK0034			y
West Midlands	UK0035			y
North East	UK0036			y
Central Scotland	UK0037			y
North East Scotland	UK0038			m
Highland	UK0039			m
Scottish Borders	UK0040			m
South Wales	UK0041			y
North Wales	UK0042			m
Northern Ireland	UK0043			m

Table 7.6 List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8f List of zones in relation to limit value for carbon monoxide

Zone	Zone code	LV		
		>LV + MOT	≤LV + MOT; >LV	≤LV
Greater London Urban Area	UK0001			y
West Midlands Urban Area	UK0002			y
Greater Manchester Urban Area	UK0003			y
West Yorkshire Urban Area	UK0004			y
Tyneside	UK0005			y
Liverpool Urban Area	UK0006			y
Sheffield Urban Area	UK0007			y
Nottingham Urban Area	UK0008			y
Bristol Urban Area	UK0009			y
Brighton/Worthing/Littlehampton	UK0010			y
Leicester Urban Area	UK0011			y
Portsmouth Urban Area	UK0012			y
Teesside Urban Area	UK0013			y
The Potteries	UK0014			y
Bournemouth Urban Area	UK0015			y
Reading/Wokingham Urban Area	UK0016			y
Coventry/Bedworth	UK0017			y
Kingston upon Hull	UK0018			y
Southampton Urban Area	UK0019			y
Birkenhead Urban Area	UK0020			y
Southend Urban Area	UK0021			m
Blackpool Urban Area	UK0022			y
Preston Urban Area	UK0023			y

Table 7.6 List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

- Form 8f List of zones in relation to limit value for carbon monoxide

Zone	Zone code	LV		
		>LV + MOT	≤LV + MOT; >LV	≤LV
Glasgow Urban Area	UK0024			y
Edinburgh Urban Area	UK0025			y
Cardiff Urban Area	UK0026			y
Swansea Urban Area	UK0027			y
Belfast Urban Area	UK0028			y
Eastern	UK0029			y
South West	UK0030			y
South East	UK0031			y
East Midlands	UK0032			y
North West & Merseyside	UK0033			m
Yorkshire & Humberside	UK0034			y
West Midlands	UK0035			y
North East	UK0036			y
Central Scotland	UK0037			y
North East Scotland	UK0038			y
Highland	UK0039			y
Scottish Borders	UK0040			y
South Wales	UK0041			y
North Wales	UK0042			y
Northern Ireland	UK0043			y

7.2 MEASURED EXCEEDENCES OF LIMIT VALUES + MARGINS TOLERANCE

Form 11 of the questionnaire requires reasons associated with the measured exceedences of the limit value and margin of tolerance to be documented. This information is summarised in Tables 7.7 to 7.9 for monitoring stations in the UK at which exceedences of the limit value and margin of tolerance were measured. Measured exceedences of the limit value and margin of tolerance for 1-hour mean NO_2 are listed in Table 7.7. Measured exceedences of the limit value and margin of tolerance for annual mean NO_2 are listed in Table 7.8. Measured exceedences of the limit value and margin of tolerance for 24-hour mean PM_{10} are listed in Table 7.9.

Table 7.7. Measured exceedences of the 1-hour mean NO_2 limit value plus margin of tolerance, 2004 (form 11e). London Marylebone Road (Greater London Urban Area)

Month	Day of month	Hour	Level ($\mu g\ m^{-3}$)	Reason code(s)
January	6	17	262	S2
January	30	7	281	S2
January	30	8	281	S2
February	10	9	265	S2
February	13	8	315	S2
February	13	9	292	S2
February	24	8	308	S2
February	24	9	265	S2
February	24	12	273	S2
February	24	15	287	S2
March	2	7	306	S2
March	2	17	267	S2
March	3	9	267	S2
May	5	8	262	S2
June	8	13	273	S2; S10
June	9	8	271	S2
June	24	7	302	S2
July	29	14	273	S2
July	29	16	275	S2
July	29	17	265	S2
September	2	10	275	S2; S10
September	15	7	292	S2
September	16	7	267	S2
September	29	13	265	S2
October	4	17	285	S2
October	6	7	262	S2
October	7	7	275	S2
October	21	19	277	S2
November	3	15	267	S2
November	9	11	288	S2
November	9	13	361	S2
November	12	10	271	S2
November	15	8	313	S2
November	16	9	285	S2

Month	Day of month	Hour	Level ($\mu g\ m^{-3}$)	Reason code(s)
November	16	10	264	S2
November	16	11	265	S2
November	16	14	317	S2
November	16	18	264	S2
November	17	16	264	S2
November	18	12	302	S2
November	18	13	264	S2
November	18	15	300	S2
November	18	16	267	S2
November	18	19	290	S2
November	25	15	262	S2
November	25	17	277	S2
November	26	11	262	S2
December	3	10	265	S2
December	3	14	290	S2
December	11	9	262	S2
December	13	16	267	S2
December	15	16	273	S2
December	20	8	277	S2

S2 = Proximity to a major road
S10 = Transport of air pollution from sources outside the Member State

Table 7.8. Measured exceedences of the annual mean NO_2 limit value plus margin of tolerance, 2004 (form 11f)

Site	Zone	Level ($\mu g\ m^{-3}$)	Reason code
Bath Roadside	UK0030	55	S2
Brentford Roadside	UK0001	54	S2
Bristol Old Market	UK0009	54	S2
Bury Roadside	UK0003	69	S2
Glasgow Kerbside	UK0024	68	S2
London A3 Roadside	UK0001	66	S2
London Bloomsbury	UK0001	58	S1
London Cromwell Road 2	UK0001	80	S2
London Marylebone Road	UK0001	110	S2
London Wandsworth	UK0001	54	S2
Oxford Centre Roadside	UK0031	68	S2
Southwark Roadside	UK0001	62	S2
Tower Hamlets Roadside	UK0001	61	S2

S1 = Heavily trafficked urban centre
S2 = Proximity to a major road

Table 7.9. Measured exceedences of the 24-hour mean PM_{10} limit value plus margin of tolerance, 2004 (form 11h). London Marylebone Road (Greater London Urban Area)

Month	Day of month	Level ($\mu g\ m^{-3}$)	Reason code(s)
January	30	66	S2
February	4	67	S2
February	5	58	S2
February	10	78	S2
February	13	58	S2;S10

Month	Day of month	Level ($\mu g\ m^{-3}$)	Reason code(s)
February	24	59	S2
March	2	96	S2;S10
March	3	85	S2;S10
March	4	68	S2
March	15	58	S2
March	17	59	S2
March	18	56	S2
March	31	64	S2;S10
April	15	56	S2;S10
April	26	58	S2;S10
May	1	68	S2;S10
June	7	59	S2
June	8	75	S2
June	9	65	S2;S10
June	10	61	S2
June	29	56	S2
July	20	63	S2
July	22	59	S2
July	28	57	S2
July	29	70	S2;S10
August	2	71	S2;S10
August	3	64	S2;S10
August	5	62	S2;S10
August	6	56	S2;S10
August	9	65	S2
August	10	60	S2
September	1	62	S2
September	2	62	S2
September	3	75	S2
September	9	62	S2;S10
September	10	69	S2;S10
September	30	59	S2
October	1	59	S2
October	5	59	S2
October	19	60	S2
October	22	56	S2
October	25	57	S2
October	26	63	S2
November	5	70	S14
November	6	58	S14
November	16	56	S2
November	25	63	S2;S10
November	30	63	S2
December	3	69	S2
December	4	65	S2
December	6	57	S2
December	7	67	S2;S10
December	9	57	S2
December	10	66	S2
December	11	75	S2

Month	Day of month	Level ($\mu g\ m^{-3}$)	Reason code(s)
December	12	66	S2;S3;S5;S10
December	13	83	S2;S10
December	14	64	S2;S10
December	15	70	S2
December	20	63	S2

S2 = Proximity to a major road
S3 = Local industry including power production
S5 = Domestic heating
S10 = Transport of air pollution from sources outside the Member State
S14 = Bonfire night celebrations

7.3 COMPARISON WITH PREVIOUS YEARS

Tables 7.11 and 7.12 provide a comparison of the monitoring and modelling results for 2004 with the results of the air quality assessments reported to the EU for 2001, 2002 and 2003 (Stedman, et al 2002, Stedman, et al 2003, Stedman, et al 2004). The listed numbers of zones exceeding the LV in Table 7.12 include the zones exceeding the LV + MOT. An exceedence of the LV can be determined by either measurements or modelling. Where an exceedence of the LV + MOT has been determined by modelling, the exceedence of the LV in this zone may still be determined by either measurements or modelling but this distinction is not shown in Tables 7.1 to 7.6.

Modelled exceedences of the 1-hour LV + MOT for SO_2 have been reported for 2004. The modelling analysis indicates that these exceedences were associated with emissions from a brick works. There were no reported exceedences of the annual or winter mean limit values for SO_2 in ecosystem areas.

An exceedence of the 1-hour LV + MOT for NO_2 has been reported for the first time in 2003 and was repeated in 2004 in London. The reasons for this exceedence at the London Marylebone Road site remain under investigation and appear to be related to an increase in primary NO_2 emissions (Abbott, 2005). Reasons may include changes in traffic management and fleet emission characteristics. There were fewer zones were found to have modelled exceedences of the LV and LV + MOT for annual mean NO_2 in 2004 than in 2003 although the number of zones reporting measured exceedences of this value increased slightly. There were no reported exceedences of the annual mean LV for NO_x in vegetation areas.

Exceedences of 'old' directives are listed in Table 7.13. Directive 85/203/EEC was exceeded at one monitoring site in both 2004 and 2003.

There were fewer zones with reported exceedences of the LV + MOT and LV for PM_{10} in 2004 than in 2003. This was due to a return to more normal conditions in 2004 compared with the unusually high secondary PM_{10} during 2003.

There were no exceedences for Lead in 2001, 2002, 2003 or 2004.

Benzene and CO concentrations were below the LV in all zones in 2004.

Table 7.11 Exceedences of limit values plus margins of tolerance for 1st and 2nd Daughter Directives

Pollutant	Averaging time	2004	2003	2002	2001
SO_2	1-hour	1 zone modelled (Eastern)	1 zone modelled (Eastern)	none	none
SO_2	24-hour[1]	none	1 zone modelled (Eastern)	none	1 zone measured (Belfast Urban Area)
SO_2	annual[2]	n/a	n/a	n/a	n/a
SO_2	winter[2]	n/a	n/a	n/a	n/a
NO_2	1-hour[3]	1 zone measured (Greater London Urban Area)	1 zone measured (Greater London Urban Area)	none	none
NO_2	annual	34 zones (6 measured + 28 modelled)	35 zones (5 measured + 30 modelled)	19 Zones (5 measured + 14 modelled)	21 Zones (4 measured + 17 modelled)
NO_x	annual[2]	n/a	n/a	n/a	n/a
PM_{10}	24-hour (Stage 1)	19 zones (1 measured + 18 modelled)	18 zones (2 measured + 16 modelled)	1 zone modelled (Greater London Urban Area)	1 zone modelled (Greater London Urban Area)
PM_{10}	annual (Stage 1)	1 zone monitored (Greater London Urban Area)	10 zones (1 measured + 9 modelled)	1 zone modelled (Greater London Urban Area)	1 zone modelled (Greater London Urban Area)
PM_{10}	24-hour[4] (Stage 2)	n/a	n/a	n/a	n/a
PM_{10}	annual[5] (Stage 2)	32 zones (3 measured + 29 modelled)	36 zones (8 measured + 28 modelled)	22 zones (3 measured + 18 modelled)	not assessed
Lead	annual	none	none	none	none
Benzene	annual	none	none	not assessed	not assessed
CO	8-hour	none	none	not assessed	not assessed

[1] No MOT defined, LV + MOT = LV
[2] Applies to vegetation and ecosystem areas only. No MOT defined, LVs are already in force
[3] No modelling for 1-hour LV
[4] Stage 2 indicative LV, no MOT defined for 24-hour LV, no modelling for 24-hour Stage 2 LV
[5] Stage 2 indicative LV

Table 7.12 Exceedences of limit values for 1st and 2nd Daughter Directives

Pollutant	Averaging time	2004	2003	2002	2001
SO_2	1-hour	1 zone modelled (Eastern)	1 zone modelled (Eastern)	none	none
SO_2	24-hour[1]	none	1 zone modelled (Eastern)	none	1 Zone measured (Belfast Urban Area)
SO_2	Annual[2]	none	none	none	none
SO_2	Winter[2]	none	none	none	not assessed
NO_2	1-hour[3]	1 zone measured (Greater London Urban Area)	3 zones measured (London, Glasgow, South East)	1 zone measured (Glasgow Urban Area)	4 zones measured
NO_2	Annual	39 zones (9 measured + 30 modelled)	42 zones (10 measured + 32 modelled)	36 zones (6 measured + 30 modelled)	38 zones (6 measured + 32 modelled)
NO_x	Annual[2]	none	none	none	None
PM_{10}	24-hour (Stage 1)	27 zones (2 measured + 25 modelled)	33 zones (10 measured + 23 modelled)	18 zones (1 measured + 17 modelled)	26 zones (5 measured + 21 modelled)
PM_{10}	annual (Stage 1)	2 zones (1 measured, London + 1 modelled, West Midlands Urban Area)	15 zones (1 measured + 14 modelled)	2 zones (Greater London Urban Area measured, Eastern modelled)	2 zones (Greater London Urban Area measured, Greater Manchester Urban Area modelled)
PM_{10}	24-hour[4] (Stage 2)	15 zones (15 measured)	36 zones (36 measured)	21 zones (21 measured)	25 zones (25 measured)
PM_{10}	annual[5] (Stage 2)	41 zones (26 measured + 15 modelled)	43 zones (35 measured + 8 modelled)	42 zones (16 measured, 26 modelled)	43 zones (28 measured, 15 modelled)
Lead	Annual	none	none	none	none
Benzene	Annual	none	1 zone modelled (Greater London Urban Area)	not assessed	not assessed
CO	8-hour	none	none	not assessed	not assessed

[1] No MOT defined, LV + MOT = LV
[2] Applies to vegetation and ecosystem areas only. No MOT defined, LVs are already in force
[3] No modelling for 1-hour LV
[4] Stage 2 indicative LV, no modelling for24-hour Stage 2 LV
[5] Stage 2 indicative LV

Table 7.13 Exceedences of old Directives

Pollutant	**Directive**	**Averaging time**	**2004 concentration (μg m^{-3})**	**2003 concentration (μg m^{-3})**	**2002 concentration (μg m^{-3})**	**2001 concentration (μg m^{-3})**
NO_2	85/203/EEC	1-hour 98%ile	233 (measured at London Marylebone Road)	235 (measured at London Marylebone Road)	No exceedences	No exceedences

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9 References

Abbott, J. (2005) Primary nitrogen dioxide emissions from road traffic: analysis of monitoring data. AEA Technology, National Environmental Technology Centre. Report AEAT - 1925

Abbott J and Vincent K (1999). Annual average sulphur dioxide concentration maps derived by dispersion modelling. AEA Technology, National Environmental Technology Centre. Report AEAT - 4629
http://www.aeat.co.uk/netcen/airqual/reports/kvann1/so2ann.html

Airborne Particles Expert Group (APEG). Source Apportionment of Airborne Particulate Matter in the United Kingdom. ISBN 0-7058-1771-7, January 1999.
http://www.defra.gov.uk/environment/airquality/airbornepm/index.htm

Air Quality Expert Group (AQEG, 2004). Nitrogen Dioxide in the United Kingdom.
http://www.defra.gov.uk/environment/airquality/aqeg/nitrogen-dioxide/index.htm

Air Quality Expert Group (AQEG, 2005). Particulate Matter in the United Kingdom.
http://www.defra.gov.uk/environment/airquality/aqeg/particulate-matter/index.htm

Bush T (2000). Article 5 Assessment of Nitrogen Dioxide, PM10, sulphur dioxide and lead in the UK. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA Technology, National Environmental Technology Centre. Report AEAT/R/ENV/0165.
http://www.defra.gov.uk/environment/airquality/article5/index.htm

Bush, T, Stedman, J and Targa, J (2005) UK air quality modelling for annual reporting 2004 on ambient air quality assessment under Council Directives 96/62/EC and 2002/3/EC relating to ozone in ambient air. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/2053.

Council Directive 96/62/EC, of 27 September 1996. On ambient air quality assessment and management (The Framework Directive). From the Official Journal of the European Communities, 21.11.1996, En Series, L296/55.

Council Directive 1999/30/EC, of 22 April 1999 Relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (The First Daughter Directive). From the Official Journal of the European Communities, 29.6.1999, En Series, L163/41.

Council Directive 2000/69/EC, of 16 November 2000 Relating to limit values for benzene and carbon monoxide in ambient air (The Second Daughter Directive). From the Official Journal of the European Communities, 13.12.2000, En Series, L313/12.

Department for Transport (DfT, 2003) Personal Communication from Malcolm Jay, April 2003)

Derwent , R.G., Simmonds, P.G., O'Doherty, S. et al (2005) External influences on Europe's air quality: baseline methane, carbon monoxide and ozone from 1999 to 2030 at Mace Head, Ireland. *Atmospheric Environment*, 40, 844-855.

Dore, C J, Watterson, JD, Goodwin, JWL et al (2004). UK Emissions of Air Pollutants 1970 to 2002 August 2004. National Atmospheric Emissions Inventory, AEA Technology, National Environmental Technology Centre.

Jenkin, M E. (2004). Analysis of sources and partitioning of oxidant in the UK—Part 1: the NOx-dependence of annual mean concentrations of nitrogen dioxide and ozone. *Atmospheric Environment* **38** 5117–5129.

Lee, D S, Kingdon, R D, Jenkin, M E, and Garland, J A (2000) Modelling the atmospheric oxidised and reduced nitrogen budgets for the UK with a Langrangian multi-layer long-range transport model. *Environmental Modelling and Assessment, 5, 83-104*

Personal communication, Helen Lawrence, netcen (2005). AEA Technology, National Environmental Technology Centre, Culham UK.

Stedman J R and Bush T (2000) Mapping of nitrogen dioxide and PM10 in the UK for Article 5 Assessment. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/0707. http://www.aeat.co.uk/netcen/airqual/reports/aeat-env-r0707.pdf

Stedman, J R, Linehan E and Conlan B (2001a). Receptor Modelling of PM_{10} Concentrations at a United Kingdom National Network Monitoring Site in Central London. *Atmospheric Environment,* **35**, 297-304.

Stedman, J R, Bush, T J, Murrells, T P and King, K (2001b). Baseline PM_{10} and NO_x projections for PM_{10} objective analysis. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/0726. http://www.aeat.co.uk/netcen/airqual/reports/naqs2001/aeat-env-r-0726.pdf

Stedman J R, Goodwin, J W L, King K, Murrells T P and Bush T J (2001c). An Empirical Model For Predicting Urban Roadside Nitrogen Dioxide Concentrations in the UK. *Atmospheric Environment*. **35** 1451-1463.

Stedman, J R, Bush, T J and Vincent K J (2002). UK air quality modelling for annual reporting 2001 on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC. AEA Technology, National Environmental Technology Centre. Report

AEAT/ENV/R/1221. http://www.airquality.co.uk/archive/reports/cat05/aeat-env-r-1221.pdf

Stedman, J R, Bush, T J, Vincent K J and Baggott S. (2003). UK air quality modelling for annual reporting 2002 on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/1564.
http://www.airquality.co.uk/archive/reports/cat05/0402061100_dd12002mapsrep1-2.pdf

Stedman, J R, Bush, T J, Grice, S E, Kent, A J, Vincent K J and Abbott, J (2005). UK air quality modelling for annual reporting 2003 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/1790.
http://www.airquality.co.uk/archive/reports/cat05/0501121424_dd12003mapsrep4.pdf

Personal communication, Sim Tang, CEH (2004). CEH Edinburgh, Centre for Ecology and Hydrology, Natural Environment Research Council.
http://www.nbu.ac.uk/cara/networks.htm

APPENDIX 1. NATIONAL NETWORK MONITORING SITES

Table A1.1. Monitoring sites operating during 2004 for AQDD1 and AQDD2 reporting

EoI station code	*Local station code*	*Zone code(s)*	*Use for Directive*						Use for Directive / Measuring method code for PM_{10} and $PM_{2,5}$	
			SO_2	*NO_2*	*NO_x*	*Lead*	*Benzene*	*CO*	PM_{10}	$PM_{2,5}$
GB0729A	Aberdeen	UK0038	y	y				y	M3	
GB0031R	Aston Hill	UK0042		y	y					
GB0600A	Barnsley 12	UK0034	y							
GB0681A	Barnsley Gawber	UK0034	y	y				y		
GB0647A	Bath Roadside	UK0030		y				y		
GB0567A	Belfast Centre	UK0028	y	y				y	M3	
GB0696A	Belfast Clara St	UK0028							M1	
GB0514A	Belfast East	UK0028	y							
GB0421A	Billingham	UK0013		y						
GB0569A	Birmingham Centre	UK0002	y	y				y	M3	
GB0727A	Blackpool	UK0022	y	y				y	M3	
GB0654A	Bolton	UK0003	y	y				y	M3	
GB0741A	Bournemouth	UK0015	y	y				y	M2	
GB0689A	Bradford Centre	UK0004	y	y				y	M3	
GB0774A	Brentford Roadside	UK0001		y				y		
GB0693A	Brighton Roadside	UK0010		y				y		
GB0845A	Brighton Roadside PM10	UK0010							M2	
GB0585A	Bristol Centre	UK0009	y	y				y	M3	
GB0639A	Bristol Old Market	UK0009		y				y		
GB0652A	Bury Roadside	UK0003	y	y				y	M3	
GB0033R	Bush Estate	UK0037		y						
GB0726A	Cambridge Roadside	UK0029		y						
GB0636A	Camden Kerbside	UK0001		y					M3	
GB0737A	Canterbury	UK0031		y					M3	
GB0580A	Cardiff Centre	UK0026	y	y				y	M3	
GB0739A	Coventry Memorial Park	UK0017	y	y				y	M3	
GB0744A	Cwmbran	UK0041	y	y				y	M3	
GB0673A	Derry	UK0043	y	y				y	M3	
GB0740A	Dumfries	UK0040		y				y	M2	
GB0839A	Edinburgh St Leonards	UK0025	y	y				y	M3	
GB0002R	Eskdalemuir	UK0040		y	y					
GB0640A	Exeter Roadside	UK0030	y	y				y		
GB0641A	Glasgow Centre	UK0024	y	y				y	M3	
GB0452A	Glasgow City Chambers	UK0024		y				y		
GB0657A	Glasgow Kerbside	UK0024		y				y	M3	
GB0034R	Glazebury	UK0033		y						
GB0735A	Grangemouth	UK0037	y	y				y	M3	
GB0637A	Haringey Roadside	UK0001		y					M3	
GB0036R	Harwell	UK0031	y	y	y				M3	M3
GB0014R	High Muffles	UK0034		y	y					
GB0686A	Hove Roadside	UK0010	y	y				y		
GB0776A	Hull Freetown	UK0018	y	y				y	M3	

EoI station code	*Local station code*	*Zone code(s)*	*Use for Directive*						Use for Directive / Measuring method code for PM_{10} and $PM_{2,5}$	
			SO_2	*NO_2*	*NO_x*	*Lead*	*Benzene*	*CO*	PM_{10}	$PM_{2,5}$
GB0742A	Inverness	UK0039		y				y	M2	
GB0037R	Ladybower	UK0032	y	y						
GB0643A	Leamington Spa	UK0035	y	y				y	M3	
GB0584A	Leeds Centre	UK0004	y	y				y	M3	
GB0597A	Leicester Centre	UK0011	y	y				y	M3	
GB0777A	Liverpool Speke	UK0006	y	y				y	M3	
GB0659A	London A3 Roadside	UK0001		y				y	M3	
GB0608A	London Bexley	UK0001	y	y				y	M3	
GB0566A	London Bloomsbury	UK0001	y	y				y	M3	M3
GB0616A	London Brent	UK0001	y	y				y	M3	
GB0697A	London Bromley	UK0001		y				y		
GB0695A	London Cromwell Road 2	UK0001	y	y				y		
GB0586A	London Eltham	UK0001	y	y					M3	
GB0650A	London Hackney	UK0001		y				y		
GB0837A	London Harlington	UK0001		y				y	M3	
GB0642A	London Hillingdon	UK0001	y	y				y	M3	
GB0672A	London Lewisham	UK0001	y	y						
GB0682A	London Marylebone Road	UK0001	y	y				y	M3	M3
GB0620A	London N. Kensington	UK0001	y	y				y	M3	
GB0656A	London Southwark	UK0001	y	y				y		
GB0644A	London Teddington	UK0001	y	y						
GB0622A	London Wandsworth	UK0001		y						
GB0743A	London Westminster	UK0001	y	y				y	M2	
GB0006R	Lough Navar	UK0043							M3	
GB0038R	Lullington Heath	UK0031	y	y						
GB0613A	Manchester Piccadilly	UK0003	y	y				y	M3	
GB0649A	Manchester South	UK0003	y	y						
GB0453A	Manchester Town Hall	UK0003		y				y		
GB0838A	Market Harborough	UK0032		y				y		
GB0583A	Middlesbrough	UK0013	y	y				y	M3	
GB0043R	Narberth	UK0041	y	y	y				M3	
GB0568A	Newcastle Centre	UK0005	y	y				y	M3	
GB0738A	Northampton	UK0032	y	y				y	M3	
GB788A	Northampton PM10	UK0032							M2	
GB0684A	Norwich Centre	UK0029	y	y				y	M3	
GB0678A	Norwich Roadside	UK0029		y						
GB0646A	Nottingham Centre	UK0008	y	y				y	M3	
GB0633A	Oxford Centre Roadside	UK0031	y	y				y		
GB0687A	Plymouth Centre	UK0030	y	y				y	M3	
GB0651A	Port Talbot	UK0027	y	y					M3	
GB0733A	Portsmouth	UK0012	y	y				y	M3	
GB0731A	Preston	UK0023	y	y				y	M3	
GB0840A	Reading New Town	UK0016	y	y				y	M3	
GB0679A	Redcar	UK0013	y	y				y	M3	
GB0617A	Rochester	UK0031	y	y					M3	M3
GB0677A	Rotherham Centre	UK0007	y	y						

EoI station code	*Local station code*	*Zone code(s)*	*Use for Directive*						Use for Directive / Measuring method code for PM_{10} and $PM_{2,5}$	
			SO_2	*NO_2*	*NO_x*	*Lead*	*Benzene*	*CO*	PM_{10}	$PM_{2,5}$
GB0660A	Salford Eccles	UK0003	y	y				y	M3	
GB0698A	Sandwell West Bromwich	UK0002	y	y				y		
GB0615A	Sheffield Centre	UK0007	y	y				y	M3	
GB0538A	Sheffield Tinsley	UK0007		y				y		
GB0044R	Somerton	UK0030		y	y					
GB0598A	Southampton Centre	UK0019	y	y				y	M3	
GB0728A	Southend-on-Sea	UK0021	y	y				y	M3	
GB0667A	Southwark Roadside	UK0001	y	y				y		
GB0754A	St Osyth	UK0029		y				y		
GB0775A	Stockport Shaw Heath	UK0003	y	y				y	M3	
GB0734A	Stockton-on-Tees Yarm	UK0036		y				y	M3	
GB0658A	Stoke-on-Trent Centre	UK0014	y	y				y	M3	
GB0582A	Sunderland	UK0036	y							
GB0609A	Swansea	UK0027	y	y				y	M3	
GB0645A	Thurrock	UK0029	y	y				y	M3	
GB0642A	Tower Hamlets Roadside	UK0001		y				y		
GB0455A	Walsall Alumwell	UK0002		y						
GB0674A	Walsall Willenhall	UK0002		y						
GB0420A	West London	UK0001		y				y		
GB0045R	Wicken Fen	UK0029	y	y	y					
GB0730A	Wirral Tranmere	UK0020	y	y				y	M3	
GB0614A	Wolverhampton Centre	UK0002	y	y				y	M3	
GB0755A	Wrexham	UK0042	y	y				y	M2	
GB0013R	Yarner Wood	UK0030		y	y					
GB0804A	Barnsley Gawber HC	UK0034					y			
GB0806A	Belfast Centre HC	UK0028					y			
GB0805A	Belfast Roadside HC	UK0028					y			
GB0807A	Birmingham Roadside HC	UK0002					y			
GB0808A	Bournemouth HC	UK0015					y			
GB0809A	Bristol Old Market HC	UK0009					y			
GB0783A	Cardiff Centre HC	UK0026					y			
GB0811A	Coventry Memorial Park HC	UK0017					y			
GB0812A	Cwmbran HC	UK0041					y			
GB0813A	Edinburgh Med. Sch. HC	UK0025					y			
GB0784A	Glasgow Kerbside HC	UK0024					y			
GB0814A	Grangemouth HC	UK0037					y			
GB0815A	Haringey Roadside HC	UK0001					y			
GB0782A	Harwell HC	UK0031					y			
GB0816A	Hove Roadside HC	UK0010					y			
GB0817A	Hull Freetown HC	UK0018					y			
GB0818A	Leamington Spa HC	UK0035					y			
GB0819A	Leed Centre HC	UK0004					y			
GB0820A	Leeds Roadside HC	UK0004					y			
GB0821A	Leicester Centre HC	UK0011					y			
GB0810A	London Bloomsbury HC	UK0001					y			
GB0797A	London Eltham HC	UK0001					y			

EoI station code	Local station code	Zone code(s)	Use for Directive						Use for Directive / Measuring method code for PM_{10} and $PM_{2,5}$	
			SO_2	NO_2	NO_x	Lead	Benzene	CO	PM_{10}	$PM_{2,5}$
GB0785A	London Marylebone Road HC	UK0001					y			
GB0823A	Manchester Piccadilly HC	UK0003					y			
GB00795A	Middlesbrough HC	UK0013					y			
GB0824A	Newcastle Centre HC	UK0005					y			
GB0827A	Northampton HC	UK0032					y			
GB0825A	Norwich Centre HC	UK0029					y			
GB0826A	Nottingham Centre HC	UK0008					y			
GB00828A	Oxford Centre HC	UK0031					y			
GB0829A	Plymouth Centre HC	UK0030					y			
GB0830A	Portsmouth HC	UK0012					y			
GB0831A	Reading HC	UK0016					y			
GB0833A	Sheffield Centre HC	UK0007					y			
GB0800A	Southampton Centre HC	UK0019					y			
GB0832A	Southend-on-Sea HC	UK0021					y			
GB0834A	Stockton-on-Tees Yarm HC	UK0036					y			
GB0834A	Stoke-on-Trent Centre	UK0014					y			
GB0635A	Brent Park	UK0001				y				
GB0417A	Brookside 2	UK0002				y				
GB0369A	Cardiff	UK0026				y				
GB0537A	Central London Lead	UK0001				y				
GB0332A	Cromwell Road Lead	UK0001				y				
GB0419A	Elswick 6	UK0005				y				
GB0361A	Eskdalemuir Lead	UK0040				y				
GB0260A	Glasgow	UK0024				y				
GB0789A	Hallen	UK0030				y				
GB0382A	IMI 2	UK0002				y				
GB0248A	Leeds Market Building	UK0004				y				
GB0370A	Manchester	UK0003				y				
GB0241A	Motherwell	UK0024				y				
GB0892A	Rotherham	UK0007				y				
GB0859A	Yarner Wood	UK0030				y				
GB0852A	Auchencorth	UK0037				y				
GB00853A	Cockley Beck	UK0033				y				
GB0856A	Monkswood	UK0029				y				
GB0858A	Wytham Wood	UK0031				y				
GB0634A	Banchory	UK0038				y				
GB00855A	Beacon Hill	UK0032				y				
GB0857A	Heigham Holmes	UK0029				y				

Table A1.2. Data capture (%) for monitoring sites operating during 2004

Site	SO2	NO2	PM10	CO	Benzene	Lead	O3	PM2.5
Aberdeen	93	90	93	93	nm	nm	94	nm
Aston Hill	nm	87	nm	nm	nm	nm	89.4	nm
Avonmouth BZL	nm	nm	nm	nm	nm	33.3	nm	nm
Barnsley 12	98.9	nm	nm	nm	nm	nm	nm	nm
Barnsley Gawber	96.6	95.9	nm	96.5	nm	nm	96.2	nm
Barnsley Gawber HC	nm	nm	nm	nm	99.9	nm	nm	nm
Bath Roadside	nm	98.3	nm	99	nm	nm	nm	nm
Belfast Centre	95.1	91.8	95	96.4	nm	nm	96.4	nm
Belfast Centre HC	nm	nm	nm	nm	98	nm	nm	nm
Belfast Clara St	nm	nm	93	nm	nm	nm	nm	nm
Belfast East	96.5	nm	nm	nm	nm	nm	nm	nm
Belfast Roadside	nm	nm	nm	nm	95.7	nm	nm	nm
Billingham	nm	99.1	nm	nm	nm	nm	nm	nm
Birmingham Centre	86	88.9	94	91.6	nm	nm	88.4	nm
Birmingham East	58.4	53.8	57	58.4	nm	nm	58	nm
Birmingham Roadside	nm	nm	nm	nm	99.4	nm	nm	nm
Birmingham Tyburn	37.5	36.5	38	37.6	nm	nm	37.6	nm
Blackpool	60.4	77.7	83	82.4	nm	nm	82.6	nm
Bolton	97.6	94.1	96	97.5	nm	nm	97.6	nm
Bottesford	nm	nm	nm	nm	nm	nm	98.7	nm
Bournemouth	97.6	96.4	95	98.6	nm	nm	98.9	nm
Bournemouth HC	nm	nm	nm	nm	99.7	nm	nm	nm
Bradford Centre	96	95.8	95	94.5	nm	nm	96.8	nm
Brentford Roadside	nm	92	nm	95.2	nm	nm	nm	nm
Brighton Preston Park	nm	15.7	nm	nm	nm	nm	14.4	nm
Brighton Roadside	nm	98.9	nm	98.9	nm	nm	nm	nm
Brighton Roadside PM10	nm	nm	94	nm	nm	nm	nm	nm
Bristol Centre	95.8	96.7	97	97.7	nm	nm	91.3	nm
Bristol Old Market	nm	98.7	nm	71.9	nm	nm	nm	nm
Bristol Old Market HC	nm	nm	nm	nm	99.4	nm	nm	nm
Brookside Metals	nm	nm	nm	nm	nm	100	nm	nm
Bury Roadside	75.9	91.6	91	93.6	nm	nm	91.9	nm
Bush Estate	nm	93.6	nm	nm	nm	nm	98.4	nm
BZL Ltd., Hallen Village	nm	nm	nm	nm	nm	100	nm	nm
Cambridge Roadside	nm	96.5	nm	nm	nm	nm	nm	nm
Camden Kerbside	nm	39.4	96	nm	nm	nm	nm	nm
Canterbury	nm	96.9	98	nm	nm	nm	nm	nm
Cardiff	nm	nm	nm	nm	nm	100	nm	nm
Cardiff Centre	97	97.5	93	96	nm	nm	91.1	nm
Cardiff Centre HC	nm	nm	nm	nm	91	nm	nm	nm
Coventry Memorial Park	98.3	97.6	92	98.3	nm	nm	98	nm
Coventry	nm	nm	nm	nm	99.7	nm	nm	nm

Site	SO2	NO2	PM10	CO	Benzene	Lead	O3	PM2.5
Memorial Park HC								
Cwmbran	96.9	99.4	100	98	nm	nm	99.5	nm
Cwmbran HC	nm	nm	nm	nm	100	nm	nm	nm
Derry	95.8	92	96	97.4	nm	nm	97.5	nm
Dumfries	nm	96.6	92	98.5	nm	nm	nm	nm
Edinburgh Med. Sch.	nm	nm	nm	nm	nm	nm	nm	nm
Edinburgh Med. Sch. HC	nm	nm	nm	nm	99.7	nm	nm	nm
Edinburgh St Leonards	98.5	91	99	98.1	nm	nm	93.9	nm
Eskdalemuir	nm	5.9	nm	nm	nm	nm	90.5	nm
Eskdalemuir	nm	nm	nm	nm	nm	100	nm	nm
Exeter Roadside	84.9	95.8	nm	87.4	nm	nm	97	nm
Glasgow	nm	nm	nm	nm	nm	100	nm	nm
Glasgow Centre	86.6	88.5	66	92.1	nm	nm	97.5	nm
Glasgow City Chambers	nm	98	nm	98.9	nm	nm	nm	nm
Glasgow Kerbside	nm	96	93	98.2	nm	nm	nm	nm
Glasgow Kerbside HC	nm	nm	nm	nm	83	nm	nm	nm
Glazebury	nm	87.3	nm	nm	nm	nm	95.9	nm
Grangemouth	98.6	98.5	98	81.2	nm	nm	nm	nm
Grangemouth HC	nm	nm	nm	nm	100	nm	nm	nm
Great Dun Fell	nm	nm	nm	nm	nm	nm	99	nm
Haringey Roadside	nm	98.2	99	nm	nm	nm	nm	nm
Haringey Roadside HC	nm	nm	nm	nm	100	nm	nm	nm
Harwell	96.4	95.7	96	nm	nm	nm	90.2	96.2
Harwell HC	nm	nm	nm	nm	75	nm	nm	nm
High Muffles	nm	70.1	nm	nm	nm	nm	99.2	nm
Hove Roadside	96	94.3	nm	98.5	nm	nm	nm	nm
Hove Roadside HC	nm	nm	nm	nm	98.3	nm	nm	nm
Hull Freetown	88.1	89.3	96	95.9	nm	nm	93.9	nm
Hull Freetown HC	nm	nm	nm	nm	100	nm	nm	nm
IMI Refiners, Walsall	nm	nm	nm	nm	nm	100	nm	nm
Inverness	nm	98.1	95	98.5	nm	nm	nm	nm
Ladybower	97.1	89.9	nm	nm	nm	nm	85.1	nm
Leamington Spa	98.4	93.8	98	88.8	nm	nm	98.7	nm
Leamington Spa HC	nm	nm	nm	nm	94.8	nm	nm	nm
Leed Centre HC	nm	nm	nm	nm	99.7	nm	nm	nm
Leeds	nm	nm	nm	nm	nm	100	nm	nm
Leeds Centre	85.5	92.1	98	79.4	nm	nm	82.7	nm
Leeds Roadside	nm	nm	nm	nm	nm	nm	nm	nm
Leeds Roadside	nm	nm	nm	nm	98.6	nm	nm	nm
Leicester Centre	97.3	85.5	95	84.9	nm	nm	97.8	nm
Leicester Centre	nm	nm	nm	nm	98.1	nm	nm	nm
Liverpool Speke	97.9	98.1	95	98.2	nm	nm	97.8	nm
Liverpool Speke	nm	nm	nm	nm	69.3	nm	nm	nm
London A3 Roadside	nm	96.8	98	96.9	nm	nm	nm	nm
London Bexley	95.8	96.1	92	94.9	nm	nm	95.5	nm
London	97.6	97.5	98	97	nm	nm	97.1	98

Site	SO2	NO2	PM10	CO	Benzene	Lead	O3	PM2.5
Bloomsbury								
London Bloomsbury HC	nm	nm	nm	nm	100	nm	nm	nm
London Brent	88.7	91	94	86.2	nm	nm	95	nm
London Brent	nm	nm	nm	nm	nm	100	nm	nm
London Bromley	nm	98.4	nm	96.1	nm	nm	nm	nm
London Cromwell	nm	nm	nm	nm	nm	100	nm	nm
London Cromwell Road 2	98.6	98.7	nm	97.7	nm	nm	nm	nm
London Eltham	99	97.2	91	nm	nm	nm	96.4	nm
London Eltham	nm	nm	nm	nm	82.3	nm	nm	nm
London Hackney	nm	99.4	nm	94.7	nm	nm	88.4	nm
London Haringey	nm	nm	nm	nm	nm	nm	94.2	nm
London Harlington	nm	99	100	92.2	nm	nm	94.7	nm
London Hillingdon	97.9	97.6	98	97.8	nm	nm	92.6	nm
London Horseferry	nm	nm	nm	nm	nm	100	nm	nm
London Lewisham	97.8	97.8	nm	nm	nm	nm	87.8	nm
London Marylebone Road	92	98.3	99	nm	nm	nm	98.1	95.9
London Marylebone Road HC	nm	nm	nm	nm	85	nm	nm	nm
London N. Kensington	97.3	98.9	95	98.9	nm	nm	97.9	nm
London Southwark	94.8	88.1	nm	94.6	nm	nm	94.8	nm
London Teddington	96.1	93.8	nm	nm	nm	nm	96.1	nm
London Wandsworth	nm	99.3	nm	nm	nm	nm	99.3	nm
London Westminster	90.7	78.3	94	90.4	nm	nm	93.7	nm
Lough Navar	nm	nm	100	nm	nm	nm	74.8	nm
Lullington Heath	89.1	92.8	nm	nm	nm	nm	95.6	nm
Manchester	nm	nm	nm	nm	nm	100	nm	nm
Manchester Piccadilly	95	93.8	97	97.2	nm	nm	97.6	nm
Manchester Piccadilly HC	nm	nm	nm	nm	98	nm	nm	nm
Manchester South	85.8	87.4	nm	nm	nm	nm	95.4	nm
Manchester Town Hall	nm	94.7	nm	81	nm	nm	nm	nm
Market Harborough	nm	90.4	nm	93.2	nm	nm	93.5	nm
Middlesbrough	98.6	64.5	97	91.7	nm	nm	99.1	nm
Middlesbrough HC	nm	nm	nm	nm	100	nm	nm	nm
Motherwell	nm	nm	nm	nm	nm	100	nm	nm
Narberth	90.5	89.4	55	nm	nm	nm	nm	nm
Newcastle	nm	nm	nm	nm	nm	100	nm	nm
Newcastle Centre	83.7	81.9	92	85	nm	nm	90.3	nm
Newcastle Centre HC	nm	nm	nm	nm	96.4	nm	nm	nm
Northampton	89.3	87.1	89	90.4	nm	nm	87.2	nm
Northampton	nm	nm	nm	nm	99.7	nm	nm	nm

Site	SO2	NO2	PM10	CO	Benzene	Lead	O3	PM2.5
HC								
Northampton PM10	nm	nm	84	nm	nm	nm	nm	nm
Norwich Centre	96.4	90.7	96	94.2	nm	nm	97.2	nm
Norwich Centre HC	nm	nm	nm	nm	99.9	nm	nm	nm
Norwich Roadside	nm	97.7	nm	nm	nm	nm	nm	nm
Nottingham Centre	95.7	90.9	96	91.3	nm	nm	97.1	nm
Nottingham Centre HC	nm	nm	nm	nm	97.7	nm	nm	nm
Oxford Centre	99.1	86.5	nm	97.2	nm	nm	nm	nm
Oxford Centre HC	nm	nm	nm	nm	98.7	nm	nm	nm
Plymouth Centre	67.6	89.1	97	88.8	nm	nm	97.8	nm
Plymouth Centre HC	nm	nm	nm	nm	91.7	nm	nm	nm
Port Talbot	97.2	83.9	96	nm	nm	nm	97.2	nm
Portsmouth	90.7	98.1	94	96.7	nm	nm	98.9	nm
Portsmouth HC	nm	nm	nm	nm	99.3	nm	nm	nm
Preston	98.2	94.3	98	93	nm	nm	98.3	nm
Reading HC	nm	nm	nm	nm	100	nm	nm	nm
Reading New Town	88.9	93.2	96	94.4	nm	nm	86	nm
Redcar	97.7	97.7	98	97	nm	nm	96.3	nm
Rochester	98.6	96.4	98	nm	nm	nm	98.6	98.7
Rotherham Centre	75.5	96.9	nm	nm	nm	nm	90	nm
Runcorn Eston Point	nm	nm	nm	nm	nm	33.3	nm	nm
Salford Eccles	90.1	96.2	94	93.9	nm	nm	87.4	nm
Sandwell West Bromwich	98.1	98.2	nm	97.8	nm	nm	97.9	nm
Scunthorpe	20.8	nm	nm	nm	nm	nm	nm	nm
Scunthorpe Town	55.5	nm	54	nm	nm	nm	nm	nm
Sheffield	nm	nm	nm	nm	nm	100	nm	nm
Sheffield Centre	80.1	97.1	97	98.1	nm	nm	98	nm
Sheffield Centre HC	nm	nm	nm	nm	96	nm	nm	nm
Sheffield Tinsley	nm	95.7	nm	97.3	nm	nm	nm	nm
Sibton	nm	nm	nm	nm	nm	nm	96.3	nm
Somerton	nm	88.8	nm	nm	nm	nm	95.6	nm
Southampton Centre	96.4	95.2	96	91	nm	nm	90.9	nm
Southampton Centre HC	nm	nm	nm	nm	95.3	nm	nm	nm
Southend-on-Sea	95.2	91.5	95	51.6	nm	nm	97.4	nm
Southend-on-Sea HC	nm	nm	nm	nm	99.7	nm	nm	nm
Southwark Roadside	95.4	75.4	nm	98.6	nm	nm	nm	nm
St Osyth	nm	91	nm	98.9	nm	nm	99	nm
Stockport Shaw Heath	45.8	90.9	87	78.3	nm	nm	nm	nm
Stockton-on-Tees Yarm	nm	98.7	95	93.9	nm	nm	nm	nm
Stockton-on-Tees Yarm HC	nm	nm	nm	nm	100	nm	nm	nm
Stoke-on-Trent Centre	86.6	93.2	78	94.2	nm	nm	98	nm
Stoke-on-Trent Centre	nm	nm	nm	nm	91.5	nm	nm	nm

Site	SO2	NO2	PM10	CO	Benzene	Lead	O3	PM2.5
Strath Vaich	nm	nm	nm	nm	nm	nm	83.9	nm
Sunderland	92.1	nm	nm	nm	nm	nm	nm	nm
Sunderland Silksworth	nm	6.3	nm	nm	nm	nm	6.3	nm
Swansea	97.6	91.5	nm	97.7	nm	nm	97	nm
Swansea Lead	nm	nm	nm	nm	nm	33.3	nm	nm
Thurrock	97.8	89.8	95	96.1	nm	nm	98.4	nm
Tower Hamlets Roadside	nm	96.3	nm	83.8	nm	nm	nm	nm
Walsall Alumwell	nm	93	nm	nm	nm	nm	nm	nm
Walsall Willenhall	nm	92.1	nm	nm	nm	nm	nm	nm
West London	nm	98.8	nm	98.8	nm	nm	nm	nm
Weybourne	nm	nm	nm	nm	nm	nm	97.1	nm
Wicken Fen	93.5	73.1	nm	nm	nm	nm	93.2	nm
Wigan Centre	22.2	22.2	nm	23	nm	nm	23.1	nm
Wigan Centre HC	nm	nm	nm	nm	25.7	nm	nm	nm
Wigan Leigh	51.4	71.4	72	72	nm	nm	70.2	nm
Wigan Leigh HC	nm	nm	nm	nm	49.3	nm	nm	nm
Wirral Tranmere	95.8	94	98	94.9	nm	nm	98.4	nm
Wolverhampton Centre	97.8	80.4	98	93.4	nm	nm	97.7	nm
Wrexham	89	95.7	94	98.4	nm	nm	nm	nm
Yarner Wood	nm	98.5	nm	nm	nm	nm	97.5	nm

APPENDIX 2. MONITORING SITES USED TO VERIFY THE MAPPED ESTIMATES

Table A2.1. Monitoring sites used to verify the mapped estimates (PM_{10} measurements by TEOM were used in the verification)

Site	Site type	Local Athority	SO_2	NO_2	PM_{10}	CO
Abingdon	URBAN BACKGROUND	Vale of White Horse DC	y	y	y	
Antrim Greystone Estate	URBAN BACKGROUND	Antrim BC	y			
Ards	URBAN BACKGROUND	Ards BC	y		y	
Armagh Dobbin Street	URBAN BACKGROUND	Armagh BC	y			
Ashford Roadside ZA2	ROADSIDE	Ashford BC		y	y	
Ballymena Ballykeel	URBAN BACKGROUND	Ballymena BC	y			
Ballymena North Road	ROADSIDE	Ballymena BC		y		
Ballymoney	URBAN BACKGROUND	Ballymoney BC			y	
Barnsley A628 Roadside	ROADSIDE	Barnsley MBC		y		
Barnsley Cudworth	URBAN BACKGROUND	Barnsley MBC	y	y	y	
Barnsley Royston	URBAN BACKGROUND	Barnsley MBC	y	y	y	
Basingstoke Eastrop	URBAN BACKGROUND	Basingstoke & Deane DC		y	y	
Bedford Stewartby BF1	RURAL	Mid Bedforshire DC	y			
Bracknell Bagshot Road	ROADSIDE	Bracknell Forest BC		y	y	
Bracknell Foxhill	URBAN BACKGROUND	Bracknell Forest BC		y	y	
Bracknell Yorktown Road Sandhurst	ROADSIDE	Bracknell Forest BC		y	y	
Broxbourne BB1	ROADSIDE	Broxbourne DC	y	y	y	
Bury Prestwich	ROADSIDE	Bury MBC		y	y	
Bury Radcliffe	ROADSIDE	Bury MBC		y	y	
Bury Town Centre	URBAN CENTRE	Bury MBC			y	
Caerphilly	URBAN BACKGROUND	Caerphilly County BC		y		
Caerphilly Ton-y-Felin Roadside	ROADSIDE	Caerphilly County BC		y	y	
Cambridge Gonville Place	ROADSIDE	Cambridge City Council		y	y	
Cambridge Newmarket Road	URBAN BACKGROUND	Cambridge City Council		y	y	
Cambridge Parker Street	ROADSIDE	Cambridge City Council		y	y	
Cambridge Silver Street	ROADSIDE	Cambridge City Council		y	y	
Canterbury Background ZY1	URBAN BACKGROUND	Canterbury City Council	y	y	y	
Canterbury Roadside ZY2	ROADSIDE	Canterbury City Council		y		y
Cardiff Briardene	URBAN BACKGROUND	Cardiff City Council	y	y	y	y
Carrickfergus Rosebrook Avenue	URBAN BACKGROUND	Carrickfergus BC	y		y	
Castlereagh Espie Way	URBAN BACKGROUND	Castlereagh BC	y		y	
Castlereagh Lough View Drive	ROADSIDE	Castlereagh BC		y	y	
Chatham Roadside ZC1	ROADSIDE	Medway DC	y	y	y	
Chepstow	ROADSIDE	Monthmouthshire CC		y	y	

Site	Site type	Local Athority	SO_2	NO_2	PM_{10}	CO
Chesterfield Birdholme School	URBAN BACKGROUND	Chesterfield BC	y	y	y	
Chesterfield Whittington Moor	ROADSIDE	Chesterfield BC	y	y	y	
Chesterfield Whittington Roadside	ROADSIDE	Chesterfield BC	y	y	y	
Craigavon Castle Lane	URBAN BACKGROUND	Craigavon BC		y		
Craigavon Lord Lurgan Park	URBAN BACKGROUND	Craigavon BC	y		y	
Derry Brandywell	URBAN BACKGROUND	Derry City Council	y		y	
Derry Dale's Corner	ROADSIDE	Derry City Council		y		
Dover Background ZD3	URBAN BACKGROUND	Dover DC	y			
Dover Background ZD4	URBAN BACKGROUND	Dover DC	y			
Dover Roadside ZD1	ROADSIDE	Dover DC		y		
Dover Roadside ZD2	ROADSIDE	Dover DC	y	y	y	
East Herts Sawbridgeworth EH2	ROADSIDE	East Hertfordshire DC	y	y	y	
East Herts Sawbridgeworth EH3	URBAN BACKGROUND	East Hertfordshire DC		y	y	
East Herts Sawbridgeworth EH4	URBAN BACKGROUND	East Hertfordshire DC		y		
East Herts Sawbridgeworth EH5	ROADSIDE	East Hertfordshire DC		y		
Flintshire	ROADSIDE	Flintshire CC		y	y	
Folkestone ZF1	SUBURBAN	Shepway DC	y	y	y	
Guildford Gyratory	ROADSIDE	Guildford BC		y	y	y
Hertsmere Borehamwood HM1	URBAN BACKGROUND	Hertsmere BC		y	y	y
Ipswich Piper's Court	ROADSIDE	Ipswich BC		y		
King's Lynn South Quay	URBAN BACKGROUND	Kings Lynn & West Norfolk BC			y	
Larne	URBAN BACKGROUND	Larne BC	y		y	
Limavady Coolessan	URBAN BACKGROUND	Limavady BC			y	
Lisburn Dunmurry High School	URBAN BACKGROUND	Lisburn City Council			y	
Lisburn Island Civic Centre	URBAN BACKGROUND	Lisburn City Council	y		y	
Lisburn Lagan Valley Hospital	ROADSIDE	Lisburn City Council		y	y	
Liverpool Islington	ROADSIDE	Liverpool City Council	y	y		
Luton Background ZL1	URBAN BACKGROUND	Luton BC	y	y	y	y
Luton LN1	URBAN BACKGROUND	Luton BC	y	y	y	y
Macclesfield Disley	ROADSIDE	Macclesfield BC		y	y	
Maidstone Roadside ZM2	ROADSIDE	Maidstone BC	y	y	y	y
Maidstone Rural ZM3	RURAL	Maidstone BC	y	y	y	
Marchlyn Mawr	REMOTE	Gwyneth Council		y		
Monmouth	URBAN BACKGROUND	Monmouthshire CC		y	y	
Newham Cam Road	ROADSIDE	London Borough of Newham	y	y	y	y
Newham Wren Close	URBAN BACKGROUND	London Borough of Newham	y	y	y	y
Newport Malpas Depot	URBAN BACKGROUND	Newport County BC		y		

Site	Site type	Local Athority	SO_2	NO_2	PM_{10}	CO
Newport St Julians Comp School	URBAN BACKGROUND	Newport County BC		y		
Newry Kilkeel	URBAN BACKGROUND	Newry and Mourne DC			y	
Newry Monaghan Row	URBAN BACKGROUND	Newry and Mourne DC	y	y	y	
Newry Trevor Hill	ROADSIDE	Newry and Mourne DC	y	y	y	
Newtownabbey Mallusk	URBAN BACKGROUND	Newtownabbey BC		y		
Newtownabbey Shore Road	ROADSIDE	Newtownabbey BC		y		
North Down Bangor	URBAN BACKGROUND	North Down BC	y		y	
North Down Holywood A2	ROADSIDE	North Down BC		y	y	
North Herts Breechwood Green NH4	URBAN BACKGROUND	North Hertfordshire DC		y	y	
North Lincs Keadby	URBAN BACKGROUND	North Lincolnshire Council	y	y	y	
North Lincs Killingholme	URBAN BACKGROUND	North Lincolnshire Council	y	y	y	
Oldham West End House	URBAN BACKGROUND	Oldham MBC	y	y	y	y
Omagh Tamlaght	URBAN BACKGROUND	Omagh BC			y	
Oxford High St	ROADSIDE	Oxford City Council		y		
Oxford St Ebbes	URBAN BACKGROUND	Oxford City Council		y		
Rhondda-Cynon-Taf Nantgarw	ROADSIDE	Rhondda-Cynon-Taf CBC			y	
Rhondda-Cynon-Taf Pontypridd	URBAN BACKGROUND	Rhondda-Cynon-Taf CBC			y	y
Ribble Valley Chatburn	URBAN INDUSTRIAL	Ribble Valey BC	y	y	y	
Ribble Valley Lillands	URBAN BACKGROUND	Ribble Valey BC	y	y	y	
S Cambs Bar Hill	ROADSIDE	South Cambridgeshire DC		y	y	
S Cambs Barrington Challis Grn	RURAL	South Cambridgeshire DC	y			
S Cambs Barrington Fruit Farm	RURAL	South Cambridgeshire DC	y			
S Cambs Impington	ROADSIDE	South Cambridgeshire DC		y	y	
Salford M60	ROADSIDE	Salford MBC	y	y	y	y
Sevenoaks 2 - Greatness ZV1	URBAN BACKGROUND	Sevenoaks DC	y	y	y	y
Slough Colnbrook	URBAN BACKGROUND	Slough BC		y	y	
Slough Town Centre A4	ROADSIDE	Slough BC		y	y	
South Beds Dunstable SB1	URBAN BACKGROUND	South Bedfordshire DC		y	y	
South Bucks Gerrards Cross	URBAN BACKGROUND	South Bucks DC		y	y	
South Holland	RURAL	South Holland DC		y		
St Albans Fleetville SA1	URBAN BACKGROUND	St Albans DC	y	y	y	y
Stevenage SE1	ROADSIDE	Stevenage BC		y	y	
Stockport Bredbury	URBAN BACKGROUND	Stockport MBC		y	y	
Strabane Springhill Park	URBAN BACKGROUND	Strabane DC	y		y	
Swale Background ZW2	URBAN BACKGROUND	Swale DC	y	y	y	
Swale Roadside ZW1	ROADSIDE	Swale DC		y	y	
Swansea Morfa Roadside	ROADSIDE	Swansea CC	y	y	y	y

Site	Site type	Local Athority	SO_2	NO_2	PM_{10}	CO
Swansea Morriston Roadside	ROADSIDE	Swansea CC	y	y	y	y
Tameside Two Trees School	URBAN BACKGROUND	Tameside MBC	y	y	y	y
Thanet Airport ZH3	AIRPORT	Thanet DC		y		
Three Rivers Rickmansworth TR1	URBAN BACKGROUND	Three Rivers DC		y	y	
Tonbridge Roadside ZT1	ROADSIDE	Tonbridge & Malling DC		y		
Trafford	URBAN BACKGROUND	Trafford MBC	y	y	y	
Trafford A56	ROADSIDE	Trafford MBC		y	y	
Tunbridge Wells Background ZT2	URBAN BACKGROUND	Tunbridge Wells DC		y		
V Glamorgan Fonmon	RURAL	Vale of Glamorgan Council	y	y		
Watford Roadside WF1	ROADSIDE	Watford BC		y	y	y
Welwyn Hatfield WGC WH1	URBAN BACKGROUND	Welwyn and Hatfield Council		y		
Wokingham Winnersh	URBAN BACKGROUND	Wokingham DC		y	y	
Wycombe Stokenchurch	URBAN BACKGROUND	Wycombe DC		y		

Data were collected from the following sources: **netcen**'s Calibration Club, the Welsh Air Quality Forum, the Herts and Beds network, the Kent network.

Table A2.2. Additional monitoring sites maintained by the electricity generating companies used calibrate the SO_2 models.

Site	Company
Bentley Hall Farm	Eon
Bexleyheath	Innogy
Blair Mains	Innogy
Bottesford	Eon
Boverton Mill Farm	Innogy
Carr Lane Drax	Innogy
Didcot South	Innogy
Downes Ground Farm	Innogy
East Tilbury	Innogy
Gainsborough Cemetery	Eon
Gillingham	Eon
Grove Reservoir	Eon
Hemingbrough	Innogy
Longniddry West	Innogy
Marton School	Eon
North Featherstone	Innogy
Northfleet	Innogy
Ruddington	Eon
Smeathalls Fm	Innogy
Stile Cop Cemetery	Eon
Telford Aqueduct	Eon
Telford School	Eon
Thorney	Eon

APPENDIX 3. PARTICULATE MATTER MASS CLOSURE RESEARCH

PROFESSOR R. DERWENT (May 2005)

Introduction

1. The aim of this paper is to provide some underpinning for the regression methods used in the NETCEN PM_{10} Receptor Model and to understand how to handle particulate ammonium in the PM_{10} maps.

2. The methodology employed is based on particulate matter data collected in two intensive campaigns:

- PUMA Campaign, University of Birmingham campus, June-July 1999,
- EC/OC Campaign, Bush Estate, July 2002 – June 2003.

These campaign data have been used to construct an approximate mass closure for PM_{10} and $PM_{2.5}$ for a central England location.

PUMA Campaign Data

3. Professor Harrison conducted some detailed particulate sampling during the PUMA Campaign at the University of Birmingham urban background site. The data from this campaign can be used to provide speciated composition data for both the fine and coarse particulate fractions.

4. In interpreting these data, it has been assumed that aerosol bound water accounts for 28% of the mass of sulphate, nitrate and ammonium. Significant amounts of sulphate and ammonium were detected in the coarse fraction in a molar ratio of 1.4 x NH_4 to SO_4. This corresponds well with ammonium to sulphate ratio of 1.5 to 1, associated with the mixture of ammonium sulphate and sulphuric acid produced by cloud-processing, an important component of the background aerosol. The origins of this material may well be of long-range or intercontinental origins.

5. A significant amount of total carbon was also reported in the coarse fraction. Again, this may reflect cloud-processing of a combustion derived aerosol. Alternatively, it may represent the take-up of semi-volatile organic compounds on to coarse particles. Nitrate appeared to be distributed in both the fine and the coarse fractions. The fine particle nitrate is presumably ammonium nitrate and the coarse, a mixture of sodium and calcium nitrates formed by displacement reactions on sea-salts and wind-blown dusts.

EC/OC Campaign Data

6. The EMEP/CCC operated an EC/OC site at Bush Estate, Midlothian from July 2002 to June 2003 and measurements were reported of elemental carbon EC and organic carbon OC, together with $PM_{2.5}$ and PM_{10}. The measurement campaign encompassed the period during the spring of 2003 that were associated with the intense pollution episodes. Outside of this period, elemental carbon showed a pronounced seasonal variation with low summer values and high winter values. Organic carbon showed a much less pronounced seasonal cycle which reflects a significant contribution from secondary organic matter of photochemical origin.

7. By assuming that there is no secondary organic matter present during winter and that primary organic matter and elemental carbon have the same seasonal cycles, then it is possible to quantify the three components: elemental carbon EC, primary organic particulate matter POM and secondary organic particulate matter, SOM. Furthermore, in converting from $\mu g\ C\ m^{-3}$ to $\mu g\ PM\ m^{-3}$, conversion factors of 1.0, 1.4 and 1.4, respectively, were used for the three components. The three-way split between the three components was therefore found to be 0.2, 0.56 and 0.24, respectively. This same split was applied to both fine and coarse fractions and universally across rural areas of the UK.

Mass Closure for a Central England Location

8. The results of the mass closure analysis are given in Table 1 below. The total $PM_{2.5}$ and PM_{10} concentrations are found to be 11.1 and 16.1 $\mu g\ m^{-3}$, of which the non-volatile components are 6.2 and 9.9 $\mu g\ m^{-3}$, respectively. This would imply TEOM to gravimetric factors of 1.79 and 1.62, respectively, for $PM_{2.5}$ and PM_{10}. These factors are somewhat higher than typical values observed for a rural location in central England. The primary, secondary and coarse splits for total PM_{10} are 3.89, 7.94 and 4.30 $\mu g\ m^{-3}$ whilst those for the non-volatile PM_{10} are 1.02, 4.55 and 4.30 $\mu g\ m^{-3}$.

Table 1. Mass closure at a rural central England location for the fine and coarse fractions and for total and non-volatile species. [$PM_{2.5}$ = fine fraction, PM_{10} = fine fraction + coarse fraction]

Component	**Fine fraction, $\mu g\ m^{-3}$**		**Coarse fraction, $\mu g\ m^{-3}$**	
	Total	**Non-volatile**	**Total**	**Non-volatile**
sulphate dry	2.40	2.40	0.15	0.15
bound water	0.67		0.04	
ammonium dry	1.13	1.13	0.04	0.04
bound water	0.31		0.01	
nitrate dry	0.68		0.83	0.83
bound water	0.19		0.23	
NaCl	0.20	0.20	0.56	0.56
EC	0.76	0.76	0.26	0.26
POM	2.14		0.73	
SOM	0.94		0.32	
resuspended	1.70	1.70	1.84	1.84
Total	11.12	6.19	5.01	3.69