UK air quality modelling for annual reporting 2007 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.

2007 is the seventh year for which an annual air quality assessment for the first Daughter Directive pollutants is required and the fifth year for which an annual air quality assessment has been undertaken for the second Daughter Directive pollutants. 2007 is the fourth 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.

This report does not contain any supplementary modelling information on ozone. The accompanying technical report (Kent and Stedman, 2008) 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
- Information on the verification of the models used and comparisons with data quality objectives
- Detailed modelling results and comparisons with limit values.

Maps of background concentrations of SO_2, NO_2, PM_{10}, benzene and CO in 2007 on a 1km x 1km grid have been prepared. Maps of roadside concentrations of NO_2, PM_{10}, benzene and CO have been prepared for a total of 10,106 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) (where applicable) and limit values (LV). Table E2 contains details of exceedences of old directives.

Table E1. Summary results of air quality assessment for 2007

Pollutant	Averaging time	Number of zones exceeding limit value + margin of tolerance	Number of zones exceeding limit value
SO_2	1-hour	n/a	none
SO_2	24-hour[1]	n/a	none
SO_2	annual[2]	n/a	none
SO_2	winter[2]	n/a	none
NO_2	1-hour[3]	1 zone measured (Greater London Urban Area)	2 zones measured
NO_2	annual	39 zones (6 measured + 33 modelled)	41 zones (8 measured + 33 modelled)
NO_x	annual[2]	n/a	none
PM_{10}	24-hour (Stage 1)	n/a	6 zones (3 measured + 3 modelled)
PM_{10}	annual (Stage 1)	n/a	1 zone measured (Greater London Urban Area)
PM_{10}	24-hour[4] (Stage 2)	n/a	30 zones (28 measured + 2 modelled))
PM_{10}	annual[5] (Stage 2)	25 zones (5 measured + 20 modelled)	41 zones (27 measured + 14 modelled)
Lead	annual	n/a	none
Benzene	annual	none	none
CO	8-hour	n/a	none

[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 E2. Exceedences of old Directives

Pollutant	Directive	Averaging time	Concentration ($\mu g\ m^{-3}$)
NO_2	85/203/EEC	1-hour 98%ile	229 (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) 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) 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.

The Framework Directive includes a requirement for Member States to undertake preliminary assessments of ambient air quality, prior to the implementation of the Daughter Directives under Article 5 this Directive. The objectives of these assessments are to establish estimates for the overall distribution and levels of pollutants, and to identify additional monitoring required to fulfil obligations within the Framework Directive. Reports describing the preliminary assessment for the UK for AQDD1 and AQDD2 have been prepared (Bush 2000 and 2002). AQDD1 and AQDD2 define the number of air quality monitoring sites required on the basis of the concentrations of pollutants and population statistics. The number of monitoring sites required is significantly reduced if other means of assessment, in addition to fixed monitoring sites, are also available. Air quality modelling has therefore 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.

Directive 2008/50/EC on ambient air quality and clean air for Europe entered into force in June 2008. This directive will replace the framework and daughter directives two years after entering into force (June 2010). Air quality reporting therefore continues as required by the framework and daughter directives until then.

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. A questionnaire has been completed for submission to the EU containing the results of this air quality assessment. A copy of the completed questionnaire can be found on the Central Data Repository of the European Environment Agency (CDR, 2008). The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the limit values set out in the Directives. 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.

The third Daughter Directive includes a requirement for an annual air quality assessment for ozone. The ozone air quality assessment is covered in a separate technical report (Kent and Stedman, 2008).

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

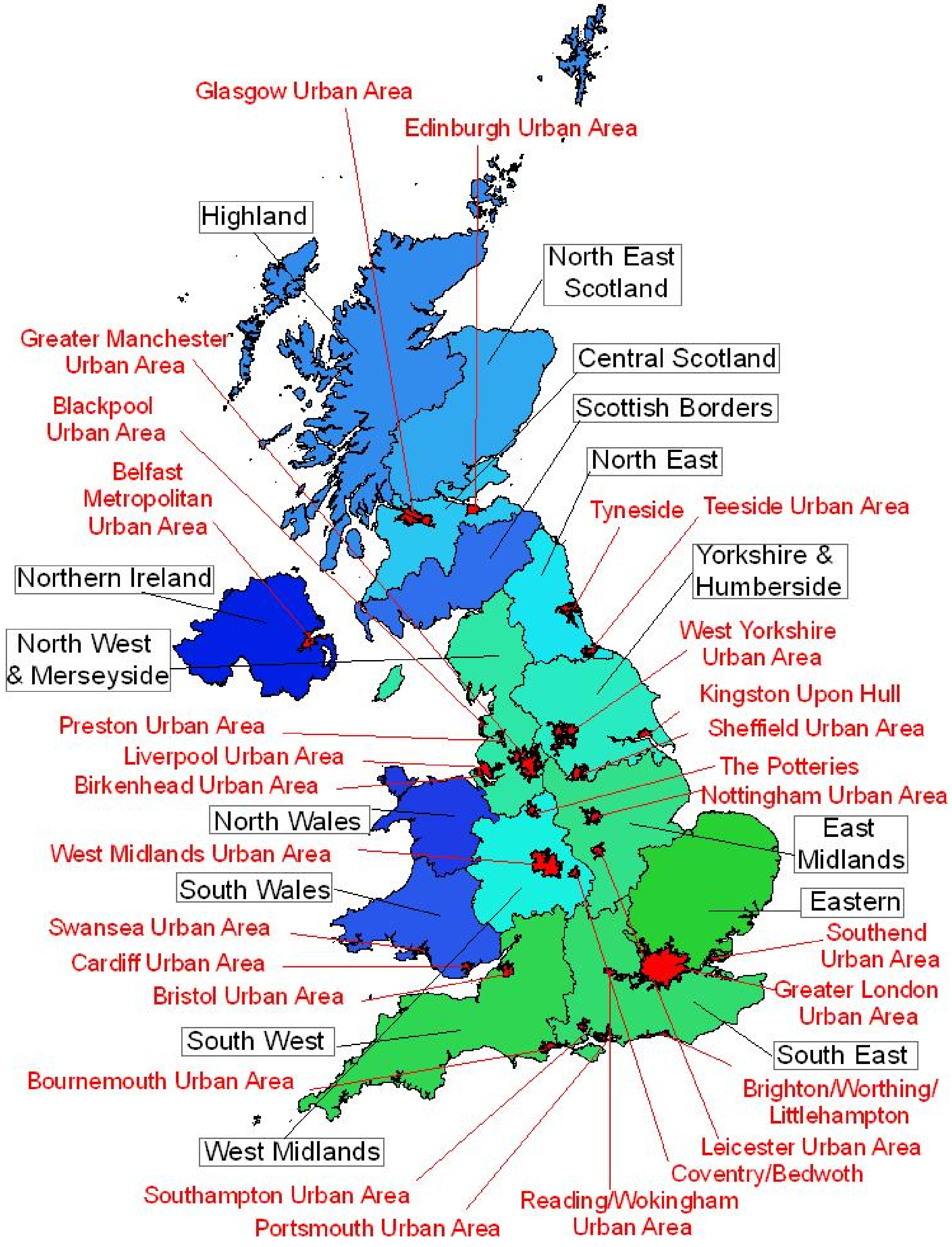
- Details of the modelling methods
- Information on the verification of the models used and comparisons with data quality objectives
- Detailed modelling results.

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 (CDR, 2008) 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 previous years (Kent *et al.*, 2007b; Kent *et al.*, 2007a; Stedman *et al.*, 2006a; 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. Table 1.1 contains details of area, population (from 2001 census) and urban road length contained in each zone and agglomeration. The zones and agglomerations map for the UK is presented in Figure 1.1.

Figure 1.1. UK zones and agglomerations for 2007



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

Table 1.1. Zones for AQDD 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 2007 for the purpose of AQDD1 and AQDD2 are listed in Form 3 of the questionnaire which can be found on the CDR (2008). Not all sites had sufficient data capture during 2007 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 for the entire year in the analysis in order to ensure that we can make maximum use of data from the monitoring sites operational for the whole of 2007 for reporting purposes. Data capture statistics for sites operational during 2007 are also presented in Form 3 of the reporting questionnaire.

Network changes in the Automatic Urban and Rural Network (AURN) taking place in 2007 resulted in a significant site closures during the year. The majority of closures were at the end of September 2007. This has affected the data capture of sites that are used in the calibration and checking of the models. Using a standard data capture threshold of 75%, many of these sites would be omitted from the analysis, even though the data for their period of operation is good quality, simply due to the limited period of operation throughout the year. Therefore, in an effort to use as many of these available partial year sites as possible, we have elected to scale sites that ceased operation during 2007 to estimate an annual mean concentration that is representative of the full year. In order to arrive at an estimated full year annual mean, we have used the scaling method presented in the Local Air Quality Management Technical Guidance (LAQM.TG(03), 2003) which uses monitoring data from nearby monitoring sites within the AURN to calculate a ratio between the period with measurements at the sites which closed and the full year. This method was used to calculate annual means for CO, NO_X and NO_2, PM_{10} (TEOM) and SO_2. These annual means were used for calibrating the model, but were not reported in the questionnaire. Details of the method are provided in Appendix 5.

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 2007 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 came into force in 2001. There is no applicable margin of tolerance for the hourly or 24-hourly SO_2 metric, the PM_{10} (Stage 1) 24-hour or annual metrics, the lead annual mean metric or the maximum daily 8-hour CO metric because these limit values all came into force in 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. A reported exceedence of the limit value + margin of tolerance also means that 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' must be prepared.

Table 1.2. Limit values for SO_2

	Averaging period	**LV**	**LV + MOT 2007**	**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	N/A	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 2007	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 than 18 times a calendar year	230 $\mu g\ m^{-3}$, NO_2 not to be exceeded more than 18 times a calendar year	1 January 2010
2. Annual LV for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$ NO_2	46 $\mu g\ m^{-3}$, NO_2	1 January 2010
3. LV for the protection of vegetation	Calendar year	30 $\mu g\ m^{-3}$ 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 2007	Date by which LV is to be met
1. 24-hour LV for the protection of human health	24 hour	50 $\mu g\ m^{-3}$ not to be exceeded more than 35 times a calendar year	N/A	1 January 2005
2. Annual LV for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$	N/A	1 January 2005

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

	Averaging period	LV	LV + MOT 2007	Date by which LV is to be met
1. 24-hour LV for the protection of human health	24 hour	50 $\mu g\ m^{-3}$ 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 $\mu g\ m^{-3}$	26 $\mu g\ m^{-3}$	1 January 2010

Table 1.5. Limit values for lead

	Averaging period	LV	LV + MOT 2007	Date by which LV is to be met
Annual LV for the protection of human health	Calendar year	0.5 $\mu g\ m^{-3}$	N/A	1 January 2005

Table 1.6. Limit values for benzene

	Averaging period	LV	LV + MOT 2007	Date by which LV is to be met
Annual LV for the protection of human health	Calendar year	5 $\mu g\ m^{-3}$	8 $\mu g\ m^{-3}$	1 January 2010

Table 1.7. Limit values for CO

	Averaging period	LV	LV + MOT 2007	Date by which LV is to be met
8-hour LV for the protection of human health	Maximum daily 8-hour mean	10 $mg\ m^{-3}$	N/A	1 January 2005

1.6 Data quality objectives for modelling results and model verification

AQDD1 sets data quality objectives (DQOs) in terms of accuracy, which act as a guide for quality assurance programmes when identifying an acceptable level of accuracy for assessment methods appropriate for supplementary assessment under the first Daughter Directive. Accuracy is defined in the Directives as the maximum deviation of the measured and calculated concentration levels, over the period considered by the limit value, without taking into account the timing of events.

DQOs have been set at 50-60% (we have compared with 50%) for hourly averages, 50% for daily averages and 30% for annual averages of SO_2, NO_2 and NO_x. For PM_{10} and lead the DQO for annual averages is 50%. DQOs have not been defined for daily averages of PM_{10} at present. The second Daughter Directive sets the DQOs applicable to assessment methods for annual average benzene and 8-hour average CO concentrations at 50%.

The models used to calculate the maps of air pollutants presented in this report have been calibrated using the national network monitoring data, for sites listed in Form 3 of the reporting questionnaire. Sites with less than a years worth of data, which could not be submitted in the questionnare were, however, also used for this calibration where it was possible to scale the data, as described in Appendix 6. Data from these sites alone cannot, therefore, be used to assess the reliability of the mapped estimates in relation to the DQOs for modelling. Measurement data from sites not included in the calibration are required to make this assessment. Data from sites quality assured by AEA under contract and not part of the national network, including Local Authority sites in the AEA Calibration Club, Scottish Air Quality Archive monitoring sites, Welsh Air Quality Forum monitoring sites and sites from the Kent and Medway Air Quality Monitoring Network, have therefore been used for the verification of the modelled estimates. The description ‘Verification Sites’ is used to describe all the monitoring sites included in the verification analysis, as only a subset of these sites, quality assured under contract by AEA, are formally members of the Calibration Club. For 2007 we have also obtained monitoring data from the London Air Quality Network (LAQN) and Hertfordshire and Bedfordshire Air Quality Monitoring Network, courtesy of ERG. The monitoring sites used for this comparison are listed in Appendix 1. Sites with a data capture of at least 75% have been included in the verification analysis. Model verification results are listed in the following sections on each pollutant.

1.7 Air quality modelling

Full details of the modelling methods implemented are given in the following sections. A brief introduction is presented here. Maps of background concentrations of SO_2, NO_2, PM_{10}, benzene and CO have been prepared on a 1km x 1km grid for the 2007 calendar year. Emissions estimates used in calculating pollutant concentrations have been taken from the National Atmospheric Emissions Inventory (Dore *et al.*, 2008). Maps of roadside concentrations of NO_2, PM_{10} and benzene and CO have also been prepared for 10,106 urban major road links (A-roads and motorways). Emissions maps utilised in this modelling work are presented in the NAEI report (Dore *et al.*, 2008).

The dominant contributions to ambient SO_2 concentrations in the UK are from power stations and refineries. Emissions of SO_2 from point sources were therefore modelled explicitly, whereas, the more diffuse area sources were 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 sources, and a slightly different modelling approach has therefore been adopted. Point sources have been modelled explicitly for all these pollutants. For benzene contributions from large combustion sources have been modelled explicitly. Contributions from other point source have been modelled using a volume source dispersion kernel approach in order to represent the process and fugitive emission release characteristics of these sources. Rural network measurements have been used to define regional concentrations of NO_2, NO_X and secondary PM_{10}. Regional benzene concentrations have been estimated from rural NO_2 concentrations. The area source contribution to ambient NO_X, PM_{10}, benzene and CO concentrations has been modelled using a dispersion kernel approach. The coefficients calibrating these area source models have been determined empirically using measurement data from the national networks.

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. The roadside increment has been calculated from road link emission estimates using dispersion coefficients derived empirically using data from roadside monitoring sites.

Emissions estimates for the UK are provided by the National Atmospheric Emission Inventory (NAEI) (Dore et *al.*, 2008). Emission maps from the 2006 NAEI have been used for the modelling work described here. Emission estimates for area sources have been scaled to values appropriate to 2007, using UK sector total emissions from 2006 and 2007.

The dispersion kernels have been revised for the 2007 modelling for all pollutants, see Appendix 3.

The method for calculating emissions from aircraft has been revised for the 2007 modelling. The aircraft emissions were calculated using data obtained from the NAEI (Dore et *al.*, 2008) for emissions from planes in various phases of flying (e.g. take off). These data were used to calculate factors to scale the NAEI emissions grids of total emissions from aircraft in order to calculate the ground level emissions on the basis that emissions from aircraft in the air will have a much smaller impact on surface concentrations. Taxi out, hold, take off, landing, reverse thrust, taxi in, APU arrival and APU departure were classed as ground level emissions and initial climb, climb out and approach were classed as emissions aloft. The factors calculated are shown in table 1.8 below.

Table 1.8. Scaling factors for ground level aircraft emissions

Pollutant	Proportion at ground
CO	0.3120
NMVOC	0.7334
NOx	0.3523
PM10	0.6199
SO2	0.5134

1.8 Air quality in Gibraltar in 2007

Air quality monitoring is undertaken in Gibraltar and these data are submitted to the Commission each year via a separate questionnaire to that compile for the UK (CDR 2008). Two continuous automatic monitoring stations were in operation in 2007 – Rosia Road (roadside site) and Bleak House (background site). The data from the monitoring campaigns are presented in Appendix 5, including tables of the relevant forms from the questionnaire and details of the monitoring sites.

2 SO_2

2.1 Introduction

Maps of annual mean, winter mean, 99.73 percentile of hourly mean and 99.18 percentile of daily mean SO_2 concentrations have been calculated for 2007. The percentile concentrations presented here correspond to the number of allowed exceedences of the 1-hour and 24-hour limit values for SO_2. The modelling methods have been described by Abbott and Vincent (1999 and 2006). Emissions from point and area sources were modelled separately and the results combined within a geographical information system to produce the respective concentration maps.

Emissions from larger point sources (sources with emissions ≥ 500 tonnes per year) were modelled using the dispersion model ADMS 4.0 (CERC, 2008). Hourly emissions profiles for the power stations in England and Wales for 2007 were provided by the Environment Agency. Emissions from power stations in Northern Ireland were modelled using emissions profiles typical of electricity generation in summer and winter. Emissions from non-power station point sources were based upon data obtained from the Environment Agency's Pollution Inventory. Emissions from smaller point sources (< 500 tonnes) were modelled using the "small point source model". This model is described in more detail in Appendix 2. The emissions for both the non-power station large and small point sources are for 2006; 2007 emissions for these types of sources were not available when the modelling work was conducted.

For the large point emission sources, concentrations are predicted for 5 km x 5 km receptors within a number of receptor areas (or tiles), which together covered the UK. The size of the receptor areas was typically 100 km x 100 km, extending out to 150 km where appropriate. All sources within the receptor area and extending out 100 km from the square's border were assumed to influence concentrations within the receptor area. Emissions were modelled using sequential meteorological data for Waddington in Lincolnshire. This site was chosen as the most representative of meteorology in the vicinity of the largest point sources in the UK. This approach ensures that the combined impact of several sources on ambient high percentile concentrations is estimated correctly.

The contribution to ambient SO_2 concentrations from area sources was calculated using a dispersion kernel approach. Emission estimates for area sources have been scaled to values appropriate to 2007, using UK sector total emissions for 2006 and 2007. Concentrations are predicted for 1 km x 1 km receptors. Dispersion kernels were calculated using ADMS 4 and hourly sequential meteorological data for 2007 from Waddington. Modelling of the area sources is described in more detail in Appendix 3.

Details of the method to combine the component parts are described in the following sections. The map of winter mean SO_2 concentrations was derived from the annual mean map using a factor of 1.29, which is the ratio between the average concentration measured at rural SO_2 monitoring sites during the 2006-2007 winter period and annual concentration for during 2007, respectively.

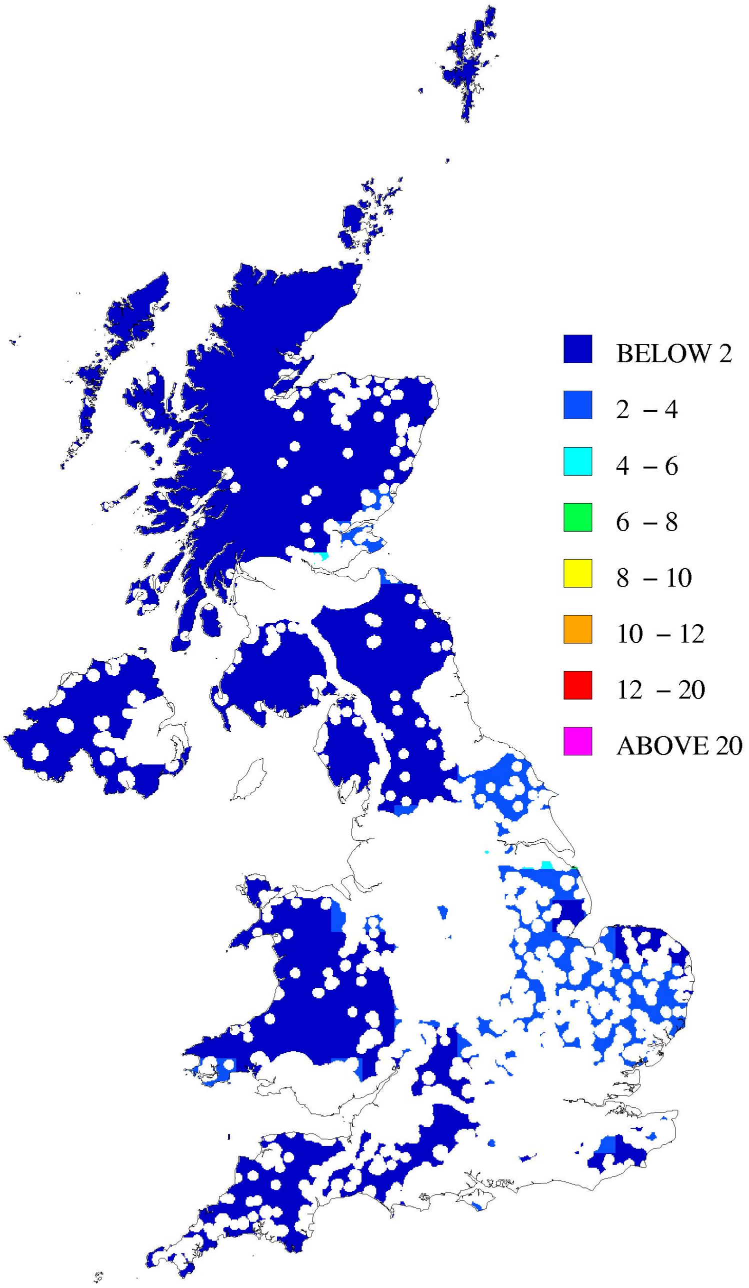
A different method was used to calculate the high percentile concentrations in Northern Ireland, where the dominant source for peak SO_2 concentrations is domestic emissions (see Section 2.3).

2.2 Maps of winter and annual mean concentrations

A map of annual mean SO_2 concentration for 2007 in ecosystem areas is shown in Figure 2.1. This map has been calculated by removing non-ecosystem areas from the background SO_2 map and calculating the zonal mean of the 1km^2 grid squares for a 30km^2 grid.

Mean concentrations on a 30km^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, 2007 ($\mu g\ m^{-3}$) in ecosystem areas



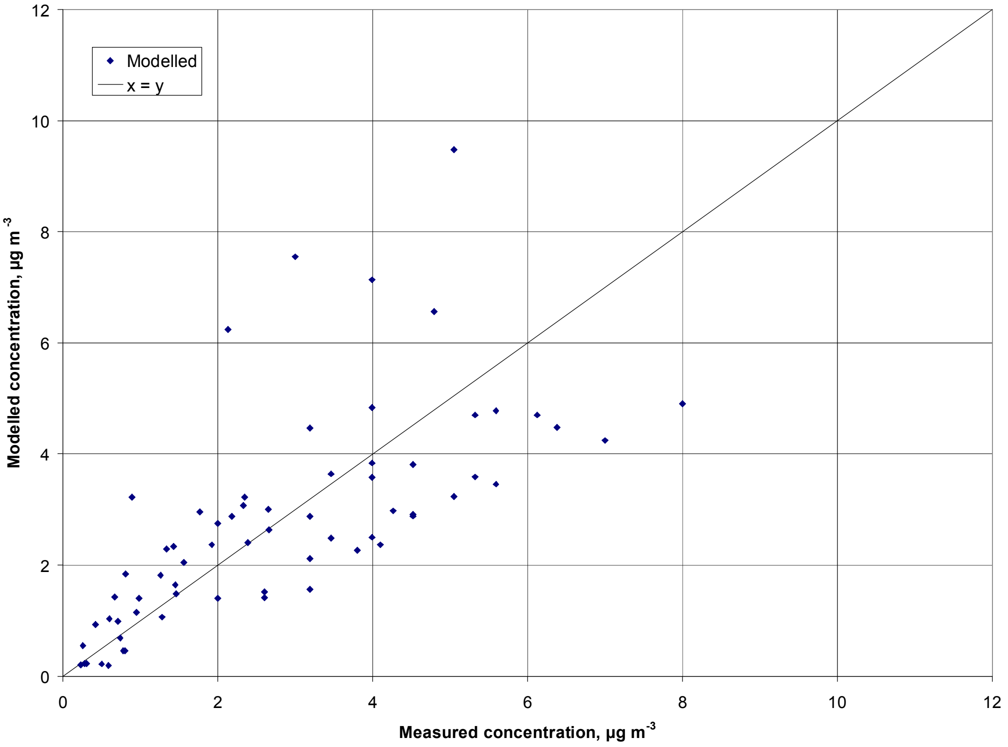
The factors used to combine the point source and area source contributions are shown in Table 2.1. A residual concentration of 0.19 $\mu g\ m^{-3}$ was added. This residual was derived by a linear least squares fit between the measured and modelled concentrations. The residual is associated with contributions from more distant sources, for example, from continental European sources that are not explicitly modelled.

Table 2.1 Coefficients for annual mean model

	Points coefficient	Area coefficient	Constant $\mu g\ m^{-3}$
Annual mean	1	1	0.19

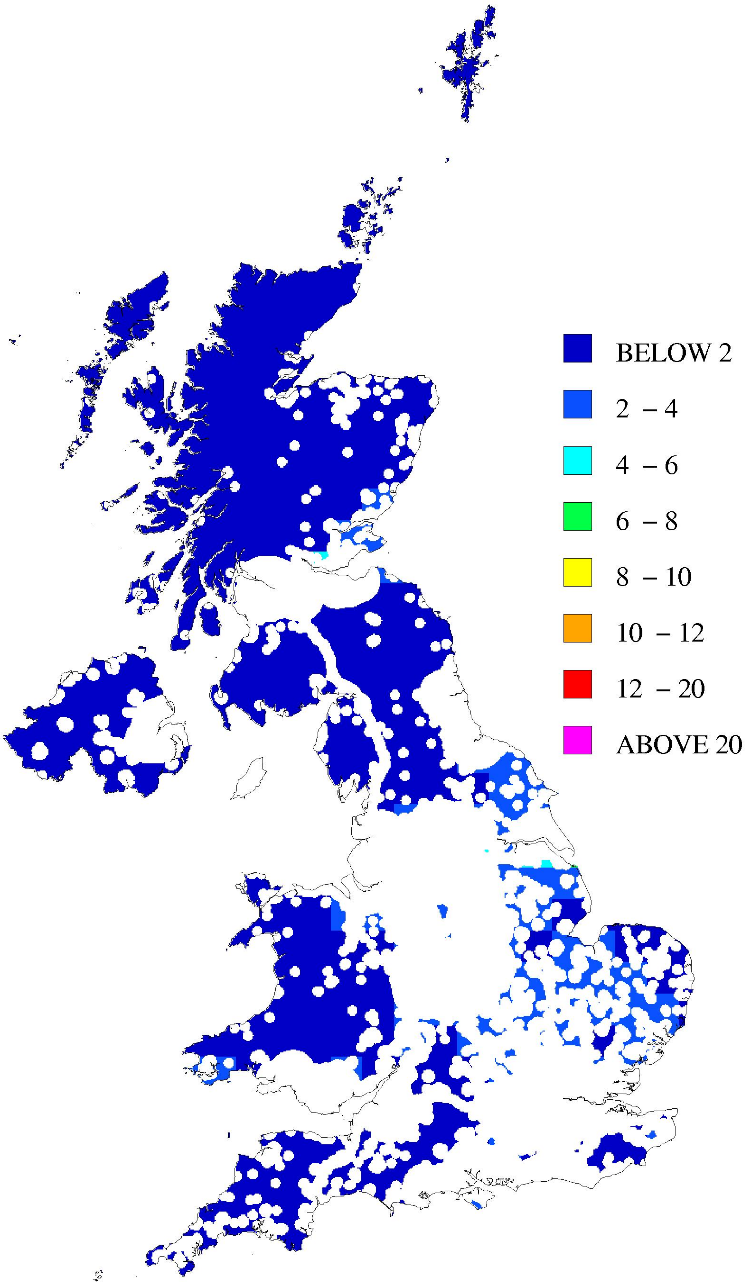
Measured concentrations from Rural SO_2 Monitoring Network sites (Lawrence, *pers comm.* 2008), rural, suburban and industrial sites in the national automatic monitoring networks and rural automatic monitoring sites maintained by the electricity generating companies were used to check the method used to combine the modelled components. A list of the sites maintained by the electricity generating companies is included in Appendix 1. The comparison plot for 2007 is shown in Figure 2.2.

Figure 2.2. Comparison plot for 2007 annual mean SO_2 concentration



A map of winter mean SO_2 concentrations for the period October 2006 to March 2007 has also been calculated and is shown in Figure 2.3. This map was calculated by multiplying the annual mean map for 2007 by 1.29, which is the ratio between the average concentration measured at rural SO_2 monitoring sites during the 2006-2007 winter period and annual concentration for during 2007.

Figure 2.3. Winter mean SO_2 concentration, 2006-2007 (μg 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 2007 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, 2007 ($\mu g\ m^{-3}$)

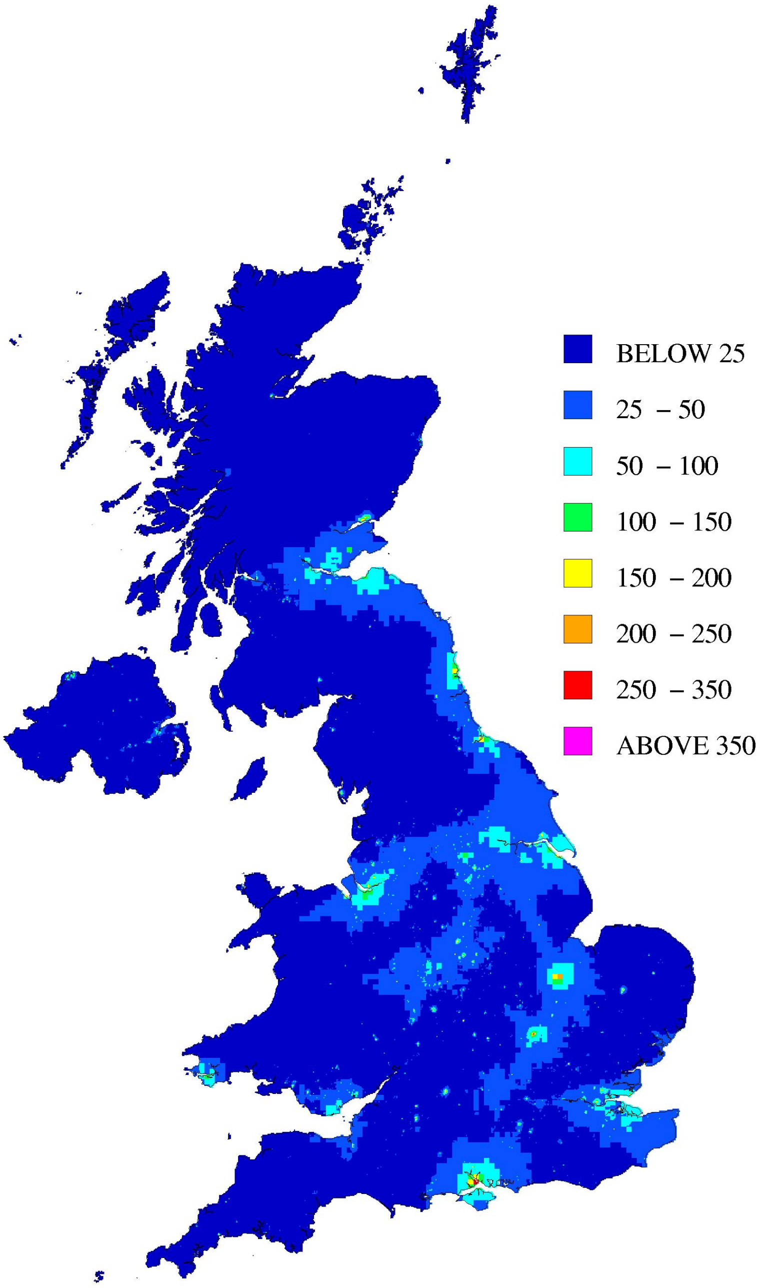
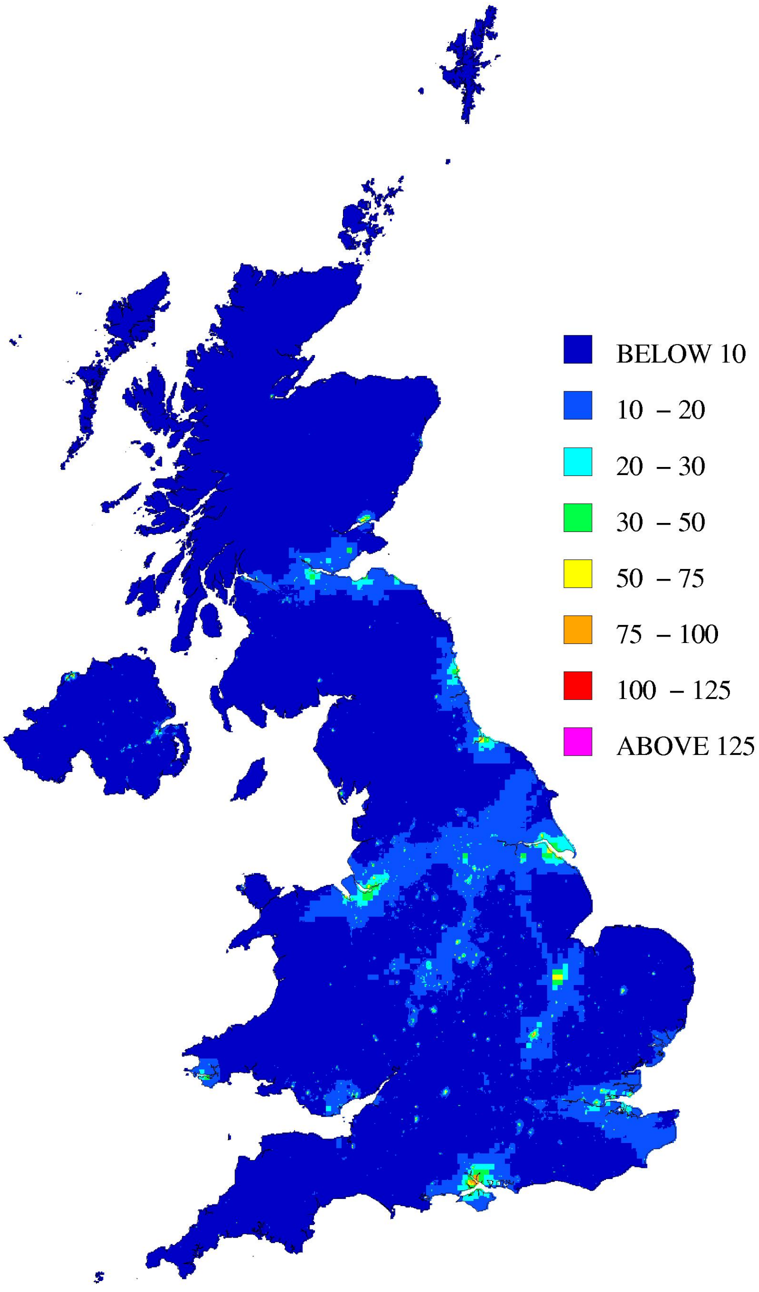


Figure 2.5. 99.18 percentile of 24-hour mean SO_2 concentration, 2007 ($\mu g\ m^{-3}$)



The methodology to produce the maps has been updated to include research on combining concentrations arising from area and industrial sources undertaken for the Environment Agency (Abbott and Vincent, 2006). This methodology aims to derive a better estimate of the percentile concentrations at locations distant from the industrial sources. A weighted regression analysis was carried out by Abbott and Vincent assuming that the variance of the residuals was proportional to the modelled concentration. The regression model was of the form:

$$c_{measured} = \max\begin{bmatrix} Ac_{\mathrm{mod}\,elled\_industrial,\%ile} + 2(c_{\mathrm{mod}\,elled\_area} + c_{long\_range})_{annual} \\ 2Ac_{\mathrm{mod}\,elled\_industrial,annual} + k(c_{\mathrm{mod}\,elled\_area} + c_{long\_range})_{annual} \end{bmatrix}$$

The constant A was obtained from the regression analysis. The background multiplier factor, k, was derived from monitoring data. The factor "2", used to scale the $(c_{modelled\_area} + c_{long\_range})_{annual}$ and $c_{modelled\_industrial,annual}$ components, has been shown to be a robust factor that allows short-term average concentrations to be estimated from modelled annual mean concentrations arising from non-industrial or industrial sources (Abbott *et al.*, 2005). Table 2.2 presents the A and k factors used in the derivation of the maps.

Table 2.2 Factors for percentile models

Metric	Constant A	Background multiplier factor, k	c_{long_range}
99.73 percentile of 1-hour values	1.09	10.1	0.19
99.18 percentile of 24-hour values	1.23	3.3	0.19

The justification for treating industrial sources and area emissions separately is because peaks in high percentile modelled contributions may not coincide with peaks in high percentile background concentrations – a problem that is more pronounced in emissions from large industrial point sources because the meteorological conditions that give rise to high concentrations from tall stacks can be very different from those that produce high concentrations from emissions at low level.

Figures 2.6 and 2.7 provide an intermediate quality check at rural and suburban sites which form part of the national network and at sampling sites operated by the electricity supply companies.

Figure 2.6. Comparison plot for 2007 99.73 percentile of 1-hour mean SO_2 concentrations

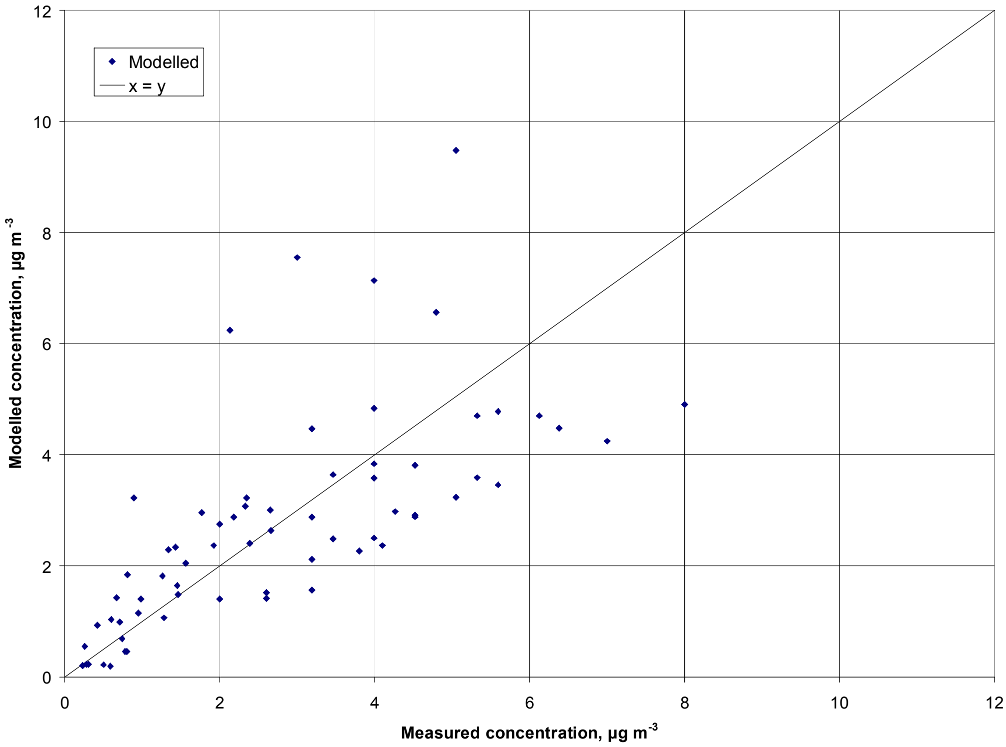
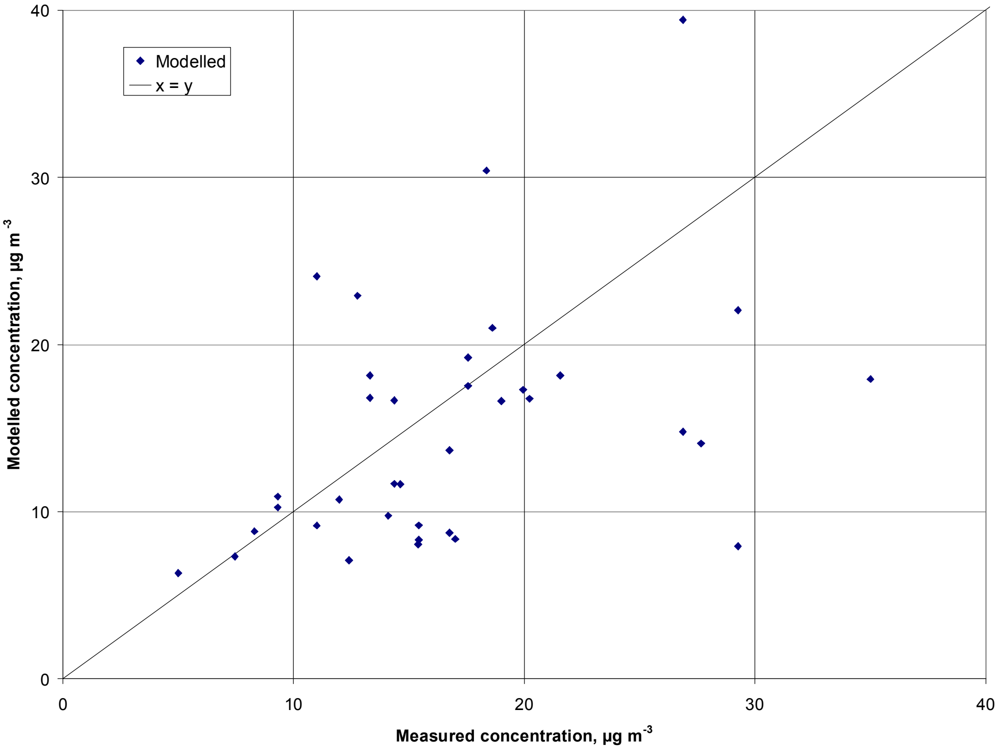


Figure 2.7. Comparison plot for 2007 99.18 percentile of 24-hour mean SO_2 concentrations



An alternative method was used to derive the high percentile concentrations in Northern Ireland. 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. Additionally, the smaller number of point sources in Northern Ireland means that these sources make a much smaller contribution to the observed high percentile concentrations.

Maps of high percentile concentrations in Northern Ireland have been calculated from the mapped annual mean SO_2 concentrations using a linear least squares fit between measured annual mean and measured high percentile concentrations in Northern Ireland during 2007 at national network and AEA Calibration Club monitoring sites. Figures 2.8a and 2.8b show the relationship between the annual mean and the 99.73 percentile of 1-hour mean values and the 99.18 percentile of 24-hour mean values at the sampling sites in Northern Ireland.

The equations used to derive the high percentile maps are:

Predicted 99.73 %ile in Northern Ireland = 6.91 × *Modelled Annual Mean* + 2.22

Predicted 99.18 %ile in Northern Ireland = 3.36 × *Modelled Annual Mean* + 0.13

Figure 2.8a: Relationship between mean concentration and 99.73 percentile of 1-hour concentrations at sampling sites in Northern Ireland

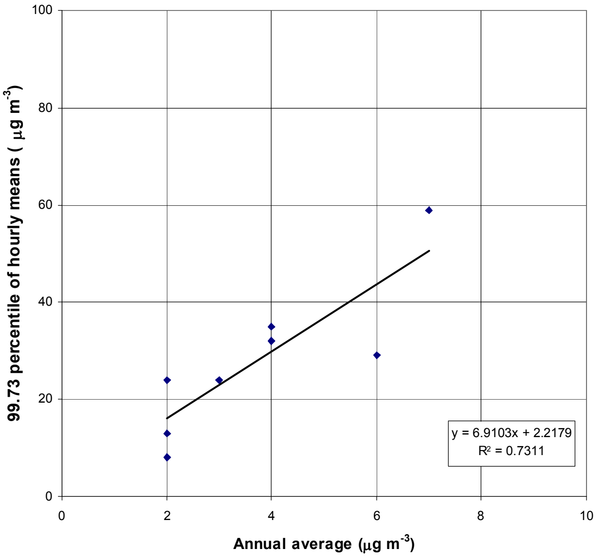
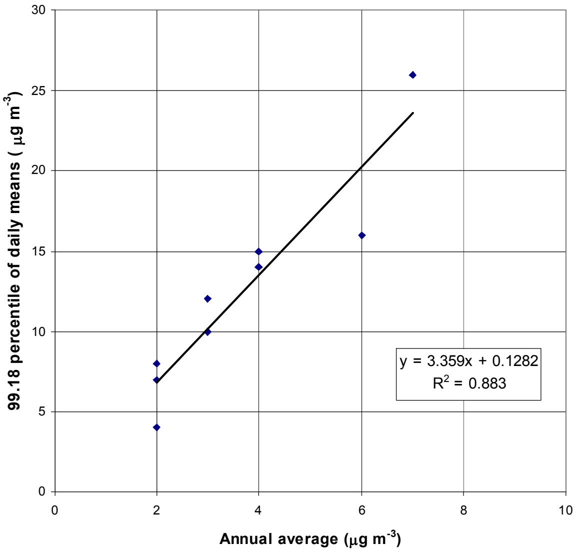


Figure 2.8b: Relationship between mean concentration and 99.18 percentile of 24-hour concentrations at sampling sites in Northern Ireland



A more detailed modelling study was carried out to estimate the ambient SO_2 concentrations in the vicinity of the bickworks at Stewartby in Bedfordshire. Full details of this assessment are included in Appendix 4.

2.4 Verification of mapped values

Figures 2.9, 2.10 and 2.11 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 2007 at monitoring site locations in the UK. Both the national network sites and the verification sites are shown. The ‘Quality Check 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 AEA’s Calibration Club monitoring sites. A complete list of the AURN sites used are presented in Form 3 of the reporting questionnaire. Details of verification sites are presented in Table A1.1 of Appendix 1 and the sites maintained by the electricity generating companies are listed in Table A1.2. Lines representing y = x – 30 % and y = x + 30% or 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 2.9. Verification of annual mean SO_2 model 2007

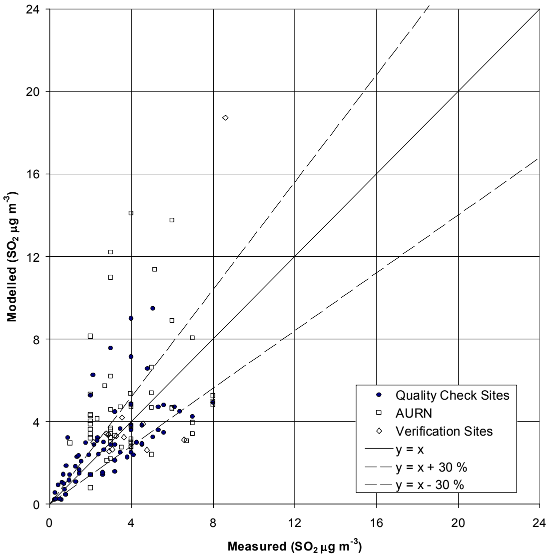


Figure 2.10. Verification of 99.73 percentile of 1-hour mean SO_2 model 2007

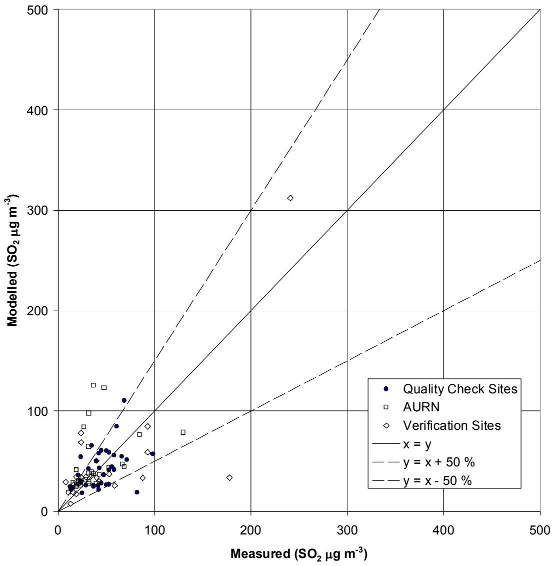
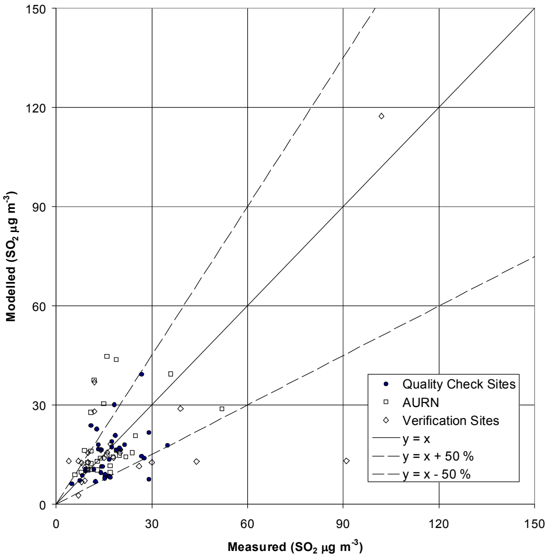


Figure 2.11. Verification of 99.18 percentile of 24-hour mean SO_2 model 2007



Summary statistics for 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.

The mean measured and modelled concentrations for the each averaging time agrees reasonably well. The agreement between measured and modelled concentrations on a site-by-site basis (quantified using R^2) has historically been poor for all metrics both for sites in the national network and the verification sites. Note that the annual mean map is not compared directly with the annual mean limit value, the zonal mean of the 1km^2 grid squares in ecosystem areas has been calculated for a 30km^2 grid, as discussed above.

Reasons for the poor agreement include:

- Emissions from large industrial emission sources are decreasing. This will result in an increase in the relative contribution from other sources. The emission characteristics of these sources are less well known;
- The receptor grid used in the model predictions (concentrations are predicted at 5 km intervals) may be too coarse for the smaller emission sources;
- The modelling method does not explicitly model concentrations arising from non-UK sources.

The R^2 values in Tables 2.3 to 2.5 for national network sites were comparable to those reported in the 2005 and 2006 modelling - with the exception of annual mean concentration predicted at the verification sites which is significantly improved compared to the 2006 value

Methods to improve the prediction could include:

- Improving emission characteristics for smaller emission sources;
- Increasing the resolution of the receptor area (5 km to 1 km or 2 km);
- Considering using region specific meteorological data;
- Using a long-range transport model to predict sulphur dioxide concentrations from non-UK sources.

Table 2.3. Summary statistics for comparison between modelled and measured annual 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 ±30%	Number of sites in assessment
National Network	2.69	3.42	0.37	64	66[a]
Verification Sites	4.21	4.32	0.59	58	45

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 ($\mu g\ m^{-3}$)	Mean of model estimates ($\mu g\ m^{-3}$)	R^2	% of sites outside DQO of ±50%	Number of sites in assessment
National Network	36.44	32.50	0.16	36	36[b]
Verification Sites	52.17	46.93	0.56	35	23

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 in assessment
National Network	16.34	12.29	0.15	22	36[c]
Verification Sites	22.96	17.61	0.44	48	23

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

2.5 Comparison of modelling results with limit values

Modelling results for SO_2 have not been tabulated here because the modelled and measured SO_2 concentrations for 2007 are below the limit values for all zones. In contrast to previous years there were no modelled exceedences in the Eastern Zone associated with industrial emissions at the brickworks at Stewartby. The detailed modelling work carried out for this locations is described further in Appendix 4.

3 NO_2/NO_X

3.1 Introduction

Two limit values concerning ambient NO_2 concentrations for the protection of human health have been specified in the First Daughter Directive: an annual mean of 40 µg m^{-3} and an hourly concentration of 200 µg m^{-3}, with 18 permitted exceedences each year. Additionally an annual mean limit value for NO_X of 30 µg m^{-3} (as NO_2) has been specified, which only applies for vegetation areas as defined in the directive. This section of the report describes modelling work carried out for 2007 to assess compliance with these limit values.

Annual mean concentrations of NO_X and NO_2 have been modelled for the UK for 2007 at background and roadside locations. Maps of annual mean NO_2 concentrations for these locations in 2007 are presented in Figures 3.1 and 3.2. The modelling methods for NO_X and NO_2 have been developed over a number of years (Stedman and Bush, 2000, Stedman *et al.*, 2001b, Stedman *et al.*, 2001c, Stedman *et al.*, 2002, Stedman *et al.*, 2003 Stedman *et al.*, 2005, Stedman *et al.*, 2006a, Kent *et al.*, 2007, Kent *et al*, 2008).

Figure 3.1. Annual mean background NO_2 concentration, 2007 ($\mu g\ m^{-3}$)

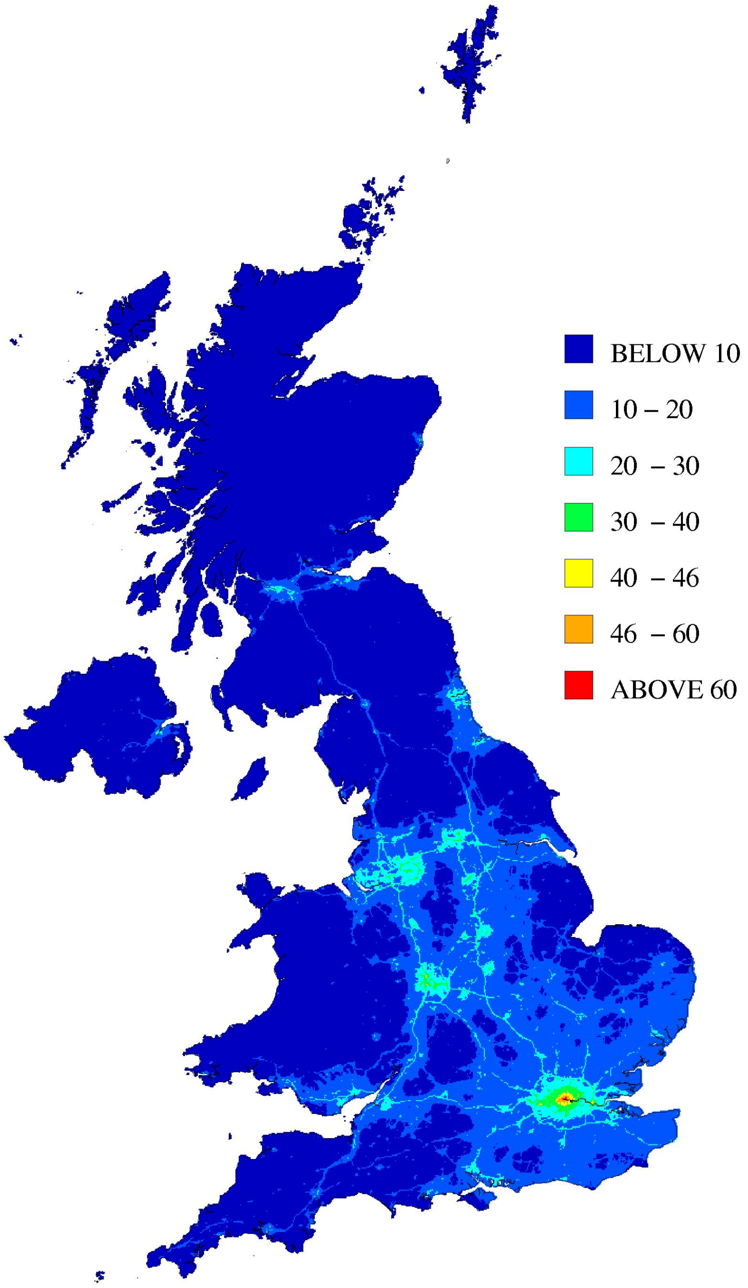
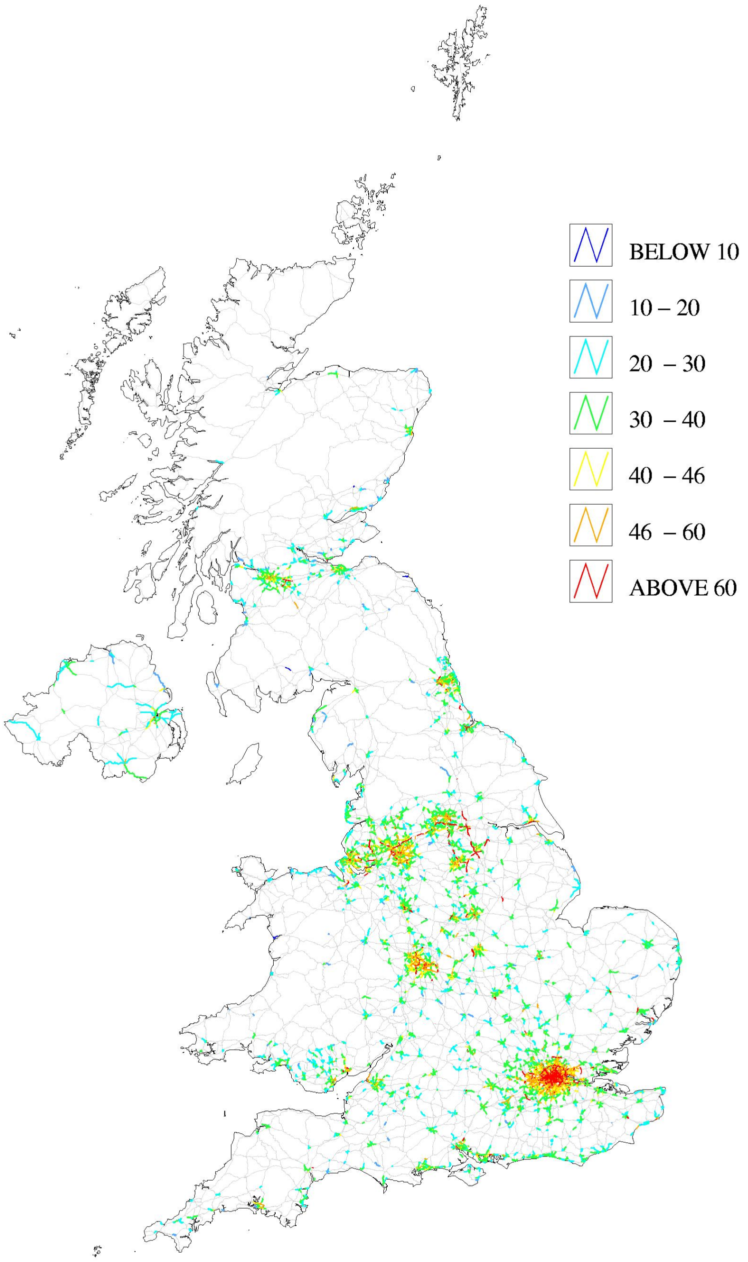
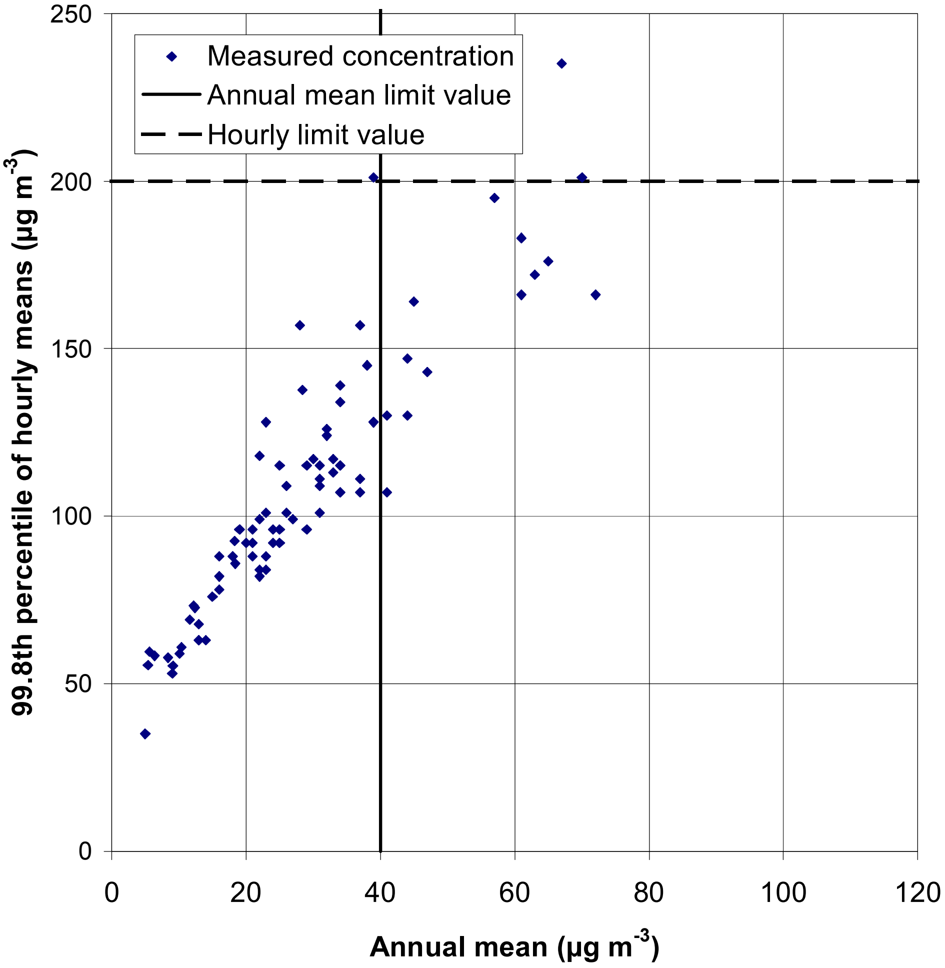


Figure 3.2. Urban major roads, annual mean roadside NO_2 concentration, 2007 ($\mu g\ m^{-3}$)



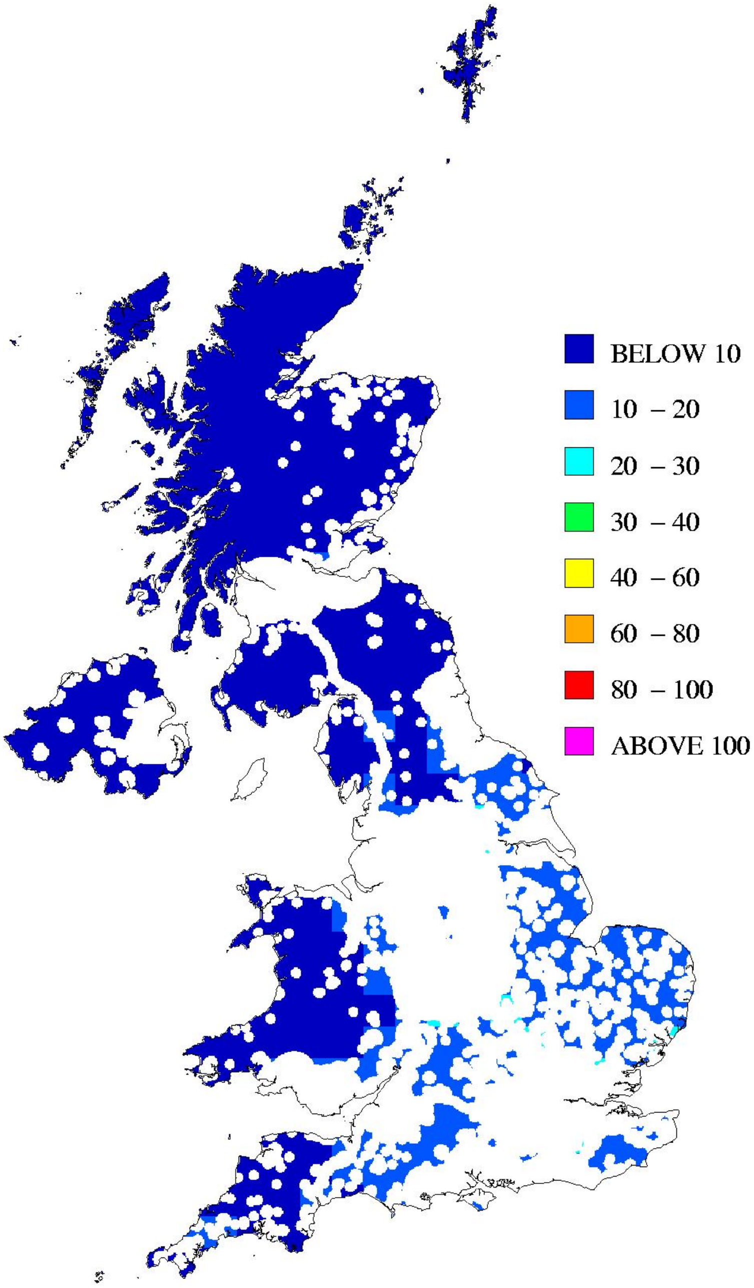
The modelling presented in this report for NO_X and NO_2 has been restricted to estimation of annual mean concentrations for comparison with the annual mean limit values. No attempt has been made to model hourly concentrations for comparison with the 1-hour limit value. This is due to the considerable uncertainties involved in modelling at such a fine temporal scale. The annual mean limit value is expected to be more stringent than the 1-hour limit value in the majority of situations (AQEG, 2004). This is illustrated in Figure 3.3 which is a scatter plot of the annual mean metric in 2007 against the 99.8th percentile (equivalent to 18 exceedences) hourly mean concentration in the same year. This plot shows a significantly higher number of sites exceeding the annual mean limit value of 40 $\mu g\ m^{-3}$ than the 200 $\mu g\ m^{-3}$ hourly limit value.

Figure 3.3. Plot of annual mean against 99.8th percentile hourly NO_2 concentrations in 2007



A map of NO_X concentrations from all sources has been calculated. This map is 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 map of annual mean NO_X concentrations in vegetation areas is presented in Figure 3.4. This map has been calculated by removing non-vegetation areas from the background NO_X map and calculating the zonal mean of the 1km^2 grid squares for a 30km^2 grid. Mean concentrations on a 30km^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 3.4. Annual mean map of NO_X concentrations for comparison with the NO_X vegetation limit value, 2007 ($\mu g\ m^{-3}$, as NO_2)



The 1km x 1km annual mean background NO_X concentration map has been calculated by summing the contributions from:

- Large point sources
- Small point sources

- Distant sources (characterised by the rural background concentration)
- Local area sources

The area source model has been calibrated using data from the national automatic monitoring networks (AURN) for 2007. At locations close to busy roads an additional roadside contribution has been added to account for contributions to total NO_X from road traffic sources. The contributions from each of these components are described in section 3.2

In order to estimate the NO_2 concentrations, modelled NO_X concentrations derived from the approach outlined above are converted to NO_2 using the updated oxidant-partitioning model which describes the complex inter-relationships of NO, NO_2 and ozone as a set of chemically coupled species (Jenkin, 2004; Murrells et al, 2008). This approach provides additional insights into the factors controlling ambient levels of NO_2 (and O_3), and how they may vary with NO_X concentration. Details of the methods used to estimate ambient NO_2 from these estimates of NO_X are presented in Section 3.3. The modelling results are presented in section 3.4.

3.2 NO_X Modelling

3.2.1 NO_X 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 2006 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 4.0) and sequential meteorological data for 2007 from Waddington. A total of 158 large point sources were modelled for NO_X. Surface roughness was assumed to be 0.1 metres. Concentrations were calculated for a 100km x 100km square composed of a regularly spaced 5km x 5km resolution receptor grid. Each receptor grid was centred on the point source. For each large point source information was retrieved from our stack parameters database. This database has been developed over a period of time under the PCM contract and is updated annually as required. Data sources for this database include a survey of Part A authorisation notices held by the Environment agency and previously collated datasets on emission release parameters from large SO_2 point sources (Abbott and Vincent, 1999). Parameters used in the modelling from the stack parameters database include:

- Stack height
- Stack diameter
- Discharge velocity
- Discharge temperature

Where release parameters were unavailable, engineering assumptions were applied.

3.2.2 NO_X contributions from small point sources

Contributions from NO_X point sources with less than 500 tonnes per annum emissions in the 2006 NAEI were modelled using the small points model described in Appendix 2.

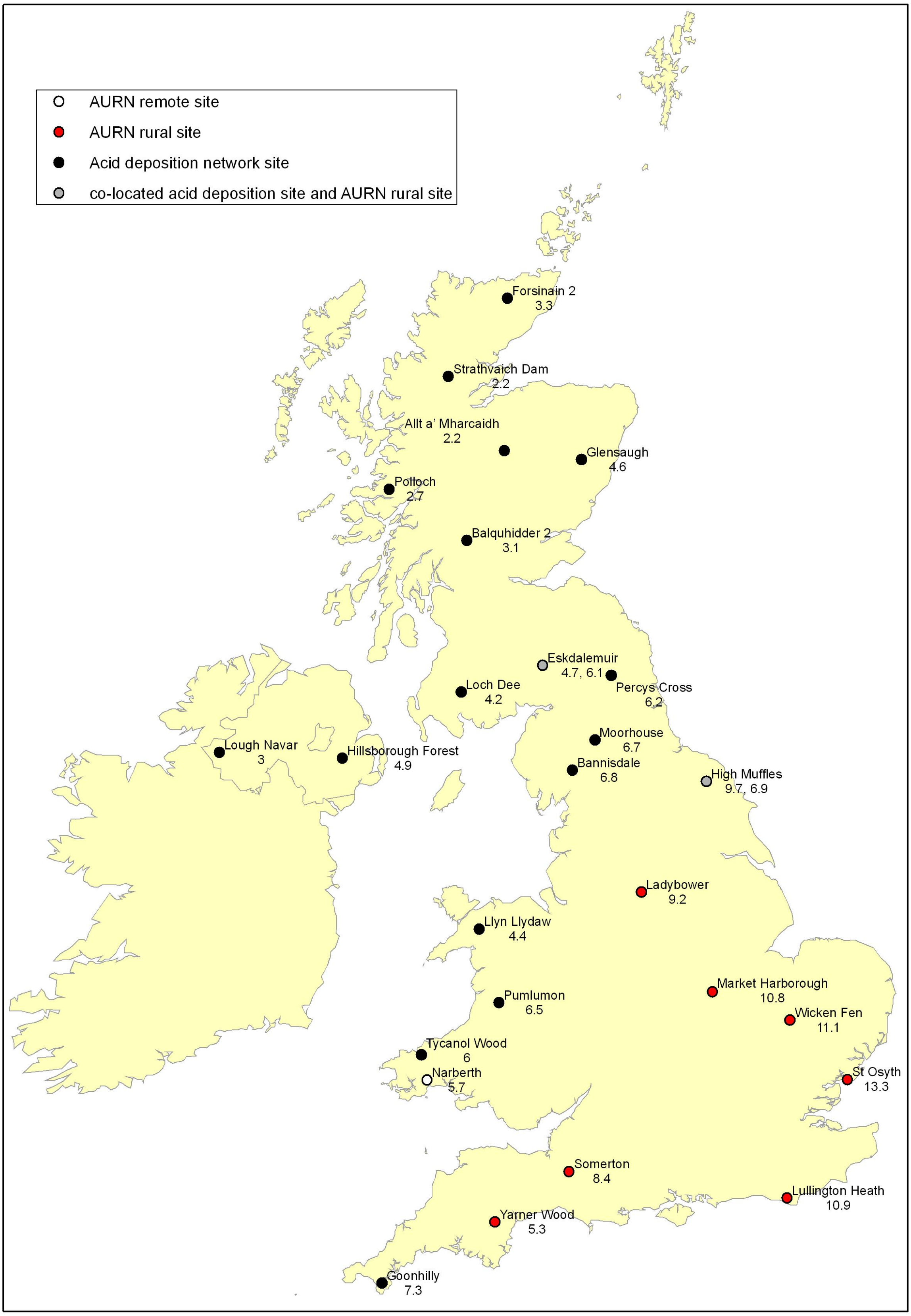
3.2.3 NO_X contribution from rural background concentrations

Rural annual mean background NO_X concentrations have been estimated using:

- NO_X measurements at 10 selected rural AURN sites
- NO_X estimated from NO_2 measurements at 18 rural NO_2 diffusion tube sites from the Acid Deposition Monitoring Network (Lawrence, *pers comm. 2008*)

Figure 3.5 shows the locations of these monitoring sites.

Figure 3.5. Monitoring sites used to interpolate rural background NO_X concentrations (annual mean NO_X concentrations for 2007 ($\mu g\ m^{-3}$, as NO_2) are shown below the site name)



Rural NO_x was estimated from rural NO_2 at diffusion tube sites by dividing by 0.7835. This factor, which is a typical NO_X/NO_2 ratio measured at rural automatic monitoring sites (Stedman *et al*, 2003), does not vary significantly between years or across the country. Measurements have 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:

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

Where: A = an estimate of the contribution from area source components, derived using the area source model empirical coefficients from the 2006 modelling

B = sum of contributions from large point sources in 2007 modelling

C = sum of contributions from small point sources in 2007 modelling

Automatic sites, where available have been used in preference to diffusion tubes as these are considered to be more accurate. A bi-linear interpolation of corrected rural measurement data has been used to map regional background concentrations throughout the UK.

3.2.4 NO_X contributions from local area sources

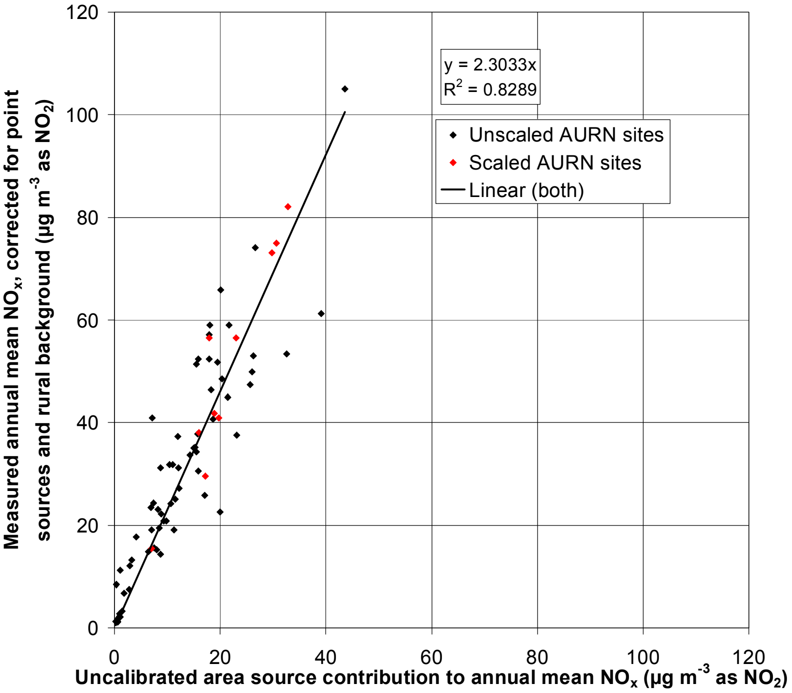
The modelled uncalibrated area source contribution has been calculated by applying an ADMS 4.0 derived dispersion kernel to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each monitoring site. Hourly sequential meteorological data from Waddington in 2007 has been used to construct the dispersion kernels, as described in Appendix 3.

Figure 3.6 shows the calibration of the area source model. The modelled concentrations from all point sources and corrected rural NO_X concentrations have been subtracted from the measured annual mean NO_X concentration at background sites. This corrected background concentration is compared with the modelled area source contribution to annual mean NO_X to calculate the calibration coefficients used in the area source modelling.

Adjustment factors were applied to the emissions from selected transport sources to represent the diminishing influence of emissions on air quality at the UK land surface, as described in Section 1.7. A factor of 0.3523 was applied to aircraft emissions and a factor of 0.25 was applied to emissions from ships.

The modelled area source contribution was multiplied by the empirical coefficient to calculate the calibrated area source contribution for each grid square in the country. The point source contributions and regional rural concentrations were then added, resulting in a map of background annual mean NO_x concentrations.

Figure 3.6. Calibration of area source NO_x model, 2007 ($\mu g\ m^{-3}$, as NO_2)



3.2.5 NO_X Roadside concentrations

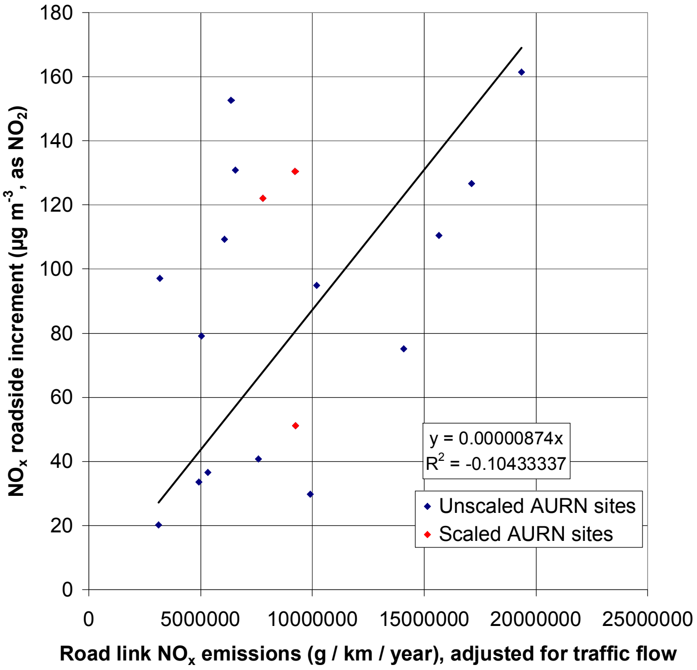
We have assumed that the annual mean concentration of NO_X at roadside locations is made up of two parts: the background concentration (as described above) and a roadside increment:

roadside NO_X concentration = background NO_X concentration + NO_X roadside increment

The NAEI provides estimates of NO_X emissions for major road links in the UK for 2006 (Dore *et al.*, 2008) and these have been adjusted to provide estimates of emissions in 2007. Figure 3.7 shows the roadside increment of annual mean NO_X concentrations (i.e. measured roadside NO_X concentration – modelled background NO_X concentration) at roadside or kerbside AURN monitoring sites plotted against NO_X emission estimates adjusted for traffic flow for the individual road links alongside which these sites are located. The background NO_X component at these roadside monitoring sites is taken from the background map described in Section 3.2.4 above.

The calibration coefficient derived is then used to calculate the roadside increment on each road link by multiplying it by an adjusted road link emission (see figure 3.8). Roadside concentrations for urban major road links (A-roads and motorways) only are reported to the EU and included in this report.

Figure 3.7. Calibration of NO_X roadside increment model, 2007 (µg m^{-3}, as NO_2)



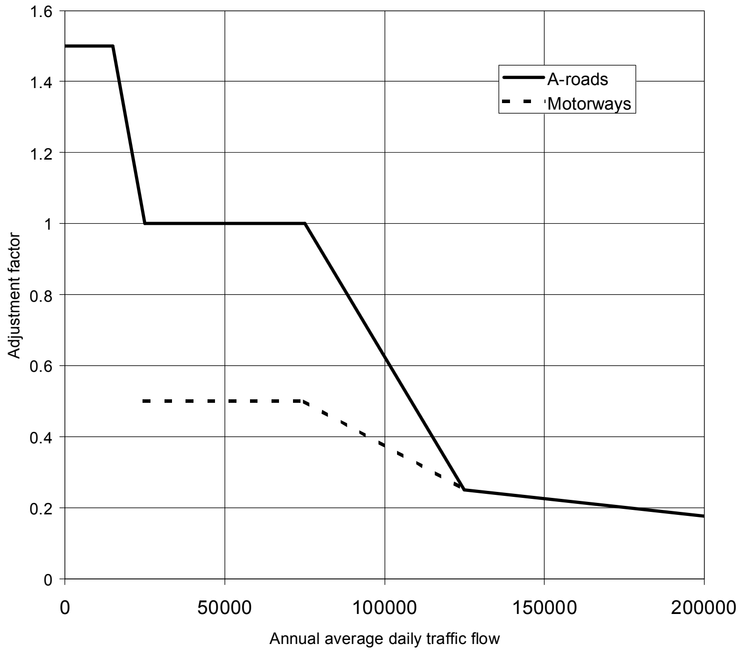
The dispersion of emissions from vehicles travelling along an urban road is influenced by a number of factors. These factors generally contribute to make the dispersion of emissions less efficient on urban roads with lower flows. Factors include:

- Traffic speed (urban roads with lower flows are more likely to have slower moving traffic and thus cause less initial dispersion due to mechanical and thermal turbulence)
- Road width (dispersion will tend to be more efficient on wider roads, such as motorways than on smaller roads in town centres)
- Proximity of buildings to the kerbside (urban roads with lower flows are more likely have with buildings close to the road, giving a more confined setting and reduced dispersion)

We are only considering urban roads here because the model does not cover rural roads.

Detailed information on the dispersion characteristics of each urban major road link within the NAEI is not available. We have therefore adopted an approach similar to that used within the DMRB Screening Model (Highways Agency, 2003) and applied adjustment factors to the estimated emissions. These adjustment factors are illustrated in Figure 3.8 and depend on the total traffic flow on each link and are higher for the roads with the lowest flow and lower for roads with the highest flow. Thus the traffic flow is used as a surrogate for road width and other factors influencing dispersion. Motorways are generally wider than A-roads and the emission have therefore been adjusted accordingly, as illustrated in Figure 3.8.

Figure 3.8 The adjustment factors applied to road link emissions



3.3 NO_2 Modelling

3.3.1 Introduction

Maps of estimated annual mean NO_2 concentrations (Figure 3.1 and 3.2) have been calculated from our modelled NO_X concentrations using the updated oxidant-partitioning model (Jenkins, 2004; Murrells et al, 2008). This model uses representative equations to account for the chemical coupling of O_3, NO and NO_2 within the atmosphere. A key advantage of this approach for modelling NO_2 concentrations is that we can directly address emission scenarios by varying regional oxidant levels and/or primary NO_2 emissions.

3.3.2 The updated oxidant-partitioning model

The oxidant-partitioning model, developed by Jenkins (2004), enables NO_2 concentrations to be calculated using the following equations (concentrations in ppb):

$$[NO_2] = [OX].([NO_2]/[OX]) \qquad (i)$$

$$[OX] = f\text{-}NO_2.[NO_X] + [OX]_B \qquad (ii)$$

$$[NO_2]/[OX] = f(NO_X) \qquad (iii)$$

Where OX is the total oxidant, f-NO_2 is the primary NO_2 (defined as the proportion of NO_X emitted directly as NO_2) and B is the regional oxidant.

In Jenkin (2004) $[NO_2]/[OX]$ was calculated using two equations, one of which represented background locations and one for roadside locations. However, updated equations for $[NO_2]/[OX]$ have subsequently been developed in Murrells et al (2008) which we have used in the modelling here. These are better than the original equations presented in Jenkin (2004) because they account for the under-prediction of the annual mean metric caused by averaging points along an idealised curve (Murrells et al, 2008) rather than being based on an empirical fit to monitoring data.

Murrells et al (2008) present five equations for calculating $[NO_2]/[OX]$ as a function of $[NO_X]$. These include:

- An idealized relationship, which has been generated by solving the analytical chemistry for an idealised site with a constant NO_X concentration throughout the year.
- Four relationships for realistic cases. These are four further analytical solutions derived for sites where the NO_X concentration varies from hour to hour. The different relationships represent different levels of hourly variation.

The four relationships for realistic cases are presented in Table 3.1 below. They have been derived to apply at sites with different levels of inter-hourly variability in NO_X concentrations. Murrells et al (2008) have used NO_X quartile ratios to represent this variability, where the NO_X quartile ratio is the ratio of the 75th percentile to 25th percentile of measured NO_X**.**

Table 3.1. The four 'realistic case' relationships in the updated oxidant-partitioning model (Murrells et al, 2008)

PCM Category (Category in Murrells et al (2008) shown in brackets)	Derived for site with a NO_X quartile ratio of:	Relationship (where y = [NO2]/[OX] and x = [NOx], in ppb)
1 (I)	<2.5	y = 4.856E-14x^6 - 3.290E-13x^5 - 9.371E-09x^4 + 2.824E-06x^3 - 3.684E-04x^2 + 2.582E-02x
2 (II)	2.5-3.5	y = -1.673E-13x^6 + 1.195E-10x^5 - 3.469E-08x^4 + 5.305E-06x^3 - 4.692E-04x^2 + 2.595E-02x
4 (IIIa)	3.5	y = -2.423E-13x^6 + 1.607E-10x^5 - 4.329E-08x^4 + 6.132E-06x^3 - 5.020E-04x^2 + 2.593E-02x
3 (III)	>3.5	y = -2.881E-13x^6 + 1.857E-10x^5 - 4.843E-08x^4 + 6.620E-06x^3 - 5.211E-04x^2 + 2.591E-02x

The following sections describe the method for calculating a map of regional oxidant in the UK (section 3.3.3), local oxidant calculations for background and roadside locations (section 3.3.4), Calculating [NO2]/[OX] in the PCM model (section 3.3.5) and how we have applied the updated oxidant-partitioning model in the UK (section 3.3.6).

3.3.3 UK regional oxidant map

A map of UK regional oxidant for 2007 ($[OX]_B$ in equation ii above) has been calculated using the method outlined in Murrells et al (2008). Previous assessments made use of estimates of regional oxidant published by Jenkin (2004). The revised method proposed by Murrells et al (2008) has the benefit of incorporating an understanding of the drivers influencing the spatial pattern of regional oxidant concentrations and how these vary from year to year.

The regional oxidant concentration is considered to consist of two components:

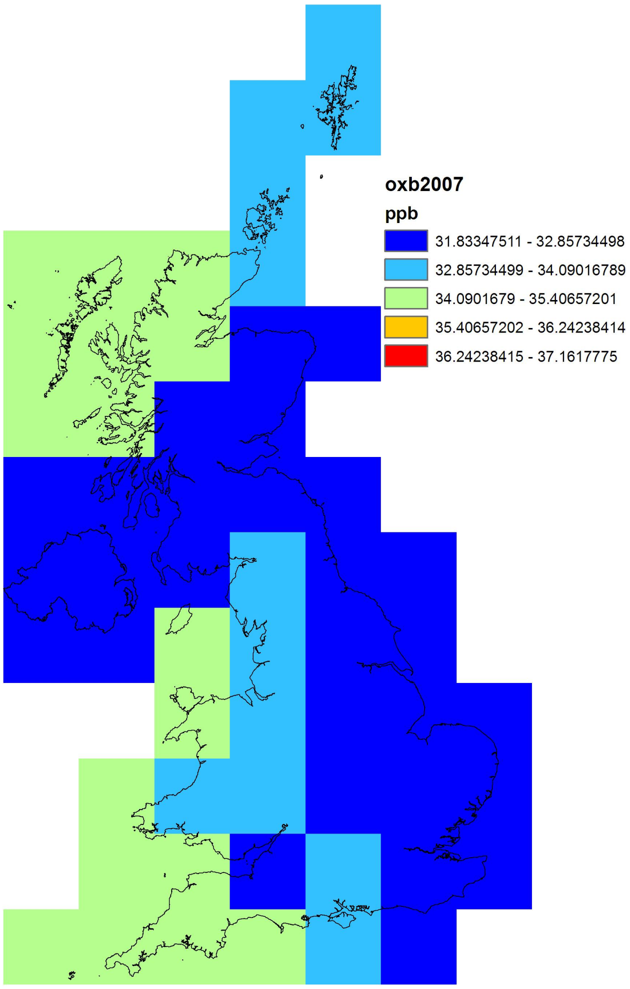
$$[OX]_B = [OX]_H + [OX]_R \qquad (iv)$$

where $[OX]_H$ is the hemispheric background concentration and $[OX]_R$ is a regional modification. An analysis of monitoring data from the AURN presented by Murrells et al (2008) has shown that both of these components vary across the UK.

The value of $[OX]_H$ has been found to decrease in a north-easterly direction across the UK with distance from the coast as a result of losses due to dry deposition. The regional modification $[OX]_R$ has been found to have two components. A positive regional modification due to the photochemical generation of oxidant in the summer shows a decrease in a north-westerly direction from the south east of England, as the distance from the major source regions for ozone precursors in continental Europe increases. A negative regional modification due to dry deposition in the winter has been found to show an increase in a south-westerly direction from the north east coast.

The regional variation in these different components has been described by Murrells et al (2008) using a model for which the year specific parameters can be derived from an analysis of monitoring data. Figure 3.9 shows the map of regional oxidant for 2007. Values have been calculated on a 100 km x 100 km grid.

Figure 3.9 Regional oxidant $[OX]_B$ for 2007 (ppb)



3.3.4 Local oxidant calculations

Local oxidant is calculated in the updated oxidant-partitioning model as:

$$\text{Local oxidant} = f\text{-}NO_2.[NO_X] \qquad \text{(iv)}$$

Therefore to calculate local oxidant levels, we need to know f-NO_2 levels from different local sources. In general it is possible to make a distinction between f-NO_2 for road traffic sources and f-NO_2 from other non-road traffic sources. f-NO_2 from road traffic sources is thought to be generally rising, although this trend displays considerable variation with location (AQEG, 2007). By comparison, f-NO2 from non-traffic sources has remained relatively constant with time.

Local oxidant calculations in the roadside NO_2 model

Road traffic f-NO_2 for use in the 2007 modelling has been calculated using the following method.

NO_X emissions for individual vehicle classes on each UK urban major road link have been obtained from the NAEI 2006. The split between NO_X emissions from taxis (not explicitly included in the 2006 NAEI) and cars on each major road in London has been calculated on the basis of the ratio of NO_X emissions from taxis/cars in the LAEI 2004 (GLA, 2008) on these roads. The reason that it is important to account for taxis in London is that they make up a significant proportion of the vehicle fleet, particularly in central London, and typically have higher f-NO_2 values that the average car fleet because they are predominantly diesel.

An NO_2 specific road traffic inventory has then been generated by combining the vehicle specific NO_X road traffic emissions estimates for each road link described above with f-NO_2 values for individual vehicle types taken from the 2006 NAEI.

Finally average f-NO2 for each road link has been calculated as the ratio of NO_X/NO_2 emissions.

Local oxidant is then calculated on each road link by multiplying the total NO_X concentrations by the average f-NO_2 for each road link.

Local oxidant calculations in the background NO_2 model

A map of local oxidant for the background NO_2 calculations was calculated by splitting the background annual mean NO_X map into its three constituent components:

- NO_X from non-road traffic emissions
- NO_X from road-traffic emissions
- rural background NO_X concentrations

These components were then multiplied by the relevant *f*-NO_2 value presented in Table 3.2 (for rural background NO_X the non-road background *f*-NO_2 was used) to give a map of local oxidant.

Table 3.2 Local oxidant coefficients (*f*-NO_2) for background concentrations

DfT Area type[1]	Region	Non-road *f*-NO_2 for background calculations	Road *f*-NO_2 for background calculations
1	Central London	0.140	0.230
2	Inner London	0.128	0.210
3	Outer London	0.093	0.179
4	Inner Conurbations	0.093	0.152
5	Outer Conurbations	0.093	0.149
6	Urban (population > 250,000)	0.093	0.146
7	Urban (population > 100,000)	0.093	0.145
8	Urban (population > 25,000)	0.093	0.145
9	Urban (population > 10,000)	0.093	0.148
10	Rural	0.093	0.156

[1] Locations in Northern Ireland have been assigned area types on the basis of how built up they are. This is because the DfT area types map does not cover Northern Ireland.

The non-road *f*-NO_2 values used for background calculations in Table 3.2 have been taken directly from Jenkin (2004), as there is little evidence that this has changed significantly over the past few years.

The road traffic *f*-NO_2 values for background calculations have been calculated using the average of the major road link f-NO_2 values for each area type.

3.3.5 Calculating [NO2]/[OX] in the PCM model

The four 'realistic case' relationships for calculating $[NO_2]/[OX]$ described in section 3.3.2 have been tested against monitoring data from AURN sites and shown to correspond well with data from sites with different NO_X quartile ratios. However, it is possible that this fairly simple statistic of variability may not always capture which sites have the greatest or least inter-hourly variability throughout a year.

The relationships presented in Table 3.1 have been designed to apply at sites with specific NO_X quartile ratios. However, there are no monitoring sites at most locations within the model domain (i.e. most of the individual 1 x 1km background grid squares do not contain monitoring sites and there are no monitoring sites along most of the sections of road included in the model). This means that we do not know the NO_X quartile ratios for these locations. It has therefore been necessary to adopt a proxy dataset which, as far as possible, reflects the variation in quartile ratios, while also being readily available for grid squares and road links across the UK.

Several possible dataset were considered. These included geographical distribution of sites, traffic flow on roads adjacent to monitoring sites and type of site. DfT area type was found to give the best overall correspondence to NO_X quartile ratio at monitoring sites. This dataset divides the UK into different classes depending on how urban or rural they are. There are ten classes as shown in Table 3.2. Figures 3.10 and 3.11 show area type plotted against the NO_X quartile range at background and roadside AURN monitoring sites for 2007.

Area type acts as a good proxy for NO_X quartile ratios for the following reasons. First, at background locations the level of variability in NO_X is likely to depend on how NO_X concentrations vary when the wind blows from different directions. At an urban location in the middle of a city, it is likely air blown from all directions will carry NO_X emitted from the city and so will be relatively constant. By contrast, a rural site is likely receive little NO_X when the air mass is blown from some directions (e.g. from the Atlantic), but more when it is blown from other directions (e.g. from mainland Europe, or from over UK urban/industrial areas). Second, at roadside locations, the background increment will be greater in urban areas. Thus the variability in NO_x concentrations is likely to be greater at rural locations. However, generalisation will not apply everywhere and different locations will show different levels of variation depending on local factors.

Figure 3.10 The NO_X quartile ratio at AURN background sites in 2007 sorted by area type (75% data capture threshold applied)

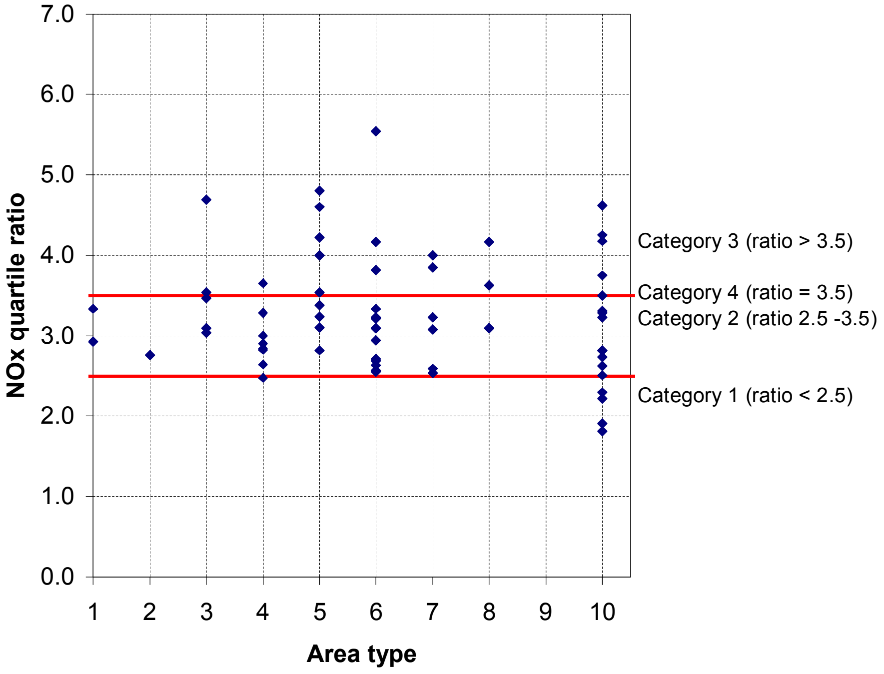
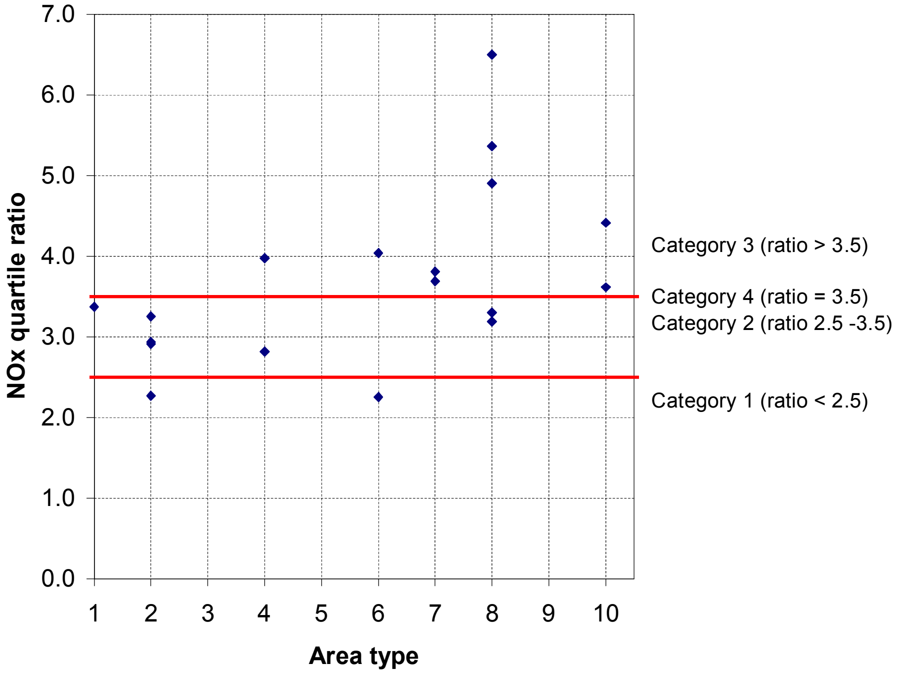


Figure 3.11 The NO_X quartile ratio at AURN roadside sites in 2007 sorted by area type (75% data capture threshold applied)

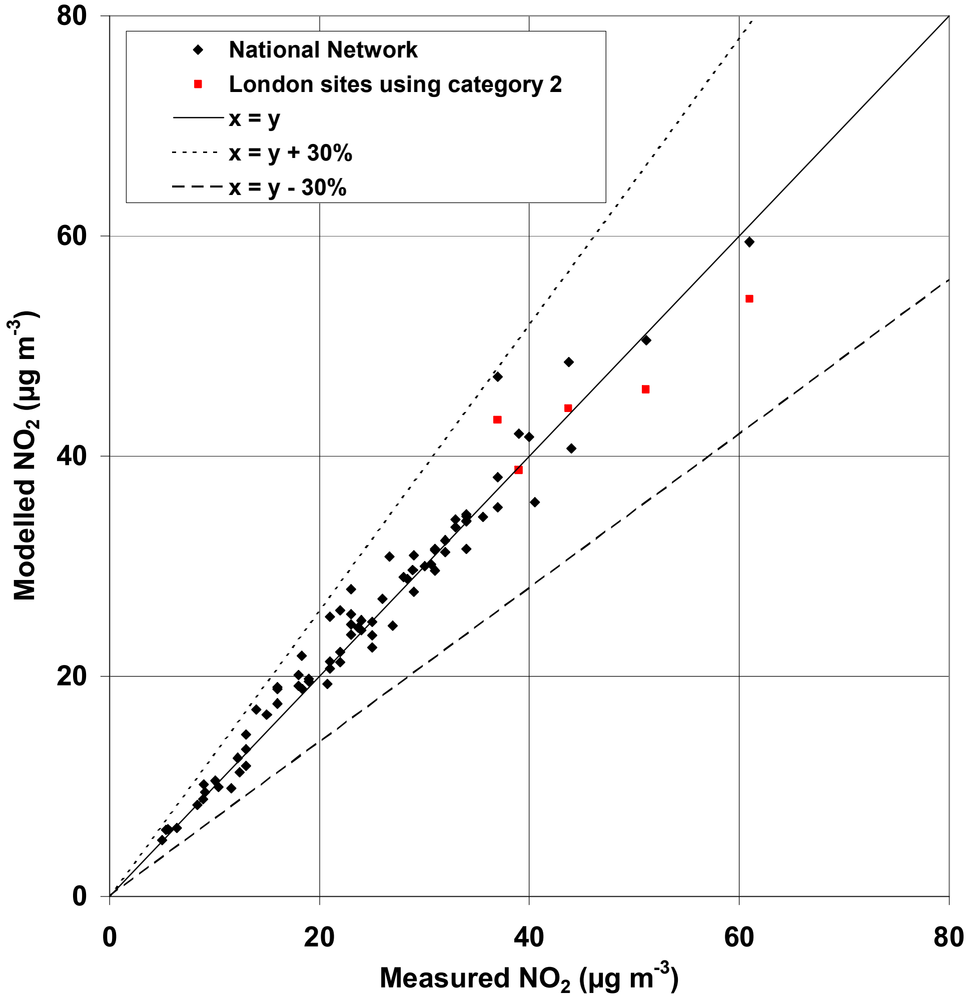


3.3.6 Application of the oxidant-partitioning model to the PCM model

Background

On the basis of Figure 3.10 above, we decided to run the background model using category 2 for all area types. However, this was found to systematically under-predict NO_2 at AURN background sites in inner and central London (i.e. area type 1 and 2 sites). Therefore, it was decided to use the category 1 relationship for these area types. Figure 3.12 shows the measured NO_2 plotted against modelled NO_2 (calculated from measured NO_x) for all different area types. Sites in area type 1 and 2 are coloured red where we used category 2.

Figure 3.12 Measured vs modelled NO_2 at AURN background monitoring sites



Roadside

On the basis of Figure 3.11 above, it was decided to run the roadside model using the following categories for each area type:

- Area type 1-5 used category 2 relationship
- Area type 6-9 used category 4 relationship
- Area type 10 used category 3 relationship

The results for this modelling are presented in section 3.4 below.

3.4 Results

3.4.1 Verification of mapped values

Figures 3.13 and 3.14 show comparisons of modelled and measured annual mean NO_X and NO_2 concentration in 2007 at background monitoring site locations. Figure 3.15 and 3.16 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). There is no requirement under AQDD1 to report modelled annual mean NO_X concentrations for comparison with limit values for the protection of human health (the NO_X limit value for the protection of vegetation only applies in vegetation areas). However, comparisons of modelled and measured NO_X concentrations and of the modelled NO_X concentrations with the data quality objectives are presented here alongside the comparisons for NO_2. This provides an additional check on the reliability of our modelled estimates of NO_2 because the non-linear relationships between NO_X and NO_2 tend to cause modelled NO_2 concentrations to be relatively insensitive to errors in the dispersion modelling of NO_X.

Figure 3.13. Verification of background annual mean NO_X model 2007

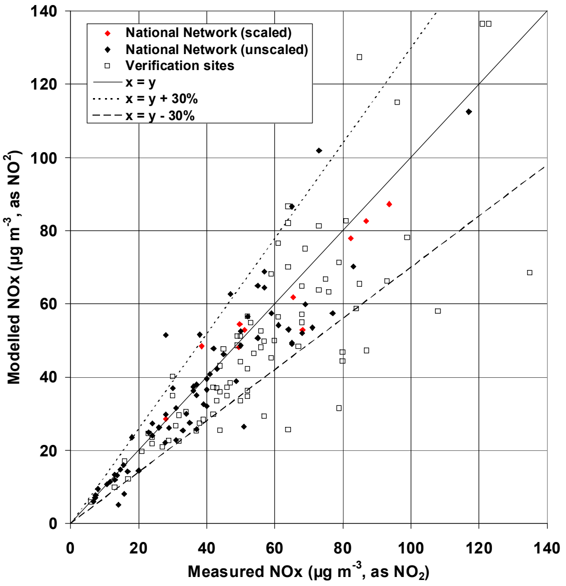


Figure 3.14. Verification of background annual mean NO_2 model 2007

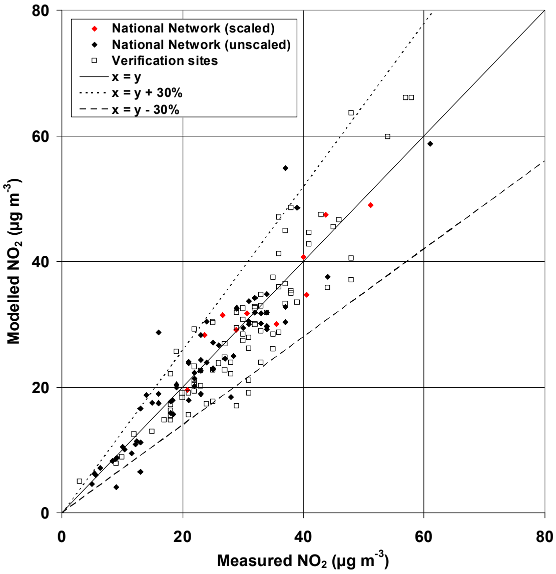


Figure 3.15. Verification of roadside annual mean NO_X model 2007

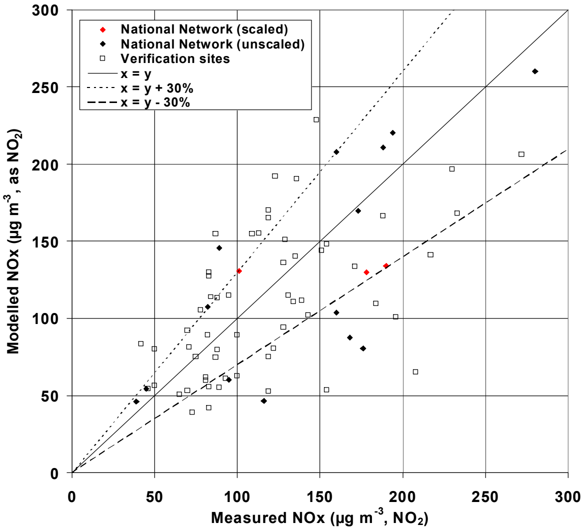
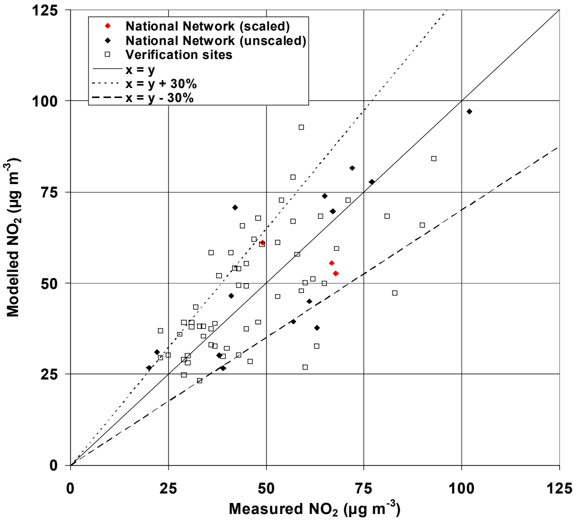


Figure 3.16. Verification of roadside annual mean NO_2 model 2007



Summary statistics for the comparison between modelled and measured NO_X and NO_2 concentrations are listed in Tables 3.3 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 above.

Table 3.3. 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 in assessment
NO_X	National Network	47.7	40.5	0.850	13.0	77
	Verification Sites	63.2	49.4	0.581	23.8	80
NO_2	National Network	26.3	24.3	0.872	7.8	77
	Verification Sites	31.5	29.3	0.829	10.0	80

Table 3.4. 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 in assessment
NO_X	National Network	134.8	129.1	0.532	41.2	17
	Verification Sites	124.2	111.5	0.406	50.8	59
NO_2	National Network	52.3	54.3	0.617	35.3	17
	Verification Sites	49.1	48.7	0.488	32.2	59

3.4.2 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 3.5. 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 2007. 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 3.5 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II))

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	162	A	1599.8	A	1554508	A
West Midlands Urban Area	UK0002	5	A	385.3	A	11937	A
Greater Manchester Urban Area	UK0003	0	A	425.7	A	0	A
West Yorkshire Urban Area	UK0004	0	A	162.3	A	0	A
Tyneside	UK0005	0	A	76.2	A	0	A
Liverpool Urban Area	UK0006	0	A	129.9	A	0	A
Sheffield Urban Area	UK0007	0	A	105.1	A	0	A
Nottingham Urban Area	UK0008	0	A	53.5	A	0	A
Bristol Urban Area	UK0009	0	A	41.9	A	0	A
Brighton/Worthing/Littlehampton	UK0010	0	A	6.6	A	0	A
Leicester Urban Area	UK0011	0	A	51.6	A	0	A
Portsmouth Urban Area	UK0012	0	A	23.6	A	0	A
Teesside Urban Area	UK0013	0	A	18.0	A	0	A
The Potteries	UK0014	0	A	34.0	A	0	A
Bournemouth Urban Area	UK0015	0	A	10.8	A	0	A
Reading/Wokingham Urban Area	UK0016	0	A	19.3	A	0	A
Coventry/Bedworth	UK0017	0	A	16.5	A	0	A
Kingston upon Hull	UK0018	0	A	32.2	A	0	A
Southampton Urban Area	UK0019	1	A	22.7	A	680	A
Birkenhead Urban Area	UK0020	0	A	17.4	A	0	A
Southend Urban Area	UK0021	0	A	10.5	A	0	A
Blackpool Urban Area	UK0022	0	A	0.0	A	0	A
Preston Urban Area	UK0023	0	A	6.3	A	0	A
Glasgow Urban Area	UK0024	0	A	124.6	A	0	A
Edinburgh Urban Area	UK0025	0	A	19.6	A	0	A
Cardiff Urban Area	UK0026	0	A	15.6	A	0	A
Swansea Urban Area	UK0027	0	A	2.5	A	0	A
Belfast Metropolitan Urban Area	UK0028	0	A	46.5	A	0	A
Eastern	UK0029	6	A	131.1	A	642	A
South West	UK0030	0	A	77.2	A	0	A
South East	UK0031	3	A	197.5	A	776	A
East Midlands	UK0032	0	A	103.8	A	0	A
North West & Merseyside	UK0033	0	A	279.1	A	0	A
Yorkshire & Humberside	UK0034	0	A	259.9	A	0	A
West Midlands	UK0035	0	A	90.2	A	0	A
North East	UK0036	0	A	69.1	A	0	A
Central Scotland	UK0037	0	A	27.7	A	0	A
North East Scotland	UK0038	0	A	30.8	A	0	A
Highland	UK0039	0	A	4.3	A	0	A
Scottish Borders	UK0040	0	A	0.0	A	0	A
South Wales	UK0041	0	A	45.5	A	0	A
North Wales	UK0042	0	A	13.4	A	0	A
Northern Ireland	UK0043	0	A	24.2	A	0	A
Total		177		4811.8		1568542	

4 PM_{10}

4.1 Introduction

Maps of annual mean PM_{10} in 2007 at background and roadside locations are shown in Figures 4.1 and 4.2. These maps have been calibrated using measurements from TEOM FDMS instruments only. Measurements from gravimetric instruments, TEOM monitors and TEOM monitors adjusted using the VCM model monitors have been used to verify the mapped estimates by applying the appropriate scaling factors prior to comparison. A detailed description of the Pollution Climate mapping (PCM) models for PM in 2004 has been provided by Stedman *et al.* (2006b). The methods used to derive the maps for 2007 are largely the same as was adopted for the 2006 maps as described Kent at al. (2007b). The main revisions to the method for 2007 are:

- The area source dispersion kernel model has been revised for 2007 [see Appendix 3]
- The area source model and roadside models have been calibrated using monitoring data from TEOM FDMS (Filter Dynamics measurement System) instruments.
- The models have been verified by comparison with measurement data from Partisol instruments corrected for known bias (Maggs et al., 2008) and from TEOM instruments, either scaled by a factor of 1.3 or corrected using the Volatile Correction Model (Green, *et al.*, 2007).

Figure 4.1. Annual mean background PM_{10} concentration, 2007 ($\mu g\ m^{-3}$, gravimetric)

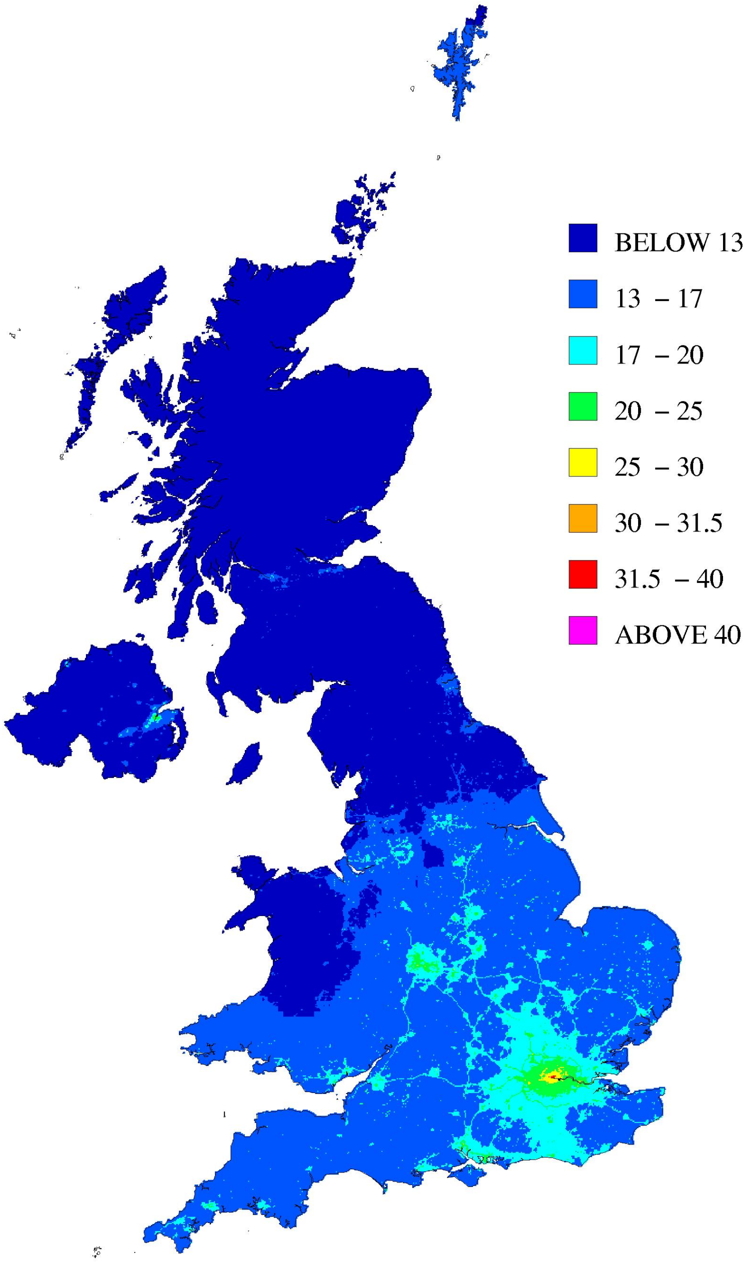
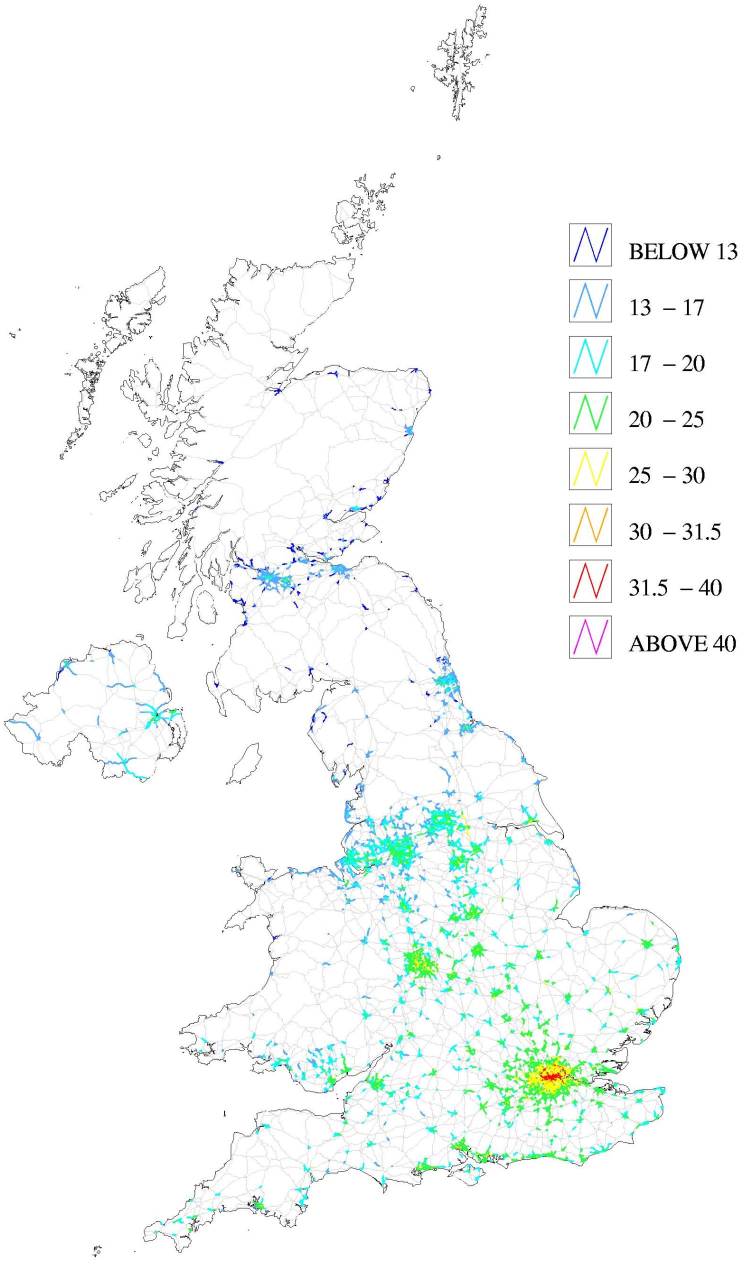


Figure 4.2. Urban major roads, annual mean roadside PM_{10} concentration, 2007 ($\mu g\ m^{-3}$, gravimetric)



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The maps of background PM_{10} concentrations have been calculated by summing contributions from different sources:

- Secondary inorganic aerosol (derived by interpolation and scaling of measurements of SO_4, NO_3 and NH_4 at rural sites)
- Secondary organic aerosol (semi-volatile organic compounds formed by the oxidation of non-methane volatile organic compounds. Estimates derived from results from the HARM/ELMO model)
- Large point sources of primary particles (modelled using ADMS and emissions estimates from the NAEI)

- Small point sources of primary particles (modelled using the small points model and emissions estimates from the NAEI)
- Regional primary particles (from results from the TRACK model and emissions estimates from the NAEI and EMEP)
- Area sources of primary particles (modelled using a dispersion kernel and emissions estimates from the NAEI)
- Iron and calcium rich dusts (estimated from a combination of measurements made in Birmingham and surrogate variables for the spatial distribution of the emission associated with these dusts)
- Sea salt (derived by interpolation and scaling of measurements of chloride at rural sites)
- 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.

Estimates of the emissions of primary PM from the 2006 UK National Atmospheric Emission Inventory (NAEI) have been used in this study (Dore, *et al.*, 2008). Sector specific scaling factors have been used to scale the emissions to provide estimates for 2007. The NAEI provides emissions estimates and projections for a wide variety of different sources. Scaling factors for sectors such as road traffic, domestic combustion and processes were then derived by summing the emissions estimates for each source for 2006 and for the projection year (2007 in this case). The methods used to calculate ambient concentrations from the estimates of primary PM emissions are described below for point, area and regional sources.

24-hour mean concentrations have not been explicitly modelled for comparison with the 24-hour limit values. An annual mean concentration of 31.5 $\mu g\ m^{-3}$, gravimetric has been taken to be equivalent to 35 days with 24-hour mean concentrations greater than 50 $\mu g\ m^{-3}$ 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. An analysis of more recent monitoring data is shown in Figure 4.4 and shows that the value of 31.5 $\mu g\ m^{-3}$ is still valid, since a 90th percentile of 24-hour mean values of greater than 50 $\mu g\ m^{-3}$ is equivalent to more than 35 days with concentration greater than 50 $\mu g\ m^{-3}$. The relationship between the number of days with concentrations greater than 50 $\mu g\ m^{-3}$, 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 $\mu g\ m^{-3}$, 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 $\mu g\ m^{-3}$ and annual mean concentration (1992 –1999)

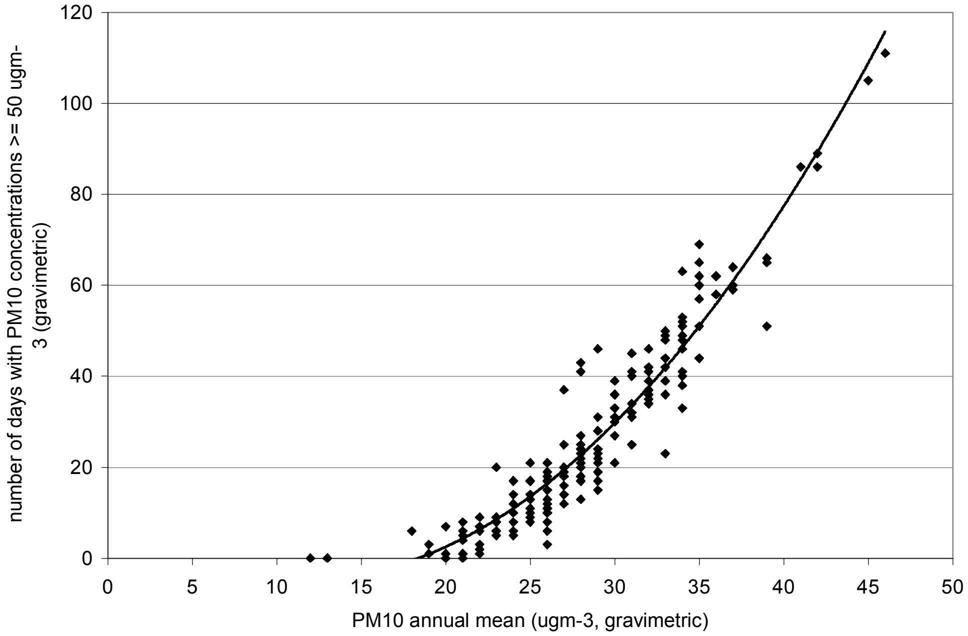
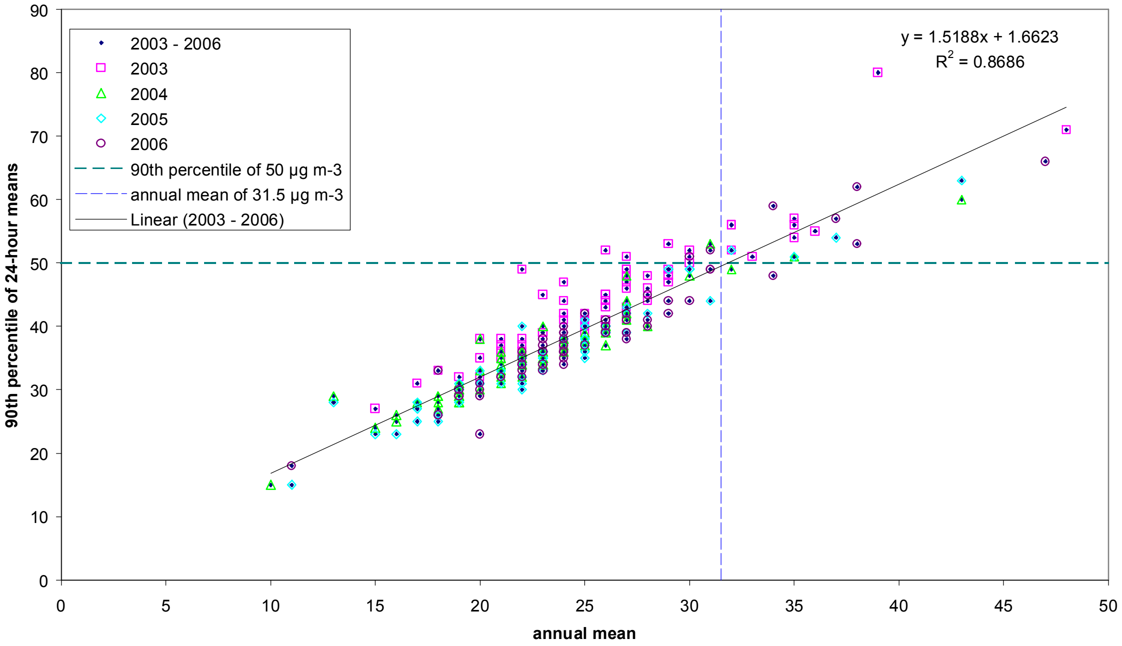


Figure 4.4. The relationship between the 90th percentile of 24-hour mean PM10 concentration and annual mean concentration ($\mu g\ m^{-3}$)(2003 –2006)



4.2 Contributions from secondary inorganic aerosol

Maps of secondary inorganic aerosol (SIA) concentrations across the UK have been calculated from rural measurements of sulphate, nitrate and ammonium concentrations by interpolation followed by the application of scaling factors derived from mass closure modelling. Measurements on a monthly basis are available for 28 rural monitoring sites for 2007 (Tang, 2008). Concentration surfaces on a 5 km x 5 km grid were calculated from the measurement data using Krigging.

These secondary components were then split into fine and coarse fractions and non-volatile and volatile components using coefficients derived with reference to the detailed PM sampling carried out during the PUMA campaign at the University of Birmingham urban background monitoring site in June and July 1999 (Harrison *et al.*, 2006 and summarised by Kent *et al.*, 2007a). The non-volatile secondary PM has been assumed to be sampled by a TEOM instrument, a gravimetric instrument should sample the sum of the non-volatile and volatile components. These secondary components were also scaled according to ‘bound water’ associated with the mass of water embedded within the particles (AQEG, 2005). Particle bound water is associated with the hygroscopic anions (Harrison *et al.*, 2006). This has been assumed to contribute to the fine and coarse components gravimetric but not the TEOM. Therefore a particle bound water scaling factor of 1.279 has been applied to the SIA components for the gravimetric maps (see Table 4.1). The scaling factors for bound water and counter ions (non-volatile) have not been used in this study but would be appropriate for mapping TEOM concentrations. The factor for coarse mode nitrate is higher as this includes the mass of the counter-ion (sodium or calcium).

The split between coarse and fine nitrate was revised for the 2006 modelling assessment with reference to measurement data from the TRAMAQ (Abdalmogith et al, 2006) and Birmingham (Harrison and Yin, 2006) studies. This revised method has also been used in this 2007 assessment. Fine PM is used to describe $PM_{2.5}$ and coarse PM is used to describe $PM_{2.5-10}$ in this report. The split between fine and coarse PM is simple to interpret for most PM constituents but is more complex for nitrate PM because there are two modes. The fine nitrate mode consists of ammonium nitrate, which is volatile, and is all in the fine $PM_{2.5}$ fraction. The coarse mode consists of sodium nitrate, which is split roughly half and half between fine $PM_{2.5}$ and coarse $PM_{2.5-10}$ fractions (Abdalmogith et al, 2006). Measurement data from the Birmingham study (Harrison and Yin, 2006) shows that the fine $PM_{2.5}$ nitrate to coarse $PM_{2.5-10}$ ratio was 3.5. Thus the fine mode nitrate to coarse mode nitrate ratio was 1.25. The factors for nitrate in Table 4.1 has been derived from a combination of this factor of 1.25 and the half and half split of the coarse mode nitrate into the fine $PM_{2.5}$ and coarse $PM_{2.5-10}$ fractions.

Table 4.1 Scaling factors for size fraction, bound water and counter ion mass for secondary inorganic and organic aerosol

Pollutant	Size fraction	Scaling factor for size fraction	Scaling factor for bound water and counter-ion mass	Scaling factor for bound water and counter-ion mass (non-volatile)
SO_4	Fine	0.94	1.279	1.00
	Coarse	0.06	1.279	1.00
NO_3	Fine mode	0.556	1.279	0.00
	Coarse mode fine	0.222	1.60	1.32
	Coarse mode coarse	0.222	1.60	1.32
NH_4	Fine	0.97	1.279	0.86
	Coarse	0.03	1.279	1.00
SOA	Fine	0.75	1.0	0.00
	Coarse	0.25	1.0	0.00

4.3 Contributions from secondary organic aerosol

Estimates of the secondary organic aerosol (SOA) concentrations on a 10km x 10km grid have been taken from the HARM/ELMO model (Whyatt *et al.*, 2007). This is a receptor oriented, Lagrangian statistical model, which tracks the changing composition of a series of air parcels travelling across the EMEP and UK areas towards designated receptor sites. SOA has been generated within the model through the photo-oxidation of terpenes and isoprene from natural emissions and anthropogenic emissions of toluene. SOA concentrations are not routinely measured but can be estimated from campaign measurements of elemental and organic carbon (EC and OC). Measured OC includes both primary and secondary components. EC and OC were measured at Bush Estate in Scotland from July 2002 to July 2003 (EMEP, 2005). The EC/OC campaign data exhibit seasonal variations at Bush that can be explained most simply by EC and primary OC contributions that peak in the winter and reach a minimum in the summer and a secondary OC contribution that peaks in the summer and is zero in the winter. More complicated explanations could and most certainly are operating. However, with the data available this is the simplest explanation of what is observed. Similar behaviour has been found at some sites in the EMEP EC/OC campaign but not at all sites. Hence we assume that the assumptions concerning the seasonal cycle in secondary OC work all across the UK, but not necessarily across Europe. Estimated peak summer time monthly concentrations of SOA were found to be 0.94 $\mu g\ m^{-3}$ and the model predicted peak summer time monthly concentrations of 0.4-0.5 $\mu g\ m^{-3}$. Since summer mean concentrations would be expected to be about double the annual mean, we consider that the modelled summer time value to provide a reasonable estimate of the annual mean and we have chosen not to scale the results. SOA is assumed to be volatile (Pankow, 1995) and thus contributes to gravimetric but not TEOM PM concentrations (Table 4.1).

4.4 Contributions from large and small point sources

Contributions to ground level annual mean primary PM concentrations from large point sources (those with annual emission greater than 200 tonnes) have been estimated by modelling each source explicitly using the atmospheric dispersion model (ADMS 4). Hourly sequential meteorological data for 2007 from Waddington was applied. Surface roughness was assumed to be 0.1 metres. Concentrations were calculated for a 100km x 100km square composed of a regularly spaced 5km x 5km resolution receptor grid. Each receptor grid was centred on the point source. A total of 54 point sources were modelled explicitly.

Contributions from PM point sources with less than 200 tonnes per annum release were modelled using the ‘small points’ model described by Stedman *et al.* (2005) and summarised in Appendix 2. This model consists of separate ‘in-square’ and ‘out-of-square’ components, in which concentrations are estimated using dispersion kernels, which have been calculated by using ADMS to model the dispersion of unit emissions from a central source to a grid of receptors at a spatial resolution of 1km x 1km squares.

4.5 Contributions from distant sources of primary particles

Contributions from long-range transport of primary particles on a 10km x 10km grid have been estimated using the TRACK receptor oriented, Lagrangian statistical model (Lee *et al.*, 2000). Emissions of primary PM were taken from the NAEI for the UK sources and EMEP for sources in the rest of Europe. Primary PM was modelled as an inert tracer. All sources within 10km 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 Iron and calcium rich dusts

A method for estimating the mass of iron (Fe) and calcium (Ca) rich dusts was included in the modelling method for PM_{10} for the first time in 2006 and the same method has been used for 2007. Iron and calcium rich dusts were previously included in the constant residual PM concentration (Kent *et al.*, 2007a) because the emission of these dusts are not included in the NAEI, which precluded the use of a dispersion model to estimate ambient concentrations. A method was developed using the spatial distributions of vehicle km travelled and population as surrogates of the spatial distribution of the emissions of these components.

The starting point for this assessment of iron and calcium rich dusts is the measurements of a range of PM components including Fe and Ca reported by Harrison and Yin (2006) for three monitoring sites in the Birmingham area. Measurements were made and urban background site (BCCS) from May 2004 to May 2005, an urban roadside site (BROS) from May 2005 to November 2005 and at a rural site about 20km from the city (CPSS) from November 2005 to May 2006. Measurements were not made at the different sites simultaneously but the measurement periods were sufficiently long that they can be use to provide reasonable estimates of the urban and roadside increments of various PM components. The measurement data for Fe and Ca are summarised in Table 4.2

Table 4.2 Measured concentration of iron and calcium and derived estimates of iron and calcium rich dusts (μg m^{-3})

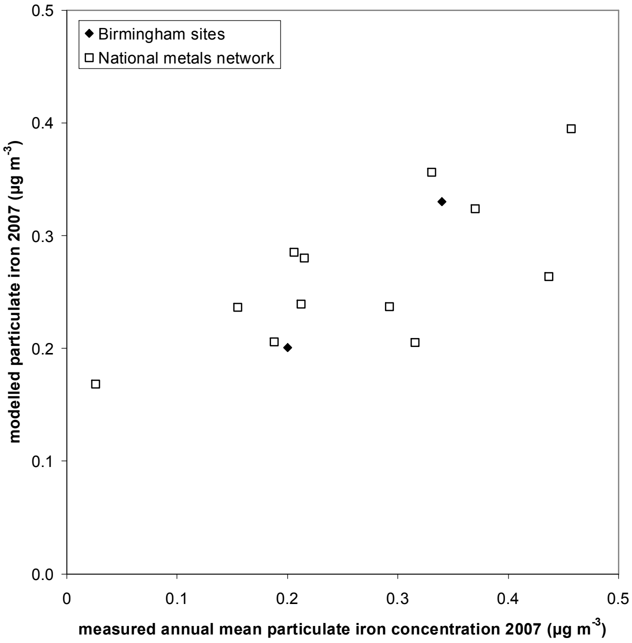
	CPSS (rural)	BCCS (urban)	conversion factor	rural x factor	Urban increment x factor
Fe fine	0.06	0.10	9.0	0.54	0.36
Fe coarse	0.14	0.24	9.0	1.26	0.89
Ca fine	0.03	0.09	4.3	0.13	0.26
Ca coarse	0.12	0.30	4.3	0.52	0.77

Table 4.2 also includes the conversion factors suggested by Harrison *et al*. (2006) for use within their pragmatic mass closure model. This factor converts to mass of elemental Fe to iron related dusts and the mass of elemental Ca to calcium related dusts. These factors have been applied to the measurement data from the rural CPSS site and the resulting PM masses have been assumed to apply across all rural areas of the UK. The urban increment in the table has been calculated by subtracting the data for CPSS from that for the urban BCCS site. It is clear that there is an urban increment for both fine and coarse iron and calcium rich dusts. Measurement data for the BROS roadside site indicates that there is a roadside increment on top of the urban increment for Fe but not for Ca. Thus it is reasonable to assume that urban increment for iron rich dusts is associated with emissions generated by road traffic but that the urban increment for calcium rich dusts is associated with urban emissions that are not related to traffic activity.

The NAEI does not include estimates of the urban emissions of iron or calcium rich dusts. Normalised distribution grids, at a 1km x 1km resolution, are however available for vehicle km travelled and resident population. We have therefore used these distribution grids as surrogate emission grids within our area source model and have calculated calibration coefficients converting the values in the distribution grid (which add up to 1.0 for the whole of the UK) to surrogate emissions using the urban increments listed in Table 4.2.

The use of data from a single urban monitoring site to calibrate this model is clearly subject to considerable uncertainty. This method should, however, provide a more realistic estimate of the urban increments for these species. An indication that this method is providing reasonable estimates is provided by Figure 4.5, which shows a comparison of modelled Fe (the sum of rural and urban fine and coarse Fe) with ambient Fe measurements for 2007 from the national metals monitoring network. The modelled estimates are clearly of the correct magnitude and provide a reasonable description of the rural to urban gradients.

Figure 4.5. Comparison of modelled and measured annual mean elemental Fe concentrations 2007 (μg m^{-3})



4.7 Sea salt

The contribution to ambient PM from sea salt has been derived directly from measurements of particulate chloride (Tang, *pers comm*. 2008). Data from 28 rural sites were interpolated by Krigging onto a 5km x 5km grid. A scaling factor of 1.648 was applied to convert elemental chloride mass to sodium chloride mass. 73% of the sea salt mass was assumed to be in the coarse fraction and 27% in the fine fraction. This split was derived from measurement data presented by APEG (1999) and Harrison and Yin (2006).

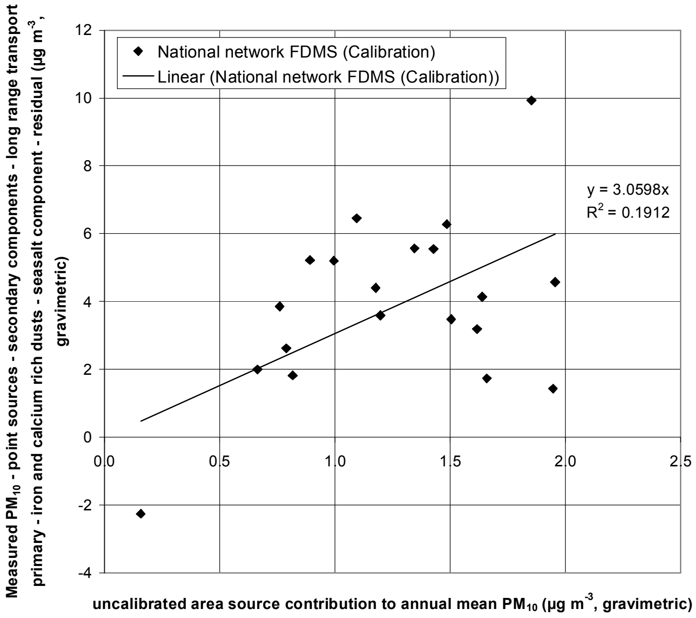
The use of chloride is potentially subject to both positive and negative artefacts. Sea salt is not the only source of particulate chloride in the atmosphere. HCl is emitted from coal burning but reductions in coal use and flue gas abatement are likely to have reduced atmospheric HCl and ammonium chloride concentrations considerably. There will also be loss of chloride from marine aerosol due to reactions with nitric acid. We consider the resulting sodium nitrate PM to be of anthropogenic origin and the contribution to PM mass from this sodium nitrate is explicitly included in our modelled concentrations. If sodium were used as our marker for sea salt then this sodium nitrate would tend to be included in the natural component.

In addition to selecting chloride as the marker for sea salt, we have also decided to simplify the analysis by assuming that the sea salt consists of sodium chloride only. Thus we have scaled the measured chloride concentration by a factor of 1.648. An alternative approach would be to scale by 1.809 to take account of the full composition of sea salt. The composition of sea salt is dominated by chloride and sodium. Other components contributing more than 1% by mass are sulphate, magnesium, calcium and potassium. Sulphate is already explicitly included in our modelled concentrations and we have not applied a sea salt correction to the measured concentrations used in the PCM model. Adding a further sea salt sulphate component would lead to double counting. The other components (magnesium, calcium and potassium) have, in effect, been treated as sodium by our use of a scaling factor of 1.648. The ratio of (chloride + sodium) to chloride in sea salt is 1.552, while the ratio of (chloride + sodium + magnesium + calcium + potassium) to chloride is 1.658. Thus our simplification of sea salt as pure sodium chloride has not had a large impact on the total mass assumed apart from the contribution from sea salt sulphate, which, as a simplification, we have included with the rest of the sulphate as anthropogenic.

4.8 Contributions from area sources

Figure 4.6 shows the calibration of the area source model. An empirical method, utilising an ADMS derived dispersion kernel has been used to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each monitoring site. These dispersion kernels were updated for 2007, see section 2.7. Hourly sequential meteorological data from Waddington in 2007 was used to construct the dispersion kernels, as described in Appendix 3. A total of 11 background FDMS monitoring sites within the national network had at least 75% data capture for PM_{10} in 2007. A further nine sites had a data capture of at least 45%. A comparison of the calibration coefficient for all sites and for sites with at least 75% data capture showed little difference so the model was calibrated using data for all 20 monitoring sites, as shown in the figure.

Figure 4.6. Calibration of PM_{10} area source model 2007 ($\mu g\ m^{-3}$, gravimetric)



The area source model has been calibrated using FDMS ambient PM monitoring data from the UK national networks. The modelled large point and small point source, SIA, SOA, iron and calcium rich dust, long range transport primary PM, sea salt and the residual concentrations have been subtracted from the measured annual mean PM concentration at background sites and compared with the modelled area source contribution to annual mean PM concentration. A residual concentration of 1 $\mu g\ m^{-3}$ was found to provide the best fit to the monitoring data.

Adjustment factors were applied to the emissions from selected transport sources to represent the diminishing influence of emissions on air quality at the UK land surface, as described in Section 1.7. A factor of 0.62 was applied to aircraft emissions and a factor of 0.25 was applied to emissions from ships.

The modelled area source contribution was multiplied by the relevant empirical coefficient to calculate the calibrated area source contribution for each grid square in the country. The area source contribution was then added to the contributions from secondary organic and inorganic particles, from small and large point sources, from regional primary particles, from sea salt and the residual, resulting in a map of background annual mean gravimetric PM_{10} concentrations.

4.9 Roadside concentrations

We have considered that the annual mean concentration of PM_{10} at a roadside location is made up of two parts: the background concentration (as described above) and a roadside increment:

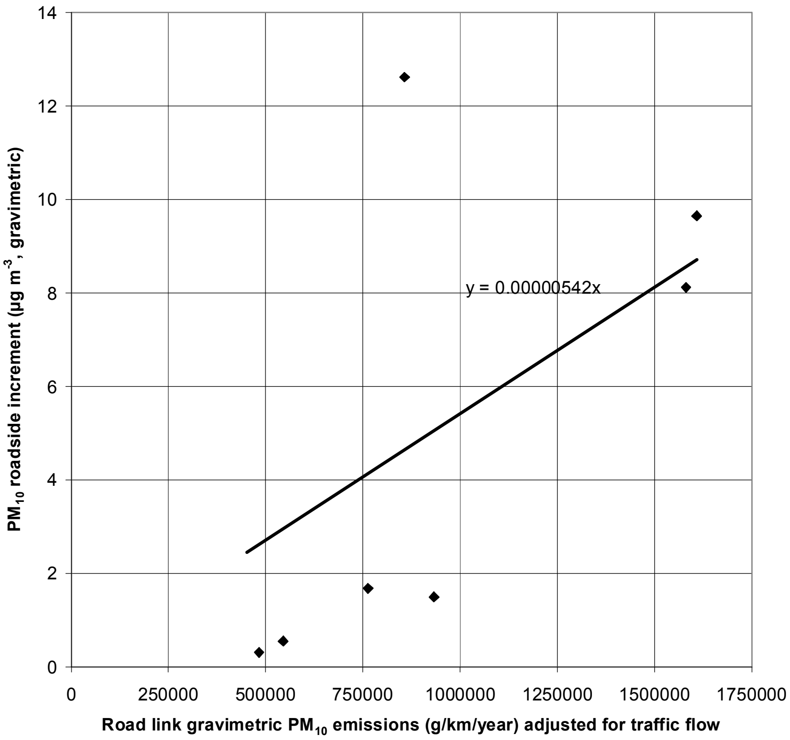
roadside concentration = background concentration + roadside increment

The NAEI provides estimates of PM_{10} emissions for major road links in the UK for 2006 (Dore et *al.*, 2008) and these have been adjusted to provide estimates of emissions in 2007. Figure 4.7 shows a comparison of the roadside increment of annual mean PM_{10} concentrations at roadside or kerbside FDMS monitoring sites with PM_{10} emission estimates for the individual road links alongside which these sites are located. Data from the one national network roadside site with FDMS measurements has been supplemented with data for an additional six sites. The sites used to calibrate this model are listed in Table 4.3. The regression line has been forced through zero to provide a reasonable model output without imposing an unrealistically high residual to the roadside increment. Emissions were adjusted for annual average daily traffic flow using the method described in Section 3.2.5. Roadside concentrations for urban major road links (A-roads and motorways) only are reported to the EU and included in this report.

Table 4.3. The roadside and kerbside FDMS monitoring sites used calibrate the roadside increment model for 2007.

Site	Network
Swansea Roadside	National network
Ealing 2 (F) - Acton Town Hall	London Air Quality Network
Tower Hamlets 4 - Blackwall	London Air Quality Network
Chichester Roadside FDMS	Sussex Air Quality Partnership
Wandsworth 4 - High Street	London Air Quality Network
Hammersmith and Fulham 1 - Broadway	London Air Quality Network
London Marylebone Road	London Air Quality Network

Figure 4.7. Calibration of PM_{10} roadside increment model 2007 ($\mu g\ m^{-3}$, gravimetric)



4.10 Verification of mapped values

Figures 4.8 and 4.9 show comparisons of gravimetric PM_{10} modelled and measured annual mean PM_{10} concentration in 2007 at both background and roadside monitoring site locations. 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 4.4 and 4.5.

The agreement between the FDMS measurement data used to calibrate the models is good, but this is to be expected. There are limited data available for FDMS verification sites and there is some indication that the model may underestimate the measurements at the roadside. The comparison with TEOM data corrected using the VCM model shows generally good agreement with some indication that the model overestimates background concentrations. The comparison with corrected national network Partisol gravimetric measurements shows good agreement at both background and roadside locations. TEOM x 1.3 measurement data for both national network and verification sites are higher than the modelled estimates, particularly at the roadside. Overall the agreement is generally good and all of the modelled values are within the data quality objectives. The good agreement with corrected Partisol data is particularly encouraging as this suggests that the 2007 assessment will show continuity with the assessments for 2005 and 2006 based on corrected Partisol data.

Figure 4.8. Verification of background annual mean PM_{10} (gravimetric) model 2007

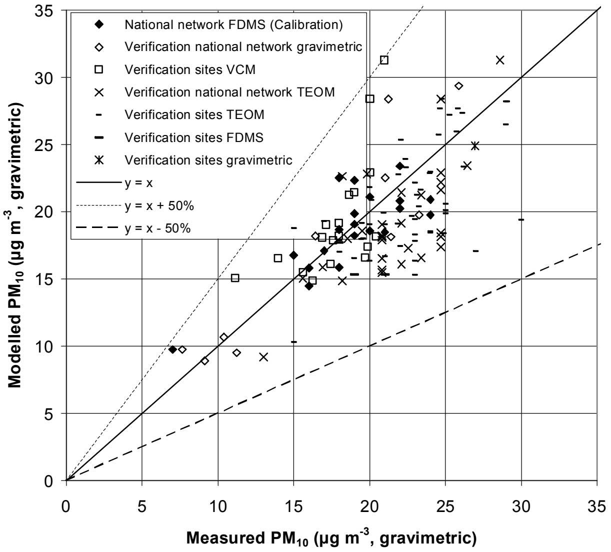


Figure 4.9. Verification of roadside annual mean PM_{10} (gravimetric) model 2007

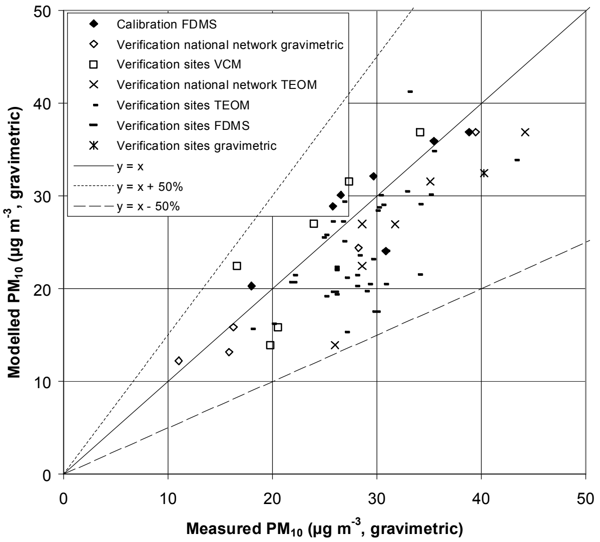


Table 4.4 Summary statistics for comparison between gravimetric modelled and measured concentrations of PM_{10} at background sites

	Mean of measurements (µg m^{-3}, grav)	Mean of model estimates (µg m^{-3}, grav)	r^2	% outside data quality objectives	Number of sites
National network FDMS (Calibration)	18.8	18.7	0.65	0	20
Verification sites FDMS	19.3	16.1	0.58	0	3
Verification sites VCM	17.8	19.3	0.37	0	18
Verification national network gravimetric	16.8	17.5	0.83	0	10
Verification sites gravimetric	26.9	24.9	-	0	1
Verification national network TEOM	21.6	19.1	0.48	0	31
Verification sites TEOM	22.8	20.9	0.36	0	53

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

	Mean of measurements (µg m^{-3}, grav)	Mean of model estimates (µg m^{-3}, grav)	r^2	% outside data quality objectives	Number of sites
Calibration FDMS	29.3	29.8	0.71	0	7
Verification sites FDMS	27.2	20.5	0.02	0	4
Verification sites VCM	23.7	24.6	0.72	0	6
Verification national network gravimetric	22.2	20.5	0.98	0	5
Verification sites gravimetric	40.3	32.5	-	0	1
Verification national network TEOM	32.4	26.5	0.79	0	6
Verification sites TEOM	28.5	24.8	0.35	0	34

4.11 PM_{10} monitoring methods and Partisol bias

PM_{10} concentrations are measured using a variety of different methods in the UK. For the years up to 2003, the PCM model used to calculate the PM_{10} maps for the annual air quality assessment required for the 1st Daughter Directive was based on TEOM x 1.3 measurements – as these were the best available measurements of gravimetric PM at the time. However since the results of the PM Equivalence Programme (Harrison, 2006) showed that TEOM measurements were not equivalent to the EU reference method (even when multiplied by 1.3) a new approach was needed. Although Partisol measurement was limited to relatively few locations, these were the only data measured by an EU Equivalent methodology in the UK. Hence, the PCM maps were based on these Partisol measurements for the years 2004, 2005 and 2006.

Detailed investigation of the Partisol measurement data in the UK has shown that there has been a positive bias in reported concentrations (Maggs et al., 2008). This bias has been identified by examination of travel blank filters and is thought to be associated with humidity although the blank value shows a large variation. Therefore, it follows that if there is a bias in the Partisol data, this is reflected in the PCM model data for the whole of the UK. If the bias is positive this may have led to the UK reporting more exceedences of the Directive than would have been the case for unbiased data. The report by Maggs et al (2008) proposes a method for correcting the measured concentrations for this bias based on the subtraction of monthly mean bias derived from the travel blank filters.

For 2007, a body of FDMS PM_{10} data are also available and PCM maps based on these data have been produced for the air quality assessment for 2007. FDMS instruments have been shown to be equivalent to the EU reference method (Harrison, 2006). Data from Partisol instruments for 2007 have been corrected using the method proposed by Maggs et al. (2008). An additional bias of 2.5 $\mu g\ m^{-3}$ has also been subtracted to account for the difference between quartz filter media and the Emfab filter media used in the UK equivalence trials. The corrected Partisol data has then been used to verify the maps calibrated using the FDMS data.

Data from TEOM measurements multiplied by a factor of 1.3 have also been used to verify the modelled estimates for 2007. It is likely that this factor of 1.3 leads to an overestimate of the annual mean gravimetric concentration in most cases. A Volatile Correction Model (VCM) has been proposed to provide a method for correcting TEOM measurement data using FDMS measurements at other locations (Green et al., 2007). Data from TEOM measurement sites in the national network which have been adjusted using the VCM have also been used to verify the modelled estimates for 2007.

The PCM models for 2005 and 2006 have been recalibrated using published corrected annual mean Partisol measurements (Maggs et al., 2008). This reanalysis results in a total of 8 zones (3 measured and 5 modelled) for 2005 and 15 zones (5 measured and 10 modelled) for 2006 exceeding the 24-hour limit value. This can be compared with total of 29 zones (3 measured and 26 modelled) for 2005 and 30 zones (5 measured and 25 modelled) for 2006 for PCM models calibrated using the Partisol data as measured. Thus the analyses for 2005 and 2006 based on the corrected data are much more consistent with this current analysis for 2007.

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 2 limit values by zone, are summarised in Tables 4.6 and 4.7 respectively. 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 these tables refers to the annual mean modelling methods 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 4.6 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)) - Results of and methods used for supplementary assessment for PM10 (Stage 1) Questionnaire Form 19c.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	12	A	226.4	A	77086	A	0	A	5	A	0	A
West Midlands Urban Area	UK0002	0	A	1.5	A	0	A	0	A	0	A	0	A
Greater Manchester Urban Area	UK0003	0	A	0.0	A	0	A	0	A	0	A	0	A
West Yorkshire Urban Area	UK0004	0	A	0.0	A	0	A	0	A	0	A	0	A
Tyneside	UK0005	0	A	0.0	A	0	A	0	A	0	A	0	A
Liverpool Urban Area	UK0006	0	A	0.0	A	0	A	0	A	0	A	0	A
Sheffield Urban Area	UK0007	0	A	0.0	A	0	A	0	A	0	A	0	A
Nottingham Urban Area	UK0008	0	A	0.0	A	0	A	0	A	0	A	0	A
Bristol Urban Area	UK0009	0	A	0.0	A	0	A	0	A	0	A	0	A
Brighton/Worthing/Littlehampton	UK0010	0	A	0.0	A	0	A	0	A	0	A	0	A
Leicester Urban Area	UK0011	0	A	0.0	A	0	A	0	A	0	A	0	A
Portsmouth Urban Area	UK0012	0	A	0.0	A	0	A	0	A	0	A	0	A
Teesside Urban Area	UK0013	0	A	0.0	A	0	A	0	A	0	A	0	A
The Potteries	UK0014	0	A	0.0	A	0	A	0	A	0	A	0	A
Bournemouth Urban Area	UK0015	0	A	0.0	A	0	A	0	A	0	A	0	A
Reading/Wokingham Urban Area	UK0016	0	A	0.0	A	0	A	0	A	0	A	0	A
Coventry/Bedworth	UK0017	0	A	0.0	A	0	A	0	A	0	A	0	A
Kingston upon Hull	UK0018	0	A	0.0	A	0	A	0	A	0	A	0	A
Southampton Urban Area	UK0019	0	A	0.4	A	0	A	0	A	0	A	0	A
Birkenhead Urban Area	UK0020	0	A	0.0	A	0	A	0	A	0	A	0	A
Southend Urban Area	UK0021	0	A	0.0	A	0	A	0	A	0	A	0	A
Blackpool Urban Area	UK0022	0	A	0.0	A	0	A	0	A	0	A	0	A
Preston Urban Area	UK0023	0	A	0.0	A	0	A	0	A	0	A	0	A
Glasgow Urban Area	UK0024	0	A	0.0	A	0	A	0	A	0	A	0	A
Edinburgh Urban Area	UK0025	0	A	0.0	A	0	A	0	A	0	A	0	A

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*
Cardiff Urban Area	UK0026	0	A	0.0	A	0	A	0	A	0	A	0	A
Swansea Urban Area	UK0027	0	A	0.0	A	0	A	0	A	0	A	0	A
Belfast Urban Area	UK0028	0	A	0.0	A	0	A	0	A	0	A	0	A
Eastern	UK0029	0	A	0.0	A	0	A	0	A	0	A	0	A
South West	UK0030	0	A	0.0	A	0	A	0	A	0	A	0	A
South East	UK0031	0	A	0.0	A	0	A	0	A	0	A	0	A
East Midlands	UK0032	0	A	0.0	A	0	A	0	A	0	A	0	A
North West & Merseyside	UK0033	0	A	0.0	A	0	A	0	A	0	A	0	A
Yorkshire & Humberside	UK0034	0	A	0.0	A	0	A	0	A	0	A	0	A
West Midlands	UK0035	0	A	0.0	A	0	A	0	A	0	A	0	A
North East	UK0036	0	A	0.0	A	0	A	0	A	0	A	0	A
Central Scotland	UK0037	0	A	0.0	A	0	A	0	A	0	A	0	A
North East Scotland	UK0038	0	A	0.0	A	0	A	0	A	0	A	0	A
Highland	UK0039	0	A	0.0	A	0	A	0	A	0	A	0	A
Scottish Borders	UK0040	0	A	0.0	A	0	A	0	A	0	A	0	A
South Wales	UK0041	0	A	0.0	A	0	A	0	A	0	A	0	A
North Wales	UK0042	0	A	0.0	A	0	A	0	A	0	A	0	A
Northern Ireland	UK0043	0	A	0.0	A	0	A	0	A	0	A	0	A
Total		12	0	228.3	0	77086	0	0	0	5	0	0	0

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)) - Results of and methods used for supplementary assessment for PM10 (Stage 2) Questionnaire Form 19c.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							1380	A	1888.1	A	7252761	A
West Midlands Urban Area	UK0002							222	A	515.4	A	804171	A
Greater Manchester Urban Area	UK0003							5	A	255.4	A	12258	A
West Yorkshire Urban Area	UK0004							2	A	134.3	A	2630	A
Tyneside	UK0005							0	A	17.2	A	0	A
Liverpool Urban Area	UK0006							1	A	60.8	A	2316	A
Sheffield Urban Area	UK0007							8	A	95.3	A	6235	A
Nottingham Urban Area	UK0008							19	A	105.4	A	72358	A
Bristol Urban Area	UK0009							14	A	96.7	A	43714	A
Brighton/Worthing/Littlehampton	UK0010							15	A	77.6	A	123674	A
Leicester Urban Area	UK0011							28	A	89.6	A	135417	A
Portsmouth Urban Area	UK0012							36	A	64.8	A	173177	A
Teesside Urban Area	UK0013							0	A	6.9	A	0	A
The Potteries	UK0014							2	A	45.0	A	4111	A
Bournemouth Urban Area	UK0015							4	A	61.6	A	8693	A
Reading/Wokingham Urban Area	UK0016							17	A	79.4	A	50735	A
Coventry/Bedworth	UK0017							22	A	30.7	A	89426	A
Kingston upon Hull	UK0018							5	A	34.9	A	6958	A
Southampton Urban Area	UK0019							28	A	63.1	A	97068	A
Birkenhead Urban Area	UK0020							0	A	1.3	A	0	A
Southend Urban Area	UK0021							4	A	44.3	A	11934	A
Blackpool Urban Area	UK0022							0	A	0.0	A	0	A
Preston Urban Area	UK0023							1	A	1.7	A	687	A
Glasgow Urban Area	UK0024							0	A	23.3	A	0	A
Edinburgh Urban Area	UK0025							0	A	0.0	A	0	A

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*
Cardiff Urban Area	UK0026							6	A	37.5	A	21939	A
Swansea Urban Area	UK0027							2	A	11.5	A	1833	A
Belfast Urban Area	UK0028							25	A	52.5	A	128493	A
Eastern	UK0029							392	A	648.4	A	497629	A
South West	UK0030							66	A	204.2	A	41933	A
South East	UK0031							475	A	902.8	A	608941	A
East Midlands	UK0032							74	A	292.2	A	91894	A
North West & Merseyside	UK0033							3	A	143.5	A	2535	A
Yorkshire & Humberside	UK0034							25	A	215.3	A	20628	A
West Midlands	UK0035							65	A	192.5	A	72945	A
North East	UK0036							0	A	16.1	A	0	A
Central Scotland	UK0037							0	A	3.5	A	0	A
North East Scotland	UK0038							0	A	3.3	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							20	A	70.4	A	23498	A
North Wales	UK0042							0	A	9.4	A	0	A
Northern Ireland	UK0043							0	A	5.0	A	0	A
Total								2966	0	6601.0	0	10410588	0

5 Benzene

5.1 Introduction

Maps of annual mean benzene concentrations at background and roadside locations in 2007 are presented in Figures 5.1 and 5.2. Benzene concentrations have been calculated using a similar approach to that adopted for NO_X although a different approach has been adopted for the modelling of fugitive and process emissions from point sources.

Figure 5.1. Annual mean background benzene concentration, 2007 (μg m^{-3})

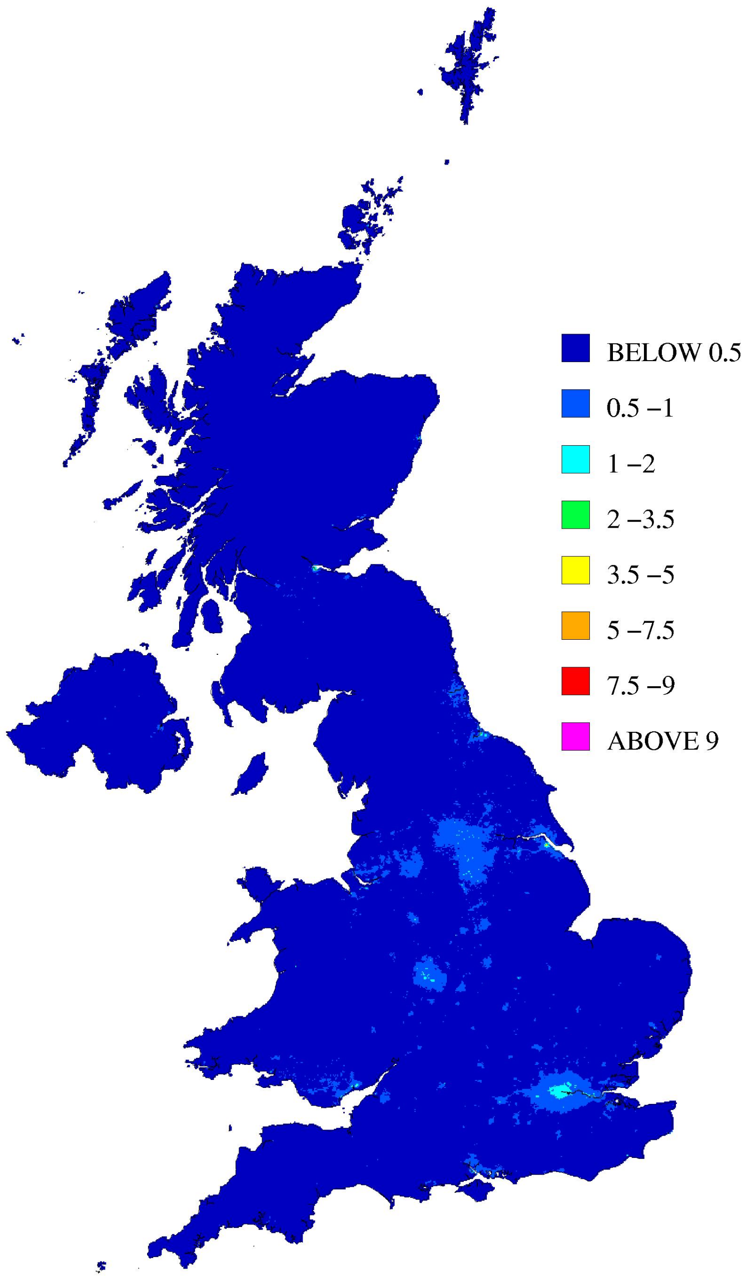
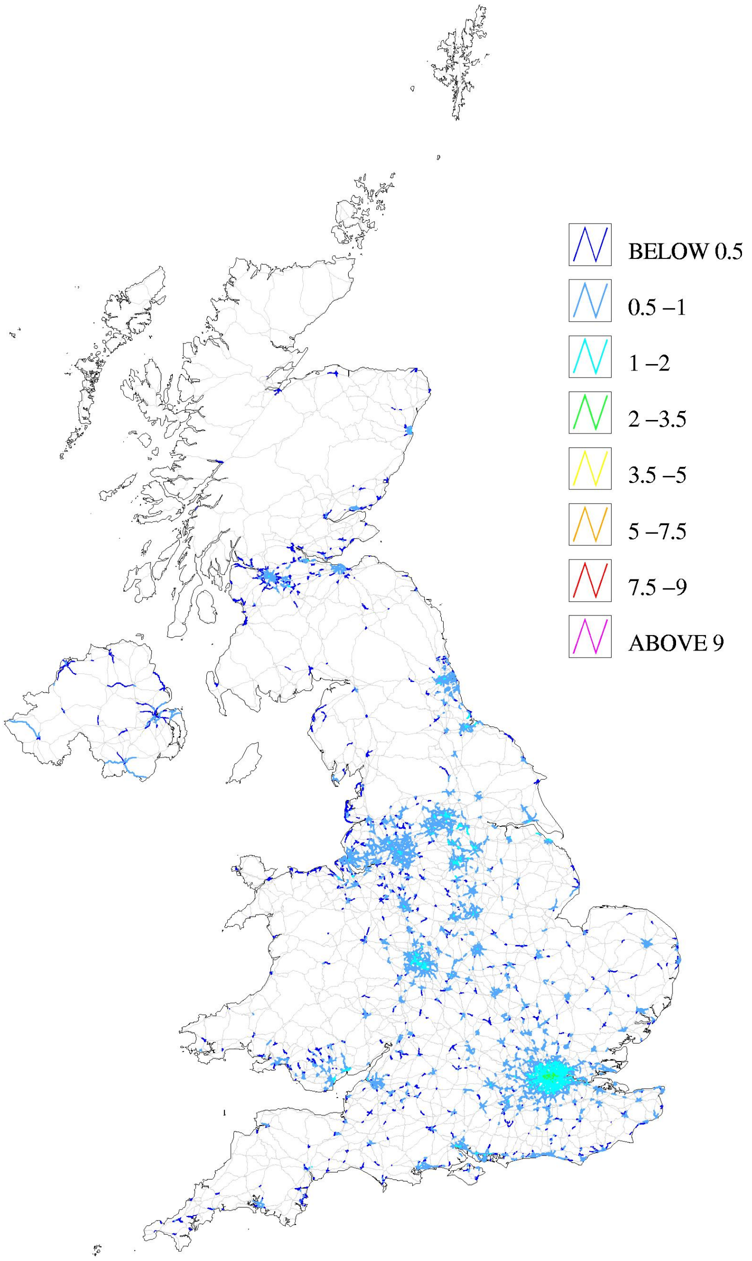


Figure 5.2. Urban major roads, annual mean roadside benzene concentration, 2007 ($\mu g\ m^{-3}$)



It has been considered that annual mean background benzene concentrations are made up of contributions from:

- Distant sources (characterised by an estimate of rural background concentration)
- Combustion point sources
- Fugitive and process point sources
- Local area sources.

The area source model has been calibrated using data from the national monitoring networks.

At locations close to busy roads an additional roadside contribution was added to account for contributions to total benzene from road traffic sources.

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 2006 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 4.0) and sequential meteorological data for 2007 from Waddington. A total of 25 point sources were modelled. Surface roughness was assumed to be 0.1 metres. Concentrations were calculated for a 100km x 100km square composed of a regularly spaced 5km x 5km resolution receptor grid. Each receptor grid was centred on the point source.

5.3 Contributions from fugitive and process point sources

The contributions to ambient concentrations from fugitive and process emission point sources were modelled using a modified version of the small points model described in Appendix 2. 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 1km x 1km grid square that includes the source) and the concentration in surrounding grid squares ('the out-square concentration'). The benzene small points fugitive model has been revised for 2007. The results from this model were verified by comparison with benzene diffusion tube measurements in the vicinity of oil refineries made available by the local authorities at Killingholme (where only data from 2005 were available) and Grangemouth. The previous model (developed in 2004, and described in Kent et al (2007b)) gave good agreement between the maximum modelled and measured values at Grangemouth and Killingholme, but was conservative because it predicted a large area with high concentrations. The model has therefore been revised for 2007 by assuming that a greater proportion of the grid square containing the emissions is within the factory fence. The model now shows better agreement with the range of measured values. As expected, this generalised model was not able to provide a full description of the exact spatial pattern of measured concentrations close to each refinery but the overall patterns and, more importantly, the maximum modelled concentrations, were in reasonably good agreement.

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 2007.

5.5 Contributions from area sources

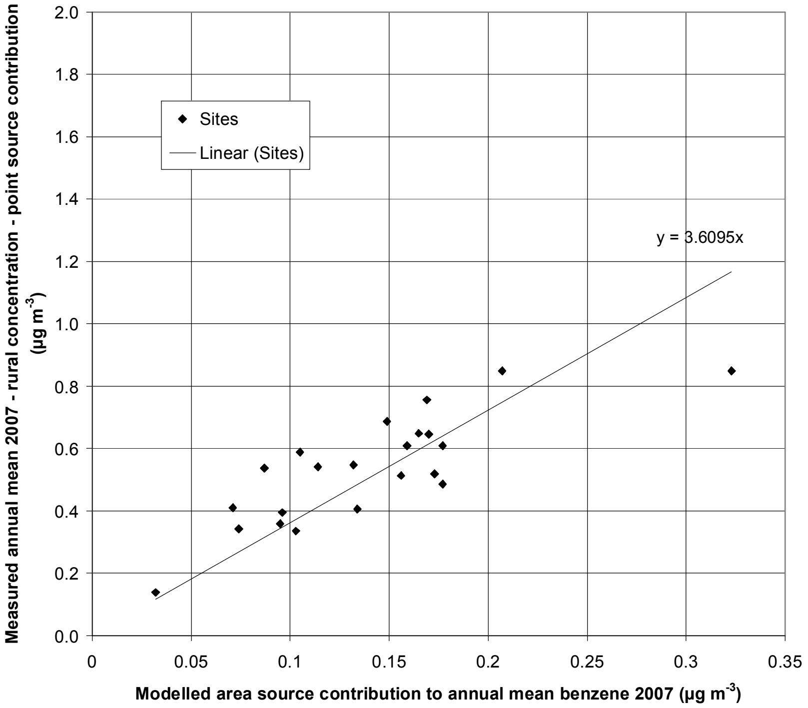
Figure 5.3 shows the calibration of the area source model. The modelled concentrations from point sources and estimated rural benzene concentrations have been subtracted from the measured annual mean concentration at automatic and pumped tube background measurement sites. This corrected background concentration is compared with the modelled area source contribution to annual mean benzene. An empirical method has been used to calculate the contribution to ambient concentrations from area sources. This approach applies an ADMS derived dispersion kernel to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each monitoring site. Hourly sequential meteorological data from

Waddington in 2007 has been used to construct the dispersion kernels, as described in Appendix 3. The method has been updated for the 2007 mapping, see Appendix 3.

Adjustment factors were applied to the emissions from selected transport sources to represent the diminishing influence of emissions on air quality at the UK land surface, as described in Section 1.7. A factor of 0.7334 was applied to aircraft emissions and a factor of 0.25 was applied to emissions from ships.

The modelled area source contribution was multiplied by the empirical coefficient to calculate the calibrated area source contribution for each grid square in the country. The point source contributions and constant regional rural concentration were then added, resulting in a map of background annual mean benzene concentrations.

Figure 5.3. Calibration of area source benzene model 2007 (μg m^{-3})

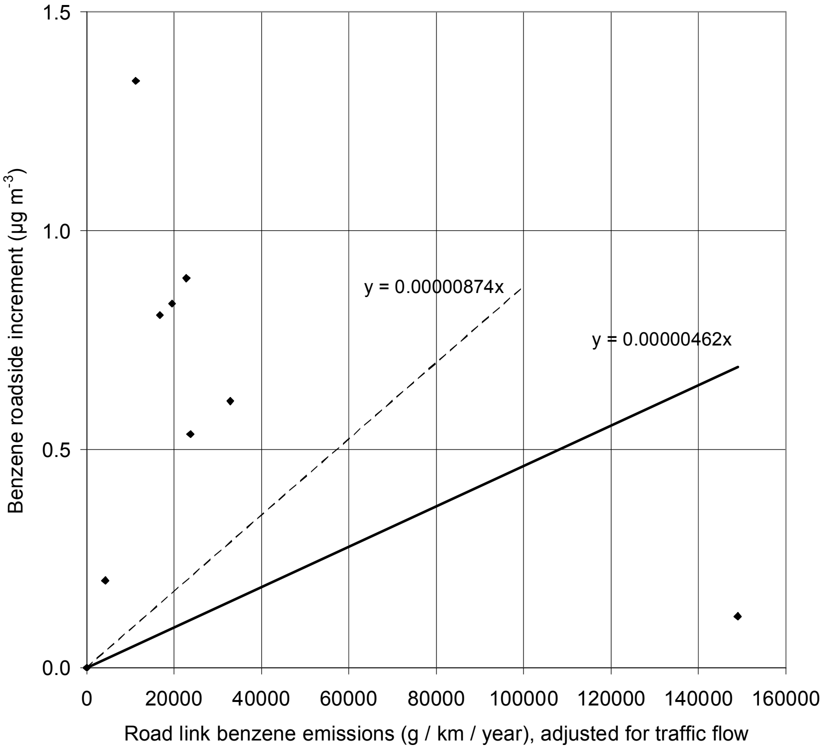


5.6 Roadside concentrations

Calibration of the benzene roadside increment model is shown in Figure 5.4. Roadside concentrations of annual mean benzene for 2007 have been modelled using a similar method to the NO_X modelling described in Section 3.6.

The relationship in this calibration plot is poor and it was decided that this was not an adequately meaningful relationship to ensure that the model was robust. As a result, the roadside calibration coeffient for NO_x (coefficient = 0.00000874) was used (see Figure 5.4 and Table 5.2). Using this coefficient, only 3 sites (30%) fell outside the data quality objectives range, one being overestimated and the other two being underestimated.

Figure 5.4. Comparison of benzene roadside increment and road link emission 2007 (μg m^{-3})



5.7 Verification of mapped values

Figures 5.5 and 5.6 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 5.5. Verification of background annual mean benzene model 2007

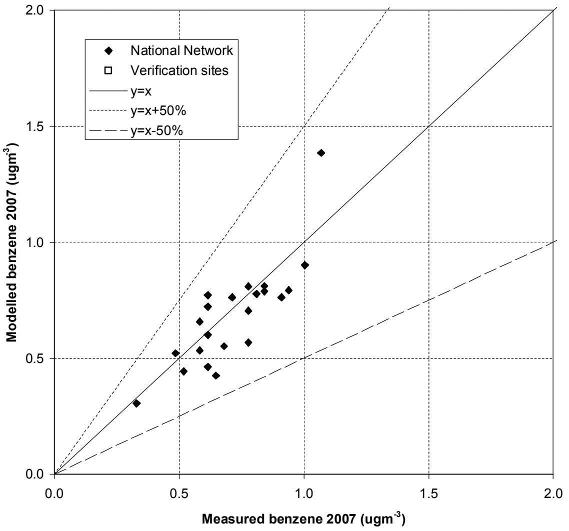
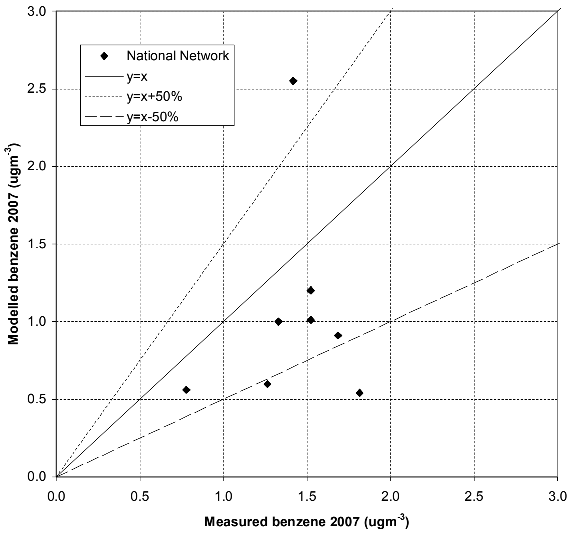


Figure 5.6. Verification of roadside annual mean benzene model 2007



Summary statistics for the comparison between modelled and measured benzene concentrations are listed in Tables 5.1 and 5.2. No monitoring sites were available to provide an independent verification of the background or roadside models.

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 modelled (µg m^{-3})	r^2	%outside data quality objectives	Number of sites
National Network Sites	0.76	0.69	0.68	23	30

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 modelled (µg m^{-3})	r^2	%outside data quality objectives	Number of sites
National Network Sites	1.42	1.04	0.01	30	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 for 2007 are below the limit value for all zones.

6 CO

6.1 Introduction

Maps of maximum 8-hour mean CO concentrations at background and roadside locations in 2007 are presented in Figures 6.1 and 6.2.

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 annual mean maps are prepared as an intermediate step within the modelling exercise. The annual mean maps are not presented in this report but details of the calibration and the verification of the annual mean background and roadside models are presented because they are directly relevant to the model output of the maximum 8-hour metric.

CO concentrations have been calculated using a similar approach to that adopted for NO_X but without the inclusion of a mapped regional rural component because regional rural CO concentrations in the UK are not well characterised within the monitoring networks.

It has been considered that annual mean background CO concentrations are made up of contributions from:

- Large point sources
- Small point sources
- Local area sources
- Regional background

The area source model has been calibrated using data from the national monitoring networks. At locations close to busy roads an additional roadside contribution was added to account for contributions to total CO from road traffic sources.

Figure 6.1. Maximum 8-hour mean background CO concentration, 2007 (mg m^{-3})

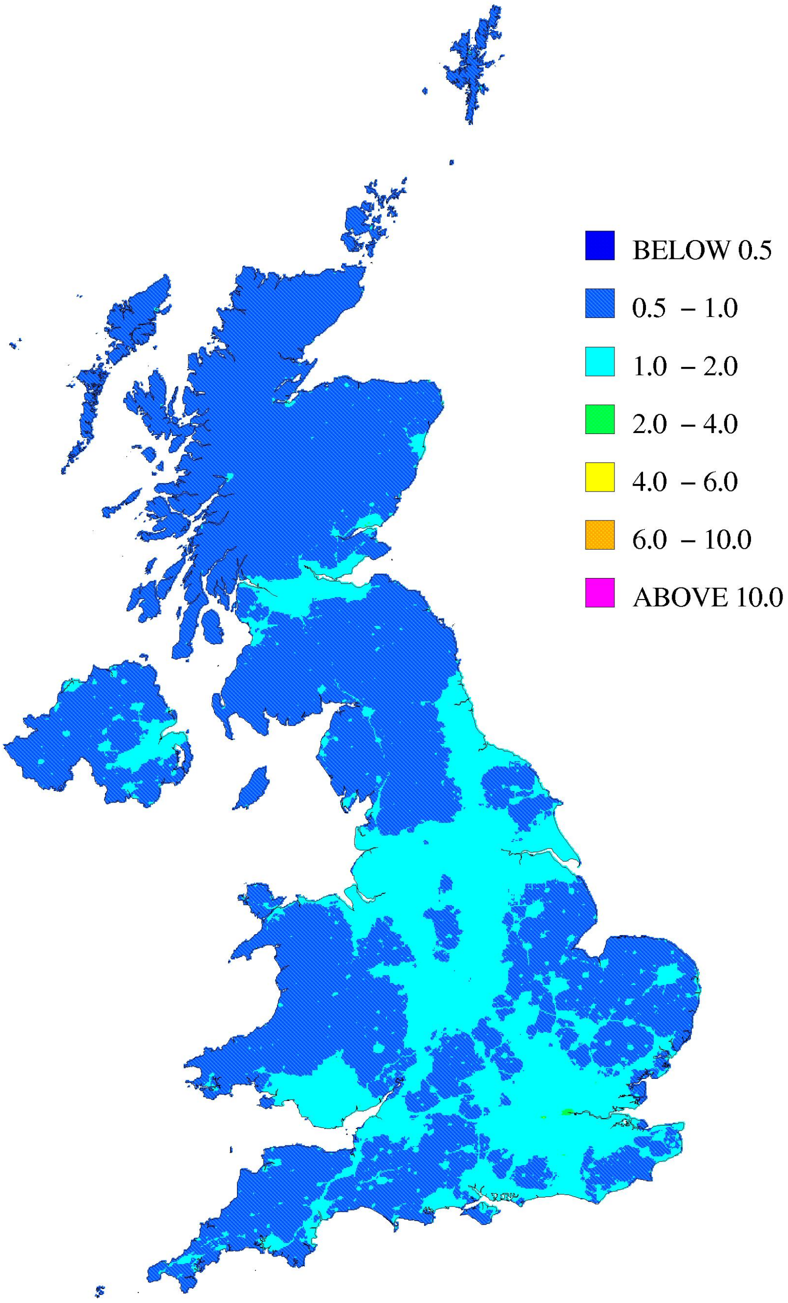
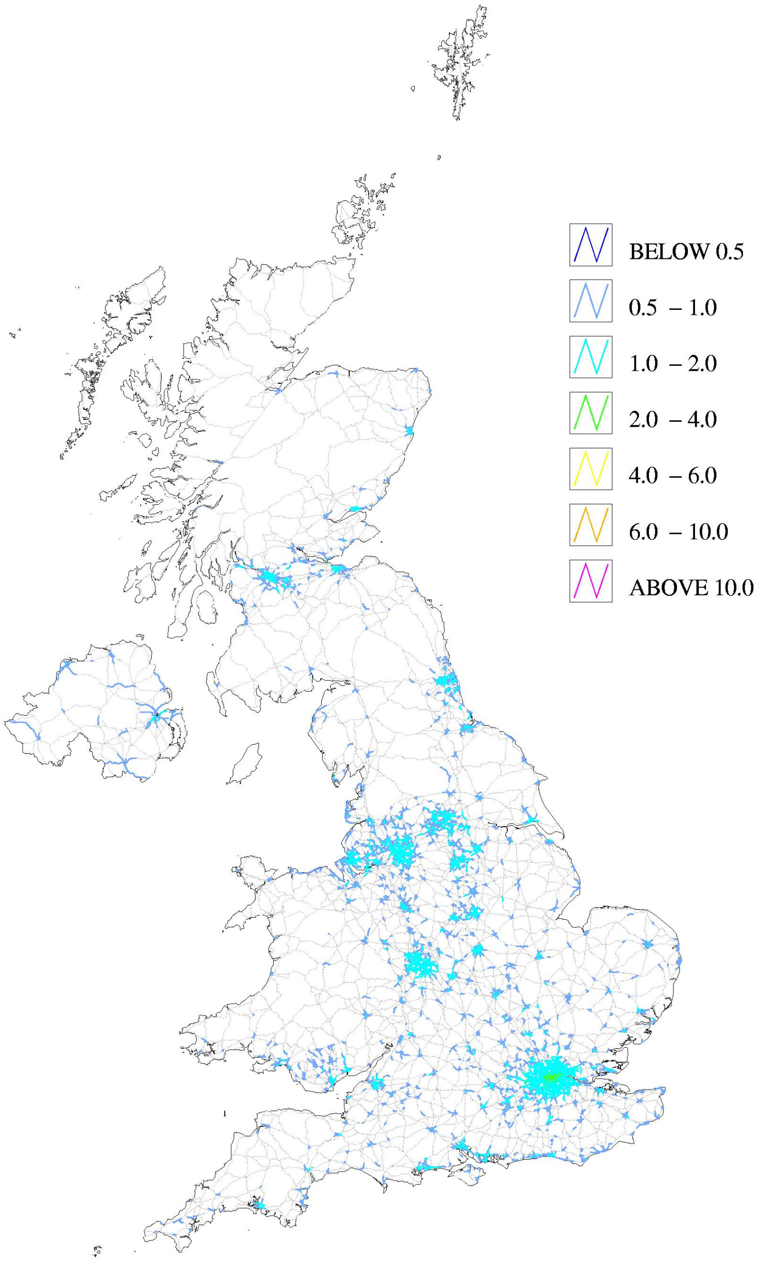


Figure 6.2. Urban major roads, maximum 8-hour mean roadside CO concentration, 2007 (mg m^{-3})



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 2006 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 4.0) and sequential meteorological data for 2007 from Waddington. A total of 96 large point sources were modelled. Surface roughness was assumed to be 0.1 metres. Concentrations were calculated for a 100km x 100km square composed of a regularly spaced 5km x 5km resolution receptor grid. Each receptor grid was centred on the point source.

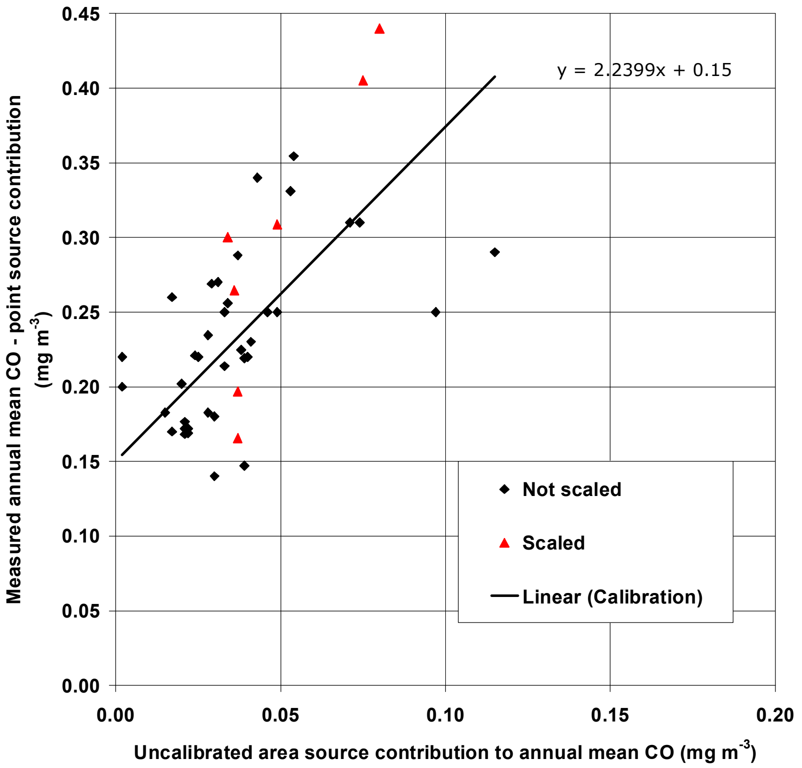
6.3 Contributions from small point sources

Contributions from CO point sources with less than 3000 tonnes per annum release were modelled using the small points model described in Appendix 2.

6.4 Contributions from area sources

Figure 6.3 shows the calibration of the annual mean area source CO model for background locations.

Figure 6.3. Calibration of 2007 background annual mean CO model (mg m^{-3})



Measured annual mean CO concentrations at background sites have been corrected for contributions from modelled large and small point sources and compared with the modelled area source contribution to annual mean CO concentration. Calibration plots are shown in mg m^{-3}. An empirical method has been used to calculate the contribution to ambient concentrations from area sources. This approach applies an ADMS derived dispersion kernel to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each monitoring site. Hourly sequential meteorological data from Waddington in 2007 has been used to construct the dispersion kernels, as described in Appendix 3. The method has been updated for the 2007 mapping, see Appendix 3.

Adjustment factors were applied to the emissions from selected transport sources to represent the diminishing influence of emissions on air quality at the UK land surface, as described in Section 1.7. A factor of 0.3120 was applied to aircraft emissions and a factor of 0.25 was applied to emissions from ships.

The modelled area source contribution was multiplied by the empirical coefficient to calculate the calibrated area source contribution for each grid square in the country. The point source contributions and constant regional rural concentration were then added, resulting in a map of background annual mean CO concentrations.

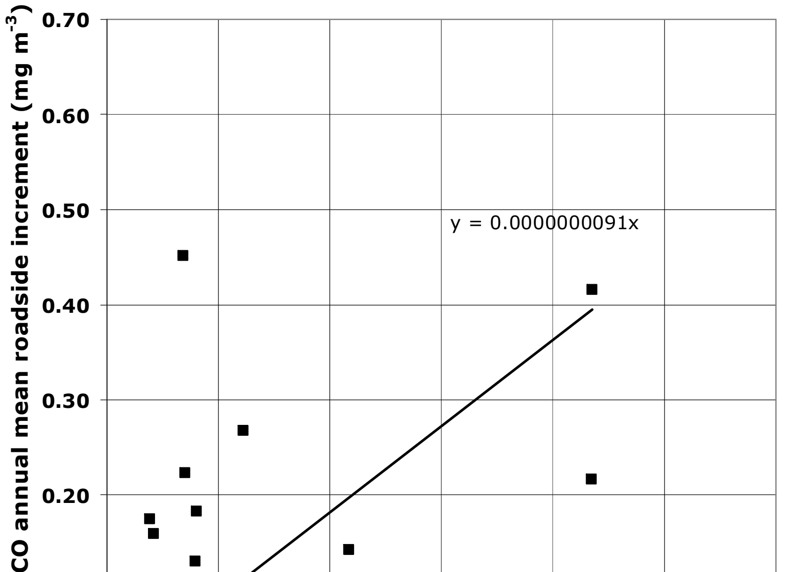
6.5 Roadside annual mean CO concentrations

Calibration of the CO annual mean roadside increment model is shown in Figure 6.4. We have considered that the annual mean concentration of CO at a roadside location is made up of two parts - the background concentration (as described above) and a roadside increment:

roadside CO concentration = background CO concentration + CO roadside increment

The NAEI provides estimates of CO emissions for major road links in the UK for 2006 (Dore et *al.*, 2008) and these have been adjusted to provide estimates of emissions in 2007. The background CO component at these roadside monitoring sites was derived from the map described above. The roadside increment was calculated by multiplying an adjusted road link emission by the empirical dispersion coefficient determined from Figure 6.4. The traffic flow adjustment factors used were the same as those applied in the roadside NO_X modelling (Section 3.2.5) and are presented in Figure 3.6. The relationship between the measured annual mean roadside CO concentration and road link emissions is clearly poor. This is due to a combination of the greater uncertainty associated with current low measured CO concentrations and road link emission inventories. Emissions of CO are highly dependent on local traffic conditions, particularly at low speeds and detailed information on speeds and congestion are not available from national inventories.

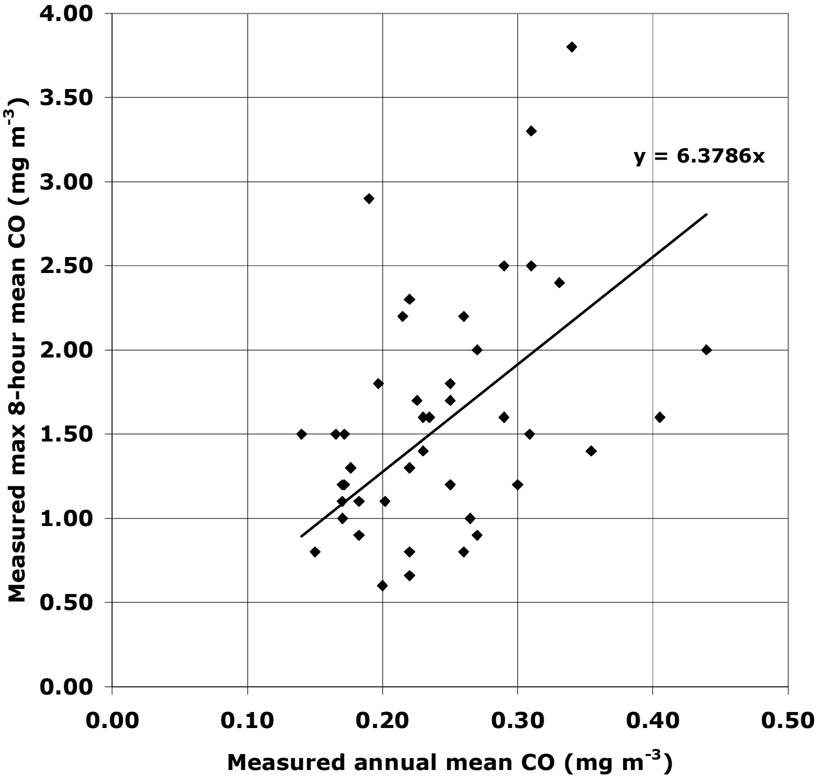
Figure 6.4. Calibration of 2007 roadside annual mean CO model (mg m^{-3})



6.6 Modelling the maximum 8-hour mean CO concentration

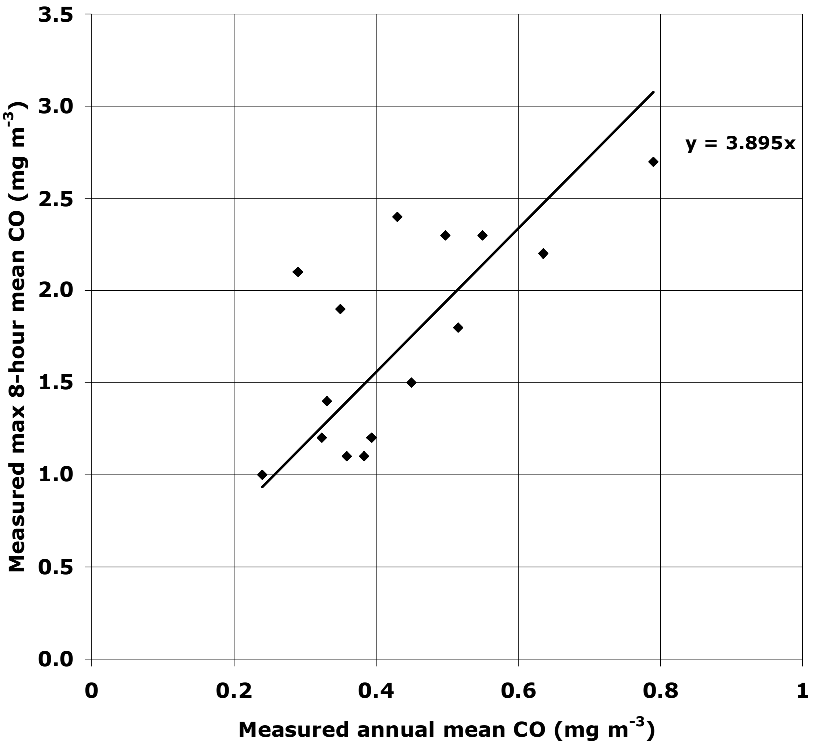
The map of maximum 8-hour mean CO concentrations at background locations shown in Figure 6.1 was calculated from the map of background annual mean CO concentrations by scaling annual mean map with the relationship between measured annual mean concentrations and the measured maximum 8-hour concentrations from the national network. Figure 6.5 shows this relationship.

Figure 6.5 Calibration of 2007 background maximum 8-hour mean CO model (mg m^{-3})



The map of maximum 8-hour mean CO concentrations at roadside locations shown in Figure 6.2 was calculated from map of annual mean concentrations at roadside locations. The empirical relationship used to scale the annual mean roadside map to derive the maximum 8-hour mean map is presented in Figure 6.6. Roadside concentrations for urban roads only are reported to the EU and included in this report.

Figure 6.6. Calibration of 2007 roadside maximum 8-hour CO model (mg m^{-3})



6.7 Verification of mapped values

Figures 6.7 to 6.10 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 6.7. Verification of background annual mean CO model 2007

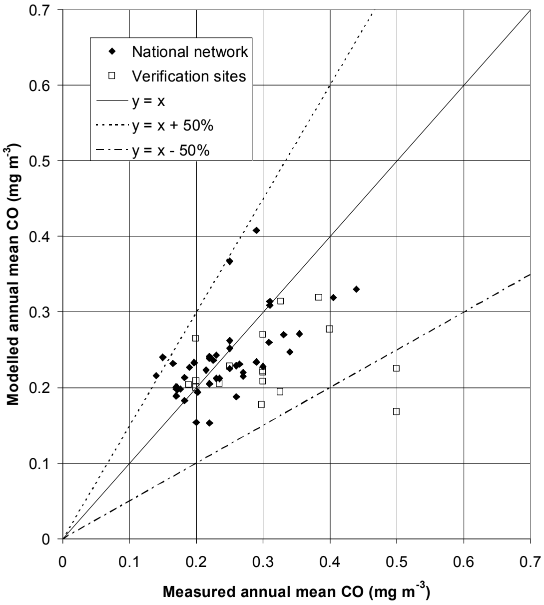


Figure 6.8. Verification of background maximum 8-hour mean CO model 2007

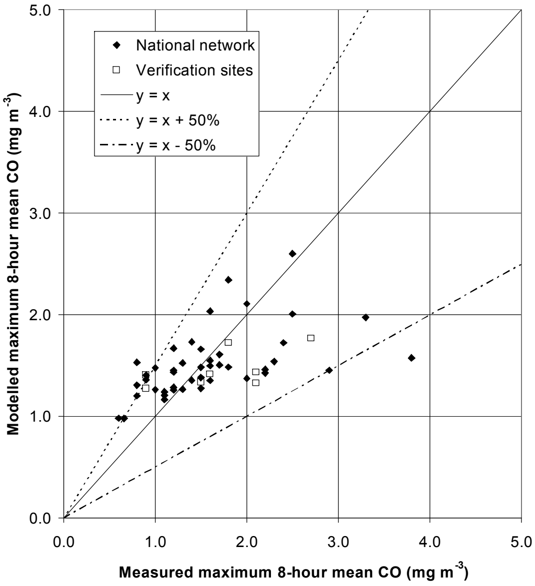


Figure 6.9. Verification of roadside annual mean CO model 2007

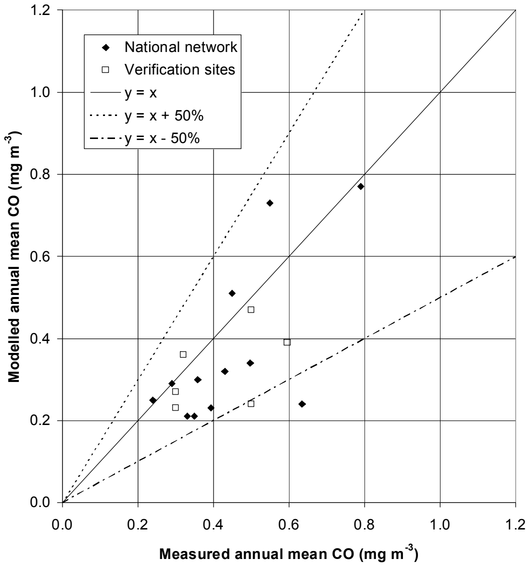


Figure 6.10. Verification of roadside maximum 8-hour mean CO model 2007

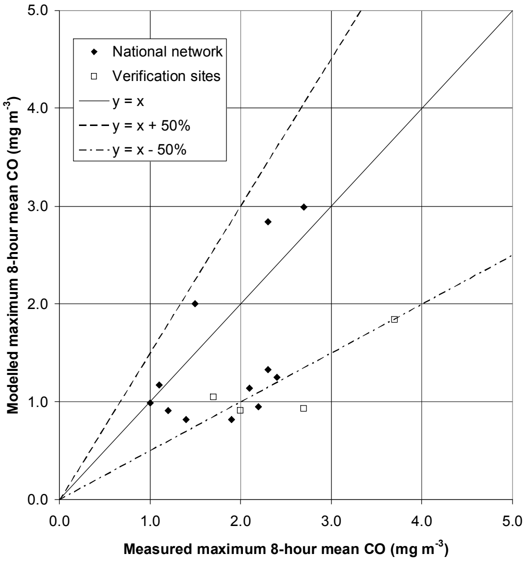


Table 6.1. Summary statistics for comparison between modelled and measured annual mean CO concentrations at background sites (mg m^{-3})

	Mean of measurements (mg m^{-3})	Mean of model estimates (mg m^{-3})	r^2	% outside data quality objectives	Number of sites
National Network	0.24	0.23	0.38	4.5	44
Verification Sites	0.34	0.23	0.01	11.8	17

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	1.58	1.48	0.29	15.9	44
Verification Sites	1.95	1.46	0.12	22.2	9

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	0.44	0.36	0.48	8.3	12
Verification Sites	0.43	0.33	0.25	16.7	6

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	1.75	1.41	0.27	16.7	12
Verification Sites	2.38	1.27	0.69	75.0	4

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 for 2007 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 2007

The tables included in this section are from Form 8 of the questionnaire. Exceedence (or otherwise) of the limit value (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 or not required for that zone (where the Article 5 Assessment illustrates that concentrations are lower than the Lower Assessment Threshold) 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.

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 Table 7.3, however we have assumed that a modelled exceedence of the Stage 1 24-hour LV implies an exceedence of the Stage 2 24-hour LV.

We have assessed that lead concentrations were below the LV in all zones where measurements have not been made on the basis of emission inventory results (objective estimation).

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) for SO_2 (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

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			m		m		n		n
Leicester Urban Area	UK0011			y		y		n		n
Portsmouth Urban Area	UK0012			m		m		n		n
Teesside Urban Area	UK0013			y		y		n		n
The Potteries	UK0014			m		m		n		n
Bournemouth Urban Area	UK0015			m		m		n		n
Reading/Wokingham Urban Area	UK0016			m		m		n		n
Coventry/Bedworth	UK0017			m		m		n		n
Kingston upon Hull	UK0018			y		y		n		n
Southampton Urban Area	UK0019			y		y		n		n
Birkenhead Urban Area	UK0020			m		m		n		n
Southend Urban Area	UK0021			m		m		n		n
Blackpool Urban Area	UK0022			m		m		n		n
Preston Urban Area	UK0023			m		m		n		n
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			m		m		n		n
Belfast Urban Area	UK0028			y		y		n		n
Eastern	UK0029			y		y		y		y
South West	UK0030			m		m		m		m

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
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			m		m		m		m
Central Scotland	UK0037			y		y		m		m
North East Scotland	UK0038			m		m		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			m		m		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) for NO_2 and NO_X (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

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

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
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		m			n
Belfast Urban Area	UK0028			y	m				n
Eastern	UK0029			y	m				y
South West	UK0030			y	y				y
South East	UK0031			y	y				y
East Midlands	UK0032			y	m				y
North West & Merseyside	UK0033			y	m				m
Yorkshire & Humberside	UK0034			y	m				y
West Midlands	UK0035			y	m				m
North East	UK0036			y	m				m
Central Scotland	UK0037			y	m				y
North East Scotland	UK0038			y	m				m
Highland	UK0039			y		m			m
Scottish Borders	UK0040			y			y		y
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) for PM_{10} (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

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	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV
Greater London Urban Area	UK0001	y			y			y		y		
West Midlands Urban Area	UK0002	m					y	y		m		
Greater Manchester Urban Area	UK0003			y			y	y		y		
West Yorkshire Urban Area	UK0004			y			y	y		m		
Tyneside	UK0005			y			y		y		m	
Liverpool Urban Area	UK0006			y			y	y			m	
Sheffield Urban Area	UK0007			y			y	y		m		
Nottingham Urban Area	UK0008			y			y	y		m		
Bristol Urban Area	UK0009			y			y	y		m		
Brighton/Worthing/Littlehampton	UK0010	y					y	y		y		
Leicester Urban Area	UK0011			m			m	m		m		
Portsmouth Urban Area	UK0012			y			y		y	m		
Teesside Urban Area	UK0013			y			y	y			y	
The Potteries	UK0014			y			y	y		m		
Bournemouth Urban Area	UK0015			y			y	y		y		
Reading/Wokingham Urban Area	UK0016			y			y	y		m		
Coventry/Bedworth	UK0017			y			y	y		m		
Kingston upon Hull	UK0018			y			y	y		m		
Southampton Urban Area	UK0019	m					y	y		m		
Birkenhead Urban Area	UK0020			y			y		y		m	
Southend Urban Area	UK0021			y			y	y			y	
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			y
Cardiff Urban Area	UK0026			y			y	y			y	
Swansea Urban Area	UK0027	m[a]					y	m			m	
Belfast Urban Area	UK0028			y			y		y	m		
Eastern	UK0029			y			y	y		m		
South West	UK0030			y			y	y		m		
South East	UK0031			y			y	y		m		

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	≤LV	>LV+ MOT	≤LV+ MOT; >LV	≤LV
East Midlands	UK0032			y			y		y	m		
North West & Merseyside	UK0033			m			m		m		m	
Yorkshire & Humberside	UK0034			y			y	y		m		
West Midlands	UK0035			y			y	y		m		
North East	UK0036			y			y	y			y	
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			y			y		y	m		
North Wales	UK0042			y			y	y			y	
Northern Ireland	UK0043			y			y		y		y	

[a] Two monitoring sites were used in Swansea urban area (UK0027) to measure PM10 concentrations in the vicinity of the Port Talbot industrial area in 2007. These are:

- Port Talbot (GB0651A), which was operational until 22/07/2007 and had a data capture of 54% in 2007 with 32 days exceeding the Stage 1 daily limit value
- Port Talbot Margam (GB0906A), which was operational from 28/07/2007 and had a data capture of 43% in 2007 with 13 days exceeding the Stage 1 daily limit value 313.

The two sites are located approximately 1 km apart. Neither site recorded an exceedence of the daily limit value on its own, but the combined data suggests that there would have been an exceedence. On this basis, we have made an objective assessment that there was an exceedence of the daily PM10 limit value in this zone in 2007.

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) for lead (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

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

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) for benzene (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

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			m
Teesside Urban Area	UK0013			y
The Potteries	UK0014			y
Bournemouth Urban Area	UK0015			m
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
Blackpool Urban Area	UK0022			m
Preston Urban Area	UK0023			m
Glasgow Urban Area	UK0024			y
Edinburgh Urban Area	UK0025			m
Cardiff Urban Area	UK0026			m
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) for CO (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

Zone	Zone code	LV		
		>LV + MOT	≤LV + MOT; >LV	≤LV
Greater London Urban Area	UK0001			y
West Midlands Urban Area	UK0002			m
Greater Manchester Urban Area	UK0003			y
West Yorkshire Urban Area	UK0004			y
Tyneside	UK0005			y
Liverpool Urban Area	UK0006			m
Sheffield Urban Area	UK0007			y
Nottingham Urban Area	UK0008			m
Bristol Urban Area	UK0009			y
Brighton/Worthing/Littlehampton	UK0010			m
Leicester Urban Area	UK0011			y
Portsmouth Urban Area	UK0012			m
Teesside Urban Area	UK0013			y
The Potteries	UK0014			m
Bournemouth Urban Area	UK0015			m
Reading/Wokingham Urban Area	UK0016			m
Coventry/Bedworth	UK0017			m
Kingston upon Hull	UK0018			y
Southampton Urban Area	UK0019			y
Birkenhead Urban Area	UK0020			m
Southend Urban Area	UK0021			m
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			m
South East	UK0031			m
East Midlands	UK0032			y
North West & Merseyside	UK0033			m
Yorkshire & Humberside	UK0034			m
West Midlands	UK0035			m
North East	UK0036			m
Central Scotland	UK0037			m
North East Scotland	UK0038			m
Highland	UK0039			m
Scottish Borders	UK0040			m
South Wales	UK0041			m
North Wales	UK0042			m
Northern Ireland	UK0043			m

7.2 Measured exceedences of Limit Values + Margins of Tolerance

Form 11 of the questionnaire requires reasons associated with the measured exceedences of the limit value and margin of tolerance to be documented. In most cases the reason is prescribed by the guidance documents for the questionnaire but there is scope to introduce bespoke reason for unique situations. Table 7.7 below presents the reason codes and associated explanations that were used in the compilation of the 2007 questionnaire.

Reasons for the specific exceedences submitted for 2007 are summarised for different pollutants in Tables 7.8 to 7.11 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 7.8. Measured exceedences of the limit value and margin of tolerance for annual mean NO_2 are listed in Table 7.9. Measured exceedences of the limit value for 24-hour mean and annual mean PM_{10} are listed in Tables 7.10 and 7.11 (there is no margin of tolerance for PM_{10} in 2007 as the limit values are now in force).

Table 7.7 Reason codes for exceedences submitted to Commission

Code	Explanation
S1	Heavily trafficked urban centre
S2	Proximity to a major road
S3	Local industry including power production
S4	Quarrying or mining activities
S5	Domestic heating
S6	Accidental emission from an industrial source
S7	Accidental emission from a non-industrial source
S8	Natural source(s) or natural event(s)
S9	Winter sanding of roads
S10	Transport of air pollution from sources outside the Member State
S11	Local petrol station
S12	Parking facility
S13	Benzene storage

Table 7.8. Measured exceedences of the 1-hour mean NO_2 limit value plus margin of tolerance, 2007 (Form 11e)

Site	Zone	Month	Day of month	Hour	Level ($\mu g/m^3$)	Reason code(s) *
Camden Kerbisde	UK0001	2	7	8	244	S2
Camden Kerbisde	UK0001	3	28	15	237	S2
Camden Kerbisde	UK0001	4	3	6	243	S2
Camden Kerbisde	UK0001	4	4	6	244	S2
Camden Kerbisde	UK0001	4	4	7	231	S2
Camden Kerbisde	UK0001	8	1	7	231	S2
Camden Kerbisde	UK0001	10	4	17	258	S2
Camden Kerbisde	UK0001	10	8	14	250	S2
Camden Kerbisde	UK0001	10	18	7	241	S2
Camden Kerbisde	UK0001	10	19	8	248	S2
Camden Kerbisde	UK0001	10	26	6	233	S2
Camden Kerbisde	UK0001	11	2	18	237	S2
Camden Kerbisde	UK0001	11	14	15	248	S2
Camden Kerbisde	UK0001	11	14	16	248	S2
Camden Kerbisde	UK0001	11	14	17	258	S2
Camden Kerbisde	UK0001	11	14	18	246	S2
Camden Kerbisde	UK0001	11	15	15	237	S2

Site	Zone	Month	Day of month	Hour	Level (μg/m^3)	Reason code(s) *
Camden Kerbisde	UK0001	11	15	16	290	S2
Camden Kerbisde	UK0001	11	15	17	244	S2
Camden Kerbisde	UK0001	11	15	18	231	S2
Camden Kerbisde	UK0001	11	16	8	235	S2
Camden Kerbisde	UK0001	11	16	17	264	S2
Camden Kerbisde	UK0001	11	16	18	254	S2
Camden Kerbisde	UK0001	11	23	16	296	S2
Camden Kerbisde	UK0001	11	27	7	243	S2
Camden Kerbisde	UK0001	12	11	16	265	S2
Camden Kerbisde	UK0001	12	11	17	235	S2
Camden Kerbisde	UK0001	12	11	18	309	S2
Camden Kerbisde	UK0001	12	11	19	246	S2
Camden Kerbisde	UK0001	12	12	6	309	S2
Camden Kerbisde	UK0001	12	12	7	390	S2
Camden Kerbisde	UK0001	12	12	8	371	S2
Camden Kerbisde	UK0001	12	12	9	342	S2
Camden Kerbisde	UK0001	12	12	10	342	S2
Camden Kerbisde	UK0001	12	12	11	344	S2
Camden Kerbisde	UK0001	12	12	12	302	S2
Camden Kerbisde	UK0001	12	12	13	279	S2
Camden Kerbisde	UK0001	12	12	14	248	S2
Camden Kerbisde	UK0001	12	12	15	283	S2
Camden Kerbisde	UK0001	12	12	16	267	S2
Camden Kerbisde	UK0001	12	12	17	281	S2
Camden Kerbisde	UK0001	12	12	18	283	S2
Camden Kerbisde	UK0001	12	12	19	237	S2
Camden Kerbisde	UK0001	12	12	20	237	S2
Camden Kerbisde	UK0001	12	13	10	279	S2
Camden Kerbisde	UK0001	12	13	11	243	S2
Camden Kerbisde	UK0001	12	13	12	258	S2
Camden Kerbisde	UK0001	12	13	14	243	S2
Camden Kerbisde	UK0001	12	20	8	244	S2
Camden Kerbisde	UK0001	12	20	12	233	S2
London Marylebone Road	UK0001	1	8	7	260	S2
London Marylebone Road	UK0001	1	8	8	250	S2
London Marylebone Road	UK0001	1	12	10	235	S2
London Marylebone Road	UK0001	1	17	12	233	S2
London Marylebone Road	UK0001	1	17	18	237	S2
London Marylebone Road	UK0001	1	19	14	239	S2
London Marylebone Road	UK0001	1	19	15	287	S2
London Marylebone Road	UK0001	1	19	16	233	S2
London Marylebone Road	UK0001	1	31	8	237	S2
London Marylebone Road	UK0001	1	31	9	267	S2
London Marylebone Road	UK0001	2	1	10	231	S2
London Marylebone Road	UK0001	2	7	17	273	S2
London Marylebone Road	UK0001	2	7	18	254	S2
London Marylebone Road	UK0001	2	13	12	231	S2
London Marylebone Road	UK0001	2	13	15	252	S2
London Marylebone Road	UK0001	2	21	15	239	S2
London Marylebone Road	UK0001	2	21	16	288	S2
London Marylebone Road	UK0001	2	21	17	239	S2
London Marylebone Road	UK0001	2	27	15	246	S2

Site	Zone	Month	Day of month	Hour	Level ($\mu g/m^3$)	Reason code(s) *
London Marylebone Road	UK0001	2	28	14	233	S2
London Marylebone Road	UK0001	2	28	15	237	S2
London Marylebone Road	UK0001	2	28	16	271	S2
London Marylebone Road	UK0001	3	6	15	264	S2
London Marylebone Road	UK0001	3	8	14	250	S2
London Marylebone Road	UK0001	3	8	15	262	S2
London Marylebone Road	UK0001	3	8	16	256	S2
London Marylebone Road	UK0001	3	8	17	256	S2
London Marylebone Road	UK0001	3	12	7	260	S2
London Marylebone Road	UK0001	3	14	12	241	S2
London Marylebone Road	UK0001	3	14	14	281	S2
London Marylebone Road	UK0001	3	15	7	239	S2
London Marylebone Road	UK0001	4	24	14	252	S2
London Marylebone Road	UK0001	4	24	15	239	S2
London Marylebone Road	UK0001	4	24	16	325	S2
London Marylebone Road	UK0001	4	25	9	231	S2
London Marylebone Road	UK0001	4	25	10	243	S2
London Marylebone Road	UK0001	4	25	11	264	S2
London Marylebone Road	UK0001	4	25	13	235	S2
London Marylebone Road	UK0001	4	25	14	235	S2
London Marylebone Road	UK0001	4	25	15	231	S2
London Marylebone Road	UK0001	4	25	16	237	S2
London Marylebone Road	UK0001	5	9	15	250	S2
London Marylebone Road	UK0001	5	11	11	233	S2
London Marylebone Road	UK0001	5	11	13	244	S2
London Marylebone Road	UK0001	5	11	15	235	S2
London Marylebone Road	UK0001	5	15	13	231	S2
London Marylebone Road	UK0001	5	15	14	264	S2
London Marylebone Road	UK0001	5	18	7	233	S2
London Marylebone Road	UK0001	5	19	16	243	S2
London Marylebone Road	UK0001	5	24	13	231	S2
London Marylebone Road	UK0001	5	24	14	254	S2
London Marylebone Road	UK0001	5	24	15	309	S2
London Marylebone Road	UK0001	5	24	17	233	S2
London Marylebone Road	UK0001	5	30	14	237	S2
London Marylebone Road	UK0001	5	30	15	243	S2
London Marylebone Road	UK0001	6	14	14	300	S2
London Marylebone Road	UK0001	6	14	15	273	S2
London Marylebone Road	UK0001	6	14	16	252	S2
London Marylebone Road	UK0001	6	21	13	239	S2
London Marylebone Road	UK0001	6	21	14	241	S2
London Marylebone Road	UK0001	6	22	8	235	S2
London Marylebone Road	UK0001	6	22	14	237	S2
London Marylebone Road	UK0001	6	22	15	239	S2
London Marylebone Road	UK0001	6	28	15	233	S2
London Marylebone Road	UK0001	6	29	14	275	S2
London Marylebone Road	UK0001	6	30	12	271	S2
London Marylebone Road	UK0001	7	3	14	243	S2
London Marylebone Road	UK0001	7	4	14	256	S2
London Marylebone Road	UK0001	7	5	15	237	S2
London Marylebone Road	UK0001	7	5	16	237	S2
London Marylebone Road	UK0001	7	6	12	233	S2

Site	Zone	Month	Day of month	Hour	Level (μg/m^3)	Reason code(s) *
London Marylebone Road	UK0001	7	12	7	237	S2
London Marylebone Road	UK0001	7	12	12	235	S2
London Marylebone Road	UK0001	7	12	14	235	S2
London Marylebone Road	UK0001	7	13	15	233	S2
London Marylebone Road	UK0001	7	16	11	239	S2
London Marylebone Road	UK0001	7	16	14	252	S2
London Marylebone Road	UK0001	7	16	15	264	S2
London Marylebone Road	UK0001	7	18	15	235	S2
London Marylebone Road	UK0001	7	18	16	233	S2
London Marylebone Road	UK0001	7	19	15	235	S2
London Marylebone Road	UK0001	7	20	11	308	S2
London Marylebone Road	UK0001	7	27	16	285	S2
London Marylebone Road	UK0001	7	27	17	235	S2
London Marylebone Road	UK0001	8	1	14	233	S2
London Marylebone Road	UK0001	9	13	10	258	S2
London Marylebone Road	UK0001	9	13	15	296	S2
London Marylebone Road	UK0001	9	13	16	258	S2
London Marylebone Road	UK0001	9	13	17	246	S2
London Marylebone Road	UK0001	9	20	15	233	S2
London Marylebone Road	UK0001	9	25	6	233	S2
London Marylebone Road	UK0001	10	3	14	244	S2
London Marylebone Road	UK0001	10	3	15	248	S2
London Marylebone Road	UK0001	10	9	10	239	S2
London Marylebone Road	UK0001	10	11	13	265	S2
London Marylebone Road	UK0001	10	11	14	231	S2
London Marylebone Road	UK0001	10	15	6	262	S2
London Marylebone Road	UK0001	10	26	12	256	S2
London Marylebone Road	UK0001	10	31	15	260	S2
London Marylebone Road	UK0001	10	31	16	294	S2
London Marylebone Road	UK0001	11	1	7	243	S2
London Marylebone Road	UK0001	11	1	8	260	S2
London Marylebone Road	UK0001	11	8	8	269	S2
London Marylebone Road	UK0001	11	8	14	231	S2
London Marylebone Road	UK0001	11	13	7	252	S2
London Marylebone Road	UK0001	11	13	8	254	S2
London Marylebone Road	UK0001	11	16	0	264	S2
London Marylebone Road	UK0001	11	16	6	252	S2
London Marylebone Road	UK0001	11	16	7	267	S2
London Marylebone Road	UK0001	11	16	10	288	S2
London Marylebone Road	UK0001	11	16	11	290	S2
London Marylebone Road	UK0001	11	16	12	260	S2
London Marylebone Road	UK0001	11	16	14	325	S2
London Marylebone Road	UK0001	11	16	15	329	S2
London Marylebone Road	UK0001	11	16	16	308	S2
London Marylebone Road	UK0001	11	16	17	317	S2
London Marylebone Road	UK0001	11	16	18	315	S2
London Marylebone Road	UK0001	11	16	19	287	S2
London Marylebone Road	UK0001	11	16	21	258	S2
London Marylebone Road	UK0001	11	21	15	256	S2
London Marylebone Road	UK0001	11	21	16	298	S2
London Marylebone Road	UK0001	11	21	17	252	S2
London Marylebone Road	UK0001	11	21	18	243	S2

Site	Zone	Month	Day of month	Hour	Level (µg/m^3)	Reason code(s) *
London Marylebone Road	UK0001	11	21	19	241	S2
London Marylebone Road	UK0001	11	22	15	237	S2
London Marylebone Road	UK0001	11	27	8	252	S2
London Marylebone Road	UK0001	11	27	14	252	S2
London Marylebone Road	UK0001	11	28	8	243	S2
London Marylebone Road	UK0001	11	28	17	244	S2
London Marylebone Road	UK0001	11	29	7	233	S2
London Marylebone Road	UK0001	11	29	8	300	S2
London Marylebone Road	UK0001	11	30	17	233	S2
London Marylebone Road	UK0001	12	5	16	264	S2
London Marylebone Road	UK0001	12	6	14	231	S2
London Marylebone Road	UK0001	12	6	15	264	S2
London Marylebone Road	UK0001	12	11	17	288	S2
London Marylebone Road	UK0001	12	11	21	252	S2
London Marylebone Road	UK0001	12	11	22	233	S2
London Marylebone Road	UK0001	12	11	23	244	S2
London Marylebone Road	UK0001	12	12	0	239	S2
London Marylebone Road	UK0001	12	12	7	271	S2
London Marylebone Road	UK0001	12	12	8	267	S2
London Marylebone Road	UK0001	12	12	9	258	S2
London Marylebone Road	UK0001	12	12	10	298	S2
London Marylebone Road	UK0001	12	12	12	300	S2
London Marylebone Road	UK0001	12	13	15	241	S2
London Marylebone Road	UK0001	12	22	10	252	S2
London Marylebone Road	UK0001	12	27	16	239	S2
London Marylebone Road	UK0001	12	28	10	265	S2
London Marylebone Road	UK0001	12	29	9	306	S2
London Marylebone Road	UK0001	12	29	10	300	S2
London Marylebone Road	UK0001	12	30	15	244	S2
London Marylebone Road	UK0001	12	30	20	244	S2
London Marylebone Road	UK0001	12	30	22	244	S2
London Marylebone Road	UK0001	12	30	23	243	S2
London Marylebone Road	UK0001	12	31	10	315	S2
London Marylebone Road	UK0001	12	31	11	304	S2
London Marylebone Road	UK0001	12	31	12	302	S2
London Marylebone Road	UK0001	12	31	13	292	S2
London Marylebone Road	UK0001	12	31	14	285	S2
London Marylebone Road	UK0001	12	31	15	327	S2
London Marylebone Road	UK0001	12	31	16	273	S2
London Marylebone Road	UK0001	12	31	17	306	S2
London Marylebone Road	UK0001	12	31	18	321	S2
London Marylebone Road	UK0001	12	31	19	252	S2
London Marylebone Road	UK0001	12	31	21	241	S2

* see Table 7.7 for details

Table 7.9. Measured exceedences of the annual mean NO_2 limit value plus margin of tolerance, 2007 (Form 11f)

Site	Zone	Level ($\mu g\ m^{-3}$)	Reason code(s) *
Bath Roadside	UK0030	63	S2
Bristol Old Market	UK0009	61	S2
Bury Roadside	UK0003	65	S2
Camden Kerbside	UK0001	77	S2
Glasgow City Chambers	UK0024	47	S1
Glasgow Kerbside	UK0024	70	S2
London Bloomsbury	UK0001	61	S1;S2
London Cromwell Road 2	UK0001	72	S2
London Marylebone Road	UK0001	102	S2
Oxford Centre Roadside	UK0031	57	S2
Tower Hamlets Roadside	UK0001	67	S2

* see Table 7.7 for details

Table 7.10. Measured exceedences of the 24-hour mean PM_{10} limit value, 2007 (Form 11h).

Site	Zone	Month	Day of month	Level ($\mu g\ m^{-3}$)	Reason code(s) *
Brighton Roadside PM10	UK0010	1	14	59	S2
Brighton Roadside PM10	UK0010	1	30	55	S2
Brighton Roadside PM10	UK0010	2	4	54	S2
Brighton Roadside PM10	UK0010	2	5	63	S2
Brighton Roadside PM10	UK0010	2	6	53	S2
Brighton Roadside PM10	UK0010	2	7	58	S2
Brighton Roadside PM10	UK0010	2	11	52	S2
Brighton Roadside PM10	UK0010	2	13	55	S2
Brighton Roadside PM10	UK0010	2	15	54	S2
Brighton Roadside PM10	UK0010	2	16	54	S2
Brighton Roadside PM10	UK0010	2	19	59	S2
Brighton Roadside PM10	UK0010	2	28	66	S2
Brighton Roadside PM10	UK0010	3	24	52	S2;S10
Brighton Roadside PM10	UK0010	3	25	99	S2;S10
Brighton Roadside PM10	UK0010	3	26	69	S2;S10
Brighton Roadside PM10	UK0010	3	27	92	S2;S10
Brighton Roadside PM10	UK0010	3	28	117	S2;S10
Brighton Roadside PM10	UK0010	3	29	64	S2;S10
Brighton Roadside PM10	UK0010	3	30	71	S2;S10
Brighton Roadside PM10	UK0010	3	31	69	S2;S10
Brighton Roadside PM10	UK0010	4	1	67	S2;S10
Brighton Roadside PM10	UK0010	4	2	66	S2;S10
Brighton Roadside PM10	UK0010	4	6	51	S2
Brighton Roadside PM10	UK0010	4	12	64	S2;S10
Brighton Roadside PM10	UK0010	4	13	80	S2;S10
Brighton Roadside PM10	UK0010	4	14	82	S2;S10
Brighton Roadside PM10	UK0010	4	15	79	S2;S10
Brighton Roadside PM10	UK0010	4	16	71	S2;S10
Brighton Roadside PM10	UK0010	4	22	52	S2;S10
Brighton Roadside PM10	UK0010	4	24	51	S2
Brighton Roadside PM10	UK0010	4	27	53	S2
Brighton Roadside PM10	UK0010	5	6	55	S2
Brighton Roadside PM10	UK0010	5	12	54	S2
Brighton Roadside PM10	UK0010	10	3	58	S2
Brighton Roadside PM10	UK0010	10	7	52	S2
Brighton Roadside PM10	UK0010	10	11	57	S2
Brighton Roadside PM10	UK0010	10	17	55	S2
Brighton Roadside PM10	UK0010	10	26	54	S2
Brighton Roadside PM10	UK0010	11	26	58	S2
Brighton Roadside PM10	UK0010	12	3	70	S2
Camden Kerbside	UK0001	1	25	62	S2
Camden Kerbside	UK0001	1	29	66	S2
Camden Kerbside	UK0001	2	2	55	S2
Camden Kerbside	UK0001	2	3	54	S2
Camden Kerbside	UK0001	2	5	66	S2
Camden Kerbside	UK0001	2	6	82	S2
Camden Kerbside	UK0001	2	7	77	S2
Camden Kerbside	UK0001	2	16	60	S2
Camden Kerbside	UK0001	2	17	55	S2

Site	Zone	Month	Day of month	Level ($\mu g\ m^{-3}$)	Reason code(s) *
Camden Kerbside	UK0001	3	24	64	S2;S10
Camden Kerbside	UK0001	3	25	91	S2;S10
Camden Kerbside	UK0001	3	26	66	S2;S10
Camden Kerbside	UK0001	3	27	85	S2;S10
Camden Kerbside	UK0001	3	28	91	S2;S10
Camden Kerbside	UK0001	3	30	61	S2;S10
Camden Kerbside	UK0001	3	31	57	S2;S10
Camden Kerbside	UK0001	4	1	52	S2;S10
Camden Kerbside	UK0001	4	2	60	S2;S10
Camden Kerbside	UK0001	4	16	58	S2;S10
Camden Kerbside	UK0001	6	8	56	S2
Camden Kerbside	UK0001	6	9	59	S2
Camden Kerbside	UK0001	9	7	53	S2
Camden Kerbside	UK0001	9	12	54	S2
Camden Kerbside	UK0001	9	13	54	S2
Camden Kerbside	UK0001	10	3	55	S2
Camden Kerbside	UK0001	10	12	53	S2
Camden Kerbside	UK0001	10	19	53	S2
Camden Kerbside	UK0001	10	22	55	S2
Camden Kerbside	UK0001	10	26	53	S2
Camden Kerbside	UK0001	11	4	62	S2;S7
Camden Kerbside	UK0001	11	5	81	S2;S7
Camden Kerbside	UK0001	11	16	73	S2
Camden Kerbside	UK0001	12	11	64	S2
Camden Kerbside	UK0001	12	12	102	S2
Camden Kerbside	UK0001	12	13	70	S2
Camden Kerbside	UK0001	12	14	67	S2
Camden Kerbside	UK0001	12	19	80	S2
Camden Kerbside	UK0001	12	20	59	S2
Camden Kerbside	UK0001	12	21	65	S2
Camden Kerbside	UK0001	12	22	60	S2
Glasgow Kerbside	UK0024	1	24	56	S2
Glasgow Kerbside	UK0024	2	7	91	S2
Glasgow Kerbside	UK0024	2	8	58	S2
Glasgow Kerbside	UK0024	2	9	62	S2
Glasgow Kerbside	UK0024	2	14	51	S2
Glasgow Kerbside	UK0024	2	16	60	S2
Glasgow Kerbside	UK0024	2	23	55	S2
Glasgow Kerbside	UK0024	3	22	65	S2
Glasgow Kerbside	UK0024	3	23	86	S2
Glasgow Kerbside	UK0024	3	24	68	S2
Glasgow Kerbside	UK0024	3	25	70	S2;S10
Glasgow Kerbside	UK0024	3	26	94	S2;S10
Glasgow Kerbside	UK0024	3	27	102	S2;S10
Glasgow Kerbside	UK0024	3	28	62	S2;S10
Glasgow Kerbside	UK0024	3	29	54	S2;S10
Glasgow Kerbside	UK0024	3	30	92	S2;S10
Glasgow Kerbside	UK0024	4	2	55	S2;S10
Glasgow Kerbside	UK0024	4	13	65	S2;S10
Glasgow Kerbside	UK0024	4	14	70	S2;S10
Glasgow Kerbside	UK0024	4	20	52	S2

Site	**Zone**	**Month**	**Day of month**	**Level ($\mu g\ m^{-3}$)**	**Reason code(s) ***
Glasgow Kerbside	UK0024	5	3	51	S2
Glasgow Kerbside	UK0024	8	14	51	S2
Glasgow Kerbside	UK0024	8	21	53	S2
Glasgow Kerbside	UK0024	9	28	51	S2
Glasgow Kerbside	UK0024	10	23	52	S2
Glasgow Kerbside	UK0024	10	24	60	S2
Glasgow Kerbside	UK0024	10	25	63	S2
Glasgow Kerbside	UK0024	11	14	73	S2
Glasgow Kerbside	UK0024	11	15	68	S2
Glasgow Kerbside	UK0024	11	20	58	S2
Glasgow Kerbside	UK0024	12	11	56	S2
Glasgow Kerbside	UK0024	12	13	54	S2
Glasgow Kerbside	UK0024	12	14	62	S2
Glasgow Kerbside	UK0024	12	15	55	S2
Glasgow Kerbside	UK0024	12	18	60	S2
Glasgow Kerbside	UK0024	12	19	60	S2
Glasgow Kerbside	UK0024	12	21	51	S2
Glasgow Kerbside	UK0024	12	22	51	S2
London Marylebone Road	UK0001	1	11	51	S2
London Marylebone Road	UK0001	1	12	55	S2
London Marylebone Road	UK0001	1	16	51	S2
London Marylebone Road	UK0001	1	26	56	S2
London Marylebone Road	UK0001	1	30	53	S2
London Marylebone Road	UK0001	1	31	57	S2
London Marylebone Road	UK0001	2	1	78	S2
London Marylebone Road	UK0001	2	7	79	S2
London Marylebone Road	UK0001	2	13	67	S2
London Marylebone Road	UK0001	2	15	62	S2
London Marylebone Road	UK0001	2	16	59	S2
London Marylebone Road	UK0001	2	19	60	S2
London Marylebone Road	UK0001	2	20	61	S2
London Marylebone Road	UK0001	2	21	55	S2
London Marylebone Road	UK0001	2	22	55	S2
London Marylebone Road	UK0001	2	23	59	S2
London Marylebone Road	UK0001	2	28	52	S2
London Marylebone Road	UK0001	3	2	52	S2
London Marylebone Road	UK0001	3	6	56	S2
London Marylebone Road	UK0001	3	8	66	S2
London Marylebone Road	UK0001	3	10	55	S2
London Marylebone Road	UK0001	3	14	62	S2
London Marylebone Road	UK0001	3	15	56	S2
London Marylebone Road	UK0001	3	25	93	S2;S10
London Marylebone Road	UK0001	3	26	73	S2;S10
London Marylebone Road	UK0001	3	27	85	S2;S10
London Marylebone Road	UK0001	3	28	79	S2;S10
London Marylebone Road	UK0001	3	30	54	S2;S10
London Marylebone Road	UK0001	3	31	52	S2;S10
London Marylebone Road	UK0001	4	1	52	S2;S10
London Marylebone Road	UK0001	4	2	60	S2;S10
London Marylebone Road	UK0001	4	5	52	S2
London Marylebone Road	UK0001	4	19	55	S2

Site	Zone	Month	Day of month	Level (μg m^{-3})	Reason code(s) *
London Marylebone Road	UK0001	4	20	61	S2
London Marylebone Road	UK0001	4	22	59	S2
London Marylebone Road	UK0001	4	23	68	S2
London Marylebone Road	UK0001	4	24	60	S2
London Marylebone Road	UK0001	4	25	51	S2
London Marylebone Road	UK0001	5	6	51	S2
London Marylebone Road	UK0001	5	8	63	S2
London Marylebone Road	UK0001	5	10	51	S2
London Marylebone Road	UK0001	5	11	52	S2
London Marylebone Road	UK0001	5	12	56	S2
London Marylebone Road	UK0001	5	15	58	S2
London Marylebone Road	UK0001	5	18	59	S2
London Marylebone Road	UK0001	5	19	51	S2
London Marylebone Road	UK0001	5	24	55	S2
London Marylebone Road	UK0001	5	30	55	S2
London Marylebone Road	UK0001	5	31	59	S2
London Marylebone Road	UK0001	6	9	54	S2
London Marylebone Road	UK0001	6	12	59	S2
London Marylebone Road	UK0001	6	13	56	S2
London Marylebone Road	UK0001	6	14	59	S2
London Marylebone Road	UK0001	6	15	59	S2
London Marylebone Road	UK0001	6	18	61	S2
London Marylebone Road	UK0001	6	19	62	S2
London Marylebone Road	UK0001	6	20	58	S2
London Marylebone Road	UK0001	6	21	61	S2
London Marylebone Road	UK0001	6	22	52	S2
London Marylebone Road	UK0001	6	28	58	S2
London Marylebone Road	UK0001	6	29	52	S2
London Marylebone Road	UK0001	7	3	58	S2
London Marylebone Road	UK0001	7	4	52	S2
London Marylebone Road	UK0001	7	6	56	S2
London Marylebone Road	UK0001	7	12	60	S2
London Marylebone Road	UK0001	7	13	58	S2
London Marylebone Road	UK0001	7	16	57	S2
London Marylebone Road	UK0001	7	17	55	S2
London Marylebone Road	UK0001	7	18	52	S2
London Marylebone Road	UK0001	7	26	59	S2
London Marylebone Road	UK0001	7	27	63	S2
London Marylebone Road	UK0001	8	1	57	S2
London Marylebone Road	UK0001	8	3	56	S2
London Marylebone Road	UK0001	8	11	58	S2
London Marylebone Road	UK0001	8	17	53	S2
London Marylebone Road	UK0001	8	25	51	S2
London Marylebone Road	UK0001	9	19	60	S2
London Marylebone Road	UK0001	9	20	64	S2
London Marylebone Road	UK0001	9	21	62	S2
London Marylebone Road	UK0001	9	22	54	S2
London Marylebone Road	UK0001	9	24	59	S2
London Marylebone Road	UK0001	10	3	69	S2
London Marylebone Road	UK0001	10	9	61	S2
London Marylebone Road	UK0001	10	11	83	S2

Site	Zone	Month	Day of month	Level (μg m^{-3})	Reason code(s) *
London Marylebone Road	UK0001	10	12	51	S2
London Marylebone Road	UK0001	10	14	59	S2
London Marylebone Road	UK0001	10	15	79	S2
London Marylebone Road	UK0001	10	16	66	S2
London Marylebone Road	UK0001	10	19	57	S2
London Marylebone Road	UK0001	10	21	58	S2
London Marylebone Road	UK0001	10	22	61	S2
London Marylebone Road	UK0001	10	26	70	S2
London Marylebone Road	UK0001	10	27	62	S2
London Marylebone Road	UK0001	10	31	74	S2
London Marylebone Road	UK0001	11	1	55	S2
London Marylebone Road	UK0001	11	2	51	S2
London Marylebone Road	UK0001	11	4	61	S2;S7
London Marylebone Road	UK0001	11	5	103	S2;S7
London Marylebone Road	UK0001	11	8	51	S2
London Marylebone Road	UK0001	11	16	105	S2
London Marylebone Road	UK0001	11	17	66	S2
London Marylebone Road	UK0001	11	21	62	S2
London Marylebone Road	UK0001	11	24	62	S2
London Marylebone Road	UK0001	11	27	70	S2
London Marylebone Road	UK0001	11	28	58	S2
London Marylebone Road	UK0001	11	29	53	S2
London Marylebone Road	UK0001	11	30	53	S2
London Marylebone Road	UK0001	12	4	61	S2
London Marylebone Road	UK0001	12	5	55	S2
London Marylebone Road	UK0001	12	6	53	S2
London Marylebone Road	UK0001	12	11	69	S2
London Marylebone Road	UK0001	12	12	97	S2
London Marylebone Road	UK0001	12	13	73	S2
London Marylebone Road	UK0001	12	14	68	S2
London Marylebone Road	UK0001	12	19	85	S2
London Marylebone Road	UK0001	12	20	67	S2
London Marylebone Road	UK0001	12	21	76	S2
London Marylebone Road	UK0001	12	22	72	S2
London Marylebone Road	UK0001	12	23	52	S2

* see Table 7.7 for details

Table 7.11. Measured exceedences of the annual mean PM_{10} limit value (Stage 1), 2007 (Form 11i)

Site	Zone	Level (μg m^{-3})	Reason code(s) *
London Marylebone Road	UK0001	45	S2;S10

* see Table 7.7 for details

7.3 Comparison with previous years

Tables 7.12 and 7.13 provide a comparison of the monitoring and modelling results for 2007 with the results of the air quality assessments reported to the EU for 2001, 2002, 2003, 2004, 2005 and 2006 (Stedman, *et al.,* 2002, Stedman, *et al.,* 2003, Stedman, *et al.,* 2005, Stedman, *et al.,* 2006a, Kent, *et al.*, 2007a, Kent, *et al.*, 2007b). 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.

No modelled exceedences of the 1-hour LV and 24-hour LV for SO_2 were reported for 2007. Modelled exceedences of the 1-hour LV and 24-hour LV for SO_2 were reported for 2006, 2005 and 2004. These exceedences were limited to Stewartby in Eastern zone. There were also 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, 2005, 2006 and 2007 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). Increasing contributions to ambient NO_2 from primary NO_2 directly emitted from road traffic sources have been the focus of research by the Air Quality Expert Group (AQEG, 2007). Reasons may include changes in traffic management and fleet emission characteristics. The number of zones in which there were modelled exceedences of the annual mean LV + MOT increased from 2006 to 2007, as it did from 2005 to 2006, although the number of measured exceedences remained the same. Exceedences of the 1-hour mean limit value and annual mean LV in increased in 2007 compared to 2006, though only by 1 zone or 2 zones, respectively. There were no reported exceedences of the annual mean LV for NO_X in vegetation areas.

Exceedences of ‘old’ directives are listed in Table 7.14. Directive 85/203/EEC was exceeded at one monitoring site, Marylebone Road, in 2007 as in the previous 4 years.

Far fewer zones exceeded the Stage 1 24-hour limit value for PM_{10} in 2007 than originally reported for 2005 and 2006. The larger number of zones originally reported as exceeding in 2005 and 2006 was in part due to a measurement bias in the Partisol measurements used to calibrate the PCM models used for these assessments. A total of 29 zones (3 measured and 26 modelled) for 2005 and 30 zones (5 measured and 25 modelled) for 2006 were reported as exceeding the daily limit value.

In 2008, evidence emerged that the gravimetric samplers used to validate the 2005 model were reading higher levels of PM10 than other sampling units TEOM-FDMS) which had also been shown to be equivalent to the reference method. An extensive investigation of this issue (Maggs, 2008) concluded that this over-read was genuine and that no single cause could be identified. The result of the investigation was a recommendation that the gravimetric sampling data used should be corrected.

The annual mean PM_{10} concentrations measured using Partisol instruments for 2005 and 2006 have therefore been corrected for this bias. The PCM models have been recalibrated using these revised concentrations and the air quality assessments for 2005 and 2006 have been repeated to provide a more realistic assessment of the exceedence status of each zone. We have therefore included the results of these new assessments for 2005 and 2006 alongside the previously reported results. These revised assessments show a total of eight zones (3 measured and 5 modelled) for 2005 and 15 zones (five measured and ten modelled) for 2006 exceeding the daily limit value.

There were no exceedences for Lead in 2001, 2002, 2003, 2004, 2005, 2006 or 2007.

There were no exceedences of the benzene LV reported in 2007. One exceedence of the benzene LV was modelled in 2006 but there were no modelled exceedences of the LV + MOT. These exceedences were modelled in close proximity to a large oil refinery at Killingholme. CO concentrations were below the LV in all zones in 2007, 2006 and 2005.

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

Pollutant	Averaging time	2007	2006	2005	2004	2003	2002	2001
SO_2	1-hour	n/a	n/a	n/a	1 zone modelled (Eastern)	1 zone modelled (Eastern)	none	none
SO_2	24-hour[1]	n/a	n/a	n/a	none	1 zone modelled (Eastern)	none	1 zone measured (Belfast Urban Area)
SO_2	annual[2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SO_2	winter[2]	n/a	n/a	n/a	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)	1 zone measured (Greater London Urban Area)	1 zone measured (Greater London Urban Area)	1 zone measured (Greater London Urban Area)	none	none
NO_2	annual	39 zones (6 measured + 33 modelled)	38 zones (6 measured + 32 modelled)	35 zones (6 measured + 29 modelled)	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	n/a	n/a	n/a
PM_{10}	24-hour (Stage 1)	n/a	n/a	n/a	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)	n/a	n/a	n/a	1 zone modelled (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	n/a	n/a	n/a
PM_{10}	annual[5] (Stage 2)	25 zones (5 measured + 20 modelled)	36 zones (8 measured + 28 modelled)	32 zones (3 measured + 29 modelled)	32 zones (3 measured + 29 modelled)	36 zones (8 measured + 28 modelled)	22 zones (3 measured + 19 modelled)	not assessed
Lead	annual	n/a	n/a	n/a	none	none	none	none

Pollutant	**Averaging time**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Benzene	annual	none	none	none	none	none	not assessed	not assessed
CO	8-hour	n/a	n/a	n/a	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 7.13 Exceedences of limit values for 1st and 2nd Daughter Directives

Pollutant	**Averaging time**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
SO_2	1-hour	none	1 zone modelled (Eastern)	1 zone modelled (Eastern)	1 zone modelled (Eastern)	1 zone modelled (Eastern)	none	none
SO_2	24-hour[1]	none	1 zone modelled (Eastern)	1 zone modelled (Eastern)	none	1 zone modelled (Eastern)	none	1 Zone measured (Belfast Urban Area)
SO_2	Annual[2]	none	none	none	none	none	none	none
SO_2	Winter[2]	none	none	none	none	none	none	not assessed
NO_2	1-hour[3]	2 zones measured (London, Glasgow)	1 zone measured (Greater London Urban Area)	2 zones measured (London, Bristol)	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	41 zones (8 measured + 33 modelled)	39 zones (7 measured + 32 modelled)	38 zones (8 measured + 30 modelled)	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	none	none	None
PM_{10}	24-hour (Stage 1)[4]	6 zones (3 measured + 3 modelled)	30 zones (5 measured + 25 modelled) *[15 zones (5 measured + 10 modelled)]*	29 zones (3 measured + 26 modelled) *[8 zones (3 measured + 5 modelled)]*	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)[4]	1 zone (measured)	2 zones (1 measured + 1 modelled) *[1 zone (measured)]*	4 zones (1 measured + 3 modelled) *[1 zone (measured)]*	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 (London measured, Manchester modelled)
PM_{10}	24-hour[5] (Stage 2)	30 zones (28 measured + 2 modelled))	22 zones (22 measured)	13 zones (13 measured)	15 zones (15 measured)	36 zones (36 measured)	21 zones (21 measured)	25 zones (25 measured)

Pollutant	**Averaging time**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
PM_{10}	Annual[6] (Stage 2)	41 zones (27 measured + 14 modelled)	42 zones (8 measured + 34 modelled)	40 zones (26 measured + 14 modelled)	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	none	none	none
Benzene	Annual	none	1 zone modelled (Yorkshire & Humberside)	2 zones modelled (Yorkshire & Humberside, Central Scotland)	none	1 zone modelled (Greater London Urban Area)	not assessed	not assessed
CO	8-hour	none	none	none	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] Numbers given in italics are corrected for the bias of Partisol measurements (see text at beginning of section 7.3)
[5] Stage 2 indicative LV, no modelling for 24-hour Stage 2 LV
[6] Stage 2 indicative LV

Table 7.14 Exceedences of old Directives

Pollutant	Averaging time	**2007** Concentration (μg m^{-3})	**2006** Concentration (μg m^{-3})	**2005** Concentration (μg m^{-3})	**2004** Concentration (μg m^{-3})
NO_2	1-hour 98%ile	229 (measured at London Marylebone Road)	244 (measured at London Marylebone Road)	256 (measured at London Marylebone Road)	233 (measured at London Marylebone Road)

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Appendices

Appendix 1: Monitoring sites used to verify the mapped estimates

Appendix 2: Small point source model

Appendix 3: Dispersion kernels for area source model

Appendix 4: Model assessment of SO_2 concentrations at Stewartby brick works

Appendix 5: Air Quality monitoring data from Gibraltar in 2007

Appendix 6: Data scaling for 2007 annual means

Appendix 1 Monitoring sites used to verify the mapped estimates

Table A1.1. Monitoring sites used to verify the mapped estimates (PM_{10} measurements by gravimetric and TEOM instruments were used in the verification)

Site Name	Site type	LA/Network	CO	NO2	SO2	PM10
Aberdeen Anderson Dr	ROADSIDE	Aberdeen City Council		Y		Y
Aberdeen Market St	ROADSIDE	Aberdeen City Council		Y		Y
Aberdeen Union St	ROADSIDE	Aberdeen City Council		Y		Y
Abingdon	URBAN BACKGROUND	Vale of White Horse DC		Y	Y	Y
Antrim Greystone Estate	URBAN BACKGROUND	Antrim BC			Y	
Armagh Lonsdale Road	KERBSIDE	Armagh City DC		Y		
Ashford Roadside	ROADSIDE	Kent & Medway Air Quality Network		Y		Y
Ballymena Ballykeel	URBAN BACKGROUND	Ballymena BC			Y	Y
Ballymena North Road	KERBSIDE	Ballymena BC		Y		
Barnsley A628 Roadside	ROADSIDE	Barnsley MBC		Y		
Barnsley Old Mill Lane Roadside	ROADSIDE	Barnsley MBC		Y		Y
Barnsley Royston	ROADSIDE	Barnsley MBC		Y		Y
Belfast Roadside	ROADSIDE	Belfast City Council		Y		
Boston Haven Bridge Road	ROADSIDE	Boston BC		Y		
Cambridge Gonville Place	ROADSIDE	Cambridge City Council		Y		Y
Cambridge Newmarket Road	ROADSIDE	Cambridge City Council		Y		
Cambridge Parker Street	ROADSIDE	Cambridge City Council		Y		Y
Canterbury Roadside	ROADSIDE	Kent & Medway Air Quality Network		Y		
Cardiff Briardene	ROADSIDE	Welsh Air Quality Forum	Y	Y		Y
Carrickfergus Rosebrook Avenue	URBAN BACKGROUND	Carrickfergus BC			Y	Y
Castlereagh Lough View Drive	ROADSIDE	Castlereagh BC		Y		Y
Chatham Roadside	ROADSIDE	Kent & Medway Air Quality Network		Y		Y
Chepstow	ROADSIDE	Monthmouthshire CC		Y		Y
Chesterfield Whittington Roadside	ROADSIDE	Chesterfield BC		Y		Y
Derry Brandywell	URBAN BACKGROUND	Derry City Council			Y	Y
Derry Dale's Corner	KERBSIDE	Derry City Council		Y		
Dover Docks	URBAN INDUSTRIAL	Kent & Medway Air Quality Network		Y	Y	
Dundee Broughty Ferry Road	ROADSIDE	Dundee City Council				Y
Dundee Lochee Road	ROADSIDE	Dundee City Council		Y		

Dundee Mains Loan	URBAN BACKGROUND	Dundee City Council				Y
Dundee Seagate	KERBSIDE	Dundee City Council		Y		
Dundee Union Street	KERBSIDE	Dundee City Council		Y		Y
Dundee Whitehall Street	KERBSIDE	Dundee City Council		Y		
Fife Cupar	ROADSIDE	Welsh Air Quality Forum		Y		Y
Fife Kincardine	ROADSIDE	Welsh Air Quality Forum		Y		
Gatwick LGW3	AIRPORT	BAA	Y	Y		Y
Glasgow Anderston	URBAN BACKGROUND	Glasgow City Council	Y	Y	Y	Y
Glasgow Battlefield Road	ROADSIDE	Glasgow City Council		Y		Y
Glasgow Byres Road	ROADSIDE	Glasgow City Council	Y	Y		Y
Glasgow Waulkmillglen Reservoir	RURAL	Glasgow City Council		Y		Y
Guildford Gyratory	ROADSIDE	Guildford BC		Y		
Heathrow Bedfont Court	AIRPORT	BAA				Y
Heathrow Green Gates	AIRPORT	BAA		Y		Y
Heathrow LHR2	AIRPORT	BAA	Y	Y		Y
Heathrow Main Road	AIRPORT	BAA	Y	Y	Y	Y
Heathrow Moorbridge	AIRPORT	BAA				Y
Heathrow Oaks Road	AIRPORT	BAA		Y		Y
Ipswich Piper's Court	ROADSIDE	Ipswich BC		Y		
Larne Craigyhill	URBAN BACKGROUND	Larne BC			Y	
Lisburn Dunmurry High School	URBAN BACKGROUND	Lisburn City Council			Y	Y
Lisburn Island Civic Centre	URBAN BACKGROUND	Lisburn City Council				Y
Lisburn Lagan Valley Hospital	ROADSIDE	Lisburn City Council		Y		Y
Liverpool Islington	ROADSIDE	Liverpool City Council		Y		
Macclesfield Disley	ROADSIDE	Macclesfield BC		Y		Y
Maidstone Rural	RURAL	Kent & Medway Air Quality Network		Y	Y	Y
Marchlyn Mawr	REMOTE	Welsh Air Quality Forum		Y		
Newham Cam Road	ROADSIDE	London Borough of Newham	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		
Newry Monaghan Row	URBAN BACKGROUND	Newry and Mourne DC			Y	Y
Newry Trevor Hill	KERBSIDE	Newry and Mourne DC		Y		Y
Newtownabbey Ballyclare	URBAN BACKGROUND	Newtownabbey Borough Council			Y	Y
Newtownabbey Sandyknowes	ROADSIDE	Newtownabbey Borough Council		Y		

Newtownabbey Shore Road	ROADSIDE	Newtownabbey Borough Council		Y		
North Down Bangor	URBAN BACKGROUND	North Down BC			Y	Y
North Down Holywood A2	ROADSIDE	North Down BC		Y		Y
North Lincs Broughton	URBAN BACKGROUND	North Lincolnshire Council				Y
North Lincs Killingholme	URBAN INDUSTRIAL	North Lincolnshire Council		Y	Y	Y
North Lincs Santon	URBAN INDUSTRIAL	North Lincolnshire Council		Y	Y	Y
Oldham West End House	URBAN BACKGROUND	Oldham MBC	Y	Y	Y	Y
Oxford High St	ROADSIDE	Oxford City Council		Y		Y
Perth	ROADSIDE	Perth & Kinross Council		Y		Y
Perth 2	ROADSIDE	Perth & Kinross Council		Y		Y
Rhondda Broadway	ROADSIDE	Welsh Air Quality Forum		Y		
Rhondda Tylorstown	ROADSIDE	Welsh Air Quality Forum		Y		
Rhondda-Cynon-Taf Nantgarw	ROADSIDE	Welsh Air Quality Forum				Y
S Cambs Bar Hill	RURAL	South Cambridgeshire DC		Y		
S Cambs Barrington Fruit Farm	RURAL	South Cambridgeshire DC			Y	
S Cambs Impington	ROADSIDE	South Cambridgeshire DC		Y		
Salford M60	ROADSIDE	Salford MBC	Y	Y		Y
Scunthorpe Allanby Street	ROADSIDE	North Lincolnshire Council				Y
Scunthorpe East Common Lane	URBAN BACKGROUND	North Lincolnshire Council				Y
Scunthorpe Gallagher Retail Park	ROADSIDE	North Lincolnshire Council		Y		
Scunthorpe Kingsway House	ROADSIDE	North Lincolnshire Council		Y		
Scunthorpe Lincoln Gardens	URBAN BACKGROUND	North Lincolnshire Council				Y
Scunthorpe Town NOx and CO	URBAN INDUSTRIAL	North Lincolnshire Council		Y		
Slough Chalvey	ROADSIDE	Slough BC		Y		
Slough Colnbrook	URBAN BACKGROUND	Slough BC		Y		Y
Slough Town Centre A4	URBAN BACKGROUND	Slough BC		Y		Y
South Bucks Gerrards Cross	ROADSIDE	South Bucks DC		Y		Y
South Holland	RURAL	South Holland DC		Y		Y
Spalding Monkhouse School	URBAN BACKGROUND	South Holland DC		Y		Y
Stansted 3	AIRPORT	BAA	Y	Y		Y
Stansted 4	AIRPORT	BAA		Y		
Stockport Hazel Grove	ROADSIDE	Stockport MBC		Y		Y
Strabane Springhill Park	URBAN BACKGROUND	Strabane DC			Y	
Swansea Morfa Roadside	ROADSIDE	Welsh Air Quality Forum	Y	Y		Y

Swansea Morriston Roadside	ROADSIDE	Welsh Air Quality Forum	Y	Y		Y
Tameside Two Trees School	URBAN BACKGROUND	Tameside MBC	Y	Y	Y	Y
Thanet Airport	URBAN BACKGROUND	Kent & Medway Air Quality Network		Y		
Trafford	URBAN BACKGROUND	Trafford MBC		Y	Y	Y
Trafford A56	ROADSIDE	Trafford MBC		Y		Y
V Glamorgan Fonmon	RURAL	Welsh Air Quality Forum		Y	Y	Y
V Glamorgan Penarth	ROADSIDE	Welsh Air Quality Forum		Y		
West Dunbartonshire Balloch	ROADSIDE	Welsh Air Quality Forum		Y		
Wigan Leigh 2	URBAN BACKGROUND	Wigan Metropolitan Borough Council		Y		Y
Wokingham Winnersh	URBAN BACKGROUND	Wokingham DC		Y		Y
Wokingham Woodward Close	ROADSIDE	Wokingham DC		Y		Y
Wrexham Isycoed	URBAN INDUSTRIAL	Welsh Air Quality Forum		Y	Y	
Wycombe Stokenchurch	URBAN BACKGROUND	Wycombe District Council		Y		
Caerphilly Town Centre	URBAN CENTRE	Welsh Air Quality Forum		Y		Y
Chatham Luton Background	URBAN BACKGROUND	Kent	Y	Y	Y	Y
Folkestone Suburban	SUBURBAN	Kent		Y	Y	Y
Gravesham Industrial Background	URBAN BACKGROUND	Kent		Y		
Newport St Julians Comp Sch	URBAN BACKGROUND	Newport City Council		Y		Y
Oxford St Ebbes (Cal Club)	URBAN BACKGROUND	Oxford City Council		Y		Y
Stockport Shaw Heath 2	URBAN BACKGROUND	Stockport	Y	Y	Y	
Swale Sheerness	URBAN BACKGROUND	Kent		Y	Y	Y
Tewkesbury Town Centre	URBAN CENTRE	Air Quality Consultants		Y		
Thanet Margate Background	URBAN BACKGROUND	Kent		Y		
Tunbridge Wells Town Centre	URBAN BACKGROUND	Kent		Y		
Barking & Dagenham 1 - Rush Green	S	ERG		Y	Y	
Barking & Dagenham 2 - Scrattons Farm	S	ERG		Y		Y
Barnet 1 - Tally Ho Corner	K	ERG		Y		Y
Barnet 2 - Finchley	U	ERG		Y		Y
Bexley 2 - Belvedere	S	ERG		Y		Y
Bexley 4 - Erith	I	ERG		Y		Y
Bexley 7 - Thames Rd North	R	ERG		Y		
Bexley 8 - Thames Rd South	R	ERG		Y		
Brent 4 - Ikea	R	ERG		Y		
Brent 5 - Neasden Lane	I	ERG		Y		Y

Brent 6 - John Keble Primary School	R	ERG		Y		
Brentwood 1 - Town Hall	U	ERG		Y		
Brighton Mobile (Gloucester Road)	R	ERG		Y		
Bromley 7 - Central	R	ERG	Y	Y		
Broxbourne (Roadside)	R	ERG		Y		Y
Camden 3 - Shaftesbury Avenue	R	ERG		Y		
Camden 4 - St Martins College, NOX 1	U	ERG		Y		
Camden 5 - St Martins College, NOX 2	U	ERG		Y		
Castle Point 1 - Town Centre	U	ERG		Y	Y	
Chichester Roadside	R	ERG		Y		Y
City of London - Sir John Cass School	U	ERG		Y		
City of London 1 - Senator House	U	ERG		Y	Y	
Crawley 2 - Gatwick Airport	U	ERG		Y		
Croydon 2 - Purley Way	R	ERG		Y		
Croydon 4 - George Street	R	ERG		Y		Y
Croydon 5 - Norbury	K	ERG		Y		
Croydon 6 - Euston Road	S	ERG		Y		
Crystal Palace 1 - C Palace Parade	R	ERG	Y	Y		Y
E. Herts Sawbridgeworth (Background)	U	ERG		Y		Y
E. Herts Sawbridgeworth (Roadside)	R	ERG		Y		Y
Ealing 1 - Ealing Town Hall	U	ERG		Y	Y	
Ealing 2 - Acton Town Hall	R	ERG	Y	Y		
Ealing 6 - Hanger Lane	R	ERG		Y		
Ealing 7 - Southall	U	ERG		Y		Y
Eastbourne Background	U	ERG		Y		Y
Enfield 1 - Bushhill Park	S	ERG		Y		
Enfield 3 - Salisbury Sch Ponders End	U	ERG	Y	Y	Y	
Enfield 4 - Derby Road Upper Edmonton	R	ERG		Y		
Greenwich 10 - A206 Burrage Grove	R	ERG		Y		
Greenwich 12 - Millennium Village	U	ERG		Y		
Greenwich 13 - Plumstead High Street	R	ERG		Y		
Greenwich 4 - Eltham	S	ERG		Y	Y	
Greenwich 5 - Trafalgar Road	R	ERG		Y		Y
Greenwich 7 - Blackheath	R	ERG		Y		Y

Greenwich 8 - Woolwich Flyover	R	ERG		Y		Y
Greenwich 9 - Westhorne Ave	R	ERG		Y		
Greenwich Bexley 6 - A2 Falconwood	R	ERG		Y		Y
Hackney 4 - Clapton	U	ERG	Y	Y		
Hackney 6 - Old Street	R	ERG		Y		Y
Hammersmith and Fulham 1 - Broadway	R	ERG		Y		Y
Hammersmith and Fulham 2 - Brook Green	U	ERG		Y		Y
Haringey 2 - Priory Park	S	ERG		Y		
Harrow 1 - Stanmore Background	U	ERG		Y	Y	Y
Harrow 2 - North Harrow Roadside	R	ERG		Y		Y
Hastings Roadside	R	ERG		Y		
Havering 1 - Rainham	R	ERG		Y		
Havering 3 - Romford	R	ERG		Y		Y
Heathrow Airport	U	ERG	Y	Y		Y
Henley Roadside, South Oxon	R	ERG		Y		
Hertsmere Borehamwood 2 (Background)	U	ERG		Y		Y
Hillingdon 1 - South Ruislip	R	ERG		Y		Y
Hillingdon 2 - Hillingdon Hospital	R	ERG		Y		Y
Hillingdon 3 - Oxford Avenue	R	ERG		Y		Y
Horsham Roadside (Park Way)	R	ERG		Y		Y
Hounslow 2 - Cranford	S	ERG		Y	Y	Y
Hounslow 4 - Chiswick High Rd	R	ERG		Y		Y
Hounslow 5 - Brentford	R	ERG	Y	Y		Y
Islington 1 - Upper Street	U	ERG		Y		Y
Islington 2 - Holloway Road	R	ERG	Y	Y		Y
Islington 6 - Arsenal	U	ERG		Y		Y
Kens and Chelsea 1 - North Kensington	U	ERG	Y	Y	Y	Y
Kens and Chelsea 3 - Knightsbridge	R	ERG		Y		
Kens and Chelsea 4 - Kings Rd	R	ERG		Y		
Lambeth 1 - Christchurch Road	R	ERG		Y		
Lambeth 3 - Loughborough Junct	U	ERG		Y	Y	
Lambeth 4 - Brixton Road	K	ERG		Y		
Lambeth 5	R	ERG		Y		
Lewes 2 Roadside	R	ERG		Y		Y

Lewisham 1 - Catford	U	ERG		Y	Y	
Lewisham 2 - New Cross	R	ERG		Y		Y
Luton (Background)	U	ERG	Y	Y	Y	Y
Mid Beds Sandy (Roadside)	R	ERG		Y		
Mole Valley 3 - Dorking	U	ERG		Y		Y
N. Herts Breechwood Green (Background)	U	ERG		Y		Y
Redbridge 1 - Perth Terrace	U	ERG		Y		
Redbridge 3 - Fullwell Cross	K	ERG		Y		
Redbridge 4 - Gardner Close	R	ERG	Y	Y		
Redbridge 5 - A406 Southend Rd	R	ERG	Y	Y		
Reigate and Banstead 1 - Horley	S	ERG		Y		Y
Reigate and Banstead 2 - Horley South	S	ERG		Y		
Reigate and Banstead 3- Poles Lane	RU	ERG		Y		
Richmond 1 - Castelnau	R	ERG		Y		Y
Richmond 2 - Barnes Wetlands	S	ERG		Y		Y
Richmond 27 - Lincoln Avenue, Twickenham	R	ERG	Y	Y		Y
Sevenoaks Background - Greatness	U	ERG	Y	Y	Y	Y
Sevenoaks Roadside - Bat and Ball	R	ERG		Y		
South Beds Dunstable (Background)	U	ERG		Y		Y
Southwark 1 - Elephant and Castle	U	ERG	Y	Y	Y	Y
St. Albans Fleetville (Background)	U	ERG	Y	Y	Y	Y
Stevenage (Roadside)	R	ERG		Y		Y
Sussex Mobile (location 11)	K	ERG	Y	Y		Y
Sutton 3 - Carshalton	S	ERG		Y		
Sutton 4 - Wallington	K	ERG		Y		
Sutton 5 - Beddington Lane	I	ERG		Y		Y
Telscombe Cliffs Roadside	R	ERG		Y		Y
Three Rivers Rickmansworth (Background)	U	ERG		Y		Y
Thurrock - Purfleet	R	ERG		Y		
Thurrock 3 - Stanford-le-Hope	R	ERG		Y		
Tower Hamlets 1 - Poplar	U	ERG		Y	Y	Y
Tower Hamlets 3 - Bethnal Green	U	ERG		Y	Y	Y
Tower Hamlets 4 - Blackwall	R	ERG		Y		
Wallingford Roadside, South Oxon	R	ERG		Y		

Waltham Forest 1 - Dawlish Road	U	ERG		Y	Y	Y
Waltham Forest 3 - Chingford	R	ERG		Y		Y
Waltham Forest 5 - Leyton	U	ERG		Y	Y	Y
Wandsworth 2 - Town Hall	U	ERG	Y	Y	Y	
Wandsworth 4 - High Street	R	ERG	Y	Y		
Watford (Roadside)	R	ERG		Y		
Welwyn Hatfield WGC	U	ERG		Y		
Dover Langdon Cliff	URBAN BACKGROUND	Kent			Y	
Bedford - Kempston	I	ERG			Y	
Bedford Stewartby (Rural)	I	ERG			Y	
Aberdeen CO and SO2	URBAN BACKGROUND	Aberdeen City Council	Y			
Bolton CO and SO2	URBAN BACKGROUND	Bolton	Y			
Manchester Piccadilly SO2 CO	URBAN CENTRE	Manchester	Y			
Port Talbot Margam CO	URBAN INDUSTRIAL	Welsh Air Quality Forum	Y			
Portsmouth Background AURN	U	ERG	Y			
Port Talbot Dyffryn School	URBAN INDUSTRIAL	Welsh Air Quality Forum				Y
Bexley 2 (F) - Belvedere	S	ERG				Y
Chichester Roadside FDMS	R	ERG				Y
Croydon 3 - Thornton Heath	S	ERG				Y
Ealing 8 - Horn Lane	I	ERG				Y
Enfield 5 - Bowes Road A406	R	ERG				Y
Islington 4 - Foxham Gardens	U	ERG				Y
Kens and Chelsea 2 - Cromwell Rd	R	ERG				Y
Kens and Chelsea 5 - Earls Court Rd	K	ERG				Y
Waltham Forest 3 - Chingford (FDMS)	R	ERG				Y

Data were collected from the following sources: AEA’s Calibration Club, the Welsh Air Quality Forum, the Scottish Air Quality Archive, the Kent and Medway Air Quality Monitoring Network and monitoring data held by ERG.

Table A1.2. Additional monitoring sites maintained by the electricity generating companies used to calibrate the SO_2 models

Site	Company
Bentley Hall Farm	EON
Bexleyheath	RWE
Blair Mains	RWE
Bottesford	EON
Carr Lane (Drax)	RWE
Didcot South	RWE
Downes Ground Farm	RWE
East Tilbury	RWE
Font-y-gary	RWE
Gainsborough Cemetery	EON
Gillingham	EON
Grove Reservoir	EON
Hemingbrough	RWE
Longniddry West	RWE
Marton School	EON
North Featherstone	RWE
Northfleet	RWE
Rosehurst Farm	RWE
Ruddington Field	EON
Smeathalls Fm	RWE
Stile Cop Cemetery	EON
Telford Aqueduct	EON
Telford School	EON
Thorney	EON
West Bank	RWE
West Thurrock	RWE
Weston On Trent	EON

Appendix 2 Small point source model

INTRODUCTION

Small industrial sources have generally been represented in earlier maps (Stedman *et al.*, 2002) as 1 km square volume sources. However, this approach has in some cases lead to unreasonably high concentrations close to the source. The overestimation arises because the release height, buoyancy and momentum of discharges from industrial chimneys are not taken into account. A revised small point source model has been developed which uses dispersion kernels that will take these factors into account.

The dispersion model ADMS 3.0 was used to prepare the dispersion kernels.

DISCHARGE CONDITIONS

The National Atmospheric Emission Inventory contains limited information concerning the discharge characteristics of individual emission sources. In many cases the information is limited to data on the total annual emission of individual pollutants. It is therefore necessary to make some general assumptions concerning the discharge height, the discharge temperature, the volumetric flow rate of the discharge and the discharge velocity. Our approach has been to make reasonable, but generally conservative assumptions corresponding to industrial practice.

Sulphur dioxide

For sulphur dioxide, it was assumed that the plant operates continuously throughout the year. The stack height was estimated using the following equations taken from the 3rd edition of the Chimney Heights Memorandum:

If the sulphur dioxide emission rate, R_A kg/h, is less than 10 kg/h, the chimney height, U m, is given by:

$$U = 6R_A^{0.5}$$

If R_A is in the range 10-100 kg/h:

$$U = 12R_A^{0.2}$$

Emission rates in excess of 100 kg/h were not considered in this study.

No account was taken of the effects of buildings: it was assumed that the increase in chimney height to take account of building effects provided by the Memorandum would compensate for the building effects.

It was then assumed that the sulphur dioxide concentration in the discharge would be at the limit for indigenous coal and liquid fuel for new and existing plant provided by Secretary of States Guidance- Boilers and Furnaces, 20-50 MW net rated thermal input PG1/3(95). The limit is 3000 mg m^{-3} at reference conditions of 273 K, 101.3 kPa, 6% oxygen for solid fuel firing and 3% oxygen for liquid firing and dry gas. It was assumed that the oxygen content in the discharge corresponds with the reference condition. The moisture content of the discharge was ignored. It was assumed that the temperature of discharge was 373 K: higher temperatures would lead to improved buoyancy and hence lower ground level concentrations while lower temperatures usually result in unacceptable water condensation. A discharge velocity of 10 m/s was selected to be representative of most combustion source discharges. The discharge diameter d m was calculated from;

$$d = \sqrt{\frac{4qT}{273\pi cv}}$$

where q is the sulphur dioxide emission rate, g/s
T is the discharge temperature, 373K
c is the emission concentration at reference conditions, 3 g m^{-3}
v is the discharge velocity, 10 m/s

Table A2.1 shows the modelled stack heights and diameters.

Table A2.1 Modelled stack heights and diameters for sulphur dioxide

Emission rate			Stack height, m	Stack diameter, m
g/s	kg/h	t/a		
0.1	0.36	3.2	3.60	0.08
0.2	0.72	6.3	5.09	0.11
0.5	1.8	15.8	8.05	0.17
1	3.6	31.5	11.38	0.24
2	7.2	63.1	16.10	0.34
5	18	157.7	21.39	0.54
10	36	315.4	24.57	0.76
20	72	630.7	28.23	1.08

Oxides of nitrogen

For nitrogen dioxide, it was assumed that the plant operates continuously throughout the year. The stack height was estimated using the following equation taken from the 3rd edition of the Chimney Heights Memorandum for very low sulphur fuels:

$$U = 1.36Q^{0.6}\left(1 - 4.7\times10^{-5}Q^{1.69}\right)$$

where Q is the gross heat input in MW.

This relationship applies for heat inputs up to 150 MW. For larger heat inputs a fixed height of 30 m was used corresponding to an approximate lower limit derived from available data on stack heights for large sources.

The gross heat input used in the above equation was calculated from the oxides of nitrogen emission rate using an emission factor of 10600 kg/MTh (0.100 g/MJ) for oxides of nitrogen emitted from natural gas combustion in non-domestic non-power station sources taken from the NAEI.

For fuels containing significant sulphur, the actual stack height will be greater to allow for the dispersion of sulphur dioxide so that the approach taken is expected to lead to an overestimate of ground level concentrations.

The emission limits for oxides of nitrogen provided by Secretary of States Guidance-Boilers and Furnaces, 20-50 MW net rated thermal input PG1/3(95) depend on the type of fuel and are in the range 140-650 mg m^{-3} at reference conditions. A value of 300 mg m^{-3} was used in the calculation of the stack discharge diameter. Other assumptions concerning discharge conditions followed those made for sulphur dioxide above.

Table A2.2 shows the modelled stack heights and diameters.

Table A2.2 Modelled stack heights and diameters for oxides of nitrogen

Emission rate		Height, m	Diameter, m
g/s	t/a		
0.1	3.2	1.36	0.24
0.2	6.3	2.06	0.34
0.5	15.8	3.57	0.54
1	31.5	5.40	0.76
2	63.1	8.15	1.08
5	157.7	13.72	1.70
10	315.4	19.12	2.41
20	630.7	21.34	3.41
50	1576.8	30.00	5.38
100	3153.6	30.00	7.61

Particulate matter, PM_{10}

The stack heights and diameters used for oxides of nitrogen were also used to provide the kernels for particulate matter PM_{10}. This will provide a conservative assessment of PM_{10} concentrations for the following reasons. The emission limits for total particulate matter provided by Secretary of States Guidance-Boilers and Furnaces, 20-50 MW net rated thermal input PG1/3(95) depend on the type of fuel and are in the range 5-300 mg m^{-3} at reference conditions. The emission limit for total particulate matter includes but is not limited to the contribution from PM_{10}.

DISPERSION MODELLING

The dispersion model ADMS 3.0 was used to predict ground level concentrations on two receptor grids:

- an “in-square” grid covering an area 1 km x 1 km with the source at the centre and with receptors at 33.3 m intervals;
- an “outer-grid” covering an area 30 km x 30 km with the source at the centre and with receptors at 1 km intervals.

A surface roughness value of 0.5 m was used, corresponding to areas of open suburbia. Meteorological data for Heathrow for the years 1993-2002 was used in the assessment, with most model runs using the 2000 data.

RESULTS

Sulphur dioxide

Table A2.3 shows the predicted “in-square average” concentration for the 1 km square centred on the emission source for 2000 meteorological data.

Table A2.3 Predicted in-square concentration, for sulphur dioxide

Emission rate, g/s	Average in square concentration , μg m^{-3}
0.1	0.599
0.2	0.934
0.5	1.555
1	2.19
2	2.92
5	4.57
10	6.56
20	8.86

The results shown in Table A2.3 may be approximated by the relationship

$$C=Aq^{0.5}$$

where C is the in-square concentration, μg m^{-3} and q is the emission rate, g/s. A is a proportionality factor (2.07 in 2000)

Table A2.4 shows the predicted in-square concentration for an emission rate of 10 g/s for meteorological years 1993-2002. Table A2.4 also shows the inter-annual variation in the factor A.

Table A2.4 In-square concentrations for 10 g/s emissions

Year	In-square concentration, μg m^{-3}	Factor A
1993	6.21	1.96
1994	6.01	1.90
1995	6.12	1.94
1996	6.23	1.97
1997	6.10	1.93
1998	6.18	1.95
1999	6.49	2.05
2000	6.56	2.07
2001	6.32	2.00
2002	6.51	2.06

Figure A2.1 shows the predicted “outer-grid” concentration along the east-west axis through the source for 2000 meteorological data for a range of rates of emission (in g/s). Figure A2.1 does not include results for the 1 km source square.

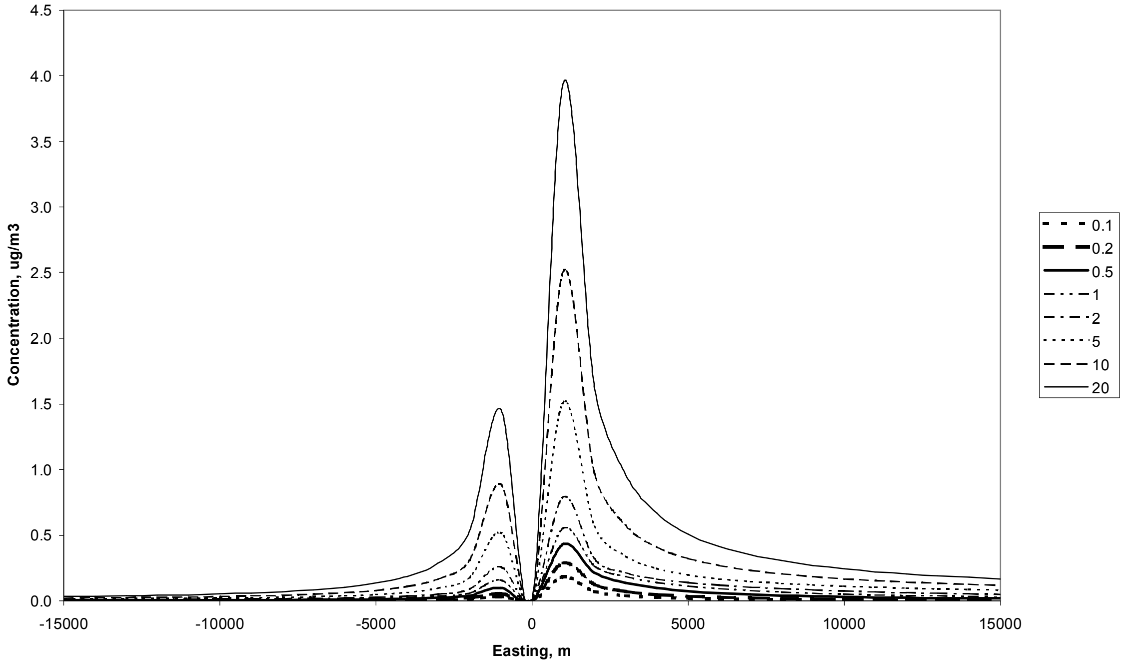

Figure A2.1 Sulphur dioxide concentration on east-west axis, 2000 meteorological data

Figure A2.2 shows the same model results plotted as $C/q^{2/3}$. The spread of the model results is greatly reduced so that as a reasonable approximation all the model results may be reduced to a single line.

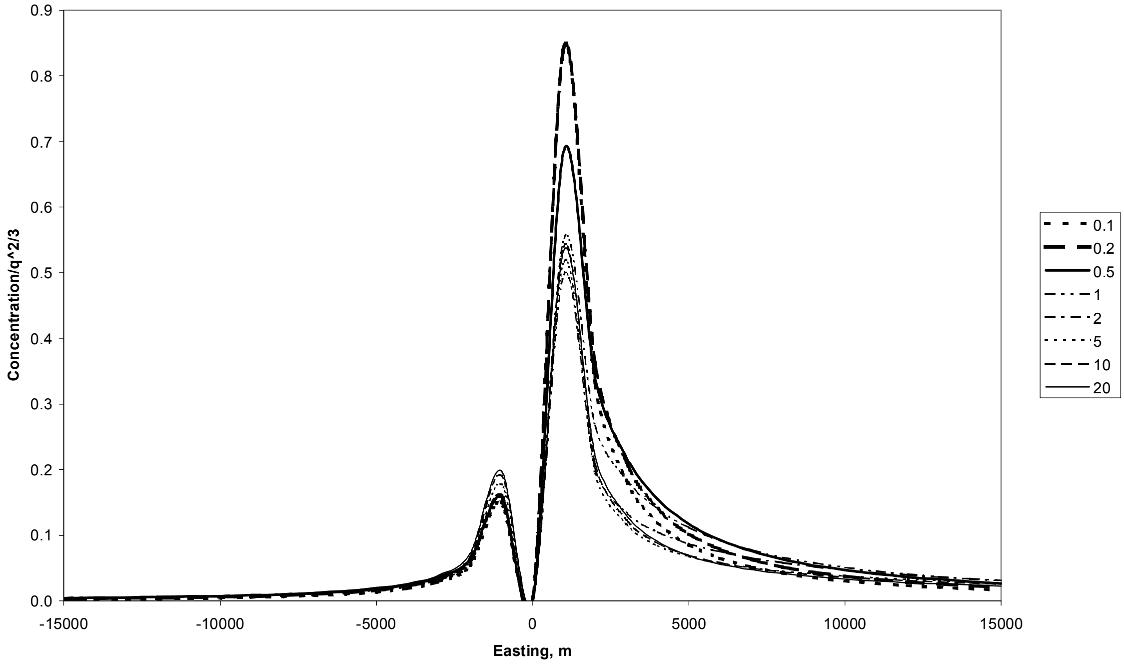

Figure A2.2 Reduced sulphur dioxide concentrations on the east-west axis, 2000 meteorological data

Thus it is proposed to use the results for an emission rate of 10 g/s for all emission rates in the range 0.1-20 g/s in the preparation of dispersion kernels for industrial sulphur dioxide emissions. The dispersion kernel will be multiplied by $10.(q/10)^{2/3}$ to provide estimates of the impact of emission q g/s at each receptor location. Separate kernels have been created from each meteorological data year 1993-2002.

Oxides of nitrogen

Table A2.5 shows the predicted “in-square average” concentration for the 1 km square centred on the emission source for 2000 meteorological data.

Table A2.5 In-square oxides of nitrogen concentrations, 2000

Emission rate, g/s	In square concentration, $\mu g\ m^{-3}$
0.1	0.464
0.2	0.764
0.5	1.37
1	1.97
2	2.6
5	3.31
10	3.58
20	4.34
50	3.745
100	4.3

The results shown in Table A2.5 may be approximated in the range 0.1-20 g/s by the relationship

$$C=B\ \log_{10}(10q)+0.464$$

where C is the in-square concentration, $\mu g\ m^{-3}$ and q is the emission rate, g/s. and B is a numerical constant, 1.68 in 2000.

For emission rates in the range 20-100 g/s , the in-square concentration is approximately 4 μg m^{-3}.

Table A2.6 shows the predicted in-square concentration for an emission rate of 20 g/s for meteorological years 1993-2002. Table A2.6 also shows the inter-annual variation in the factor B.

Table A2.6 Inter annual variation in in-square oxides of nitrogen concentration

Year	In-square concentration, μg m-^{3}	Factor B
1993	3.62	1.37
1994	3.88	1.48
1995	3.74	1.42
1996	4.3	1.67
1997	3.66	1.39
1998	3.64	1.38
1999	4.14	1.60
2000	4.34	1.68
2001	4.02	1.55
2002	4.68	1.83

Figure A2.3 shows the predicted "outer-grid" oxides of nitrogen concentration along the east-west axis through the source for a range of rates of emission (in g/s).

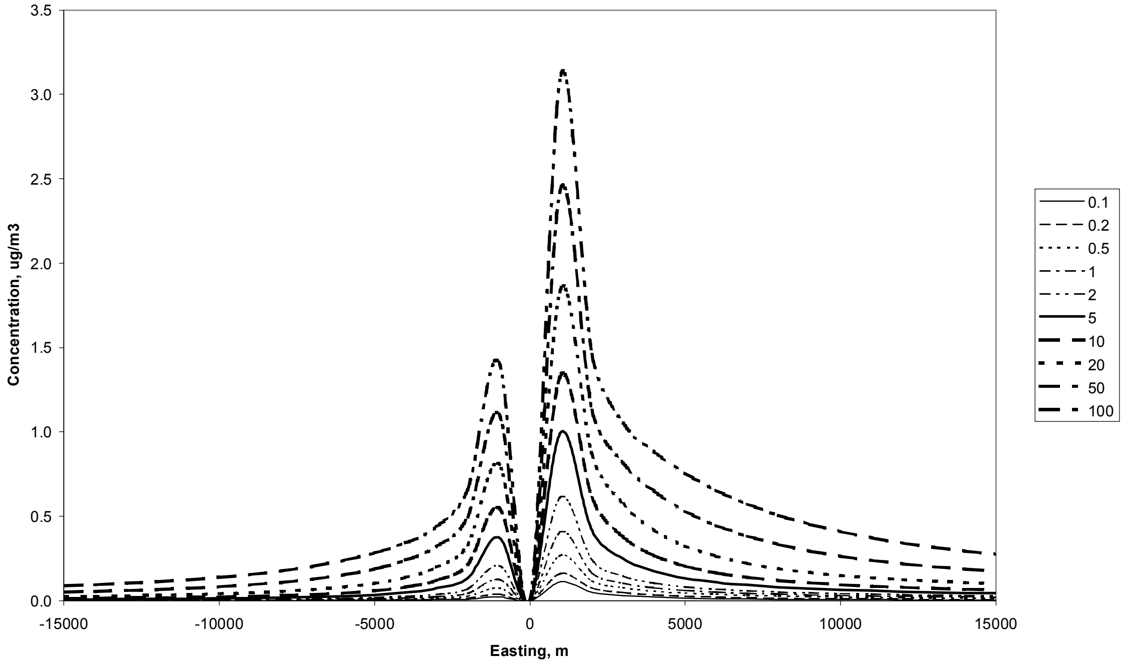

Figure A2.3 Oxides of nitrogen concentration on east-west axis, 2000 meteorological data

Figure A2.4 shows the same model results plotted as C/q$^{0.6}$. The spread of the model results is greatly reduced so that as a reasonable approximation all the model results may be reduced to a single line.

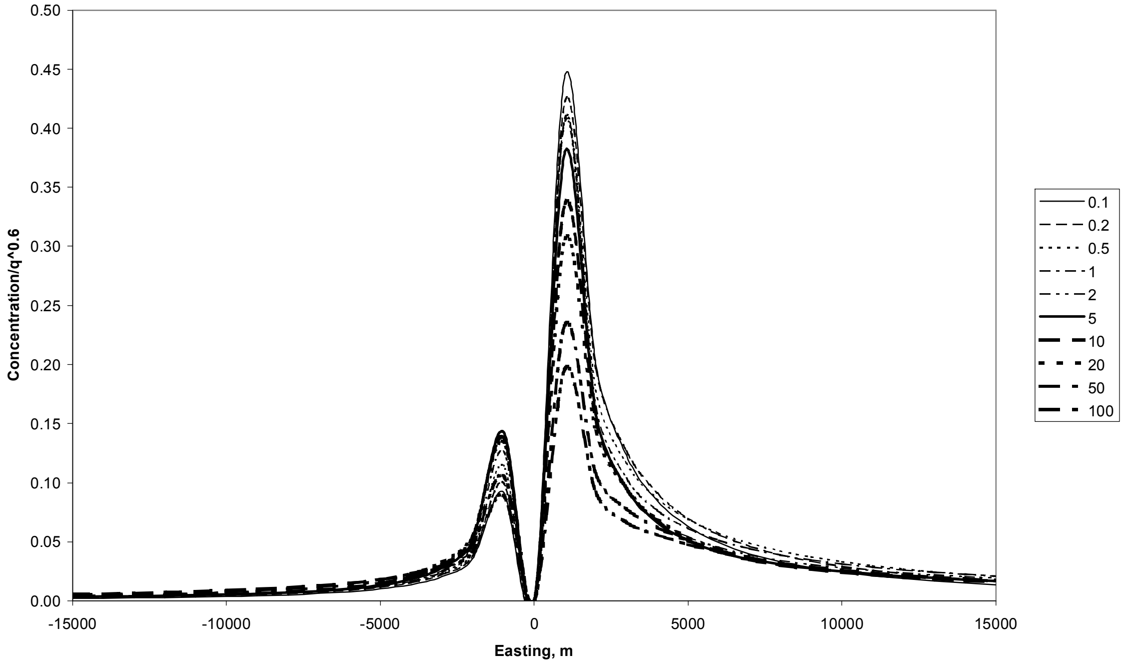

Figure A2.4 Reduced oxides of nitrogen concentrations on the east-west axis, 2000 meteorological data

Thus it is proposed to use the results for an emission rate of 20 g/s for all emission rates in the range 0.1-100 g/s in the preparation of dispersion kernels for oxides of nitrogen emissions. The dispersion kernel will be multiplied by $20.(q/20)^{0.6}$ to provide estimates of the impact of emission q g/s at each receptor location. Separate kernels have been created for each meteorological data year 1993-2002.

METHOD

Sulphur dioxide

Point sources with emissions greater than or equal to 500 tonnes per year (15.85 g/s) have been modelled explicitly using ADMS. Point sources with emissions less than 500 tonnes per year have been modelled using the small points model. This model has two components.

The in-square concentration for each source has been calculated using the following function:

$$C=1.98.q^{0.5}$$

where C is the in-square concentration, μg m^{-3} and q is the emission rate, g/s and 1.98 is a numerical constant, calculated as the average value over the years 1993-2002 for met data at Heathrow.

The outer-grid concentration has been calculated by adjusting the emissions for each source using the function:

$$Q = 10.(q/10)^{0.667}$$

where q is the emission rate, g/s and Q is the adjusted emissions. The sum of the adjusted emission was then calculated for each grid square and the outer-grid concentration calculated using a small points dispersion kernel (which was calculated as the average over the years 1993-2002 for met data at Heathrow).

The in-square and outer-grid concentrations were then summed to calculate the total contribution to ambient annual mean concentrations from these small point sources.

Oxides of nitrogen

Point sources with emissions greater than or equal to 500 tonnes per year (15.85 g/s) have been modelled explicitly using ADMS. Point sources with emissions less than 500 tonnes per year have been modelled using the small points model. This model has two components.

The in-square concentration for each source has been calculated using the following function:

$$C=1.54.\ \log_{10}(10q)+0.464$$

where C is the in-square concentration, $\mu g\ m^{-3}$ and q is the emission rate, g/s and 1.54 is a numerical constant, calculated as the average value over the years 1993-2002 for met data at Heathrow.

The outer-grid concentration has been calculated by adjusting the emissions for each source using the function:

$$Q = 20.\ (q/20)^{0.6}$$

where q is the emission rate, g/s and Q is the adjusted emissions. The sum of the adjusted emission was then calculated for each grid square and the outer-grid concentration calculated using a small points dispersion kernel (which was calculated as the average over the years 1993-2002 for met data at Heathrow).

The in-square and outer-grid concentrations were then summed to calculate the total contribution to ambient annual mean concentrations from these small point sources.

PM_{10}

The method for PM_{10} was the same as for NO_x, except that point sources with emissions greater than or equal to 200 tonnes per year (6.34 g/s) have been modelled explicitly using ADMS. Point sources with emissions less than 200 tonnes per year have been modelled using the small points model.

CO

The method for CO was the same as for NO_x, except that point sources with emissions greater than or equal to 3000 tonnes per year (95.1 g/s) have been modelled explicitly using ADMS. Point sources with emissions less than 3000 tonnes per year have been modelled using the small points model.

Benzene

The method for benzene was the different. Point sources with combustions emissions greater than or equal to 5 tonnes per year (0.16 g/s) have been modelled explicitly using ADMS. Fugitive and process point sources have been modelled using a different small points model, as described in Section 5.3.

Appendix 3 Dispersion kernels for area source model

DISPERSION KERNELS FOR AREA SOURCE MODEL

Dispersion kernels for calculating the annual mean contribution of emissions from area sources to ambient annual mean concentrations were calculating using ADMS. Separate kernels were calculated for traffic and other area sources (which were assumed to have a constant temporal profile of emissions). Kernels were generated for 2007 using sequential meteorological data from Waddington. The dispersion parameters used to calculate the kernels are listed in Table A3.1. The emission profile used to represent traffic emissions for the traffic kernels is shown in Figure A3.1. This was obtained from a distribution of all traffic in the United Kingdom by time of day (Road Traffic Statistics, 1999, Department of Transport).

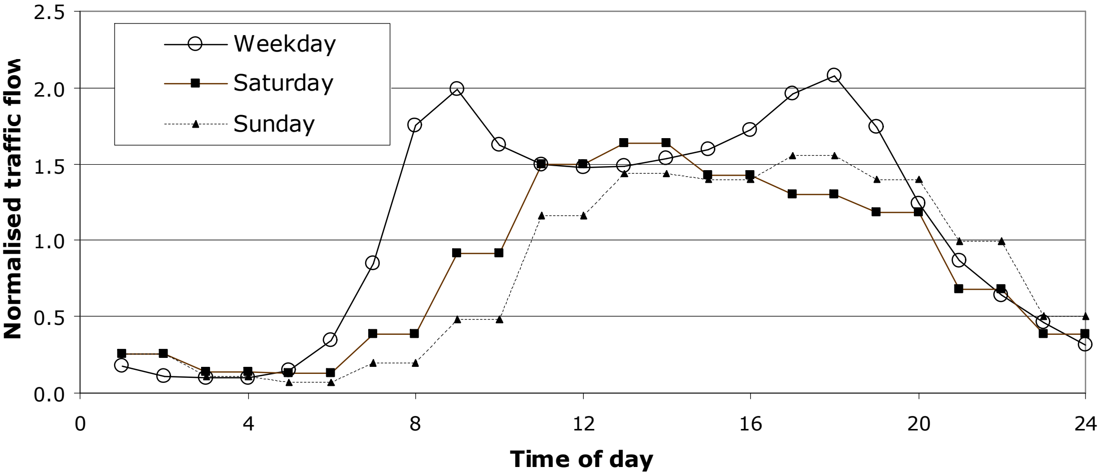

Figure A3.1 Temporal profile of traffic emissions

The dispersion kernels have been revised for the 2007 modelling for all pollutants. For NO_x, PM_{10}, benzene and CO the kernels are now on a 1km x 1km resolution matrix and are made using ADMS 4.0 (rather than the 3km x 3km resolution matrix used in previous years). The centre squares have been scaled to remove the impact of sources within 50m of the receptor location in that square on the basis that background sites are not located very close to specific sources such as major roads. Different kernels have been made for different area types, to take into account different dispersion conditions in urban areas of different sizes. Previously this was accounted for in the PCM models by the application of different empirical calibration coefficients in inner conurbations and other locations. The kernels have been made specific to different types of location by varying minimum Monin Obukhov Length (LMO). The location of the different area types are shown in figure A3.2. and surface roughness due to different land use. This has replaced the use of different calibration coefficients for inner conurbations and elsewhere.

Table A3.1: Summary of inverted dispersion kernel parameters

Kernel name	Area types	Type of location	LMO (m)	Surface roughness	Height (m) of volume source	Variable emission profile?	Emission rate (g/m^3/s)
Non road transport	1,2,4	Conurbation	75	1	30	N	3.33E-08
Non road transport	3,4,5,6,7,8	Smaller urban	20 [A]	1	30	N	3.33E-08
Non road transport	9,10	Rural	10	1	30	N	3.33E-08
Road transport	1,2,4	Conurbation	75	1	10	Y	1.0E-7
Road transport	3,4,5,6,7,8	Smaller urban	10	1	10	Y	1.0E-7
Road transport	9,10	Rural	20 [A]	1	10	Y	1.0E-7

A. ADMS 4.0 recommends using a minimum Monin Obukhov Length (LMO) of 30m for an urban area. However, sensitivity testing showed 20m works better in ADMS 4.0

The dispersion kernels used for fugitive and process point sources of benzene are the same as the non road transport kernels but with the values for the central receptor location calculated as described in section 5.3

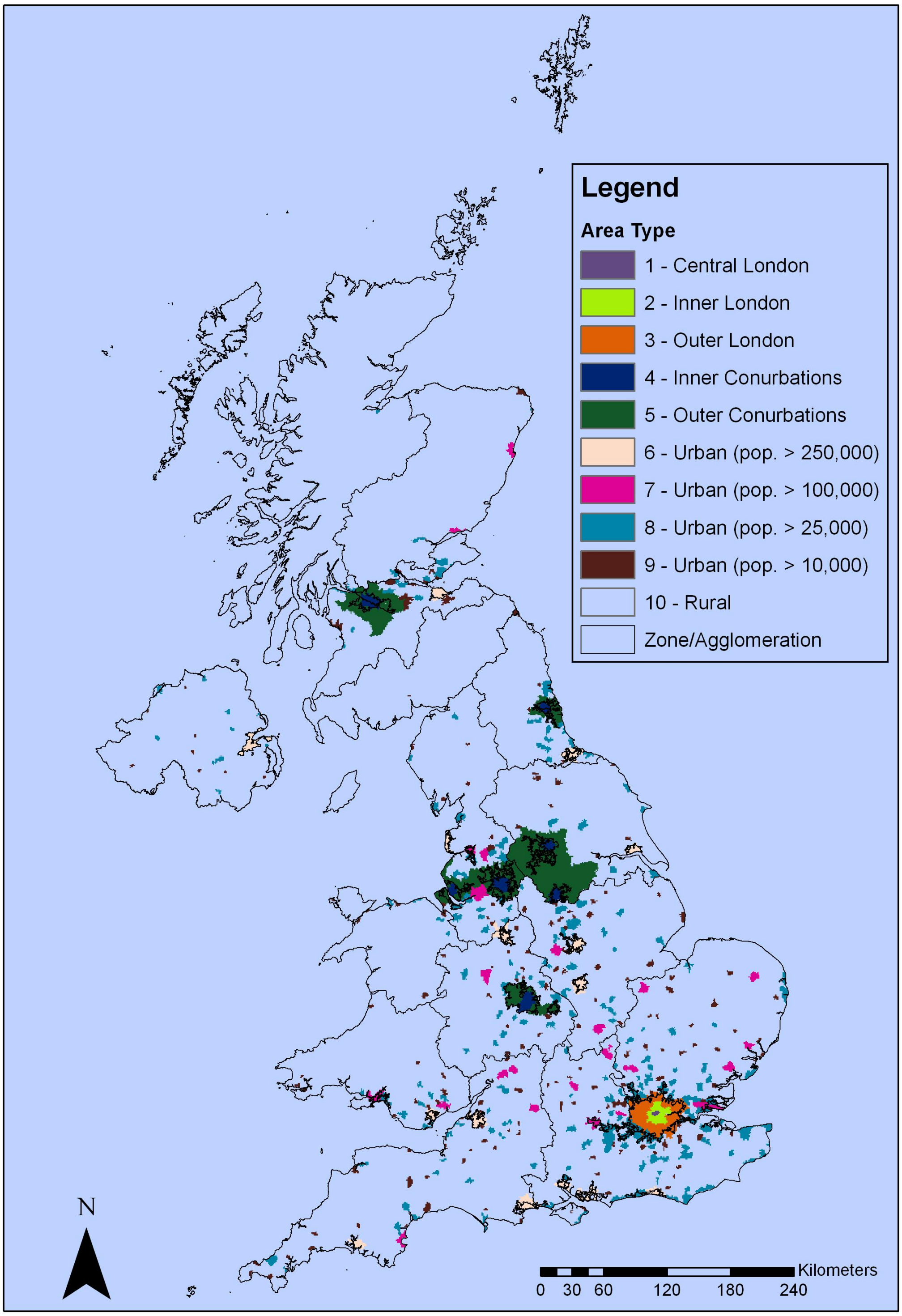

Figure A3.2: Map of UK area types

Appendix 4 Model assessment of SO_2 concentrations at Stewartby brick works

Comparing modelled and measured sulphur dioxide concentrations at Stewartby brickworks in 2007

For 2007, there were no measured or modelled exceedences of the sulphur dioxide Limit Values at Stewartby. The following discussion summarises the work undertaken to model emissions from the works in 2007 and compare the results with the measured values. There were modelled exceedences but no measured exceedences for 2006. Kent et al., (2007) provides further detail on the modelling undertaken for 2006.

The modelling of ambient SO_2 concentrations in the vicinity of Stewartby was carried out by estimating concentrations on a 1km grid. Our assessment was informed by reports prepared for the process operator (Hanson) and forwarded to us by the Environment Agency. These reports (Report References C12-P030R15[1] and C12-P030R16[2]) reviewed the air quality management plan at Stewartby Brick works for 2006 and 2007, respectively.

Model input parameters were obtained from Table A4.2 of the C12-P030R15 report. Sulphur dioxide emissions in 2007 were about one third less than emissions in 2006. Table A4.1 (below) provides the emission estimates in 2005 through to 2007.

Table A4.1: Sulphur dioxide emissions from Stewartby Brickworks from 2005 to 2007.

Year	Sulphur dioxide emission, Tonnes year^{-1}
2005	8414
2006	9978
2007	6723

Kent *et al.,* (2007), compared the measured and modelled concentration values presented in Hanson Report (C12-P030R15) for 2006. Two dispersion models ADMS and AERMOD were used to predict concentrations at the Broadmead sampling site. Both models significantly over predicted (by more than a factor of 2) the annual average concentration, whereas for the 99.73 percentile of hourly values the ADMS model over predicted (by about 13 %) and the AERMOD under predicted (also by 13 %). Both models over predicted the 99.18 percentile of daily values (by about 25 %). No modelled concentrations were present in the Hanson report for 2007 (C12-P030R16).

Table A4.2 compares the measured concentration for each averaging time with the concentrations predicted by the national scale modelling (see Section 2 of this report) for 2007. As was the case for the modelling undertaken for 2006, the modelled annual average concentration is twice the measured concentration. The 99.18th percentile of daily values and the 99.73rd percentile of hourly values are below their respective Limit Values.

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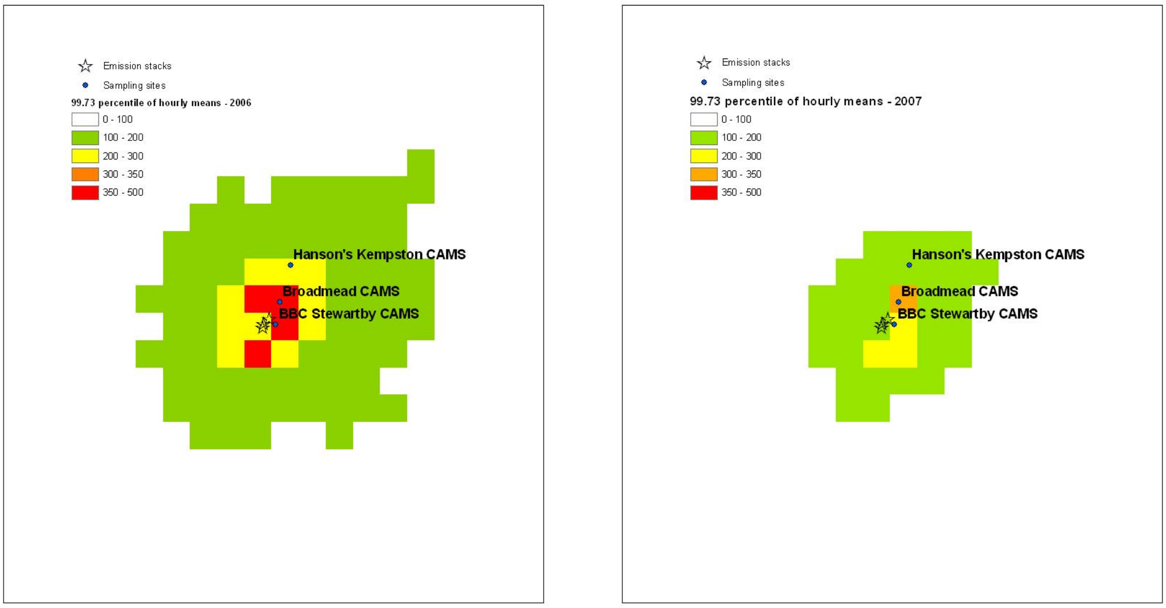
[1] Review of the Air Quality Management Plan: Stewartby Brickworks. July 2007 Report Reference C12-P03-R15. A report produced for Hanson by Gair Limited.

[2] Review of the Air Quality Management Plan: Stewartby Brickworks. April 2008 Report Reference C12-P03-R16. A report produced for Hanson by Gair Limited.

Table A4.2: A comparison of modelled and measured sulphur dioxide concentrations in 2007 at the Broadmead continuous analyser measurement system (CAMS).

Receptor location		Source within Hanson report, $\mu g\ m^{-3}$	Annual average, $\mu g\ m^{-3}$	99.9 percentile of 15 minute means, $\mu g\ m^{-3}$	99.73 Percentile of hourly concentrations, $\mu g\ m^{-3}$	99.18 percentile of daily values, $\mu g\ m^{-3}$	Measured or modelled used
Broadmead CAMS	Hanson report. C12-P03-R16	Table 2.2	8.6	328	251	102	Measured
Broadmead CAMS	National scale modelling presented in Section 2		17.0	556	346	117	ADMS

Figures A4.1 and A4.2 present the modelled concentrations for the 99.73 percentile of hourly values and the 99.18 percentile of daily mean values for both 2006 and 2007, respectively. While exceedances were predicted for 2006 there are no exceedances in 2007.


a) 2006

b) 2007

Figure A4.1: 99.73 percentile of hourly concentrations ($\mu g\ m^{-3}$). Squares are 1 km x 1 km.

a) 2006 **b) 2007**

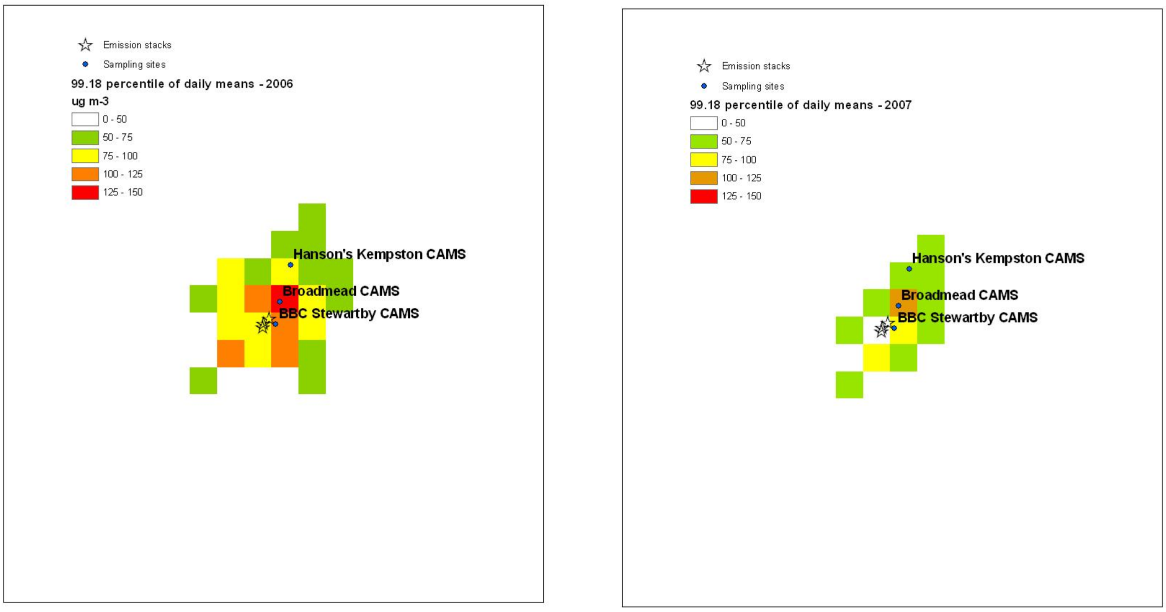


Figure A4.2: 99.18 percentile of daily concentrations (μg m^{-3}). Squares are 1 km x 1 km.

Appendix 5 Air Quality monitoring data from Gibraltar in 2007

Introduction

Gibraltar is subject to the same European environmental legislation as the UK. Gibraltar is comprised of a single non-agglomeration zone for which no modelling assessment has been undertaken but data from an automatic monitoring campaign is presented in this report. The exceedence status of the Gibraltar zone has been determined from monitoring data only. This Appendix summarises ambient air quality concentrations reported in 2007 by the Gibraltar monitoring campaign and places it in the context of the Daughter Directive Limit Values as Section 7 did for the UK. The ozone air quality assessment for Gibraltar is covered in a separate technical report (Kent and Stedman, 2008).

Table A5.1 Gibraltar Air Quality Monitoring Network site details

Site	Site type	Latitude	Longitude	Altitude	Pollutants
Gibraltar Rosia Road	ROADSIDE	36 08 00N	05 21 11W	15m	Benzene, CO, NO_2, PM_{10}, $PM_{2.5}$, SO_2, Lead
Gibraltar Bleak House	URBAN BACKGROUND	36 06 46N	05 21 01W	50m	NO_2, O_3

Annual summary

Table A5.2 (Rosia Road) and Table A5.3 (Bleak House) show summary concentrations for different metrics for all pollutants reported at the two Gibraltar air quality monitoring stations. Data capture statistics are also provided.

Table A5.2 Gibraltar Rosia Road monitoring data, 2007

POLLUTANT	BENZ	CO	PM_{10}*	$PM_{2.5}$	NO_2	SO_2	LEAD
Maximum 15-minute mean	-	7.2 mg m^{-3}	-	-	216 µg m^{-3}	197 µg m^{-3}	-
Maximum hourly mean	86.58 µg m^{-3}	5.3 mg m^{-3}	-	-	172 µg m^{-3}	154 µg m^{-3}	-
Maximum running 8-hour mean	24.73 µg m^{-3}	2.2 mg m^{-3}	-	-	122 µg m^{-3}	75 µg m^{-3}	-
Maximum running 24-hour mean	11.93 µg m^{-3}	1.4 mg m^{-3}	-	-	99 µg m^{-3}	52 µg m^{-3}	-
Maximum daily mean	11.70 µg m^{-3}	1.3 mg m^{-3}	250 µg m^{-3}	54 µg m^{-3}	92 µg m^{-3}	41 µg m^{-3}	-
Average	2.28 µg m^{-3}	0.5 mg m^{-3}	45 µg m^{-3}	18 µg m^{-3}	44 µg m^{-3}	13 µg m^{-3}	-
Annual average	-	-	-	-	-	-	0.01 µg m^{-3}
Data capture	97.6 %	95.2 %	99.2 %	98.9 %	98.1 %	98.0 %	-

Table A5.3 Gibraltar Bleak House monitoring data, 2007

POLLUTANT	NO_2	O_3
Maximum 15-minute mean	285 µg m^{-3}	160 µg m^{-3}
Maximum hourly mean	176 µg m^{-3}	144 µg m^{-3}
Maximum running 8-hour mean	97 µg m^{-3}	140 µg m^{-3}
Maximum running 24-hour mean	70 µg m^{-3}	130 µg m^{-3}
Maximum daily mean	65 µg m^{-3}	128 µg m^{-3}
Annual average	25 µg m^{-3}	62 µg m^{-3}
Data capture	98.5 %	90.4 %

* PM_{10} and $PM_{2.5}$ in gravimetric units
All mass units are at 20'C and 1013mb

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

The tables presented below are from Form 8 of the questionnaire and are equivalent tables for Gibraltar as those shown for the UK in Section 7.1. Exceedence (or otherwise) of the limit value (LV) and limit value plus margin of tolerance (LV + MOT) where this exists are indicated by a ‘y’ for measured exceedences.

The results of the air quality assessments in Gibraltar for SO_2, NO_2 and NO_X, PM_{10}, lead, benzene and CO are listed in Tables A5.4 to A5.9.

Table A5.4 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) for SO_2 (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

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
Gibraltar Zone	UK(GIB)			y		y		n		n

Table A5.5 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) for NO_2 and NO_X (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

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
Gibraltar Zone	UK(GIB)			y		y			n

Table A5.6 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) for PM_{10} (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

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
Gibraltar Zone	UK(GIB)	y			y			y		y		

Table A5.7 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) for lead (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

Zone	Zone code	LV		
		>LV+MOT	≤LV+MOT; >LV	≤LV
Gibraltar Zone	UK(GIB)			y

Table A5.8 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) for benzene (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

Zone	Zone code	LV		
		>LV + MOT	≤LV+MOT; >LV	≤LV
Gibraltar Zone	UK(GIB)			y

Table A5.9 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) for CO (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

Zone	Zone code	LV		
		>LV + MOT	≤LV + MOT; >LV	≤LV
Gibraltar Zone	UK(GIB)			y

Measured exceedences of Limit Values + Margins of Tolerance

Individual exceedences of Limit Values and Limit Values + Margin of Tolerance are presented in the questionnaire in Form 11. Form 11h is presented below in Table A5.10, showing individual exceedences of the 24-hour PM_{10} limit value. Form 11i is also presented in Table A5.11, showing individual exceedences of the annual PM_{10} limit value. Forms 11a, 11b, 11e, 11f, 11j, 11k and 11l have not been presented here because there were no recorded exceedences in Gibraltar of the Limit Values and Limit Values + Margin of Tolerance that they pertain to in 2007. Forms 11c, 11d and 11g remained blank in the questionnaire as they relate to NO_X and SO_2 Limit Values applicable in vegetation and ecosystem areas only, of which none exist in Gibraltar.

Table A5.10 Measured exceedences of the 24-hour mean PM_{10} limit value, 2007 (Form 11h)

Site	Zone code	*EoI station code*	Month	Day of month	Level (mg/m^3)	Reason code(s)*
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	9	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	16	62	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	17	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	18	57	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	19	61	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	1	20	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	2	23	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	6	66	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	8	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	9	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	13	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	14	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	15	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	3	23	52	S8;S10;S3;S1

Gibraltar Rosia Road	UK(GIB)	GB0050A	3	30	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	17	56	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	18	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	19	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	23	56	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	24	109	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	25	82	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	26	55	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	4	27	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	8	58	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	9	73	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	10	70	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	11	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	18	59	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	5	21	55	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	1	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	6	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	8	69	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	19	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	28	68	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	6	29	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	3	63	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	5	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	6	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	9	73	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	10	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	11	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	12	69	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	13	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	25	58	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	26	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	27	72	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	30	68	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	7	31	67	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	1	74	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	2	61	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	3	62	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	8	62	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	9	68	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	10	74	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	11	57	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	17	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	19	56	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	20	64	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	21	71	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	22	66	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	25	95	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	26	91	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	27	74	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	28	79	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	8	29	57	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	5	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	6	64	S8;S10;S3;S1

Gibraltar Rosia Road	UK(GIB)	GB0050A	9	10	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	11	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	12	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	14	58	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	17	68	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	18	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	19	83	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	20	65	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	21	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	25	68	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	26	73	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	9	27	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	1	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	8	66	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	22	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	26	55	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	29	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	10	30	56	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	5	53	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	7	51	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	8	58	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	9	77	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	12	71	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	13	64	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	14	81	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	15	74	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	16	57	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	19	67	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	20	60	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	26	52	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	27	55	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	28	61	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	29	69	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	11	30	62	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	4	59	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	5	64	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	6	65	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	11	54	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	14	61	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	19	66	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	20	126	S8;S10;S3;S1
Gibraltar Rosia Road	UK(GIB)	GB0050A	12	21	250	S8;S10;S3;S1

* see Table 7.7 of the main report for details

Table A5.11 Measured exceedences of the annual mean PM$_{10}$ limit value, 2007 (Form 11i)

Site	**Zone code**	***EoI station code***	**Level (mg/m^3)**	**Reason code(s)**
Gibraltar Rosia Road	UK(GIB)	GB0050A	45	S8;S10;S3;S1

Appendix 6 Data scaling for 2007 annual means

The method relies on the calculation of a ratio between the full year mean and the period mean (derived from data that covers those dates during the year when the closed site was in operation). This ratio is calculated at sites that ran for the complete year and then applied to sites that only ran for a part of the year. The method relies on the suitable pairing of sites needing to be rescaled and sites that ran throughout the year.

The annual mean data for all sites in the network in operation during 2007 were examined and from this set of sites a screening was undertaken to separate any sites that ceased operation in 2007 from those that ran for the full year. Those that ceased operation in 2007 were considered for rescaling (referred to here as 'rescale' sites) and those that ran for the full year (referred to here as 'pairing sites') were paired with appropriate rescale sites and used to derive the ratios to apply to those rescale sites.

The data capture for the period of operation of each rescale site was calculated. Sites with less than 75% data capture during the limited period of operation in 2007 were deemed unsuitable for rescaling and omitted from this PCM modelling process.

A further screening was applied to the pairing sites to remove any sites that are unsuitable for the calculation of this ratio. These included roadside sites (for which local influences related to road traffic emissions can be significant) and sites with lower than 75% data capture which would not be adequately representative of the full year.

The method is based on the assumption that the seasonal patterns in pollutant concentrations usually affect a wide region and therefore other monitoring sites that did run for the whole of 2007 can be used to infer information about trends in air quality at sites that did not run for the full year. It has been considered that the most representative pairing sites for each rescale site will be those with the closest geographical proximity and the most complete data capture. The list of appropriate pairing sites (background sites with over 75% data capture for the year) were plotted in a GIS with the rescale sites for each pollutant and a spatial analysis was performed to calculate the respective distances of each pairing site from each rescale site. Each rescale site was allocated up to four pairing sites based primarily on geographical proximity (the closest pairing sites being treated as more representative of the rescale site) and then on data capture, giving preference to the most complete data records for 2007. Sites beyond 80km from a rescale site were considered as unrepresentative of that rescale site and omitted from consideration for pairing. In some cases where the rescale site is in a remote location, this has resulted in fewer than four pairing sites allocated. Where fewer than two appropriate pairing sites were allocated, the rescaling was not performed and the monitoring data was removed from the PCM modelling process.

Where two or more pairing sites were allocated to the rescale site, the ratio of the full year annual to the period mean (for the operational period of the rescale site) was calculated for each pairing site. The average of these ratios at each pairing site was then applied to the period mean in order to estimate the full year annual mean at the rescale site.

Tables A6.1 to A6.5 list (by pollutant) the sites for which the data scaling was undertaken, the intermediate steps involved and the final estimated full year annual mean. The column labelled Average ratio (Am:Pm) is the average of the ratio between the annual mean and the period mean.

Table A6.1. SO_2 rescaling summary

Site	Site Type	Period mean (µg m^{-3})	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean (µg m^{-3})
Aberdeen	URBAN BACKGROUND	3	01/01/2001	30/09/2007	97		
Belfast East	URBAN BACKGROUND	3	06/09/1989	30/09/2007	99		
Birmingham Centre	URBAN CENTRE	3	18/03/1992	30/09/2007	87	1.00	3.0
Blackpool Marton	URBAN BACKGROUND	5	14/06/2005	30/09/2007	90	0.94	4.7
Bournemouth	URBAN BACKGROUND	1	06/03/2001	30/09/2007	85		
Bradford Centre	URBAN CENTRE	10	28/11/1997	30/09/2007	86	1.17	11.7
Coventry Memorial Park	URBAN BACKGROUND	2	26/02/2001	30/09/2007	94	1.00	2.0
Exeter Roadside	ROADSIDE	1	02/07/1996	30/09/2007	99	1.00	1.0
Hove Roadside	ROADSIDE	2	03/01/2001	30/09/2007	99	1.08	2.2
London Brent	URBAN BACKGROUND	2	26/01/1996	30/09/2007	94	1.08	2.2
London Eltham	SUBURBAN	4	01/04/1996	30/09/2007	90	1.08	4.3
London Hillingdon	SUBURBAN	2	02/08/1996	30/09/2007	97	1.08	2.2
London Lewisham	URBAN CENTRE	3	16/04/1997	30/09/2007	98	1.08	3.3
London Southwark	URBAN CENTRE	3	28/02/1997	30/09/2007	84	1.08	3.3
London Teddington	URBAN BACKGROUND	3.7	08/08/1996	30/09/2007	87	1.08	4.0
Manchester Piccadilly	URBAN CENTRE	5	18/12/1995	30/09/2007	94	1.00	5.0
Manchester South	SUBURBAN	1	03/04/1997	30/09/2007	98	0.96	1.0
Oxford Centre Roadside	ROADSIDE	2	15/04/1996	30/09/2007	96	1.00	2.0
Plymouth Centre	URBAN CENTRE	1	29/09/1997	30/09/2007	83	1.00	1.0
Portsmouth	URBAN BACKGROUND	3	16/01/2001	30/09/2007	97		
Preston	URBAN BACKGROUND	3	06/06/2000	30/09/2007	95	0.96	2.9
Reading New Town	URBAN BACKGROUND	6	17/10/2003	30/09/2007	91	1.08	6.5
Redcar	SUBURBAN	7	25/06/1997	30/09/2007	84	1.17	8.2
Rotherham Centre	URBAN CENTRE	4	20/06/1997	30/09/2007	94	1.17	4.7
Southend-on-Sea	URBAN BACKGROUND	4	24/07/2000	30/09/2007	98	1.01	4.0
Stockport Shaw Heath	URBAN BACKGROUND	3	09/10/2002	30/09/2007	99	0.96	2.9
Stoke-on-Trent Centre	URBAN CENTRE	4	11/03/1997	30/09/2007	95	0.96	3.8
Sunderland	URBAN BACKGROUND	2	06/10/1992	30/09/2007	94	1.17	2.3
Swansea Roadside	ROADSIDE	4	20/09/2006	30/09/2007	98	1.00	4.0

Site	Site Type	Period mean ($\mu g\ m^{-3}$)	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean ($\mu g\ m^{-3}$)
Wigan Centre	URBAN BACKGROUND	2	08/10/2004	30/09/2007	97	0.96	1.9
Wolverhampton Centre	URBAN CENTRE	3	19/12/1995	30/09/2007	98	1.00	3.0

Table A6.2. NO_X rescaling summary

Site	Site Type	Period mean (µg m^{-3})	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean (µg m^{-3})
Bradford Centre	URBAN CENTRE	32	28/11/1997	30/09/2007	79	1.20	38.5
Brentford Roadside	ROADSIDE	146	20/06/2003	30/09/2007	98	1.30	190.0
Hove Roadside	ROADSIDE	55	16/09/1997	30/09/2007	96	1.25	68.9
London A3 Roadside	ROADSIDE	137	20/03/1997	30/09/2007	97	1.30	178.3
London Brent	URBAN BACKGROUND	38	26/01/1996	30/09/2007	95	1.30	49.4
London Bromley	ROADSIDE	76	11/08/1998	30/09/2007	96	1.33	101.1
London Hackney	URBAN CENTRE	75	06/01/1997	30/09/2007	100	1.34	100.3
London Lewisham	URBAN CENTRE	95	16/04/1997	30/09/2007	92	1.34	127.0
London Southwark	URBAN CENTRE	65	28/02/1997	30/09/2007	99	1.34	86.9
London Wandsworth	URBAN CENTRE	101	01/04/1996	30/09/2007	92	1.33	134.5
Manchester Town Hall	URBAN BACKGROUND	54	22/01/1987	30/09/2007	96	1.21	65.5
Norwich Forum Roadside	ROADSIDE	58	08/04/2005	30/09/2007	96	1.39	80.9
Port Talbot	URBAN INDUSTRIAL	28	09/01/1997	23/07/2007	98	1.20	33.5
Redcar	SUBURBAN	22	25/06/1997	30/09/2007	87	1.27	28.0
Rotherham Centre	URBAN CENTRE	56	20/06/1997	30/09/2007	90	1.22	68.2
Stockport Shaw Heath	URBAN BACKGROUND	41	09/10/2002	30/09/2007	79	1.21	49.7
Walsall Alumwell	URBAN BACKGROUND	66	05/03/1987	30/09/2007	97	1.25	82.4
West London	URBAN BACKGROUND	72	01/01/1987	30/09/2007	98	1.30	93.7
Wolverhampton Centre	URBAN CENTRE	41	19/12/1995	30/09/2007	97	1.25	51.2

Table A6.3. NO_2 rescaling summary

Site	Site Type	Period mean ($\mu g\ m^{-3}$)	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean ($\mu g\ m^{-3}$)
Bradford Centre	URBAN CENTRE	22	28/11/1997	30/09/2007	79	1.08	23.7
Brentford Roadside	ROADSIDE	60	20/06/2003	30/09/2007	98	1.11	66.7
Hove Roadside	ROADSIDE	30	16/09/1997	30/09/2007	96	1.14	34.2
London A3 Roadside	ROADSIDE	61	20/03/1997	30/09/2007	97	1.11	67.8
London Brent	URBAN BACKGROUND	26	26/01/1996	30/09/2007	95	1.11	28.9
London Bromley	ROADSIDE	44	11/08/1998	30/09/2007	96	1.11	49.0
London Hackney	URBAN CENTRE	44	06/01/1997	30/09/2007	100	1.12	49.3
London Lewisham	URBAN CENTRE	52	16/04/1997	30/09/2007	92	1.12	58.3
London Southwark	URBAN CENTRE	39	28/02/1997	30/09/2007	99	1.12	43.7
London Wandsworth	URBAN CENTRE	50	01/04/1996	30/09/2007	92	1.13	56.4
Manchester Town Hall	URBAN BACKGROUND	37	22/01/1987	30/09/2007	96	1.09	40.5
Norwich Forum Roadside	ROADSIDE	31	08/04/2005	30/09/2007	96	1.21	37.4
Port Talbot	URBAN INDUSTRIAL	18	09/01/1997	23/07/2007	73	1.07	19.2
Redcar	SUBURBAN	17	25/06/1997	30/09/2007	87	1.22	20.8
Rotherham Centre	URBAN CENTRE	32	20/06/1997	30/09/2007	90	1.11	35.6
Stockport Shaw Heath	URBAN BACKGROUND	28	09/10/2002	30/09/2007	79	1.09	30.7
Walsall Alumwell	URBAN BACKGROUND	36	05/03/1987	30/09/2007	97	1.11	40.0
West London	URBAN BACKGROUND	46	01/01/1987	30/09/2007	98	1.11	51.1
Wolverhampton Centre	URBAN CENTRE	24	19/12/1995	30/09/2007	97	1.11	26.7

Table A6.4. PM_{10} (TEOM) rescaling summary

Site	Site Type	Period mean ($\mu g\ m^{-3}$)	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean ($\mu g\ m^{-3}$)
Bradford Centre	URBAN CENTRE	19	28/11/1997	30/09/2007	94	1.00	19.0
Canterbury	URBAN BACKGROUND	17	02/01/2001	30/09/2007	99	1.02	17.3
Cwmbran	URBAN BACKGROUND	14	20/07/2001	30/09/2007	99	1.02	14.3
London A3 Roadside	ROADSIDE	24	20/03/1997	30/09/2007	98	1.02	24.4
London Brent	URBAN BACKGROUND	15	10/04/1996	30/09/2007	96	1.02	15.3
London Hillingdon	SUBURBAN	20	02/08/1996	30/09/2007	98	1.02	20.3
Redcar	SUBURBAN	16	25/06/1997	30/09/2007	84		
Stockport Shaw Heath	URBAN BACKGROUND	15	09/10/2002	30/09/2007	98	1.00	15.0
Wigan Centre	URBAN BACKGROUND	16	08/10/2004	30/09/2007	99	1.00	16.0

Table A6.5. CO rescaling summary

Site	Site Type	Period mean (mg m^{-3})	Start date	End Date	Period mean data capture (%)	Average ratio (Am:Pm)	Scaled annual mean (mg m^{-3})
Aberdeen	URBAN BACKGROUND	0.27	18/09/1999	30/09/2007	99		
Barnsley Gawber	URBAN BACKGROUND	0.21	08/07/2002	30/09/2007	92	1.12	0.24
Bath Roadside	ROADSIDE	0.53	18/11/1996	30/09/2007	94	1.20	0.63
Birmingham Centre	URBAN CENTRE	0.33	18/03/1992	30/09/2007	97	1.07	0.35
Birmingham Tyburn	URBAN BACKGROUND	0.20	16/08/2004	30/09/2007	95	1.07	0.21
Blackpool Marton	URBAN BACKGROUND	0.17	14/06/2005	30/09/2007	96		
Bournemouth	URBAN BACKGROUND	0.26	19/07/2002	30/09/2007	98		
Bradford Centre	URBAN CENTRE	0.24	28/11/1997	30/09/2007	94	1.10	0.26
Brighton Roadside	ROADSIDE	0.31	10/02/1998	30/09/2007	98	1.16	0.36
Coventry Memorial Park	URBAN BACKGROUND	0.16	26/02/2001	30/09/2007	99	1.07	0.17
Cwmbran	URBAN BACKGROUND	0.21	12/03/2002	30/09/2007	81	1.20	0.25
Derry	URBAN BACKGROUND	0.22	29/04/1997	30/09/2007	93	1.20	0.26
Dumfries	ROADSIDE	0.44	17/07/2001	30/09/2007	90	1.20	0.53
Exeter Roadside	ROADSIDE	0.43	02/07/1996	30/09/2007	99	1.20	0.52
Glasgow City Chambers	URBAN BACKGROUND	0.30	28/07/1989	30/09/2007	99	1.06	0.32
Glasgow Kerbside	KERBSIDE	0.36	10/03/1997	30/09/2007	99	1.06	0.38
Grangemouth	URBAN INDUSTRIAL	0.16	17/01/2003	30/09/2007	97	1.06	0.17
Hove Roadside	ROADSIDE	0.28	15/10/1997	30/09/2007	99	1.16	0.32
Inverness	ROADSIDE	0.34	17/07/2001	30/09/2007	98	1.16	0.39
Leamington Spa	URBAN BACKGROUND	0.16	26/07/1996	30/09/2007	96	1.07	0.17
London A3 Roadside	ROADSIDE	0.43	20/03/1997	30/09/2007	97	1.16	0.50
London Brent	URBAN BACKGROUND	0.17	26/01/1996	30/09/2007	98	1.16	0.20
London Hackney	URBAN CENTRE	0.17	06/01/1997	30/09/2007	100	1.16	0.20
London Hillingdon	SUBURBAN	0.39	02/08/1996	30/09/2007	92	1.16	0.45
London Southwark	URBAN CENTRE	0.35	28/02/1997	30/09/2007	84	1.16	0.41
Manchester Piccadilly	URBAN CENTRE	0.30	18/12/1995	30/09/2007	95	1.10	0.33
Manchester Town Hall	URBAN BACKGROUND	0.28	08/08/1991	30/09/2007	87	1.10	0.31
Northampton	URBAN BACKGROUND	0.17	12/03/2002	30/09/2007	99	1.07	0.18
Norwich Centre	URBAN CENTRE	0.17	24/07/1997	30/09/2007	99	1.07	0.18

Site	**Site Type**	**Period mean (mg m^{-3})**	**Start date**	**End Date**	**Period mean data capture (%)**	**Average ratio (Am:Pm)**	**Scaled annual mean (mg m^{-3})**
Nottingham Centre	URBAN CENTRE	0.21	02/09/1996	30/09/2007	98	1.07	0.23
Oxford Centre Roadside	ROADSIDE	0.14	15/04/1996	30/09/2007	81		
Portsmouth	URBAN BACKGROUND	0.22	21/03/2002	30/09/2007	99		
Preston	URBAN BACKGROUND	0.27	06/06/2000	30/09/2007	92	1.12	0.30
Reading New Town	URBAN BACKGROUND	0.20	17/10/2003	30/09/2007	94	1.17	0.23
Sandwell West Bromwich	URBAN BACKGROUND	0.22	04/11/1998	30/09/2007	95		
Sheffield Tinsley	URBAN INDUSTRIAL	0.26	08/08/1991	30/09/2007	98	1.12	0.29
Southend-on-Sea	URBAN BACKGROUND	0.18	24/07/2000	30/09/2007	99	1.12	0.20
Stockport Shaw Heath	URBAN BACKGROUND	0.15	09/10/2002	30/09/2007	96	1.10	0.17
Stockton-on-Tees Yarm	ROADSIDE	0.30	13/08/2002	30/09/2007	98	1.10	0.33
Stoke-on-Trent Centre	URBAN CENTRE	0.38	11/03/1997	30/09/2007	98	1.08	0.41
Swansea Roadside	ROADSIDE	0.24	20/09/2006	30/09/2007	98		
Thurrock	URBAN BACKGROUND	0.22	01/09/1996	30/09/2007	90	1.16	0.25
West London	URBAN BACKGROUND	0.38	14/08/1989	30/09/2007	89	1.16	0.44
Wigan Centre	URBAN BACKGROUND	0.16	08/10/2004	30/09/2007	98	1.10	0.18
Wirral Tranmere	URBAN BACKGROUND	0.24	14/05/2000	30/09/2007	91		
Wolverhampton Centre	URBAN CENTRE	0.30	19/12/1995	30/09/2007	91		
Wrexham	ROADSIDE	0.35	06/03/2002	30/09/2007	94		