

# Report

## **Preliminary Assessment of benzene and carbon monoxide levels in the UK**

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

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# 1 Introduction

The Framework Directive (Council Directive 96/62 EC) establishes a system under which the EU will set limit values or target values for concentrations in ambient air of specified pollutants. The 2<sup>nd</sup> Daughter Directive (Directive 2000/69/EC) sets limit values to be achieved for benzene and carbon monoxide. The limit values set in the 2<sup>nd</sup> Daughter Directive for benzene and carbon monoxide have been incorporated into proposed national objectives under the review of the UK's Air Quality Strategy (AQS, Defra et al, 2001).

Article 10 of the 2<sup>nd</sup> Daughter Directive specifies that the provisions of that Directive are to be transposed into national law by 13 December 2002. The UK will begin the assessment of ambient air quality for benzene and carbon monoxide, required by Article 6 of the Framework Directive, from 1 January 2003.

Monitoring of air quality in the UK is carried out through national networks of air quality monitoring stations (e.g. the Automatic Urban and Rural Networks and hydrocarbon networks). In addition, local authority funded monitoring activities operate throughout the UK, although in general, these are not combined with the national network. This report describes how the national monitoring networks are to be extended to meet the requirements of the Framework Directive and 2<sup>nd</sup> Daughter Directive. For carbon monoxide, this expansion will be achieved in many cases by the incorporation of local authority monitoring sites into the national network.

## 2 Preliminary Assessment

Under Article 5 of The Framework Directive, a requirement has been placed upon Member States to undertake a preliminary investigation of ambient air quality, prior to the implementation of the Daughter Directive relating to benzene and carbon monoxide (see Appendix 1).

The objectives of this assessment are to establish estimates of the overall distribution and levels of pollutants, and to identify additional monitoring requirements, which may be necessary in order to fulfil obligations under the Framework and 2<sup>nd</sup> Daughter Directive. This report provides details of the number of additional monitoring locations, which will be required for benzene and carbon monoxide in the UK. A description is provided of the assessment methods which have been applied throughout the UK, by **netcen** on behalf of the Defra, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland.

## 3 General approach

For the purpose of this assessment, the UK has been divided into 16 zones, based on official Government Office boundaries within England and boundaries provided or

authorised by the relevant Government offices within Scotland, Wales and Northern Ireland. A further 28 agglomeration zones (areas of urban population > 250,000) have also been agreed. These were based on Government geographical information system (GIS) data on urban areas for England and Wales (Hyrenkiewicz, *pers comm*, 1998), urban localities information in Scotland (Gardner *pers comm*, 1998) and CORINE land cover information within Northern Ireland (CORINE, 1998). UK zones and agglomerations are presented in Figure 1. It will be noted from Figure 1 that Greater London is defined as both an agglomeration and a zone. This is a result of a specific Government Office region being assigned to this area and the urban population exceeding 250,000. For the purpose of this assessment, Greater London will be treated as an agglomeration only. Monitoring requirements within each zone and agglomeration have been assessed separately.

Estimated pollutant concentrations within each zone have been compared with the relevant Assessment Thresholds, Limit Values and the Margins of Tolerance as defined in the 2<sup>nd</sup> Daughter Directive (see Appendix 2). Areas requiring additional monitoring have been identified by an examination of the current automatic monitoring network and the coverage of the areas with high estimated concentrations. The number of additional monitoring sites required has been calculated from the population of the individual zones and agglomerations and the incidence of exceedance of the relevant Assessment Thresholds presented in Table (a) Annex V of the 2<sup>nd</sup> Daughter Directive, (see Appendix 3). The availability of other methods of assessment (models, emissions inventories, indicative monitoring) has also been taken into account within the preliminary assessment. Supplementary assessment techniques have enabled a reduction in the monitoring requirement per zone relative to Annex V of the Directive, (Annex V presents the monitoring requirements assuming fixed monitoring as the sole source of information, see Appendix 3).

The following assumptions and definitions have been adopted for the purposes of this assessment:

1. The UK is comprised of 28 agglomeration zones and 16 non-agglomeration zones.
2. Where 'other sources of information' on pollutant concentrations are available, a number of sites less than that identified by Annex V of the Daughter Directive (which assumes fixed monitoring is the sole source of information) may enable compliance with the Daughter Directive (see Appendix 3).
3. Where concentrations of these pollutants are expected to be below the Lower Assessment Threshold (LAT), no monitoring is required, even in agglomerations. In such cases compliance with Directive Limit Values may be checked using modelling.

In order to ensure that the modelled exceedance statistics provided by this approach have not been systematically underestimated, a comparison with measured exceedance data for the 1999 calendar year has been performed at sites within the current AURN. These comparisons are presented in Appendix 4. Agreement between modelled exceedances at each monitoring location and measured exceedance statistics is generally good. However, at a small number of sites the models have not predicted the exceedance of the Upper Assessment Threshold, which has been identified in the measured data. The occurrence of such discrepancies does not affect the conclusions of the study, as exceedances are identified by modelling at other locations, either urban background or roadside, elsewhere in these zones or agglomerations, for benzene and carbon monoxide.

It should be noted that the comparison of modelled and measured data at national network monitoring station locations has only been performed for the 1999 calendar

year. This has resulted from changes in the hydrocarbon network structure from January 2000. In January 2000, the network of 13 automatic benzene monitoring locations was reduced to four sites, in preparation for the commissioning of an alternative sampler based network for compliance with the 2<sup>nd</sup> Daughter Directive. As a result, there is a paucity of measured data for comparison with modelled data from January 2000. Hence, the comparison is based upon the 1999 calendar year. For consistency, the same approach was applied to carbon monoxide.

### **3.1 MODELLED DATA USED IN THIS ASSESSMENT**

Estimates of the distribution of pollutant concentrations within each zone and agglomeration have been derived using empirically modelled high resolution pollutant maps for benzene and carbon monoxide (Bush et al, 2001 a and b). The models draw heavily upon measurement data from the UK's automatic urban and rural network (AURN), and are as a result, calibrated to these networks. In each case the most recent atmospheric emissions inventory data and monitoring data have been used in the development of the models. This approach provides a comprehensive and robust means of estimating pollutant concentrations throughout the whole of the UK, utilising current best estimates and practises.

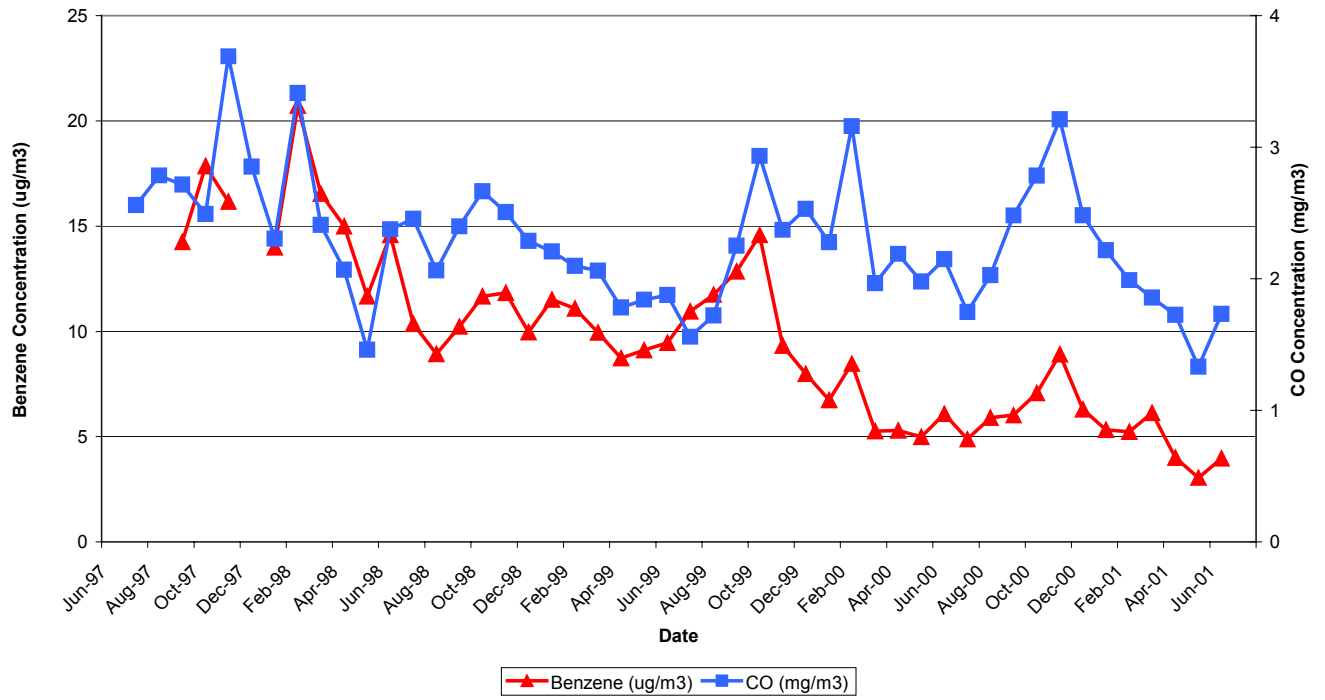
For benzene and carbon monoxide, pollutant maps for background and roadside locations were developed using the most recent calendar year of monitoring information (1999) at the time of model development. Pollutant concentrations were then calculated for 2001 using projected emissions totals from the National Atmospheric Emissions Inventory. As a result, the effect of policy measures upon diesel and petrol fuel quality and improvements in new road vehicle engine technologies has been accounted for within the estimated pollutant concentrations used for identification of a likely monitoring requirements.

This approach has been driven by the observed effect of the European Fuel Quality Directive (Council Directive 98/70/EC) upon ambient benzene concentrations and to a lesser extent carbon monoxide within the UK. In the UK, the majority of benzene emissions originate from unburnt fuel in petrol vehicle exhaust gases and fuel evaporation during refuelling. In 1999, motor vehicles accounted for about 71% of total emissions with petrol vehicles contributing a significant proportion to this total. As the result of EU Directive 98/70/EC, the maximum amount of benzene in petrol was reduced on 1 January 2000, from 5% by volume to 1% by volume. This has led to a step change in benzene emissions. The current average benzene content in gasoline sold in the UK is now about 0.6%. Observed changes in carbon monoxide concentrations are likely to have arisen from reductions in fuel sulphur content enabling three-way-catalysts to operate at higher efficiency levels and subsequently lower emissions from vehicles with three-way-catalysts.

As an illustration of the effect of the European Fuel Quality Directive upon ambient benzene and carbon monoxide concentrations, Figure 2 presents measured benzene and carbon monoxide concentrations at the Marylebone Road roadside monitoring station in London. Figure 2 shows that from October 1999, levels of ambient benzene were observed to decrease dramatically. These reductions correlate well with the timescales for introduction of low benzene petrol within the UK.



**Figure 2 Monthly average benzene and carbon monoxide concentrations measured at Marylebone Road monitoring station from July 1997**



# 4 Benzene

## 4.1 METHODOLOGY

Benzene concentrations throughout the UK have been assessed at urban background and roadside locations. Estimates of pollutant concentrations have been derived from empirical models (Bush et al, 2001a) and projected to the 2001 calendar year. Automatic monitoring data are incorporated into the empirical model used. Exceedance statistics for Upper and Lower Assessment Thresholds (UAT and LAT) have also been calculated based upon measured data between 1995 and 1999. Measured data from 2000 have not been used to calculate exceedance statistics owing to the reduced network size from January 2000 and subsequent lack for measured data. In order to check for systematic underestimation in the modelled data, the measured exceedance statistics presented in Appendix 4 have been compared with the modelled exceedance statistics in 1999 for the zone in which each monitoring station is located.

Figures 3 and 4 present maps of estimated annual average benzene concentrations at urban background and roadside locations in the UK. Exceedances of the Margin of Tolerance ( $10 \mu\text{g}/\text{m}^3$ ), Limit Value ( $5 \mu\text{g}/\text{m}^3$ ), Upper Assessment Threshold ( $3.5 \mu\text{g}/\text{m}^3$ ) and Lower Assessment Threshold ( $2 \mu\text{g}/\text{m}^3$ ) are indicated by colour coding. Roadside concentrations have been modelled for major roads in built-up areas only.

## 4.2 OBSERVATIONS AND PROPOSALS

Figure 3 shows that estimated annual mean benzene concentrations away from major roads in 2001 are expected to be below the Upper and Lower Assessment Thresholds in all areas except central London. At roadside locations presented in Figure 4, it is estimated that exceedances of the Lower Assessment Threshold are widespread in the majority of agglomerations in the UK and also non-agglomeration zones in England, South Wales and Northern Ireland. Exceedances of the Upper Assessment Threshold are limited to the larger agglomerations of England. The Limit Value for benzene is estimated to have been exceeded in 2001 at locations close to roads in inner and outer London and central Leeds. There are no predicted exceedances of the Margin of Tolerance for benzene in 2001.

Modelled roadside and urban background concentrations within Teeside agglomeration were observed to be below the Lower Assessment Threshold. This observation conflicts with measured data taken at the Middlesbrough monitoring station between 1995 and 1999. These data are presented in Table A1 of Appendix 4 and indicate that throughout this period annual average concentrations were consistently equal to or greater than the Lower Assessment Threshold. Major industrial sources of benzene have not been modelled within the UK's national empirical maps and hence, at industrial locations such as the Middlesbrough monitoring station the modelled data may underestimate ambient concentrations. As a result, within the Teeside agglomeration it is recommended that benzene monitoring is continued at an urban background location.

### 4.2.1 Requirements within agglomerations

The minimum number of monitoring sites required within agglomerations is defined by Annex V of the Daughter Directive (see Appendix 3) and assumes that fixed monitoring is the sole source of information. The number of monitoring locations required in UK agglomerations, based on the threshold exceedances presented in Figure 3 and 4, fixed

monitoring as the sole source of information and the population of the respective agglomerations, is presented in Table 1 by the '*Minimum Site Number A*' statistic.

Throughout the UK, other means of assessment (empirical modelling and emissions inventories) are available for benzene. Therefore, a number of sites less than that defined by Annex V, will enable compliance with the Directive and is presented in Table 1 by the '*Minimum Site Number B*' statistic.

Table 1 indicates that when the current (2001) network of automatic monitoring stations and the availability of other assessment methods are taken into account, a total of 19 additional monitoring sites are required for compliance with the Directive within agglomerations in England (including monitoring within the Teeside agglomeration). One additional monitoring station is required within agglomerations in both Scotland and Northern Ireland. No additional monitoring requirements were identified for agglomerations in Wales.

#### **4.2.2 Requirements within non-agglomeration zones**

Monitoring requirements in non-agglomerations zones throughout the UK, assuming fixed monitoring as the sole source of information, are presented in Table 2 by the '*Minimum Site Number A*' statistic. As for agglomeration zones, other means of assessment are available, and therefore, a smaller number of sites are required to enable compliance with the Directive, presented by the '*Minimum Site Number B*' statistic.

From Table 2 and taking into account the current (2001) network of automatic monitoring sites and the availability other assessment methods a total of 8 additional monitoring sites are required for compliance with the Directive in the non-agglomeration zones within England, 1 within Wales and 1 within Northern Ireland. No additional monitoring requirements were identified within Scotland.

**Table 1 Benzene monitoring requirements in UK agglomerations****1. England**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Greater London Urban Area	7650944	UAT	Roadside	10	1	1	0	0
West Midlands Urban Area	2296180	UAT	Roadside	6	1	0	0	1
Greater Manchester Urban Area	2277330	UAT	Roadside	6	1	0	0	1
West Yorkshire Urban Area	1445981	UAT	Roadside	4	1	0	0	1
Tyneside	885981	LAT	Roadside	1	1	0	0	1
Liverpool Urban Area	837998	LAT	Roadside	1	1	0	0	1
Sheffield Urban Area	633362	LAT	Roadside	1	1	0	0	1
Nottingham Urban Area	613726	LAT	Roadside	1	1	0	0	1
Bristol Urban Area	522784	LAT	Roadside	1	1	0	0	1
Brighton/Worthing/Littlehampton	437592	LAT	Roadside	1	1	0	0	1
Leicester Urban Area	416601	UAT	Roadside	2	1	0	0	1
Portsmouth Urban Area	409341	LAT	Roadside	1	1	0	0	1
Teesside Urban Area	369609	None	na	-	-	0	0	1***
The Potteries	367976	LAT	Roadside	1	1	0	0	1
Bournemouth Urban Area	358321	LAT	Roadside	1	1	0	0	1
Reading/Wokingham Urban Area	335757	LAT	Roadside	1	1	0	0	1
Coventry/Bedworth	331248	LAT	Roadside	1	1	0	0	1
Kingston upon Hull	310636	LAT	Roadside	1	1	0	0	1
Southampton Urban Area	276752	LAT	Roadside	1	1	0	0	1
Birkenhead Urban Area	270207	None	na	-	-	0	0	0
Southend Urban Area	266749	LAT	Roadside	1	1	0	0	1
Blackpool Urban Area	261355	None	na	-	-	0	0	0
Preston Urban Area	256411	None	na	-	-	0	0	0

Additional monitoring requirements in agglomerations in England:

19

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

\*\*\* Recommended monitoring requirement based on benzene monitoring between 1995-1999 at an industrial location within Teesside.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

(Table1 continued)

**2. Wales**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites</b> (Roadside or Urban Background)
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Swansea	272456	None	na	-	-	0	0	0
Cardiff	306904	LAT	Roadside	1	1	0	1	0

Additional monitoring requirements in agglomerations in Wales:

0

**3. Scotland**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites</b> (Roadside or Urban Background)
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Edinburgh Urban Area	416232	None	na	-	-	0	1	0
Glasgow Urban Area	1315544	LAT	Roadside	2	1	0	0	1

Additional monitoring requirements in agglomerations in Scotland:

1

**4. Northern Ireland**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites</b> (Roadside or Urban Background)
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Belfast	475987	LAT	Roadside	1	1	0	0	1

Additional monitoring requirements in agglomerations in Northern Ireland:

1

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

**Table 2 Benzene monitoring requirements in UK zones****1. England**

Zone	Population*	Exceedence	Location of Highest Exceedence	Minimum Site No.**		Existing Sites		Additional Sites (Roadside or Urban Background)
				A	B	Roadside	Background	
Greater London	7650944	na	na	na	na	na	na	na
North East	1287979	LAT	Roadside	2	1	0	0	1
North West & Merseyside	2823559	UAT	Roadside	7	1	0	0	1
Yorkshire & Humberside	2446545	LAT	Roadside	3	1	0	0	1
East Midlands	2923045	UAT	Roadside	7	1	0	0	1
West Midlands	2154783	LAT	Roadside	3	1	0	0	1
Eastern	4788766	LAT	Roadside	4	1	0	0	1
South East	3702634	LAT	Roadside	3	1	0	0	1
South West	3728319	LAT	Roadside	3	1	0	0	1

Additional monitoring requirements in zones in England:

8

[Site nos. for Greater London area not calculated as this is completely covered by the London agglomeration]

**2. Wales**

Zone	Population*	Exceedence	Location of Highest Exceedence	Minimum Site No.**		Existing Sites		Additional Sites (Roadside or Urban Background)
				A	B	Roadside	Background	
South Wales	1623660	LAT	Roadside	2	1	0	0	1
North Wales	713762	None	na	-	-	0	0	0

Additional monitoring requirements in zones in Wales:

1

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

(Table 2 continued)

**3. Scotland**

<b>Zone</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	<small>(Roadside or Urban Background)</small>
Scottish Borders	246659	None	na	-	-	0	0	0
Central Scotland	1628460	None	na	-	-	0	0	0
North East Scotland	933485	None	na	-	-	0	0	0
Highland	364639	None	na	-	-	0	0	0

Additional monitoring requirements in zones in Scotland:

0

**4. Northern Ireland**

<b>Zone</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	<small>(Roadside or Urban Background)</small>
Northern Ireland	1101868	LAT	Roadside	2	1	0	0	1

Additional monitoring requirements in zones in Northern Ireland:

1

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

# 5 Carbon monoxide

## 5.1 METHODOLOGY

Carbon monoxide concentrations throughout the UK have been assessed at urban background and roadside locations. Estimates of pollutant concentrations have been derived from empirical models (Bush et al, 2001b) and projected to the 2001 calendar year. Automatic monitoring data are incorporated into the empirical model used. For consistency with the analyses carried out for benzene, for which there is very little data after 2000, exceedance statistics for Upper and Lower Assessment Thresholds (UAT and LAT) have been calculated based upon measured data between 1995 and 1999. In order to check for systematic underestimation in the modelled data, the measured exceedance statistics presented in Appendix 4 have been compared with the modelled exceedance statistics in 1999 for the zone in which each monitoring station is located.

Figures 5 and 6 present maps of estimated maximum 8-hour mean carbon monoxide concentrations at urban background and roadside locations in the UK. Exceedances of the Margin of Tolerance (16 mg/m<sup>3</sup>), Limit Value (10 mg/m<sup>3</sup>), Upper Assessment Threshold (7 mg/m<sup>3</sup>) and Lower Assessment Threshold (5 mg/m<sup>3</sup>) are indicated by colour coding. Roadside concentrations have been modelled for major roads in built-up areas only.

## 5.2 OBSERVATIONS AND PROPOSALS

Figure 5 shows that estimated maximum 8-hour mean carbon monoxide concentrations in 2001, at locations away from busy roads are expected to be less than the Lower Assessment Threshold in all areas except central London. At locations close to busy roads, Figure 6 shows that exceedance of the Lower Assessment Threshold is widespread in the majority of UK agglomerations. Concentrations greater than the Lower Assessment Threshold are predicted in all the non-agglomeration zones in England and within South Wales, North East Scotland and Central Scotland. Exceedance of the Upper Assessment Threshold is limited to six of the larger agglomerations in England, Glasgow and the North West and Merseyside non-agglomeration zone. The Limit Value for carbon monoxide in 2001 is predicted to be exceeded in inner London only. There are no exceedances of the Margin of Tolerance in 2001.

### 5.2.1 Requirements within agglomerations

As for benzene, the minimum number of carbon monoxide monitoring sites required within each agglomeration, as defined by Annex V of the Directive, assumes fixed monitoring is the sole source of information. The number of additional monitoring sites required for each agglomeration, based on the threshold exceedances presented in Figures 5 and 6 and the population of each agglomeration, is provided in Table 3 by the '*Minimum Site Number A*' statistic. This requirement assumes fixed monitoring as the sole source of information. Owing to the availability of other assessment techniques a smaller number of sites will enable compliance with the Daughter Directive. These requirements are presented in Table 3 by the '*Minimum Site Number B*' statistic.

From Table 3, and taking into account the current (2001) network of automatic monitoring stations and the availability of other assessment techniques, a total of 2 additional monitoring sites are required in agglomerations within England. No additional monitoring requirements were identified in the agglomerations of Scotland, Wales and Northern Ireland for minimum compliance with the Directive.



### **5.2.2 Requirements within non-agglomerations zones**

The minimum number of carbon monoxide monitoring sites required within each non-agglomeration zone, as defined by Annex V of the Daughter Directive, and assuming that fixed monitoring is the sole source of information is presented in Table 4 by the '*Minimum Site Number A*' statistic. The '*Minimum Site Number B*' statistic presents a smaller set of site numbers which will enable compliance with the Daughter Directive assuming other assessment techniques are available.

From Table 4, and taking into account the current (2001) network of automatic monitoring sites and the availability of other assessment methods a total of 4 additional monitoring sites are required within non-agglomeration zones within England and 1 in Scotland. No additional monitoring requirements were identified in Northern Ireland or Wales for compliance with the Directive.

**Table 3 Carbon monoxide monitoring requirements in UK agglomerations****1. England**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Greater London Urban Area	7650944	UAT	Roadside	10	1	8	9	0
West Midlands Urban Area	2296180	UAT	Roadside	6	1	0	4	0
Greater Manchester Urban Area	2277330	UAT	Roadside	6	1	1	5	0
West Yorkshire Urban Area	1445981	UAT	Roadside	4	1	0	2	0
Tyneside	885981	UAT	Roadside	3	1	0	1	0
Liverpool Urban Area	837998	LAT	Roadside	1	1	0	1	0
Sheffield Urban Area	633362	LAT	Roadside	1	1	0	2	0
Nottingham Urban Area	613726	LAT	Roadside	1	1	0	1	0
Bristol Urban Area	522784	UAT	Roadside	2	1	2	0	0
Brighton/Worthing/Littlehampton	437592	LAT	Roadside	1	1	0	1	0
Leicester Urban Area	416601	LAT	Roadside	1	1	0	1	0
Portsmouth Urban Area	409341	LAT	Roadside	1	1	0	0	1
Teesside Urban Area	369609	None	Roadside	-	-	0	2	0
The Potteries	367976	LAT	Roadside	1	1	0	1	0
Bournemouth Urban Area	358321	LAT	Roadside	1	1	0	0	1
Reading/Wokingham Urban Area	335757	LAT	Roadside	1	1	0	1	0
Coventry/Bedworth	331248	LAT	Roadside	1	1	0	1	0
Kingston upon Hull	310636	LAT	Roadside	1	1	0	1	0
Southampton Urban Area	276752	LAT	Roadside	1	1	0	1	0
Birkenhead Urban Area	270207	None	na	-	-	0	1	0
Southend Urban Area	266749	LAT	Roadside	1	1	0	1	0
Blackpool Urban Area	261355	None	na	-	-	0	1	0
Preston Urban Area	256411	LAT	Roadside	1	1	0	1	0

Additional monitoring requirements in agglomerations in England:

2

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

(Table 3 continued)

**2. Wales**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Swansea	272456	None	na	-	-	0	1	0
Cardiff	306904	LAT	Roadside	1	1	0	1	0

Additional monitoring requirements in agglomerations in Wales:

0

**3. Scotland**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Edinburgh Urban Area	416232	LAT	Roadside	1	1	0	1	0
Glasgow Urban Area	1315544	UAT	Roadside	4	1	1 (kerbside)	2	0

Additional monitoring requirements in agglomerations in Scotland:

0

**4. Northern Ireland**

<b>Agglomeration</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Belfast	475987	LAT	Roadside	1	1	0	1	0

Additional monitoring requirements in agglomerations in Northern Ireland:

0

Note:

\*\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

**Table 4 Carbon monoxide monitoring requirements in UK zones****1. England**

Zone	Population*	Exceedence	Location of Highest Exceedence	Minimum Site No.**		Existing Sites		Additional Sites (Roadside or Urban Background)
				A	B	Roadside	Background	
Greater London	7650944	na	na	na	na	na	na	na
North East	1287979	LAT	Roadside	2	1	0	0	1
North West & Merseyside	2823559	UAT	Roadside	7	1	0	0	1
Yorkshire & Humberside	2446545	LAT	Roadside	3	1	0	0	1
East Midlands	2923045	LAT	Roadside	3	1	0	0	1
West Midlands	2154783	LAT	Roadside	3	1	0	1	0
Eastern	4788766	LAT	Roadside	4	1	0	2	0
South East	3702634	LAT	Roadside	3	1	1	0	0
South West	3728319	LAT	Roadside	3	1	2	1	0

Additional monitoring requirements in zones in England:

4

[Site nos. for Greater London area not calculated as this is completely covered by the London agglomeration]

**2. Wales**

Zone	Population*	Exceedence	Location of Highest Exceedence	Minimum Site No.**		Existing Sites		Additional Sites (Roadside or Urban Background)
				A	B	Roadside	Background	
South Wales	1623660	LAT	Roadside	2	1	0	0	1
North Wales	713762	None	na	-	-	0	1	0

Additional monitoring requirements in zones in Wales:

1

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

(Table 4 continued)

**3. Scotland**

<b>Zone</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Scottish Borders	246659	None	na	-	-	0	1	0
Central Scotland	1628460	LAT	Roadside	2	1	0	0	1
North East Scotland	933485	LAT	Roadside	1	1	0	1	0
Highland	364639	None	na	-	-	0	1	0

Additional monitoring requirements in zones in Scotland:

1

**4. Northern Ireland**

<b>Zone</b>	<b>Population*</b>	<b>Exceedence</b>	<b>Location of Highest Exceedence</b>	<b>Minimum Site No.**</b>		<b>Existing Sites</b>		<b>Additional Sites (Roadside or Urban Background)</b>
				<b>A</b>	<b>B</b>	<b>Roadside</b>	<b>Background</b>	
Northern Ireland	1101868	None	na	-	-	0	1	0

Additional monitoring requirements in zones in Northern Ireland:

0

Note:

\* Population statistics based on the 1991 National Census.

\*\* Minimum Site No. A, assumes fixed monitoring as the sole source of information.

Minimum Site No. B, assumes other means of assessment are available.

UAT refers to the Upper Assessment Threshold, LAT to the Lower Assessment Threshold.

## 6 Achieving compliance

Benzene and carbon monoxide levels have been assessed throughout the UK. On the basis of the assessments and analyses presented in this report, the minimum number of additional automatic monitoring locations in areas with high estimated pollutant concentrations have been identified. These recommendations for additional monitoring are summarised in Table 5. Fixed monitoring will be supplemented by information from other sources in all zones and agglomerations. Monitoring stations already available in the current monitoring network have also been taken into account.

**Table 5 Summary of the minimum additional number of monitoring sites required in the UK for compliance with the 2<sup>nd</sup> Daughter Directive**

<b>1. Benzene</b>					
	England	Wales	Scotland	Northern Ireland	Total
Agglomerations	19	0	1	1	
Other Zones	8	1	0	1	
<b>Total</b>	<b>27</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>31</b>
<b>2. Carbon monoxide</b>					
	England	Wales	Scotland	Northern Ireland	Total
Agglomerations	2	0	0	0	
Other Zones	4	1	1	0	
<b>Total</b>	<b>6</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>8</b>

The additional monitoring needed for formal compliance with the Directive will be satisfied by a process of affiliation of existing local authority monitoring stations and also by direct funding of new monitoring sites from the UK Government. A survey of the monitoring activities performed by local authorities was conducted in December 1999. The results of this survey have enabled the most appropriate local authority funded monitoring stations for meeting the requirements of the Daughter Directive to be identified with view to affiliation into the AURN. Table 6 presents the local authority monitoring stations that have been identified for affiliation and also indicates where direct funding from Government is required to achieve compliance with the Daughter Directive's monitoring requirements. There are currently no local authorities operating the preferred pumped tube benzene sampler, hence, all additional benzene monitoring requirements will need to be direct funded by the UK Government.

**Table 6 Carbon monoxide and benzene monitoring locations identified for minimum compliance with the 2<sup>nd</sup> Daughter Directive****England**

Agglomeration/Zone	Monitoring site	Pollutants required	Action required
Greater London Urban Area	-	-	No additional monitoring required
West Midlands Urban Area	Birmingham Kings Heath	Benzene	Direct fund benzene sampler
Greater Manchester Urban Area	Manchester Piccadilly	Benzene	Direct fund benzene sampler
West Yorkshire Urban Area	Leeds Centre	Benzene	Direct fund benzene sampler
Tyneside	Newcastle Centre	Benzene	Direct fund benzene sampler
Liverpool Urban Area	Liverpool Speke	Benzene	Direct fund benzene sampler
Sheffield Urban Area	Sheffield Centre	Benzene	Direct fund benzene sampler
Nottingham Urban Area	Nottingham Centre	Benzene	Direct fund benzene sampler
Bristol Urban Area	Bristol Old Market	Benzene	Direct fund benzene sampler
Brighton/Worthing/Littlehampton	Brighton Roadside	Benzene	Direct fund benzene sampler
Leicester Urban Area	Leicester Centre	Benzene	Direct fund benzene sampler
Portsmouth Urban Area	Portsmouth	Benzene and CO	Direct fund benzene sampler, affiliate CO
Teesside Urban Area	Middlesbrough**	Benzene	Direct fund benzene sampler**
The Potteries	Stoke Centre	Benzene	Direct fund benzene sampler
Bournemouth Urban Area	Bournemouth	Benzene and CO	Direct fund benzene sampler & CO
Reading/Wokingham Urban Area	Reading Centre	Benzene	Direct fund benzene sampler
Coventry/Bedworth	Coventry	Benzene	Direct fund benzene sampler
Kingston upon Hull	Hull Freetown	Benzene	Direct fund benzene sampler
Southampton Urban Area	Southampton Centre	Benzene	Direct fund benzene sampler
Birkenhead Urban Area			No additional monitoring required
Southend Urban Area	Southend-on-Sea	Benzene	Direct fund benzene sampler
Blackpool Urban Area	-	-	No additional monitoring required
Preston Urban Area	-	-	No additional monitoring required
North East	Yarm Roadside	Benzene and CO	Direct fund benzene sampler & CO
North West & Merseyside	Wigan - Leigh	Benzene and CO	Direct fund benzene sampler & CO
Yorkshire & Humberside	Barnsley Gawber	Benzene and CO	Direct fund benzene sampler & CO
East Midlands	Northampton	Benzene and CO	Direct fund benzene sampler, affiliate CO
West Midlands	Leamington Spa	Benzene	Direct fund benzene sampler
Eastern	Norwich Centre	Benzene	Direct fund benzene sampler
South East	Oxford Roadside	Benzene	Direct fund benzene sampler
South West	Plymouth Centre	Benzene	Direct fund benzene sampler

\*\* recommendation based on historical measurement data from an industrial location in the Teesside agglomeration

**Wales**

Agglomeration/Zone	Monitoring site	Pollutants required	Action required
Swansea	-	-	No additional monitoring required
Cardiff	-	-	No additional monitoring required
South Wales	Cwmbran	Benzene and CO	Direct fund benzene sampler, affiliate CO
North Wales	-	-	No additional monitoring required

**Scotland**

Agglomeration/Zone	Monitoring site	Pollutants required	Action required
Edinburgh Urban Area	-	-	No additional monitoring required
Glasgow Urban Area	Glasgow Kerbside	Benzene	Direct fund benzene sampler
Scottish Borders	-	-	No additional monitoring required
Central Scotland	Grangemouth	CO	Direct fund CO
North East Scotland	-	-	No additional monitoring required
Highland	-	-	No additional monitoring required

**Northern Ireland**

Agglomeration/Zone	Monitoring site	Pollutants required	Action required
Belfast	Belfast Centre	Benzene	Direct fund benzene sampler
Northern Ireland	Belfast Roadside	Benzene	Direct fund benzene sampler

## 7 References

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Council Directive 2000/69/EC, of 16 November 2000. Relating to limit values for benzene and carbon monoxide ambient air, (The 2<sup>nd</sup> Daughter Directive). From the Official Journal of the European Communities, 13.12.200, En Series, L313/12.

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Bush T, Stedman J and Murrells T (2001b). Projecting and mapping carbon monoxide concentrations in support of the Air Quality Strategy review. AEA Technology, National Environmental Technology Centre. Report No. AEAT/ENV/R/723, Culham.

Council Directive 98/70/EC, of 13 October 1998, relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC. From the Official Journal of the European Communities, 28.12.1998 L 350/58.



Figure 1 Preliminary Assessment zones and agglomerations  
Ref. netcen/12012000/gloms.shp,art5zones.shp/v6/TB

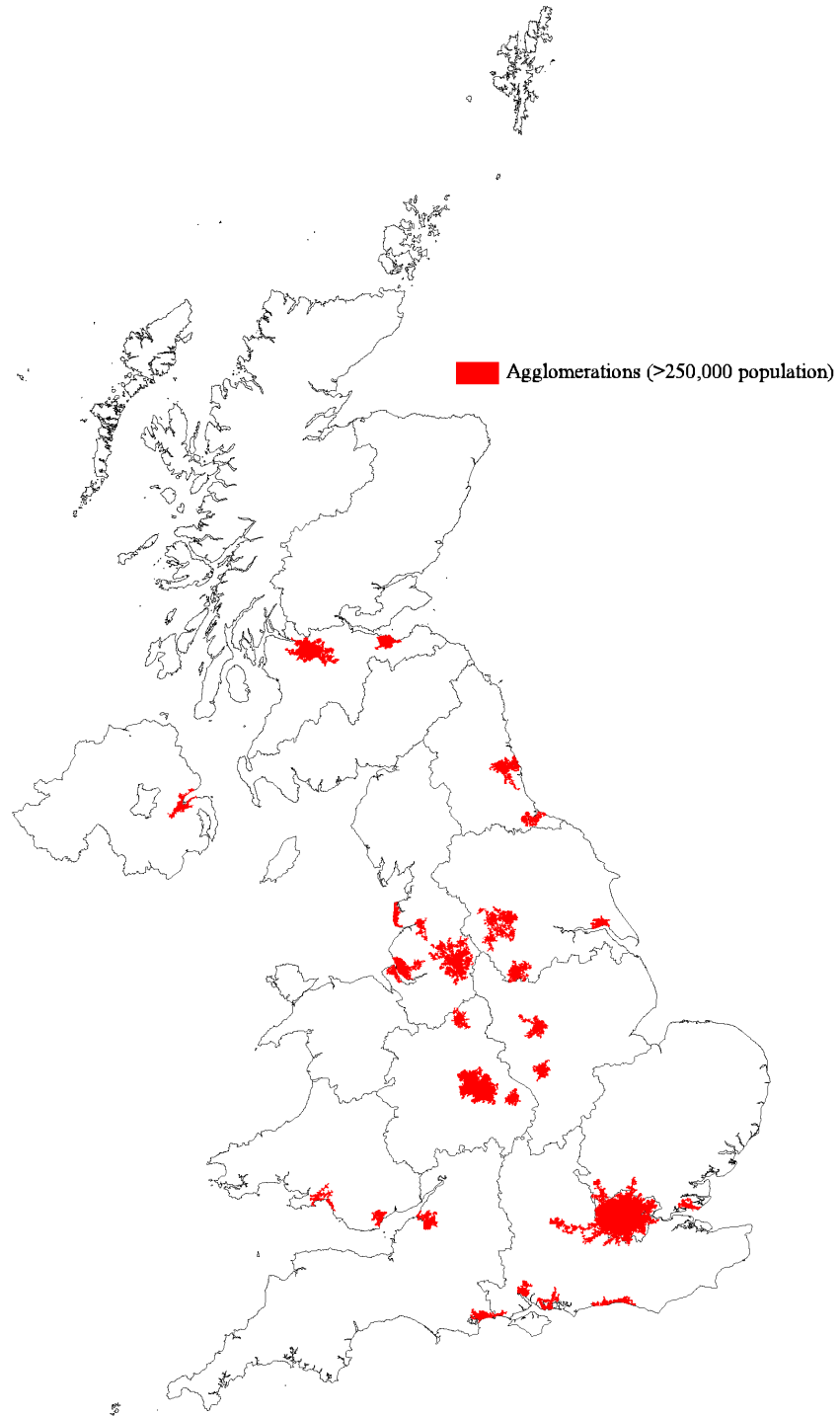
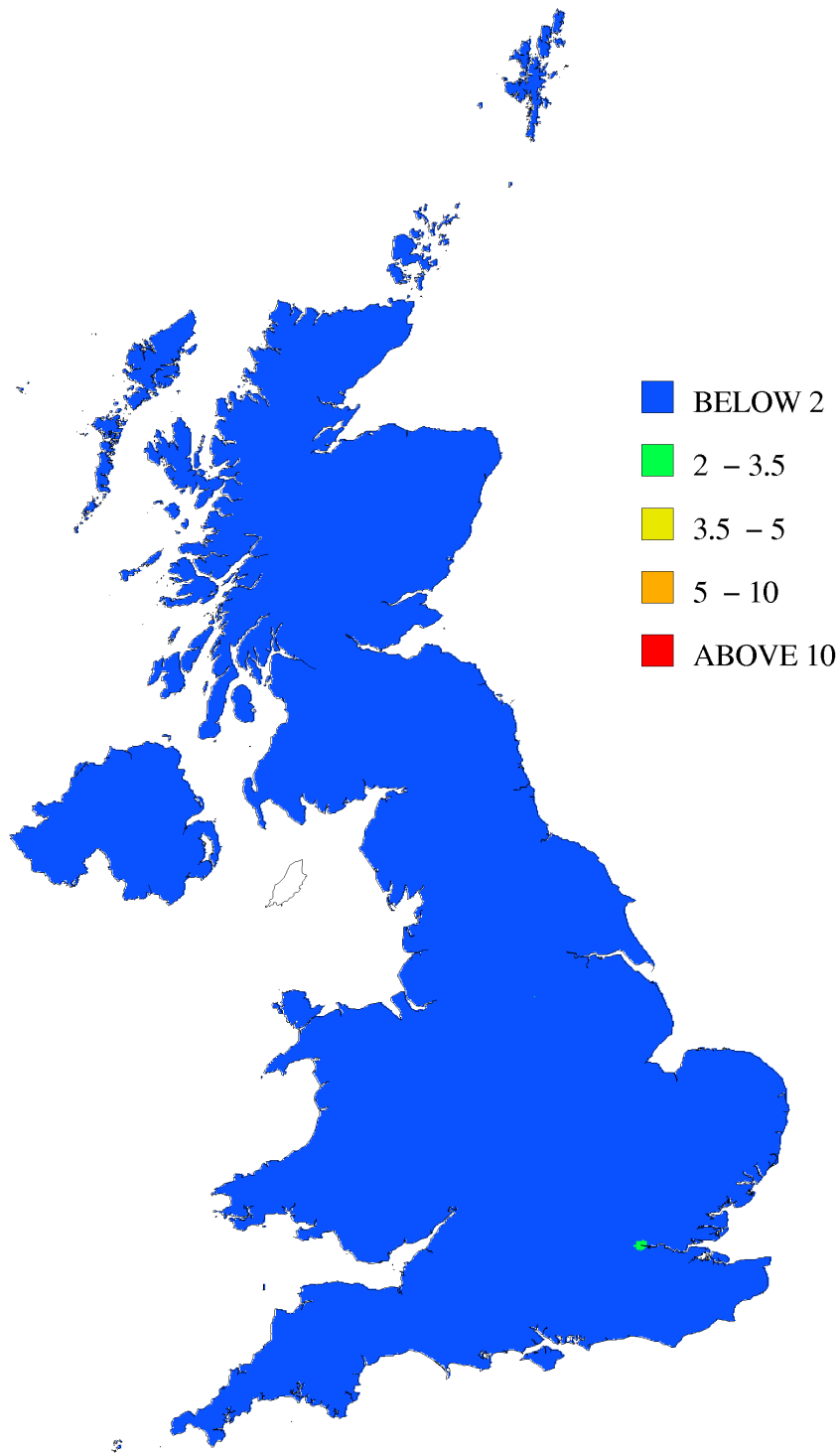
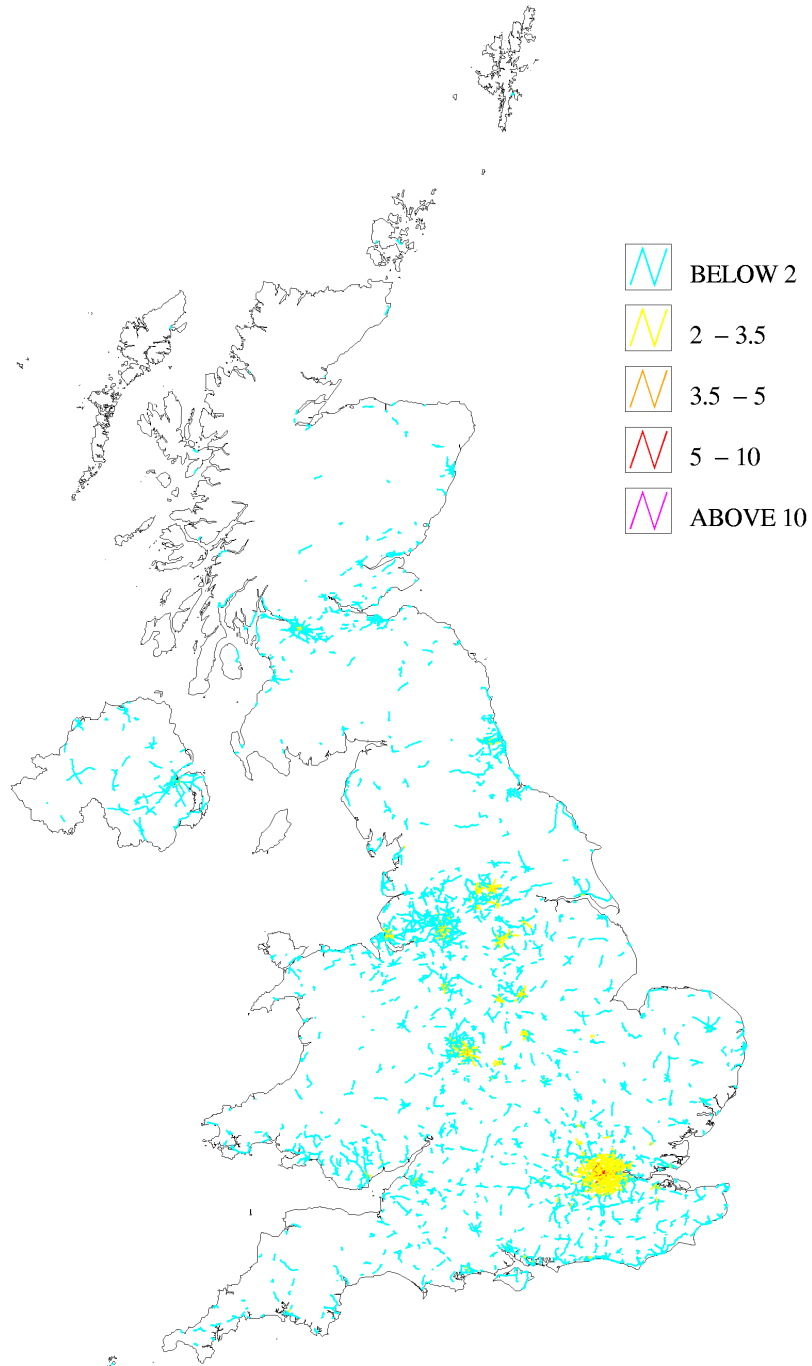


Figure 3 Estimated annual mean benzene concentrations at background locations, 2001 ( $\mu\text{g m}^{-3}$ ). Ref. netcen/14082001/naqs3tb/aq\_objective/bz/uk1bz2001at2



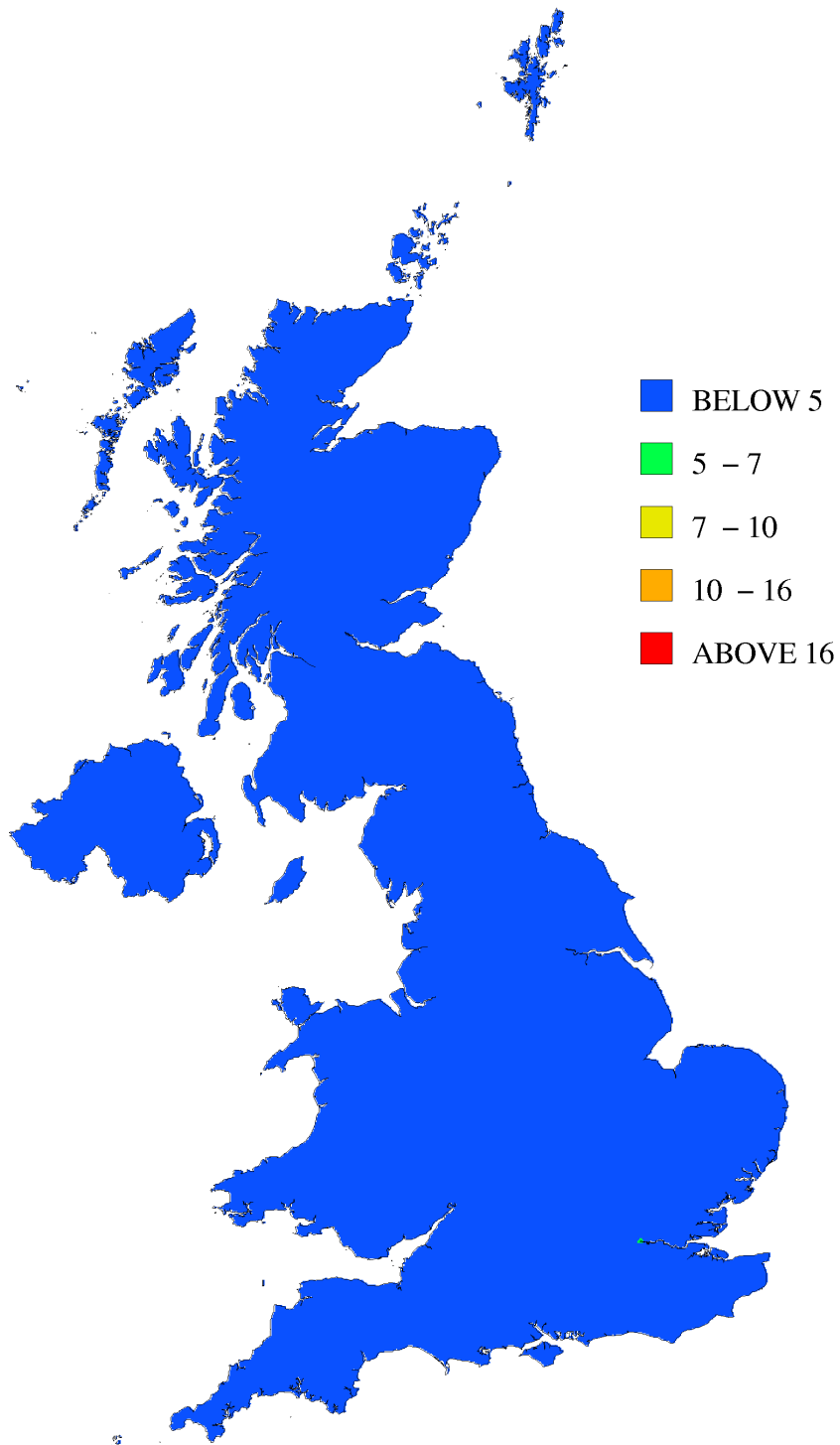
Lower Assessment Threshold =  $2 \mu\text{g m}^{-3}$ , Upper Assessment Threshold =  $3.5 \mu\text{g m}^{-3}$   
 Limit Value =  $5 \mu\text{g m}^{-3}$ , Margin of Tolerance in 2001 =  $10 \mu\text{g m}^{-3}$

Figure 4 Estimated annual mean benzene concentrations at built-up roadside locations, 2001 ( $\mu\text{g m}^{-3}$ ). Ref. netcen/14082001/policy\_evaluation/census\_scen.pat/rbz2001at2



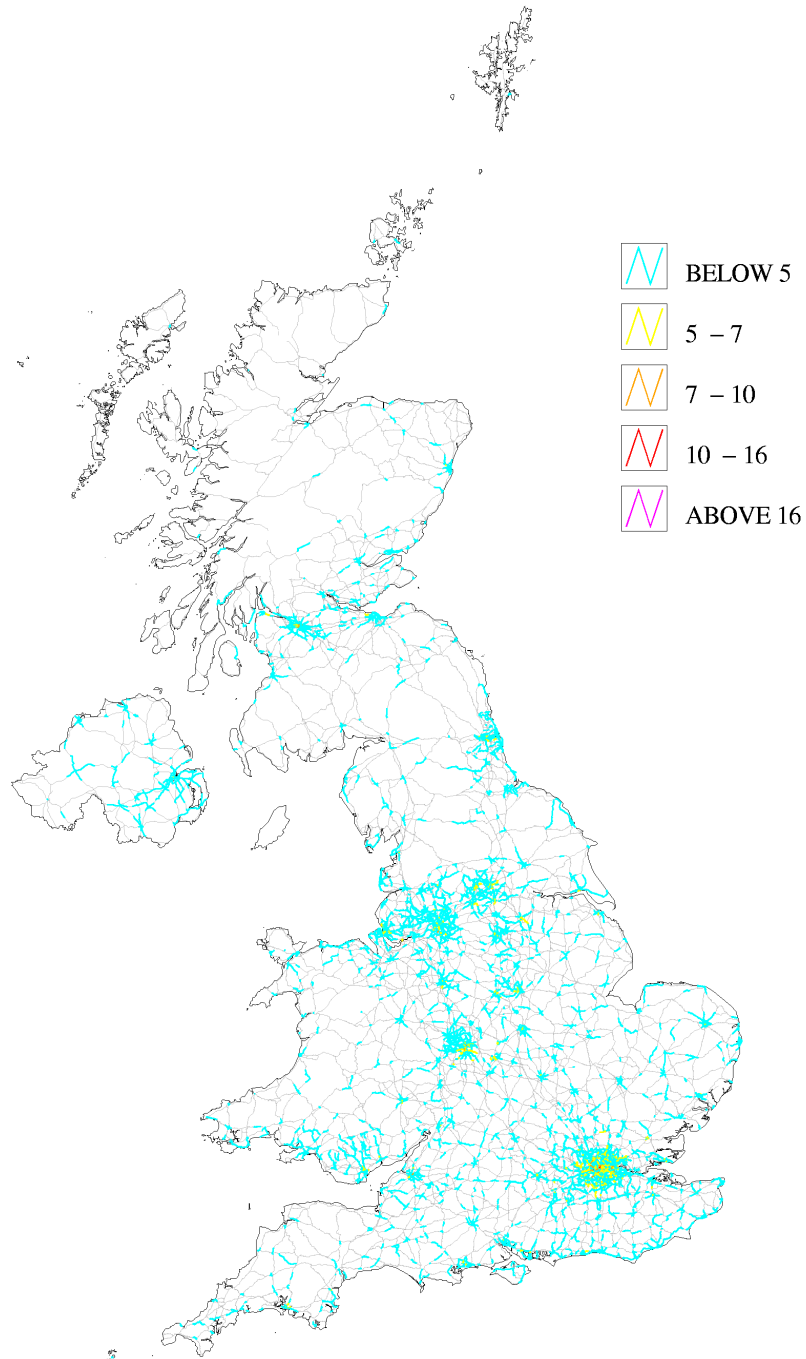
Lower Assessment Threshold = 2  $\mu\text{g m}^{-3}$ , Upper Assessment Threshold = 3.5  $\mu\text{g m}^{-3}$   
 Limit Value = 5  $\mu\text{g m}^{-3}$ , Margin of Tolerance in 2001 = 10  $\mu\text{g m}^{-3}$

Figure 5 Estimated maximum 8-hour mean carbon monoxide concentrations at background locations, 2001 ( $\mu\text{gm}^{-3}$ ). Ref. netcen/15082001/naqs3tb/aq\_objective/uk1combh20011



Lower Assessment Threshold =  $5 \mu\text{gm}^{-3}$ , Upper Assessment Threshold =  $7 \mu\text{gm}^{-3}$   
 Limit Value =  $10 \mu\text{gm}^{-3}$ , Margin of Tolerance in 2001 =  $16 \mu\text{gm}^{-3}$

Figure 6 Estimated maximum 8-hour mean carbon monoxide concentrations at built-up roadside location, 2001 ( $\text{mgm}^{-3}$ ). Ref. netcen/policy\_evaluation/census\_scen.pat/rcom8h2001.



Lower Assessment Threshold =  $5 \mu\text{gm}^{-3}$ , Upper Assessment Threshold =  $7 \mu\text{gm}^{-3}$   
 Limit Value =  $10 \mu\text{gm}^{-3}$ , Margin of Tolerance in 2001 =  $16 \mu\text{gm}^{-3}$

# Appendices

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<b>Appendix 1</b>	Article 5 of the Framework Directive
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<b>Appendix 4</b>	Comparison of measured and modelled exceedance statistics

# **Appendix 1**

## **Framework Directive: Article 5**

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## **Article 5, Preliminary assessment of ambient air quality**

Member States which do not have representative measurements of the levels of pollutants for all zones and agglomerations shall undertake series of representative measurements, surveys or assessments to have data available in time for the implementation of the legislation referred to in Article 4 (1).

Source: Council Directive 2000/69/EC



# **Appendix 2**

## **Daughter Directive Limit Values and Assessment Thresholds**

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## ANNEX I

## LIMIT VALUE FOR BENZENE

The limit value must be expressed in  $\mu\text{g}/\text{m}^3$ , standardised at a temperature of 293 K and a pressure of 101,3 kPa.

	Averaging period	Limit value	Margin of tolerance	Date by which limit value is to be met
Limit value for the protection of human health	Calendar year	5 $\mu\text{g}/\text{m}^3$	5 $\mu\text{g}/\text{m}^3$ (100 %) on 13 December 2000, reducing on 1 January 2006 and every 12 months thereafter by 1 $\mu\text{g}/\text{m}^3$ to reach 0 % by 1 January 2010	1 January 2010 <sup>(1)</sup>

<sup>(1)</sup> Except within zones and agglomerations within which a time-limited extension has been agreed in accordance with Article 3(2).

## ANNEX II

## LIMIT VALUE FOR CARBON MONOXIDE

The limit value must be expressed in  $\text{mg}/\text{m}^3$ . The volume must be standardised at a temperature of 293 K and a pressure of 101,3 kPa.

	Averaging period	Limit value	Margin of tolerance	Date by which limit value is to be met
Limit value for the protection of human health	Maximum daily 8-hour mean	10 $\text{mg}/\text{m}^3$	6 $\text{mg}/\text{m}^3$ on 13 December, reducing on 1 January 2003 and every 12 months thereafter by 2 $\text{mg}/\text{m}^3$ to reach 0 % by 1 January 2005	1 January 2005

The maximum daily 8-hour mean concentration will be selected by examining 8-hour running averages, calculated from hourly data and updated each hour. Each 8-hour average so calculated will be assigned to the day on which it ends. i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day will be the period from 16:00 to 24:00 on that day.

Source: Council Directive 2000/69/EC

ANNEX III

**DETERMINATION OF REQUIREMENTS FOR ASSESSMENT OF CONCENTRATIONS OF BENZENE AND CARBON MONOXIDE IN AMBIENT AIR WITHIN A ZONE OR AGGLOMERATION**

**I. Upper and lower assessment thresholds**

The following upper and lower assessment thresholds will apply:

(a) Benzene

	Annual average
Upper assessment threshold	70 % of limit value (3,5 µg/m <sup>3</sup> )
Lower assessment threshold	40 % of limit value (2 µg/m <sup>3</sup> )

(b) Carbon Monoxide

	Eight-hour average
Upper assessment threshold	70 % of limit value (7 mg/m <sup>3</sup> )
Lower assessment threshold	50 % of limit value (5 mg/m <sup>3</sup> )

**II. Determination of exceedances of upper and lower assessment thresholds**

Exceedances of upper and lower assessment thresholds must be determined on the basis of concentrations during the previous five years where sufficient data are available. An assessment threshold will be deemed to have been exceeded if it has been exceeded during at least three separate years out of those previous five years.

Where fewer than five years' data are available, Member States may combine measurement campaigns of short duration during the period of the year and at locations likely to be typical of the highest pollution levels with results obtained from information from emission inventories and modelling to determine exceedances of the upper and lower assessment thresholds.

Source: Council Directive 2000/69/EC

# **Appendix 3**

## **Annex V of the Daughter Directive**

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## ANNEX V

**CRITERIA FOR DETERMINING NUMBERS OF SAMPLING POINTS FOR FIXED MEASUREMENT OF CONCENTRATIONS OF BENZENE AND CARBON MONOXIDE IN AMBIENT AIR**

Minimum number of sampling points for fixed measurement to assess compliance with limit values for the protection of human health in zones and agglomerations where fixed measurement is the sole source of information:

## (a) Diffuse sources

Population of agglomeration or zone (thousands)	If concentrations exceed the upper assessment threshold <sup>(1)</sup>	If maximum concentrations are between the upper and lower assessment thresholds
0-249	1	1
250-499	2	1
500-749	2	1
750-999	3	1
1 000-1 499	4	2
1 500-1 999	5	2
2 000-2 749	6	3
2 750-3 749	7	3
3 750-4 749	8	4
4 750-5 999	9	4
≥ 6 000	10	5

<sup>(1)</sup> To include at least one urban-background station and one traffic-oriented station provided this does not increase the number of sampling points.

## (b) Point sources

For the assessment of pollution in the vicinity of point sources, the number of sampling points for fixed measurement should be calculated taking into account emission densities, the likely distribution patterns of ambient air pollution and potential exposure of the population.

Source: Council Directive 2000/69/EC

# **Appendix 4**

## **Comparison of measured and modelled exceedance statistics**

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Table A1 Identified exceedances of the Lower Assessment Threshold (LAT) for benzene based upon measured data (1995-1999) and modelled data (1999 only) for UK agglomerations .

Agglomeration	Monitoring location	Measured annual mean benzene (ugm-3)					Modelled annual mean benzene 1999 (ugm <sup>-3</sup> )*	LAT Exceedance category		
		1995	1996	1997	1998	1999		Measured	Modelled*	Article 5**
Belfast Urban Area	Belfast South	3	3	3	2.3	2.2	2.0	Yes	No	Yes
Bristol Urban Area	Bristol East	4	4		3.1	2.7	2.4	Yes	Yes	Yes
Cardiff Urban Area	Cardiff East		4		3.2		1.9	n/a	No	Yes
Edinburgh Urban Area	Edinburgh Med. Sch.		2.3		1.9	1.8	1.4	No	No	No
Greater London Urban Area	London Eltham	3.4	3.5	3.4	2.7	2.6	2.5	Yes	Yes	Yes
	London UCL	5.6	6.2	5.8		3.7	4.0	Yes	Yes	Yes
Liverpool Urban Area	Liverpool Speke		2.9				1.7	n/a	No	Yes
Southampton Urban Area	Southampton Centre		6.3		5.2	4.3	2.0	Yes	No	Yes
Teeside Urban Area	Middlesbrough	3.6	3.3	3.4	2.5	2.6	1.7	Yes	No	Yes***
West Midlands Urban Area	Birmingham East	3.4		3.4	2.8		2.4	Yes	Yes	Yes
West Yorkshire Urban Area	Leeds Potternewton	3.2	3.4	3.7			2.8	Yes	Yes	Yes

Absence of data indicates insufficient data available to calculate exceedance (data capture <90%)

\* indicates modelled annual average concentration at the location of the automatic monitor

\*\* indicates the exceedance statistic assigned to an agglomeration or zone as a whole, based on modelled or measured exceedances throughout the agglomeration or zone at urban background, roadside or industrial locations

\*\*\* recommendation for continued monitoring at Middlesbrough industrial background location

Table A2 Identified exceedances of the Lower Assessment Threshold (LAT) for carbon monoxide based upon measured data (1995-1999) and modelled data (1999 only) for UK agglomerations.

Agglomeration	Site Name	Measured 8-hour mean CO mgm <sup>-3</sup>					Modelled 8-hour mean CO 1999 (mgm <sup>-3</sup> ) *	LAT Exceedance category		
		1995	1996	1997	1998	1999		Measured	Modelled *	Article 5 **
Belfast Urban Area	Belfast Centre	16.2	9.4	8.1	4.1	4.3	3.6	Yes	No	Yes
Brighton/Worthing/L'hampton	Brighton Roadside					4.1	5.1	n/a	Yes	Yes
	Hove Roadside			(5.5)	5.1	3.6	3.9	n/a	No	Yes
Bristol Urban Area	Bristol Centre	5.3	5.9	(6.1)	3.7	3	4.1	Yes	No	Yes
	Bristol Old Market		(9.9)	9.2	6.6	(5.7)	4.8	Yes	No	Yes
Cardiff Urban Area	Cardiff Centre	4.2	3.7	6	2.8	2.7	2.8	No	No	Yes
Coventry/Bedworth	Coventry Centre				3.6		3.1	n/a	No	Yes
Edinburgh Urban Area	Edinburgh Centre	3.7		2.9	3.5	1.7	2.6	No	No	Yes
Glasgow Urban Area	Glasgow Centre		(7.9)	6.7	3	4.5	4.8	n/a	No	Yes
	Glasgow City Chambers	5.5		7.9	3.5	4.2	4.7	n/a	No	Yes
	Glasgow Kerbside			(9.6)	4.4	4.4	4.7	n/a	No	Yes
Greater London Urban Area	Hounslow Roadside			(14)	(7.9)	5.8	6.1	Yes	Yes	Yes
	London A3 Roadside			(8)	(8.8)	3.8	n/a	n/a		Yes
	London Bexley	5.5	9.9	5.3	3.9		2.4	Yes	No	Yes
	London Bloomsbury		7.4	7.8	3.7	3.8	6.2	n/a	Yes	Yes
	London Brent		9.3	11.5	4.9	5.1	4.0	Yes	No	Yes
	London Bridge Place	6.5	6.7	(8.2)	4.2		5.6	Yes	Yes	Yes
	London Cromwell Road	7.8					8.6	n/a	Yes	Yes
	London Cromwell Road 2					5.1	8.6	n/a	Yes	Yes
	London Hackney			7.1	7.1	(5.5)	4.2	Yes	No	Yes
	London Hillingdon		(9)	8.1	7.2	3	3.8	Yes	No	Yes
	London Marylebone Road			(11.1)	7.3	8.5	8.3	Yes	Yes	Yes
	London N. Kensington		(9.3)	9	3.5	3.9	4.9	n/a	No	Yes
	London Southwark				5.7	4.8	5.5	n/a	Yes	Yes
	Southwark Roadside			(14)	(6.6)	6.5	6.4	Yes	Yes	Yes
	Sutton Roadside			12.1	4.6	4.3	3.6	n/a		Yes
	Tower Hamlets Roadside		(10.7)	11.5	7.9	6.5	6.4	Yes	Yes	Yes
	West London	12.9	6.3	9.3	3.6	4.3	5.0	Yes	No	Yes
Grtr Manchester Urban Area	Bolton				5.2	4.8	2.3	n/a	No	Yes
	Bury Roadside			(5.5)	4.8	4.4	4.8	n/a	No	Yes
	Manchester Piccadilly		5.5	4.6	(5.1)	4.1	3.2	n/a	No	Yes
	Manchester Town Hall	8.5			4.4	4.1	3.3	n/a	No	Yes
	Salford Eccles				5.2	5.1	2.9	n/a	No	Yes
	Stockport				5.5	3.8	2.8	n/a	No	Yes
Kingston upon Hull	Hull Centre	4.5	3.5	3.7	4.1	2.9	1.7	No	No	Yes
Leicester Urban Area	Leicester Centre	9.2	5	5.8	3.7	2.8	3.5	No	No	Yes
Liverpool Urban Area	Liverpool Centre	2.6	3.2	3.8	2.2	2.1	3.7	No	No	Yes
Nottingham Urban Area	Nottingham Centre			5.5	8.2	3.4	3.6	n/a	No	Yes
Reading/Wokingham Urban Area	Reading					3.2	2.9	n/a	No	Yes
Sheffield Urban Area	Sheffield Centre		4.9	4.6	3.5	2.7	3.4	No	No	Yes
	Sheffield Tinsley		4.5	4.1	3.5	3.4	3.3	No	No	Yes



Agglomeration	Site Name	Measured 8-hour mean CO mgm <sup>-3</sup>					Modelled 8-hour mean CO 1999 (mgm <sup>-3</sup> ) *	LAT Exceedance category		
		1995	1996	1997	1998	1999		Measured	Modelled *	Article 5 **
Southampton Urban Area	Southampton Centre	(7.3)	7.5	10.7	4.4	3.4	2.8	Yes	No	Yes
Swansea Urban Area	Swansea	4.3	4.6	4.6	4.8	2.6	1.6	No	No	No
Teeside	Middlesbrough		3.5	3.4		2	2.4	No	No	Yes
	Redcar				4.5	2.8	1.2	n/a	No	Yes
The Potteries	Stoke-on-Trent Centre			(7)	8.8	5.9	3.1	Yes	No	Yes
Tyneside	Newcastle Centre	4.1	5	3.5	2.6	2.2	2.5	No	No	Yes
West Midlands Urban Area	Birmingham Centre	8	4.5	3.8	3		3.6	No	No	Yes
	Birmingham East	10.4	6.7	7.7	3.8	4.4	3.2	Yes	No	Yes
	Sandwell West Bromwich					2.2	2.8	n/a	No	Yes
	Wolverhampton Centre		5.6	5.3	3.8	2.8	1.9	n/a	No	Yes
West Yorkshire Urban Area	Bradford Centre				6	6.5	3.9	n/a	No	Yes
	Leeds Centre	6.4	5.1	5.5	3.8	3.9	5.1	Yes	Yes	Yes

Values in parentheses indicate exceedance of the maximum 8-hour mean LAT calculated from <90% data capture  
Absence of data indicates insufficient data available to calculate formal exceedance (data capture <90%) and maximum 8-hour mean <LAT

\* indicates modelled annual average concentration at the location of the automatic monitor

\*\* indicates the exceedance statistic assigned to an agglomeration or zone as a whole, based on modelled or measured exceedances throughout the agglomeration or zone at urban background, roadside or industrial locations

Table A3 Identified exceedances of the Lower Assessment Threshold (LAT) for carbon monoxide based upon measured data (1995-1999) and modelled data (1999 only) for UK non-agglomeration zones

Agglomeration	Site Name	Measured 8-hour mean CO mgm <sup>-3</sup>					Modelled 8-hour mean CO 1999 (mgm <sup>-3</sup> ) *	LAT Exceedance category		
		1995	1996	1997	1998	1999		Measured	Modelled *	Article 5 **
Eastern	Norwich Centre			(7.4)	6	3.4	2.4	n/a	No	Yes
	Thurrock			7.7	4.9	3.4	1.9	n/a	No	Yes
Northern Ireland	Derry				4.9	3	1.4	n/a	No	No
South East	Oxford Centre		(8.5)	(5.8)		3.6	4.0	n/a	No	Yes
South West	Bath Roadside					5.2	4.5	n/a	No	Yes
	Exeter Roadside		(11.8)	13.9	9.4	6	n/a	Yes		Yes
	Plymouth Centre				3.4	2.8	1.7	n/a	No	Yes
West Midlands	Leamington Spa				3.1	2.9	2.1	n/a	No	Yes

Values in parentheses indicate exceedance of the maximum 8-hour mean LAT calculated from <90% data capture  
Absence of data indicates insufficient data available to calculate formal exceedance (data capture <90%) and maximum 8-hour mean <LAT

\* indicates modelled annual average concentration at the location of the automatic monitor

\*\* indicates the exceedance statistic assigned to an agglomeration or zone as a whole, based on modelled or measured exceedances throughout the agglomeration or zone at urban background, roadside or industrial locations

